

Aug. 13, 1968

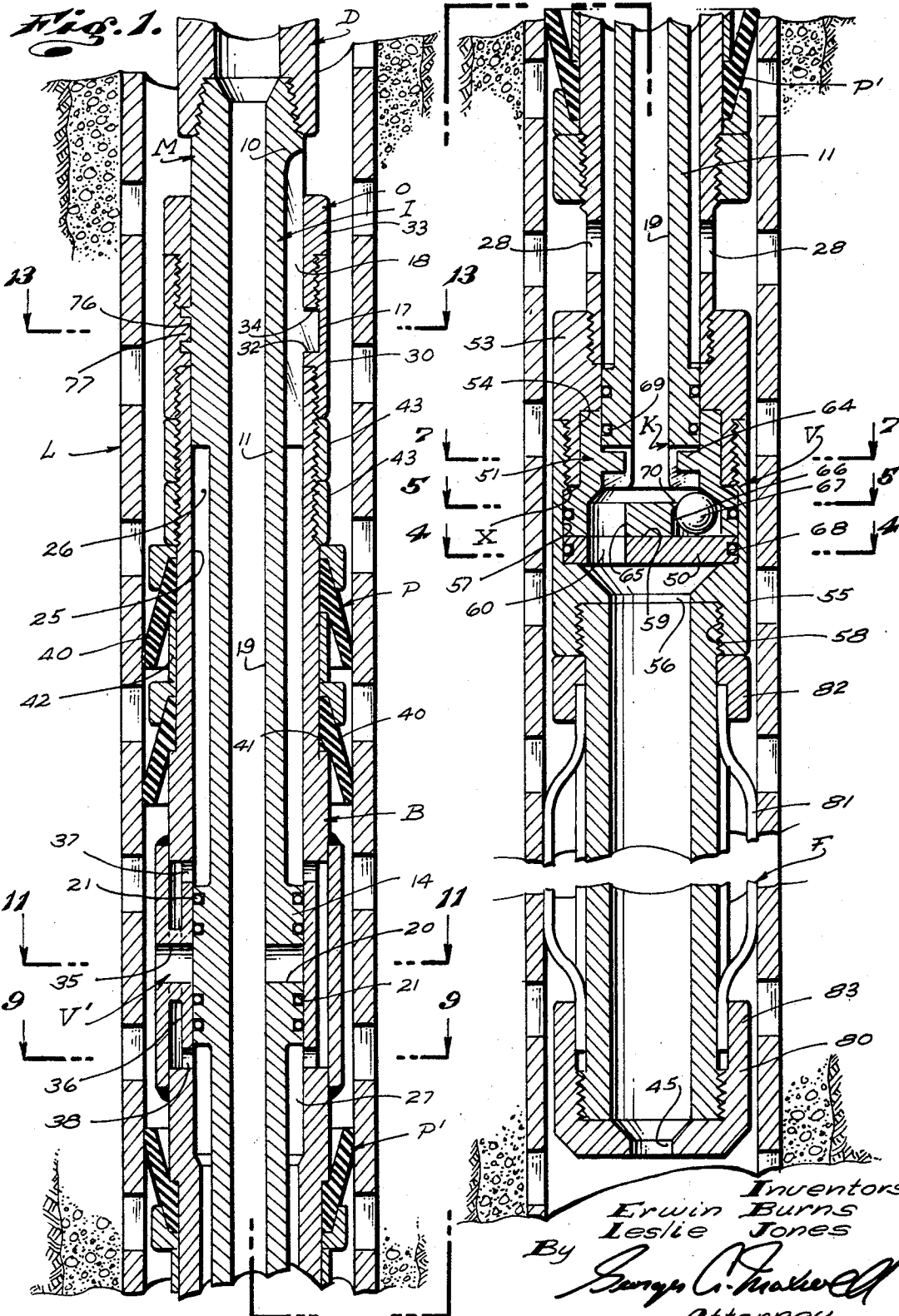
E. BURNS ETAL

3,396,798

CIRCULATING WASHER TOOL

Filed Nov. 14, 1966

3 Sheets-Sheet 1



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Fig. 2.

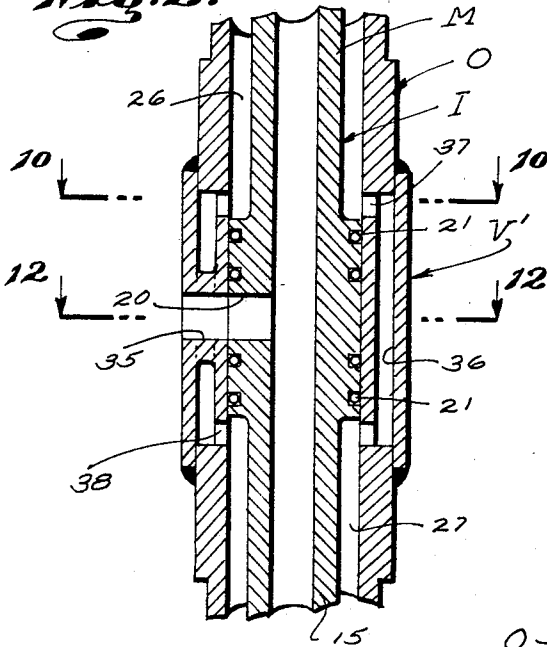


Fig. 4.

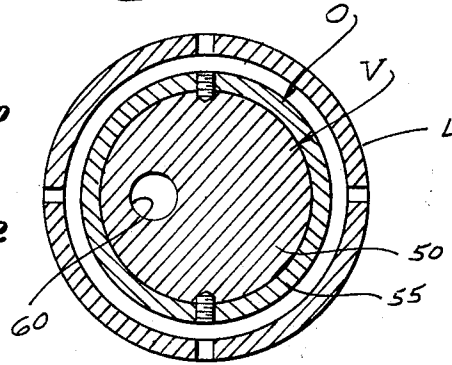


Fig. 5.

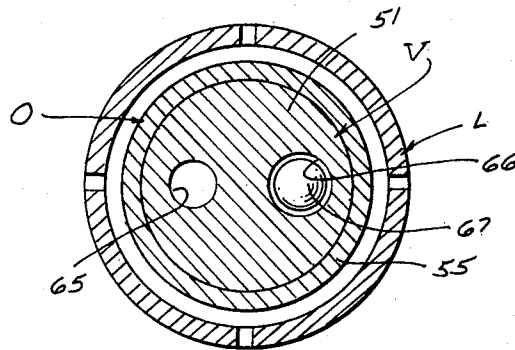


Fig. 3.

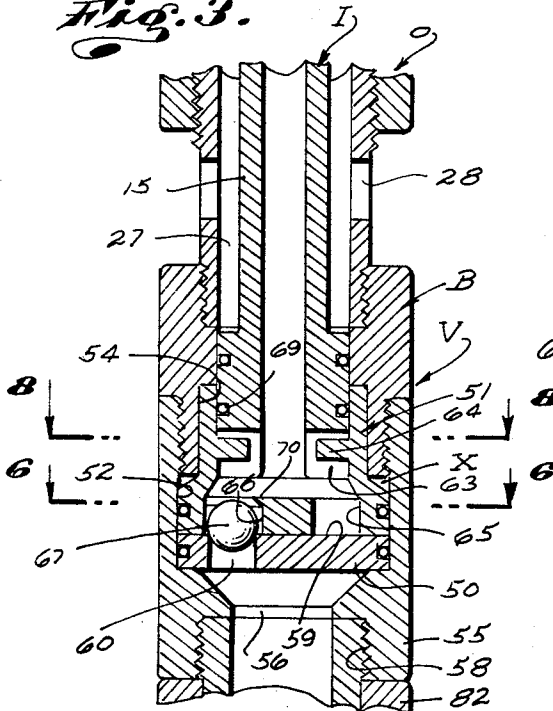
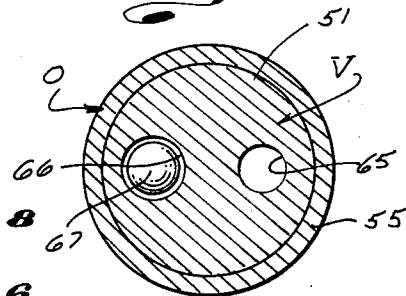


Fig. 6.



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Fig. 7.

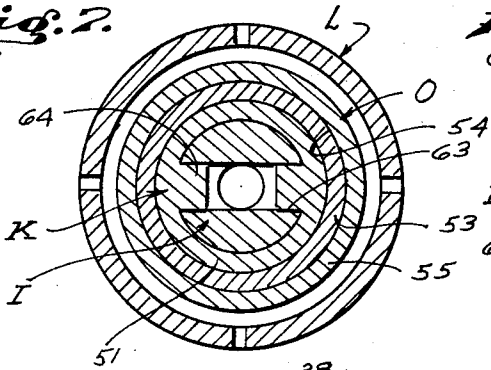


Fig. 8.

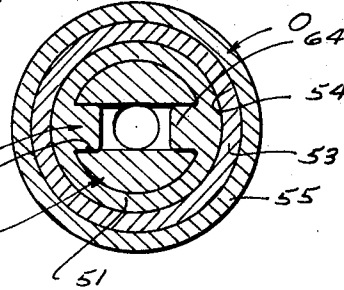


Fig. 9.

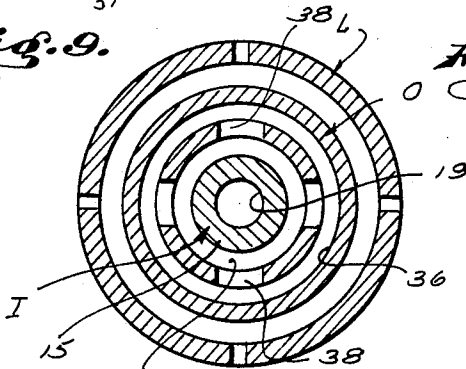


Fig. 10.

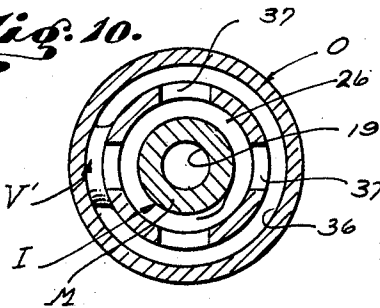


Fig. 11.

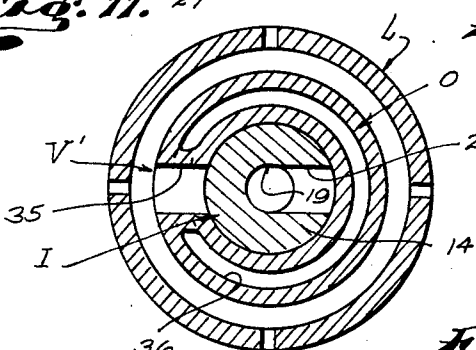


Fig. 12.

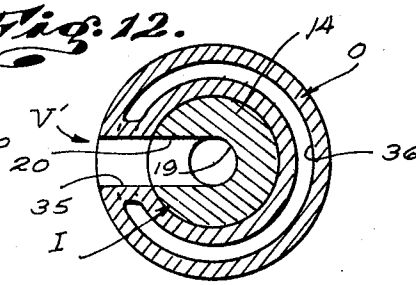


Fig. 13.

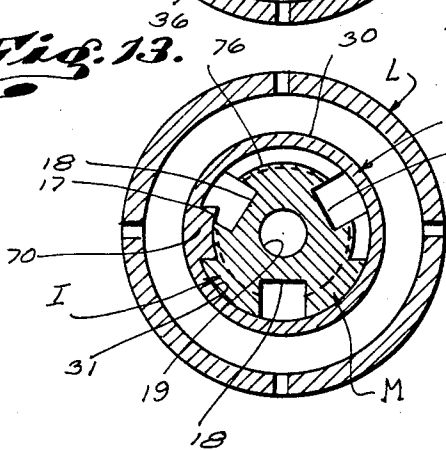
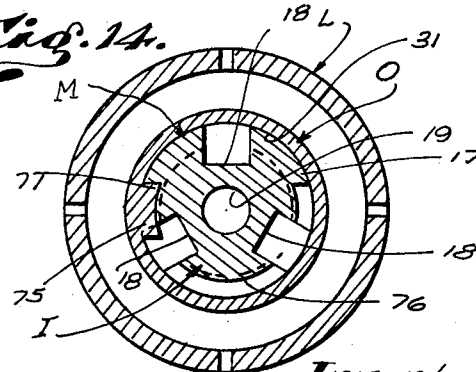


Fig. 14.



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3,396,798

CIRCULATING WASHER TOOL

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Filed Nov. 14, 1966, Ser. No. 593,924

10 Claims. (Cl. 166—147)

This invention has to do with a circulating washer tool for use in oil and gas well structures and is more particularly concerned with an improved circulating washer tool which is such that it is easier to operate, more effective and dependable in operation and more economical to manufacture and maintain than other circulating washer tools provided by the prior art.

In the art of servicing oil and gas wells, it is common practice and frequently becomes necessary to wash the well structure, that is, to flush out sand and the like which occurs in and about the perforated liner or liners arranged on the lower end of or in the well casing, which occurs in the producing formation about such liners and tends to plug the liners and the formation and stop or seriously impede the flow of production into the well structure.

Flushing or washing out of well structures for the purpose set forth above is ordinarily accomplished by means of circulating washer tools. Such tools are characterized by elongate, tubular fluid conducting bodies engageable on the lower ends of strings of fluid conducting drill pipe. The tool bodies are provided with longitudinally spaced packing means to seal between the bodies and the interior walls or surfaces of the casings or liners with which they (the tools) are related, lateral flow ports in the body between the packing means, axially downwardly disposed bottom flow parts in the lower ends of the bodies and valving means to selectively direct fluid conducted downwardly through the structures outwardly through the lateral or bottom flow ports.

In addition to the above, ordinary circulating washer tools are provided with by-pass means, that is, means in the tool bodies to permit fluid flowing through the tools into the well structures, below the packing means to flow back and upwardly in the liner and/or casing, through the tool, by or passed the packing means and thence back into the liner and/or casing whereby free flow of circulating fluid in the well structure is maintained at all times. Without such by-pass means in such tools, the packing means act as subs which impede the circulating of fluid in such a manner that the sand and the like sought to be washed from the well structure is trapped therein.

The valving and by-pass means of the circulating washer tools provided by the prior art are complicated and costly structures to manufacture, operate and maintain. The valve means in all of such structures, known to applicants, are characterized by a plurality of axially and rotatably shiftable ported tubular parts with suitable stop or indexing means, usually in the nature of pin and bayonet slot type means, and/or jaw clutch means, to stop the ported parts in two or more predetermined rotative positions. These tools are such that the operator, in order to effect opening and/or closing of the valve means, must raise or elevate the drill pipe and a part of the tool related to it, a predetermined distance, rotate the pipe and said tool parts a predetermined distance and then lower the pipe and said parts a predetermined distance. Such manipulation of such tools is of questionable certainty and is all too frequently a "hit and miss" type of operation. Since the tools are out of the view of the operator and are separated from the operator's senses of feel or touch by continuous lengths of drill pipe, which pipe is subject to such axial stretching and circumferential twisting or torqu-

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ing that it is normally not possible to determine where the lower end of the string of pipe is in the well or to determine how far the lower end of the drill pipe and the tool related thereto is moved, both axially and circumferentially, upon axial and circumferential movement or shifting of the upper end of the drill pipe string.

An object of our invention is to provide an elongate vertical, circulating washing tool engaging on the lower end of a fluid conducting drill pipe string and having spaced packing means intermediate its ends, a primary lower, axially downwardly opening fluid conducting port, an upper secondary radially outwardly opening fluid conducting port, upper and lower packing means about the exterior of the tool and spaced above and below the secondary port, primary and secondary valving means related to the primary and secondary ports, means operatively coupling the valving means together, and fluid by-pass means to conduct fluid about the tool below the packing means, through the tool by or past the packing means and then back into the well structure about the tool above said packing means.

Another object of our invention is to provide a novel rotary disc and ball type primary valving means which is such that when it is closed and is acted upon hydraulic pressure, the valve structure acts as a hydraulically actuated brake means and releasably holds the valve structure and the tool structure related to it in set position.

Still another object of our invention is to provide a ported sleeve-type secondary valving means for the upper lateral flow port in the tool which is coupled with the primary valving means and with the string of drill pipe so that when the drill pipe is rotated in one direction or the other to open or close the secondary valving means, the primary valving means is closed or opened at the same time and such that when the tool is thus operated to close the primary valving means and fluid pressure is exerted upon it from within the tool, the secondary valving means is releasably hydraulically locked in its open position.

Yet another object of this invention is to provide a tool of the character referred to having stop means to limit the rotative movement of the primary and secondary valving means.

A further object of our invention is to provide a tool of the character referred to having friction means related to those parts and portions of the tool in which the ports are arranged and on which the packing means are carried, which friction means engages the well structure about the tool so as yieldingly frictionally hold those parts and/or portions referred to above stationary and against rotation relative to the parts and/or portions of the tool coupled with the drill pipe string.

An object of this invention is to provide a tool of the character referred to having improved by-pass means through which circulating fluid and sand and the like carried by such fluid can freely flow.

It is an object and feature of our invention to provide a tool of the character referred to which is such that the tool can be operated by simply turning the drill pipe string in one direction or other to commence or start the flow of fluid through the primary port and to stop or commence the flow of fluid through the secondary port as desired, and a tool which is such that the drill pipe string with which said tool is related need not be elevated or lowered to effect operation of the tool.

Finally, it is an object of this invention to provide a tool of the character referred to which is a neat, clean and compact design, a tool which involves purse, simple and economical to manufacture and assemble parts, and a tool which is more rugged and dependable in operation and which is simpler and easier to operate than tools of

the same class or type presently employed in the well drilling and servicing art.

The foregoing and other objects and features of our invention will be fully understood and apparent from the following detailed description of a typical preferred form and embodiment of our invention, throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is an elongate sectional view of our new tool showing it related to a drill pipe string and in a well structure;

FIG. 2 is a view similar to a portion of the structure shown in FIG. 1 with parts in another position;

FIG. 3 is a sectional view of another portion of the structure shown in FIG. 1 with parts in another position;

FIG. 4 is a sectional view taken as indicated by line 4—4 on FIG. 1;

FIG. 5 is a sectional view taken as indicated by line 5—5 on FIG. 1;

FIG. 6 is a sectional view taken as indicated by line 6—6 on FIG. 2;

FIG. 7 is a sectional view taken as indicated by line 7—7 on FIG. 1;

FIG. 8 is a sectional view taken as indicated by line 8—8 on FIG. 2;

FIG. 9 is a sectional view taken as indicated by line 9—9 on FIG. 1;

FIG. 10 is a sectional view taken as indicated by line 10—10 on FIG. 3;

FIG. 11 is a sectional view taken as indicated by line 11—11 on FIG. 1;

FIG. 12 is a sectional view taken as indicated by line 12—12 on FIG. 3;

FIG. 13 is a sectional view taken as indicated by line 13—13 on FIG. 1; and

FIG. 14 is a view similar to FIG. 13 showing the parts in another position.

The tool that we provide is adapted to be engaged on the lower end of an elongate string of drill pipe D entering the top of and extending downwardly through a well casing (not shown) and into a perforated liner L at the lower end of the casing, which liner is set in a production formation F by a gravel pack G.

The tool that we provide involves an inner assembly I fixed to and carried by the string of drill pipe D and an outer assembly O rotatively carried by the inner assembly.

The inner assembly I includes an elongate, vertically extending, tubular, fluid conducting mandrel M with upper and lower portions 10 and 11. The upper portion 10 of the mandrel M is provided with a threaded pin 12 at its upper terminal end engaged in a threaded box 13 in the lower end of the drill pipe string D. The lower portion 11 of the mandrel M is of reduced diameter and depends from the upper portion 10 thereof to terminate at an enlarged cylindrical head 14.

Fixed to and depending from the enlarged head 14 is an elongate tubular wash pipe 15, which pipe is provided at its lower terminal end with a part of a drive means, which drive means part is in the form of an enlarged cylindrical, annular key 16.

The upper portion 10 of the mandrel is provided with a radially outwardly projecting stop flange 17 about its lower portion and has a plurality of circumferentially spaced, radially outwardly and downwardly opening longitudinally extending flow channels 18, which channels intersect or extend through the flange 17 and terminate in the upper portion of the said upper portion of the mandrel, below the pin 12.

The tubular mandrel M and the tubular wash pipe 15 cooperate to define a central, longitudinally extending downwardly opening flow passage 19, the upper end of which communicates with the central flow passage of the fluid conducting drill pipe D.

The enlarged cylindrical head 14 at the lower end of

the lower portion 11 of the mandrel is provided with a lateral port 20 communicating with the flow passage 19 and is provided with axially spaced, radially outwardly opening grooves above and below the port 20 and in which suitable sealing rings, such as O-rings 21 are engaged.

The head 14, with its port 20 and sealing means or rings 21 establish a valve member for an upper secondary valve means V', as will hereinafter be described.

The enlarged cylindrical key 16 of the drive means, at the lower end of the wash pipe 15, is provided with a transversely extending downwardly and radially outwardly opening key-way 22 to receive and cooperate with parts of a lower primary valving means V, as will hereinafter be described.

It will be apparent that the key-way 22 intersects and is interrupted at its center by the lower end of the flow passage 19.

The outer assembly O includes an elongate barrel B with a straight, central, longitudinal bore 25 into which the key 16 on the wash pipe 15, the head 14 on the lower end of the mandrel M, and the lower portion of the upper portion 10 of the mandrel M are slidably engaged and through which the lower portion 11 of the mandrel M and the wash pipe 15 project freely and cooperate therewith to define upper and lower longitudinally extending annular flow passages 26 and 27. The upper, annular flow passage 26 is closed at its upper and lower ends by the upper portion 10 of the mandrel and the head 14. The lower annular flow passage 27 is closed at its upper and lower ends by the head 14 and enlarged cylindrical key 16.

The longitudinal flow channels 18 in the upper portion 10 of the mandrel M communicate with the upper end of the upper flow passage 26.

The lower end portion of the barrel B is provided with circumferentially spaced radial ports 28, which ports communicate with the lower end of the lower flow passage 27, above the key 16 on the lower end of the wash pipe.

It is to be noted that the sealing rings 21 carried by the head 14 seal in the bore 25 and prevent the flow of fluid in the flow passages 26 and 27 from flowing longitudinally between the head and the bore.

An annular stop shoulder 30 with an upwardly opening socket 31 defining an annular upwardly disposed stop shoulder 32 is threadedly engaged on the upper end of the barrel with the stop flange 17 on the barrel arranged in the socket with its lower side opposing the shoulder 32. An annular retaining sleeve 33 defining an annular downwardly disposed stop shoulder 34 is threaded into the upper end of the socket 31 with the shoulder 34 thereof opposing the top side of the stop flange 17.

With the above relationship of parts, it will be apparent that the stop flange is held captive between the shoulders 32 and 34 of the outer assembly O and that the inner assembly I is coupled with the outer assembly against relative axial shifting and displacement, but is free to rotate relative to the outer assembly.

The flow channels 18 in the mandrel M extend above the sleeve 33 and are open at the exterior of the tool, above the outer assembly O to establish flow means communication between the upper annular flow passage 26 and the annulus between the upper portion of the tool and the adjacent well structure or liner L.

The central portion of the barrel occurring about the head 14 and the mandrel M is provided with a radially outwardly opening upper or secondary port 35, which port is adapted to be shifted into and out of register with the port 20 in the head 14 upon relative rotation of the inner and outer assemblies I and O. The head 14, with its port 20, sealing means 21 and the port 35 in the barrel, cooperate to define the upper secondary valve means V', referred to above.

The central portion of the barrel occurring about the head 14 on the mandrel M is also provided with fluid conducting means, which means includes an annular, axially extending transfer passage 36, which passage is of suffi-

cient longitudinal extent so that its upper end terminates above the head 14 and its lower terminates below the head 14.

The barrel B is further provided with a plurality of circumferentially spaced, radially inwardly opening upper and lower transfer ports 37 and 38 at the upper and lower ends of the transfer passage 36 (above and below the head 14) and establish communication between the transfer passage 36 and the upper and lower annular flow passages 26 and 27.

With the above relationship of parts, it will be apparent that fluid entering the lower inlet ports 28 in the barrel is free to flow upwardly through the passage 27, through the ports 38 and into the passage 36, thence, through the ports 37 into the passage 26 and, finally, out through the channels 18.

In practice, the passage 36 is established by machining an elongate channel in the exterior of the barrel, the bottom of which channel defines the inner wall of the transfer passage, drilling the ports 37 and 38 in the channel thus established, arranging a sleeve about the exterior of the barrel to bridge the channel and establishing the outer wall of the transfer passage and then welding the ends of the sleeve to the barrel.

The port 35, which must intersect the passage 36, is established by suitably drilling through the sleeve and wall of the barrel defining the passage 36 and then closing and sealing the ports 35 from the passage 36, by welding.

It will be apparent that in practice, the port 35 can be established in the barrel and through the passage 36 in any one of several other suitable manners.

The barrel B is further provided with and carries suitable packing means, there being an upper packing means P, above the port 35, and a lower packing means P', below the port 35.

In practice, the packing means can be of any suitable construction and are shown as rubber cup-type packing means. Each means P and P' is shown as including a pair of annular, radially outwardly and axially inclined rubber cups 40 slidably engaged about the barrel and held in tight fixed, axial spaced relationship thereon by means of a suitable axially disposed shoulder 41 on the barrel, a spacer sleeve 42 arranged about the barrel and between the cups and lock rings 43 threadedly engaged on and about the barrel and holding the cups and sleeves in tight clamped engagement with each other and against said shoulders.

Since the exact nature and construction of the packing means can be varied widely without departing from the spirit of this invention and since such means are available in many different forms, each of which is well known to those skilled in the art, we will not burden this application with further detailed description of the particular packing means illustrated.

It is to be noted that the packing means P and P' are provided to seal with the inner surface of the liner L, or other similar well structure at points spaced above and below the port 35 to prevent fluid issuing from the port 35 from flowing axially and to thereby urge and direct such fluid radially outwardly through the perforations in the liner and into the formation.

The outer assembly I further includes a primary lower valve means V at the lower end of the barrel and a stinger S depending from the valve means V.

The stinger is an elongate, tubular member with a central axially downwardly opening primary port 45 at its lower end, which port is adapted to direct downwardly circulating fluid into the well structure in advance of the tool and to wash out sand bridges and the like which occur in the well structure.

The primary lower valve means V is adapted to selectively control the flow of fluid from the lower end of the wash pipe 15 of the inner assembly through the stinger S of the outer assembly and out through the port 45.

The valve means V is shown as including a sectional

body B, a part, in the nature of a port plate 50 fixed within the body, a valvular cage 51 rotatively arranged in the body adjacent the part or plate 50 and a valve member 52 carried by the cage and engaging the plate.

The body 50 includes an elongate, vertically extending cylindrical upper portion 53 threadedly engaged on and depending from the lower end of the barrel and having a central bore communicating with and defining a continuation of the bore 25 of the barrel and wash pipe. The upper section 53 is also provided with a central, downwardly opening, enlarged, cylindrical socket 54. The body B further includes an elongate vertically extending cylindrical lower section 55 with a central longitudinal flow passage 56, an enlarged central upwardly opening cylindrical socket 57 and a downwardly opening central threaded socket or box 58.

The upper end portion of the socket 54 in the lower section is threaded and cooperates to receive a lower threaded portion of the upper section so that the sockets 54 and 57 cooperate to define a cylindrical valve chamber X.

The port plate 50 is a simple, horizontally disposed disc-shaped plate with a flat top surface 59. The plate 50 is arranged and fixed in the socket 57, at the lower end or bottom thereof to bridge and overlie or close the flow passage 56. The plate 50 is provided with a vertical port 60 spaced radially from the central vertical axis of the construction, which port establishes communication between the chamber X and the flow passage 56. In practice, the plate is provided with sealing means, such as O-rings 61, about its perimeter to seal between the plate and the adjacent wall of the socket 57 or chamber X and is fixed in position in the bottom of the socket or chamber, against axial and circumferential shifting, by radially inwardly extending set screws 61 carried by the body section 55.

The valvular cage 51 is an elongate, vertically extending cylindrical part arranged in the chamber X, above the plate, for free relative rotation and for limited axial movement therein. The cage 51 has a flat downwardly disposed bottom surface 62, which surface opposes and establishes sliding bearing and sealing engagement on the top surface 59 of the plate. The cage 51 is provided with an upwardly opening socket 63 corresponding in diametric extent with the bore 25 in the barrel and wash pipe and in which the key 16 on the lower end of the wash pipe is slidably engaged. A pair of laterally inwardly projecting lugs 44 are provided in the socket in the cage, at diametrically opposite sides thereof, to slidably engage in the key-way 22 in the key 16 on the lower end of the wash pipe and to establish rotary driving engagement between the wash pipe and the cage. The cage is further provided with a downwardly extending flow port 65 in the bottom thereof, communicating with the socket 57 therein, and spaced radially from the central axis of the construction a distance equal to the lateral spacing of the port 60 in the plate and which is adapted to be shifted into and out of register with the port 60 upon rotation of the cage in the valve body. The cage is further provided with an axially extending receiver opening 66 entering the bottom of the cage and communicating with the socket therein and a spherical valve member or ball check in the receiver opening and adapted to be shifted circumferentially of the plate and into and out of seating engagement in the port 60 in the plate, upon rotation of the cage in the body and relative to said plate.

In practice, the cage is slightly less in axial extent than the distance between the top surface 59 of the plate and the top of chamber X and the lugs 64 are engaged in their related key-way with sufficient working clearance so that the cage is free to work vertically or axially in the chamber X.

The cage is also provided with sealing means 68, such as O-rings about its exterior to seal between the cage and the adjacent cylindrical side wall of the chamber X.

Further, the cylindrical key 16 on the lower end of the wash pipe is provided with sealing means 69, such as O-rings, about that portion of the key which enters the cage socket, to seal between the cylindrical side wall of the cage socket and the key.

From an examination of the drawings, it will be apparent that with the sealing means 61, 68 and 69 of the valve means V and on the key 16, fluid flowing through the construction into and/or through the valve means V is prevented from flowing and escaping into and through the structure in an undesired manner.

The diametric extent of the ball check 67 is greater than the diameter of the ports 60 in the plate and the axial and diametric extent of the receiver opening 66 in the cage is greater than the diametric extent of the ball check 67. Accordingly, the ball check 67 is free to shift upwardly and wholly within the opening 66, when the opening 66 is moved out of register with the port 60 and is free to shift downwardly into seated and sealing engagement in the port 60 when the opening 66 is shifted into register with said port 60.

When the opening 66 is in register with the port 60 and the ball check 67 is seated in the upper end of the port 60, the hydrostatic head or pressure of the circulating fluid in the structure above the ball check urges and holds the ball in tight locked engagement in the port, which engagement, if the pressure is great enough, resists rotation of the cage by those turning forces which are likely to be encountered in the normal operation of the tool. That is, the ball check, in addition to functioning as a valve member, also functions as a releasable, hydraulically operated shear lock.

In operation, when the ball check is seated in the port 60 and fluid is pumped through the upper secondary valve means V', that is, through the port 35 between the packing means, the pump pressure within the tool is exerted upon the ball check, which application of pressure results in the above noted locking effect. When it is desired to unseat the ball check and rotate the inner assembly I relative to the outer assembly O, thereby closing the valve means V' and opening the valve means V, the pump is shut off and the fluid pressure in the tool and acting upon the ball check is allowed to balance with the pressure of the fluid in the well about the tool or is reduced to such an extent that the ball check can be easily and readily shifted laterally or circumferentially relative to the plate and out of engagement in the port 60 by rotation of the drill pipe D, inner assembly I and cage. By varying the diameter of the ball check, the extent to which it enters the port 60 and the resulting mechanical resistance to lateral displacement of the member from the port can be varied as circumstances require.

In addition to the above noted locking effect afforded by the ball check, a secondary locking effect is achieved by the pump pressure acting upon the bottom of the socket 57 in the cage, which pressure urges the cage axially downwardly relative to the wash pipe 15 and key 16 and into pressure frictional engagement with the plate. The bottom surface of the cage and the top surface of the plate are ground or lapped so that the fit therebetween will not permit the flow of fluid therebetween when the surfaces are urged into engagement with each other and so that the fluid, under pressure, in the flow part 55 and receiver opening 66, acting on the top surface 59 of the plate, will not flow between the cage and the plate and neutralize the effect of the fluid acting on the bottom of the cage socket.

In practice and to prevent the ball check from moving upwardly and out of engagement in the receiver opening 66, the upper edge of the openings 66 is provided with a radially inwardly projecting retaining lip 70.

The port 65 and opening 66 can be spaced circumferentially of the cage ninety degrees, 180 degrees, or any other number of degrees so that opening and closing of the valve means V can be effected by ninety degrees, 180

degrees or whatever number of degrees of rotation of the drill pipe string D and inner tool assembly I that is desired. In the case illustrated, we have shown the port 65 and opening 66 spaced 180 degrees apart with the result that the drill pipe string and inner assembly I of the tool must be rotated 180 degrees, or one-half of one revolution to effect opening and/or closing of the valve means V.

The secondary, upper valve means V' must be opened when the primary lower valve means V is closed. Accordingly, the port 20 in the head 14 of the inner assembly I is positioned so that it registers with the upper, lateral flow port 35 when the valve means V is closed and is 180 degrees out of register with the port 35 when the valve means V is open.

In practice, and to stop the valve means V and V' in their open and closed positions, a stop means 75 is provided. The stop means 75 can be of any suitable design or construction and is shown as including a radially outwardly opening channel 76 in and extending about 190 to 195 degrees about the perimeter of the stop flange 70 on the upper portion 10 of the mandrel M and a radially inwardly projecting stop lug 77, ten degrees or fifteen degrees in circumferential extent in the socket 31 and freely entering the channel 76. The lug 77 is greater in circumferential extent than the channels 18 so that it will not enter said channels when the construction is operated and permit disengagement or separation of the inner and outer assemblies.

With the stop means set forth above, it will be apparent that relative rotation of the inner and outer assemblies I and O is limited to that extent and to those predetermined positions where the valve means V and V' are opened and closed.

The stinger S at the lower end of the outer assembly and which depends from the valve means V includes an elongate, vertical, fluid conducting tube 79, the upper end of which is threadedly engaged in the socket 58 in the lower end of the lower section 55 of the body B, in open communication with the central flow passage 56 of the said body and is provided at its lower end with a nozzle 80, which nozzle is provided with and defines the downwardly directed primary port 45. The nozzle 80 is shown as a simple, upwardly opening cup-like part threaded onto and about the lower end of the tube 79.

Finally, the construction that we provided includes friction means F carried by the outer assembly and adapted to yieldingly and/or frictionally engage the well structure, such as the liner L, adjacent the tool, to yieldingly hold the outer assembly O against rotation in the well structure when it is desired to rotate the inner assembly relative thereto to effect opening and closing of the valve means.

In the case illustrated, the friction means F is shown as including outwardly opening belly springs 81 arranged in circumferential spaced relationship about and extending longitudinally of the stinger S.

The upper ends of the belly springs 81 are held and retained by a sleeve 82 engaged about and fixed to the upper portion of the tube 79 as by welding. The lower ends of the belly springs are held and retained by an upwardly projecting annular sleeve 83 at and about the lower end of the stinger tube 79. In the case illustrated, the sleeve 83 is shown as being integrally formed on and as projecting upwardly from the nozzle 80 which is threaded onto the lower end of the stinger tube.

Since friction means of the general character referred to and illustrated are well known to those skilled in the art and since the friction means employed in carrying out our invention can be varied widely, we will not burden this specification with further detailed description thereof.

In operation, when the tool that we provide is assembled and arranged in a well liner, as illustrated in FIG. 1 of the drawings, the lower primary valve means V is open and the upper secondary valve means V' is closed, thereby directing the circulating fluid pumped downwardly

into and through the tool downwardly through the nozzle 80 throughout the interior of the liner L in advance of the tool. The fluid thus introduced into the well structure, carrying sand and the like washed from said well structure, flows back up through the liner and about the lower end portion of the tool to the lower packing means P'. The fluid flowing back upwardly through the well structure in the manner set forth above, flows through the ports 28 into and through the passage 27, ports 38, passage 36, ports 37, passage 26, flow channels 18 and, thence, into the annulus between the tool and the liner, above the upper packing means P.

It will be apparent that fluid in the annulus above the packing means P is free to flow in and through the tool in the reverse direction to the flow pattern just recited so that when it is desired to pull the tool from the well structure, the fluid is suitably by-passed around the packing means P and P' and the column of fluid in the annulus about the tool and the packing means need not be lifted.

When it is desired to wash the liner and the adjacent formation by radial outwardly flow of circulating fluid through the perforations in the liner, the drill pipe string D is rotated clockwise at least 180 degrees. Such rotation closes the primary valve means V and opens the secondary valve means V', stopping flow of circulating fluid through the nozzle 80 and establishing radial outward flow of such fluid through the port 35 and into the annulus between the tool and the liner, between the packing means P and P'. The pump and head pressure within the tool and acting upon and locking the primary valve means V, as set forth above, locks the structure in this second position so that the tools can be raised and lowered in the liner L and can be rotated in the liner against the resistance of the friction means F, as desired and without shifting or urging the tool out of the set or locked position.

When it is desired to return the tool to the first above noted position, the pump pressure on the tool is shut off, relieving the holding pressure of the valvular cage 51 on its related plate and releasing the ball check from hydraulically locked, seated engagement in the port 60, whereupon the friction means F affords greater holding torsional force than the torsional resistance afforded by the remaining structure of the tool and so that upon counterclockwise rotation of the drill pipe string, the inner tool assembly I is rotated counterclockwise to the outer tool assembly O and the valve means V is again opened and the valve means V' is again closed.

Having described only a typical preferred form and application of our invention, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any modifications or variations that may appear to those skilled in the art and which fall within the scope of the following claims.

Having described our invention, we claim:

1. A well tool of the character referred to including an elongate, vertical, inner assembly with a central, longitudinal flow passage, means at the upper end of the inner assembly to releasably connect with the lower end of an elongate string of fluid conducting pipe, a lateral port spaced between the ends of said inner assembly communicating with the flow passage, an elongate, vertical, outer assembly rotatably engaged about and extending below the inner assembly, a lateral port between the ends of said outer assembly and shiftable into and out of register with the port in the inner assembly upon relative rotation of said inner and outer assembly, upper and lower, radially outwardly extending packing means carried by the outer assembly above and below the lateral port therein to engage and seal between the tool and an adjacent well structure, said inner and outer assemblies cooperating to define upper and lower annular flow passages within the tool above and between the lateral ports and terminating below the upper end of the outer assembly and above the lower end of the inner assembly, radial inlet ports in the outer assembly below the lower packing means, establish-

ing communication between the lower annular flow passage and the exterior of the tool, flow means in the construction establishing communication between said upper annular flow passage and the exterior of the tool above the upper packing means, a transfer passage in the tool about the lateral port in the outer assembly and communicating between the upper and lower annular flow passages, an axially downwardly opening fluid conducting port in the outer assembly spaced below the lower end of the inner assembly, valve means carried by the outer assembly adjacent the lower end of the inner assembly to control the flow of fluid downwardly through the downwardly opening port and including a part in the outer assembly below the inner assembly having a flat axially upwardly disposed top surface and an axially extending flow port offset from the central axis of the construction, a valvular cage rotatively arranged in the outer assembly between the said part and the lower end of the inner assembly and having a flat, downwardly disposed bottom surface establishing flat sliding, sealing engagement in the top surface and an axially extending fluid conducting port radially offset from the central axis of the tool and adapted to be shifted into and out of register with the flow port upon relative rotation of the inner and outer assemblies, drive means between and establishing rotary driving engagement between the cage and the lower end of the inner assembly and friction means carried by the outer assembly to engage well structure adjacent the tool to hold the outer assembly stationary relative to the inner assembly upon rotation of the string of pipe and the inner assembly, said lateral ports in the construction arranged to be in register with each other when the ports of said valve means are out of register.

2. A tool as set forth in claim 1 which further includes an annular radially projecting stop flange on one assembly and a radially opening channel in the other assembly rotatably receiving the stop flange, to prevent axial displacement of the inner and outer assemblies.

3. A tool as set forth in claim 1 including stop means to limit rotation of the inner assembly relative to the outer assembly to a position where the lateral ports are in register and in the other direction to a position where the ports of the valve means are in register, said means including a semi-circular channel in one assembly opening towards the other assembly and a stop lug on the other assembly projecting into the channel.

4. A tool as set forth in claim 1 including stop means to limit rotation of the inner assembly relative to the outer assembly to a position where the lateral ports are in register and in the other direction to a position where the ports of the valve means are in register, said means including a semi-circular channel in one assembly opening towards the other assembly and a stop lug on the other assembly projecting into the channel, an annular radially projecting stop flange on one assembly and a radially opening channel in the other assembly rotatably receiving the stop flange, to prevent axial displacement of the inner and outer assemblies.

5. A tool as set forth in claim 1 wherein said valvular cage has an axially extending receiving opening radially offset from the axis of the tool and adapted to register with the flow port in the said part when the lateral ports are in register, and a ball check in the receiver opening and adapted to be shifted into and out of seated sealing engagement in the upper end of the flow port in the said port.

6. A tool as set forth in claim 1 in which said drive means includes an annular key at the lower end of the inner assembly rotatably engaged in the upper end of the cage and having a downwardly and radially outwardly opening slot, and radially inwardly projecting lugs in the cage engaged in the slot.

7. A tool as set forth in claim 1 wherein said valvular cage has an axially extending receiving opening radially offset from the axis of the tool and adapted to register

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with the flow port in the said part when the lateral ports are in register, and a ball check in the receiver opening and adapted to be shifted into and out of seated sealing engagement in the upper end of the flow port in the part, said key means including an annular key at the lower end of the inner assembly rotatably engage in the upper end of the cage and having radially opening slots, and radially inwardly projecting lugs in the cage engaged in the slot.

8. A tool as set forth in claim 1 wherein said valvular cage has an axially extending receiving opening radially offset from the axis of the tool and adapted to register with the flow port in the said part when the lateral ports are in register, and a ball check in the receiver opening and adapted to be shifted into and out of seated sealing engagement in the upper end of the flow port in the part, said tool further including an annular radially projecting stop flange on one assembly and a radially opening channel in the other assembly rotatably receiving the stop flange, to prevent axial displacement of the inner and outer assemblies.

9. A tool as set forth in claim 1 wherein said valvular cage has an axially extending receiving opening radially offset from the axis of the tool and adapted to register with the flow port in the said part when the lateral ports are in register, and a ball check in the receiver opening and adapted to be shifted into and out of seated sealing engagement in the upper end of the flow port in the part, said tool further including stop means to limit rotation of the inner assembly relative to the outer assembly to a position where the lateral ports are in register and in the other direction to a position where the ports of the valve means are in register, said means including a semi-

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circular channel in one assembly opening towards the other assembly and a stop lug on the other assembly projecting into the channel.

10. A tool as set forth in claim 1 wherein said valvular cage has an axially extending receiving opening radially offset from the axis of the tool and adapted to register with the flow port in the said part when the lateral ports are in register, and a ball check in the receiver opening adapted to be shifted into and out of seated sealing engagement in the upper end of the flow port in the part, said tool further including stop means to limit rotation of the inner assembly relative to the outer assembly to a position where the lateral ports are in register and in the other direction to a position where the ports of the valve means are in register, said means including a semi-circular channel in one assembly opening towards the other assembly and a stop lug on the other assembly projecting into the channel, an annular radially projecting stop flange on one assembly and a radially opening channel in the other assembly rotatably receiving the stop flange, to prevent axial displacement of the inner and outer assemblies.

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