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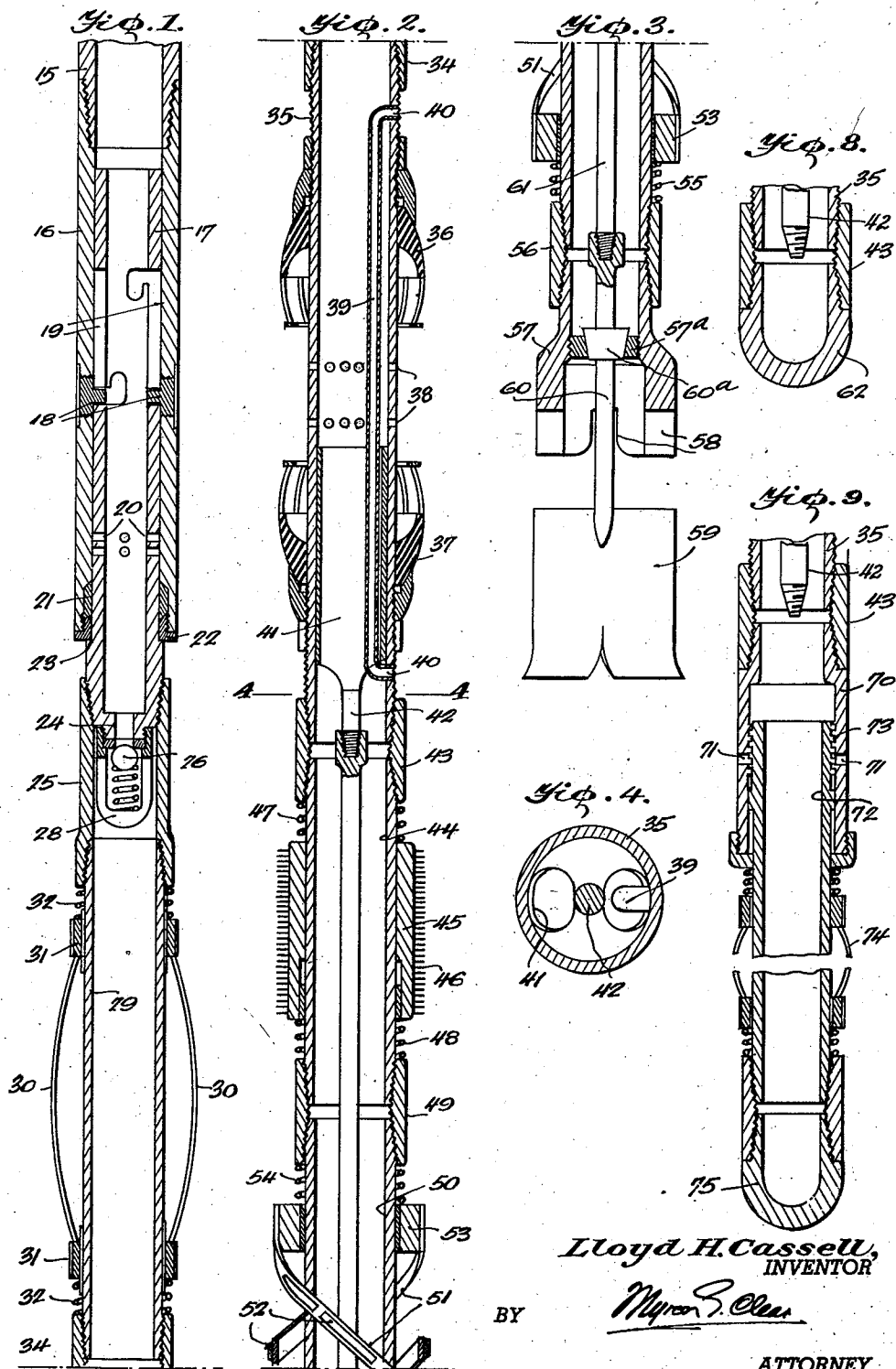
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PERFORATION CLEANER AND WASHER

Filed Sept. 22, 1941

2 Sheets-Sheet 1



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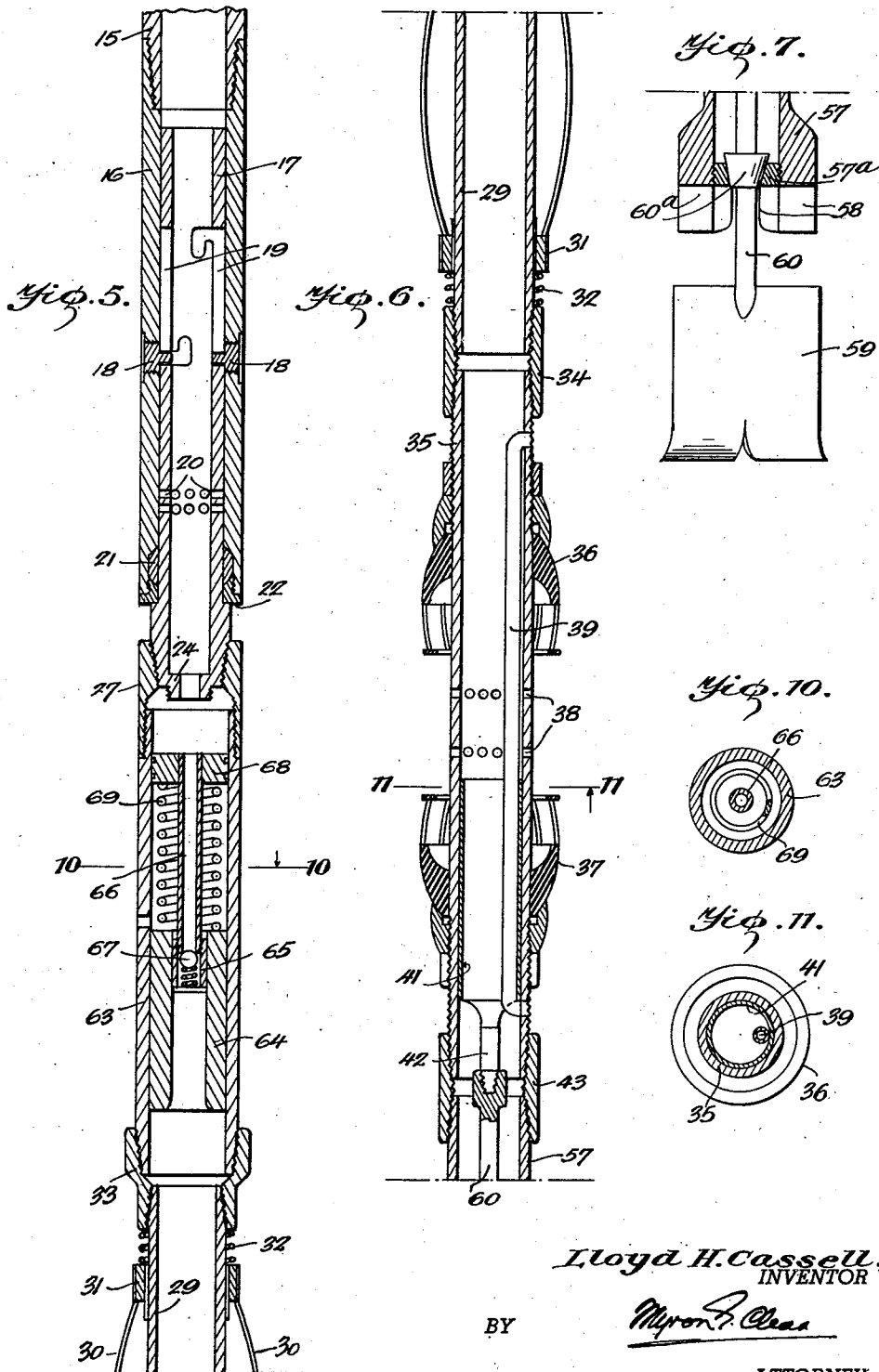
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UNITED STATES PATENT OFFICE

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PERFORATION CLEANER AND WASHER

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10 Claims. (Cl. 166—20)

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The present invention relates to apparatus for lowering in the casing of oil wells with the object of cleaning and washing the perforations of liners and perforated sections of casing in the interest of full production from the producing zones or areas, and its primary object is the provision of a tool or apparatus of this nature which will meet all practical requirements of this character of work and enable the operator to fulfill such requirements as they arise in the field.

Among others, it is an object to provide a perforation washer having provision for circulation therefrom between pack off members, as well as from points above and below the pack off area, under full control of the operator from the surface.

Another object is the provision of a tool of this character which may be run into and out of the casing without swabbing action, and may thus be employed for spotting slurry and chemicals in the hole.

Still another object is the provision of a tool having an automatically acting pressure booster functioning where circulation requirements are greater than available surface pressure supply.

A further object is the provision of a tool of this character, the several active sections of which are interchangeably connected for shifting their relative positions and varying the work capacity of the tool as a whole to suit the known conditions under which it is used.

Other and further objects of the invention, as well as its details of construction, arrangement and operation, and its resulting advantages, may be better understood and more thoroughly appreciated in the course of the following description and explanation, and by reference to the accompanying drawings, forming a part of this specification, and wherein:

Figures 1, 2 and 3 are continuing portions of a vertical longitudinal sectional view through the cleaning and washing tool with a full set-up for cement incrustated perforations.

Figure 4 is a detail cross section taken there-through substantially on line 4—4 of Figure 2.

Figures 5, 6 and 7 are continuing vertical longitudinal sectional views through the tool showing a set-up including the pressure boosting device.

Figure 8 is a vertical longitudinal section through the bull plug normally closing the lower end of the set-up of Figures 5 and 6.

Figure 9 is a detail vertical sectional view through a lower circulation member for the tool, and

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Figures 10 and 11 are detail transverse sectional views taken respectively on lines 10—10 of Figure 5 and 11—11 of Figure 6.

Referring now to these figures, the lower end portion 15 of a tubing string, upon which the tool of the present invention is lowered into an oil well casing whose perforate section or liner is to be washed, is shown in Figures 1 and 5 as in threaded connection at its lower end with the upper end of the barrel 16 of an upper circulating and washing section of the complete tool. This barrel 16 slidably and rotatably telescopes a circulating valve mandrel 17 and has diametrically opposite radially inwardly projecting pins 18 threaded and locked in connection therewith and positioned in the correspondingly arranged Z-slots 19 of the mandrel. This arrangement is such that by turning the barrel 16 a quarter turn counterclockwise while in its lower position shown (in Fig. 1), the barrel 16 may be raised to its upper position so that its lower end uncovers the circulation ports 20 of the mandrel to thus permit of direct upper circulation into the casing of the well. While in its upper position, a further quarter turn of barrel 16 counterclockwise moves the pins 18 into the upper transverse portions of the slots 19 and locks the barrel in elevated position. While the barrel is in its upper position it is necessary to turn the barrel first clockwise, then drop the same and again turn it clockwise, to lock the barrel in its normal closed position wherein its lower portion covers and closes the circulation ports 20. Preferably this lower end of the barrel 16 carries internal packing 21 around the mandrel 17, with a packing nut 22 which engages an external annular shoulder 23 of the mandrel in the closed position to take strain from the Z-slot pins 18.

The lower projecting end of mandrel 17 is preferably threaded and provided with a reduced threaded extension 24, and may be coupled by its said threads either to the upper end of a short tubular section 25 as seen in Figure 1 which serves as a housing for a back pressure valve 26, or to a coupling collar 27 as in Figure 5 where it is desired to supplant the back pressure valve 26 and its housing with the pressure booster shown in the latter figure and described hereinafter.

Where valve 26 and its housing 25 are used, the cage 28 of said valve is threadedly connected to the reduced extension 24 of the mandrel 17, and the lower end of its housing 25 is threadedly connected to the upper end of a bow spring arrangement including a tubular bow spring sup-

port or holder 29 having external casing gripping bow springs 30, the ends of which are carried by heads 31 splined on holder 29 and engaged by springs 32 which serve to take up shocks in action and relieve the bow springs 30 of breaking strains. This bow spring and its holder serve to hold the mandrel 17 against rotation in the well casing to a sufficient extent that the barrel 16 may be turned relative thereto, and is shown in Figures 5 and 6 in connection at its upper end by a coupling collar 33 with the lower end of the pressure booster.

On both Figures 2 and 6, the lower end of the bow spring holder 29 is shown as connected at its lower end by a coupling collar 34 with the upper end of the tubular main circulating and washing mandrel 35 which supports packing rubbers 36 and 37 externally on its upper and lower portions in selectively spaced and opposed relation above and below the intermediate circulation ports 38 of said mandrel. Through these ports 38, washing fluid under pressure in the tubing string is forced to pass laterally through the perforations of a liner or perforate section of the casing in which the washing tool is used, the high pressure area being defined between the packers 36 and 37, although the relation and spacing of the latter may be varied and nothing said here is to be taken as preventing the use of additional packers of this or similar nature at other points on the tool, arranged to provide for a similar function.

Within the washing mandrel 35, it will be noted a by-pass pipe 39 extends beyond the two packers 36 and 37 above mentioned, with its curved ends opening laterally through the wall of the mandrel, as at 40, respectively above and below the said packers to provide for displacement of well fluids around the packers and the high pressure circulating area therebetween, when going into and/or coming out of the hole, with the object of preventing swabbing action in the casing. Also within the mandrel 35, and having a sliding fit therein, is a valve sleeve 41. This sleeve normally rests in a position substantially below the circulating ports 38 but may be shifted in a manner presently described, to an upper position in which it covers the said ports and prevents circulation out through the same when it is desired that circulation be effected from the tool at a lower point for a purpose which will presently appear. The valve sleeve 41 preferably has a depending axial stem 42 threaded at its lower end which is shown as terminating approximately at the lower end of mandrel 35 when the valve sleeve is in lower, inactive position.

The lower end of mandrel 35 is shown in Figure 2 as connected by a coupling collar 43 with the upper end of a tubular brush holder 44 on which a brush cylinder 45 with outstanding wire or other bristles 46, is splined and confined between end springs 47 and 48 tensioning its endwise movements on the holder and absorbing any shocks incidental to such movements.

Figure 2 also shows the lower end of the brush holder 44 as connected by a coupling collar 49 to the upper end of a scraper or abrader holding cylinder 50 on which helically curved springs 51, equipped with abrading pieces 52, extend between heads 53 which are splined on said cylinder and confined between shock absorbing controlling springs 54 and 55. This scraper or abrader is used where a prior cementing operation in a well is known as probably setting up an incrustation of cement within the liner or perforate section of

the casing. Such an incrustation must be removed to free the perforations for thorough washing, and this is provided for in using the scraper or abrader for removing the incrustation, followed in the downward movement of the tool by the brush cylinder whose bristles enter the perforations and serve to clean the same in a preparatory manner for the subsequent operation of the washing mandrel.

In the use of the scraper and brush which are optional features of the tool as a whole, the lower end of scraper cylinder 50 is preferably connected by a coupling collar 56 to a hollow bit head 57 having its lower end longitudinally slotted at diametrically opposed points at 58 to receive, in rotatable driving relation, the upper edge of a blade bit 59. This bit is normally suspended substantially below and free of the head, on an axial stem 60 which rises therefrom within the head 57 and is coupled at its upper end to a connecting stem 61 passing upwardly through the scraper cylinder 50 and brush holder 44, and coupled to the lower end of the valve sleeve stem 42. Thus if the bit 59 encounters a sand bridge or cement lining in the casing, downward pressure of the tool on the arrested bit forces the head 57 downwardly into engagement with the bit so that its upper edge is within the heads slots 58 and a driving connection is affected whereby rotation of the tubing string will rotate the bit for cutting away the bridge or lining. At the same time the stem 60, 61 is shifted upwardly in the tool bore and by reason thereof, the valve sleeve 41 is thrust upwardly in the washing mandrel 35 to a position wherein it covers and closes the circulation ports 38 and thus forces circulation downwardly through the bit head 57 and outwardly around the working bit 59.

This arrangement provides for a controlled bottom circulation whereby in any case the bit 59 encounters an obstacle, the sleeve valve 41 will be raised to force circulation from the lower end of the tool and should it so happen that the lower end of the tool is, at this time, within an imperforate section of the casing, the return circulation will go around the lower section of the tool and through the by-pass 39. In the arrangement of Figures 5, 6 and 7, the bottom circulating features are shown as connected directly to the lower end of the washing mandrel 35, the bit head 57 being connected to coupling collar 43 and the bit stem 60 being connected directly to the sleeve valve stem 42.

In order to normally close off the lower circulation the bit head preferably has an internal valve seat 57^a and the bit stem 60 has a conical valve member 60^a which is seated on said seat when the tool is in normal run in position with the sleeve valve 41 in lower open position. Valve member 60^a is thus raised when the bit encounters an obstacle, and the lower circulation is opened as the normal intermediate or washing circulation between the packers is closed by sleeve valve 41.

However, since the brush holder, scraper cylinder and bit head and bit are optional features of the tool which are used when it is known that obstacles may be expected in entering the perforated section of the well casing, by reason of previous cementing operations therein, these features may be eliminated in other instances, and the coupling collar 43 at the lower end of the washing mandrel used as in Figure 8 to attach thereto an ordinary bull plug 62 for closing the lower end of the tool as it is used in a washing opera-

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tion or for spotting cement or chemicals in the well.

When bull plug 62, shown in Figure 8, is used, the stem 61 is disconnected from stem 42 on sleeve valve 41, and the sleeve valve remains in the lower or open position. Also when the bull plug and lower circulating valve assembly shown in Figure 9 is used, the stem 61 is omitted and valve 41 remains open.

It will be understood that the upper circulation features including barrel 16 and the ported mandrel 17, as well as the washing mandrel 35 and its described equipment, are the same in Figures 5 and 6 as they are in Figures 1 and 2, although in Figures 5 and 6 a pressure booster previously referred to, is utilized between mandrels 17 and 35 for use in any instance where it is necessary to circulate from the washing mandrel ports 38 under a pressure above that available at the surface.

The pressure booster includes a cylindrical casing 63 connected at its upper end directly to the lower end of the upper valve mandrel 17 by means of the before referred to coupling collar 27, and upon removal of the before described back pressure valve 26 and its housing 25. Within the lower portion of casing 63, whose lower end may be directly connected with the upper end of bow spring holder 29 by coupling collar 33, is a liner 64 whose reduced bore forms a piston cylinder substantially smaller than the internal diameter of casing 63. In this reduced piston cylinder a tubular piston 65 is connected to the lower end of a hollow piston rod 66, the piston 65 including a ball valve 67 spring seated upwardly at the lower end of hollow rod 66. The upper end of hollow rod 66 is fixed to, and opens upwardly through, a piston 68 of a size to slidably interfit the casing 63 above liner 64 so that under normal conditions washing fluid is forced downwardly through piston 68, hollow rod 66 and past the downwardly opening ball valve 67 without affecting the booster whose parts are held in a normal upper position by a coiled spring 69 under compression between the larger, upper piston 68 and the liner 64.

When, however, resistance to normal outflow of washing fluid outwardly from the circulation ports of the washing mandrel, caused by clogged casing perforations, is such that it cannot be overcome by the fluid pressure available at the surface, pressure builds up above and below the booster piston, and pressure above the larger piston 68 forces the same downwardly so as to subject the fluid below the downwardly moving small piston, already at high pressure, to a pressure increased above that acting against piston 68 by the differential between the areas of the booster pistons. The action, it will be observed, is entirely automatic and by bleeding pressure from the tubing string above the booster after an action thereof, its parts may return to the upper or normal position for a second action should break through be only partially affected during a first action thereof.

Moreover, though equipped with a top circulating means including barrel 16 and mandrel 17, and washing mandrel 35 with its circulating ports and by-pass 39 around the packing rubbers, there may be instances of use where it is additionally important not to disturb fluid in the well in any manner while coming out of the hole, as for instance in spotting slurry or chemicals incidental to washing operation. In such instances, the bull plug 62 described as a closure for the lower end of

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the tool, may be removed and its coupling collar 43 utilized to couple a lower circulating section to the lower end of the washing mandrel. This section is shown in Figure 9 and includes an upper barrel 70 having circulation ports 71 in its wall normally covered and closed by the upper end portion of a valve mandrel 72 which is disposed in the barrel.

The barrel 70 and mandrel 72 have engaging coarse, left hand threads as at 73 and by turning the tool to the right a few turns, with the mandrel held against rotation in the casing, the latter may be dropped to a limited extent relative to the barrel sufficient to uncover and open the lower circulating ports 71. For holding the valve mandrel 72 while rotating barrel 70 relative thereto, it is provided below the barrel with casing engaging bow springs 74 in an arrangement similar to the before described bow springs 30. The lower end of valve mandrel 72 may be closed by a bull plug 75, and it is thus obvious that by reason of this provision for circulating out below the washing mandrel 35 as well as above the same, with both lower and upper circulations controlled by valves under manipulation from the surface, a washing and cleaning operation may be completed and chemicals and cement spotted where needed, with full safety against danger of sanding up and sticking of the tool as well as elimination of any undesirable swabbing action or disturbance of well fluids in coming out after the washing operation has been completed.

During washing operations, where circulating out through the washing mandrel ports 38 between the packers 36 and 37, it is to be understood the tool is raised and lowered in the perforate section of the casing to circulate out through various portions thereof until the perforations are clear and open and circulating pressure is normal to thereby insure subsequent free flow of fluid into the casing from the producing areas. Since, under some circumstances, when the tool is shifted and circulation pressure is cut off, fluid in the tubing string might drain into the well, the seating springs of back pressure valve 26 and valve 67 of the booster are preferably made of sufficient strength to hold the column of fluid in the tubing string thereabove and thus avoid delays and waste of washing fluid.

Having thus fully described the invention, what is claimed is:

1. A perforation cleaning and washing tool for run into a well on fluid pressure supply tubing, said tool including means forming a tubular casing in communication at its upper end with the tubing, said casing having external packing members in vertically spaced relation and laterally opening circulation ports between said packing members, means forming upper and lower circulation ports in the casing above and below said packing members, upper and lower valves independently controlling said upper and lower circulation ports, means controllable by manipulation of the tool in a well for independently opening and closing each of said valves, and means forming a fluid by-pass through the casing having its upper and lower ends opening laterally through the wall of the casing respectively above and below said packing members and between the latter and the upper and lower circulation ports.

2. A perforation washer for run into a well on fluid pressure supply tubing, said washer including a washing mandrel having laterally opening circulation ports, packing members fixed on said mandrel above and below said ports, a tubular

member connected to the tubing and the mandrel and forming a fluid pressure supply connection therebetween, said member having therein an upper cylinder and a lower cylinder of substantially less diameter than the upper cylinder, and a pressure boosting member in said tubular member including an upper piston slidably interfitted with the upper cylinder, and a lower smaller piston slidably interfitted with the lower cylinder, a hollow stem connecting said pistons and opening at its upper and lower ends through the pistons to form with the pistons a vertically slidable piston assembly having a channel therethrough for the normal passage of fluid pressure from the supply tubing to the mandrel, yieldable means normally urging the piston assembly upwardly in said cylinders, and a check valve in said channel of the piston assembly preventing back flow of fluid pressure from the mandrel to the supply tubing.

3. A perforation cleaning and washing tool, including a hollow mandrel for run in a well on well tubing, said mandrel having vertically spaced external packing members and laterally opening circulation ports between said packing members, a valve for controlling said circulation ports, a tubular member below, and carried by, the said mandrel and open at its lower end, forming a bottom circulation port, a valve normally closing said bottom circulation port, and means within the mandrel and said tubular member including a shiftable stem for simultaneously opening the valve normally closing said bottom circulation port and closing the valve controlling the lateral circulation ports in the mandrel.

4. A perforation cleaning and washing tool, including a hollow mandrel for run in a well on well tubing, said mandrel having vertically spaced external packing members and laterally opening circulation ports between said members, a valve sleeve slidable in said mandrel and normally uncovering said ports, and means connected to said valve sleeve and depending below the mandrel for engagement with a well obstruction for shifting said valve sleeve to cover said ports.

5. A perforation cleaning and washing tool, including a hollow mandrel for run into a well on well tubing, said mandrel having vertically spaced external packing members and laterally opening circulation ports between said members, a valve member slidable relative to the mandrel for covering and uncovering said ports, a tubular member below and carried by the mandrel and in open communication with the mandrel, and the lower end of which tubular member forms a bottom downwardly opening circulation port, a valve member for closing and opening said bottom circulation port, and control means depending through said last named valve and below said tubular member and connected to both of said valve members and operable by engagement thereof with an obstruction when said tool is lowered into the well to simultaneously open one valve member and close the other.

6. A perforation cleaning and washing tool for run into a well on fluid pressure supply tubing, said tool including means forming a tubular casing in communication at its upper end with the tubing, said casing having external packing members in vertically spaced relation and laterally opening circulation ports between said packing members, means forming upper and lower circulation ports in the casing above and below said packing members, upper and lower valves independently controlling said upper and lower cir-

ulation ports, means controllable by manipulation of the tool in a well for independently opening and closing each of said valves, means forming a fluid by-pass through the casing having its upper and lower ends opening laterally through the wall of the casing respectively above and below said packing members and between the latter and the upper and lower circulation ports, and a valved boosting member arranged in said casing and including a piston, said piston being operated by tubing pressure to force circulation outwardly through said circulation ports.

7. A perforation cleaning and washing tool for run into a well on fluid pressure supply tubing, said tool comprising means forming a tubular casing in communication with the well tubing and having vertically spaced external packing members and laterally opening circulation ports between said members, said casing being also provided with a lower circulation port below said packing members, a stem, valve means on said stem, said stem being operable by engagement with an obstruction when the tool is lowered into the well to move the valve means thereon relative to the tool to open said lower circulation port and said stem being movable downwardly relative to the tool as it is lifted to cause said valve means thereon to close said lower circulation port, upper valve means arranged to open and close said laterally opening circulation ports, and means for connecting the upper and lower valve means for closing the laterally opening circulation ports when the lower circulation port is opened and for opening the laterally opening circulation ports when the lower circulation port is closed.

8. A perforation cleaning and washing tool for run into a well on fluid pressure supply tubing, said tool comprising means forming a tubular casing in communication with the well tubing and having vertically spaced external packing members and laterally opening circulation ports between said members, said casing being also provided with a lower circulation port below said packing members, a stem, valve means on said stem, said stem being operable by engagement with an obstruction when the tool is lowered into the well to move the valve means thereon relative to the tool to open said lower circulation port and said stem being movable downwardly relative to the tool as it is lifted to cause said valve means thereon to close said lower circulation port, upper valve means arranged to open and close said laterally opening circulation ports, means for connecting the upper and lower valve means for closing the laterally opening circulation ports when the lower circulation port is opened and for opening the laterally opening circulation ports when the lower circulation port is closed, and means forming a fluid by-pass through the casing independent of said lower circulation port and having upper and lower ends opening laterally through the wall of the casing respectively above and below the upper and lower packing members, the lower end of said fluid by-pass being located above said lower circulation port.

9. A perforation cleaning and washing tool for run into a well on fluid pressure supply tubing, said tool comprising means forming a tubular casing in communication with the well tubing and having vertically spaced external packing members and laterally opening circulation ports between said members, said casing also having a lower circulation port below said packing members, a stem, valve means on said stem, said stem

operable by engagement with an obstruction when the tool is lowered into the well to move the valve means thereon relative to the tool to open said lower circulation port and said stem movable downwardly relative to the tool as it is lifted to cause said valve means thereof to close said lower circulation port, and means forming a fluid by-pass through the casing independent of said lower circulation port and having upper and lower ends opening laterally through the wall of the casing respectively above and below the upper and lower packing members, the lower end of said by-pass opening above the said lower circulation port.

10. A perforation cleaning and washing tool including a hollow mandrel to run in a well on well tubing, said mandrel having upper and lower spaced packing members thereon, and a tubular by-pass in said mandrel having its upper and lower ends opening laterally through the wall of

the mandrel respectively above and below said packing members, said by-pass providing for return circulation therethrough from the bottom.

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