This invention relates to an improvement in well washing devices, particularly for the cleaning of debris from the walls of deep wells by the forcing of liquid under pressure against the sides of the bore to wash down the debris therefrom for removal.

In the drilling in and cleaning out of oil wells, it is customary practice to circulate washing fluid, such as oil, downward through the casing outside the drill stem for upward circulation through the drill stem to carry off the cuttings and particles of debris loose in the well. After the major portion of the debris thus loosened has been removed, some of the debris remains adhering to the sides of the well bore, and it is desirable to direct jets of liquid against such sides for washing down the debris adhering thereto.

It has been the practice to accomplish this action by opening ports in the sides of the drill stem and circulating washing fluid, such as oil, downwardly through the drill stem for discharge through such ports against the sides of the well bore. The opening of the ports has been accomplished by the introduction of an auxiliary member into the drill stem to open a port controlling valve in a side thereof, while also closing the passageway therebelow, to effect the washing fluid through the ports, as set forth in my prior application on Well tools, Serial No. 204,095, filed February 2, 1939.

This action results in a loss of time inasmuch as the member thus introduced must travel downward a considerable distance in the bore of the drill stem before it can accomplish its function, and unless provision is made for retaining the member in an upper portion of the drill stem, the equipment must be disconnected for the introduction of the member therein and for its removal after the washing operation.

The object of this invention is to overcome these objections by controlling the washing action automatically directly from the washing fluid forced in one direction or the other through the drill stem, thus providing a simple and efficient well washing apparatus which will effectively accomplish the desired result without danger of being choked by an auxiliary member, and which is not only automatic but also instantly ready for operation in response to the fluid travel through the drill stem to accomplish the washing action without loss of time in drilling.

This object is accomplished by the provision of a valve in the drill stem for controlling the bore therethrough, being opened or closed directly in response to the flow of the washing fluid, and when said valve closes the bore against downward flow therethrough, provision is made for opening the side ports automatically to discharge the washing fluid therethrough in the form of jets against the sides of the well bore, thereby effectively accomplishing the washing-down operation automatically in response to the direction of flow of fluid through the drill stem.

These features are embodied in a preferred form of the invention which is illustrated in the accompanying drawings, together with a modification thereof, in which:

1. Fig. 1 is a vertical sectional view through a well and portion of a well casing, showing in side elevation a rotary drilling unit having the invention applied thereto;
2. Fig. 2 is a vertical sectional view through the washing tool;
3. Fig. 3 is a horizontal sectional view thereupon the line 1—3 of Fig. 2;
4. Fig. 4 is a vertical sectional view through a modified form of washing tool;
5. Fig. 5 is a side elevation thereof; and
6. Fig. 6 is a horizontal sectional view thereupon the line 5—6 of Fig. 4.

The invention is shown in Fig. 1 in connection with rotary drilling apparatus as illustrated by less conventional form, shown as used for drilling out a well bore designated generally by the numeral 1. The drilling apparatus utilizes a string of pipe constituting a drill stem 2 operatively connected with a rotary table 3 of a conventional rotary rig or other rotating apparatus.

The rotary table 3 is designed for rotating the drill stem 2 while permitting upward and downward movement of the drill stem relative thereto. To accomplish the drilling operation, the drill stem 2 carries a drill bit 4 on the lower end thereof, the drill bit being suspended from the string of pipe constituting the drill stem 2. The drill bit 4 is provided with the usual cutters or cutting teeth and has an opening therethrough for the circulation of fluid upward or downward through the drill bit to or from the axial opening through the drill stem 2.

The drilling apparatus operates in a casing 5 which lines the sides of the well downwardly from the surface of the ground to a point adjacent the lower portion thereof, and which casing 5 is closed at its upper end around the drill stem 2 by a packing gland 6 of conventional construction. A pipe 7 is shown as connected with one side of the casing 5, while a pipe 8 is connected with the upper end of the drill stem 2. The pipes 7 and 8 are used alternately as inlet and discharge pipes, one being connected with a source of fluid supply, such as a pump, for circulating the washing fluid, such as oil, downwardly through the well for discharge through the other pipe which leads to a sump, pit, tank, or the like.

In drilling in and cleaning out a well, the bore 1 below with casing 5 partly or entirely filled with debris, broken rock, dirt, etc., which should be removed therefrom. This is accomplished by circulating the washing fluid through the pipe 7,
and downwardly through the casing 5 and the bore 1 under considerable pressure, which will carry off the debris through the drill stem 2, the fluid acting on an outlet through the drill bit 4 into the drill stem, the reduced size of which outlet increases the velocity of the fluid to such an extent as to effectively remove this debris from the bore 1. This action is sufficient to remove the loose debris in the bore, but it frequently results in leaving some of the debris adhering to the sides of the bore without being washed clean therefrom, which makes it desirable to impart jets of washing fluid against the sides as the drill stem is moved up and down in the bore.

For this purpose, I have provided a washing tool, designated generally by the numeral 9, connected at the lower end of the string of pipe constituting the drill stem 2, preferably between the drill stem 2 and the drill bit 4, as shown.

The washing tool 9 is shown in Fig. 2 as constructed of an elongated tubular collar 10, the upper end of which is screwed and threaded at 11 to the lower end of the string of pipe, while the lower end is provided with tapered screw-threads 12 for attachment of the drill bit 4 thereto.

The collar 10 is provided with lateral ports 13 in the sides thereof, preferably adjacent the screw-threaded drill stem connection 11, which ports 13 are formed as radial holes in the sides of the collar 10. The ports 13 are normally closed by a sleeve valve 14 slidably mounted in an enlarged bore 15 formed in the collar 10, between a shoulder 16 at the lower end of the bore and the lower end of the connected drill stem pipe 2. A coiled spring 17 normally tends to press the sleeve valve 14 upwardly in port closing position, said spring being interposed between the lower end of the sleeve valve 14 and a shoulder 18 in the collar 10.

A check valve 19 is mounted in the sleeve valve 14, being pivotally connected therewith at 20, which valve 19 has a downwardly turned lip or flange 21 on the free edge thereof in position to engage and bear upon a pin 22 which extends radially in a side of the sleeve valve 14 opposite the pivot 19. The valve 19 is constructed of semi-circular shape in cross section as shown in Fig. 3, which causes it to conform to the tubular shape of the sleeve valve 14 and prevents any appreciable reduction in the bore therethrough and through the washing tool 9 from the string of pipe 2, which permits of substantially full flow of fluid therethrough when the valve is open.

During the normal drilling in and cleaning out operation when the washing fluid is forced downward outside the drill stem 2 for upward circulation therethrough in carrying off the cuttings and the debris, the sleeve valve 14 will close the ports 13 under the influence of the spring 17 and the upward circulation of washing fluid through the drill stem will hold the valve 19 open, permitting full flow of fluid therethrough.

However, when it is desired to apply jets of washing fluid against the side walls of the well bore 1, it is only necessary to reverse the direction of circulation and pump the washing fluid downward through the drill stem, where the fluid will act on the flange 21 of the check valve 19 to cause said check valve to swing downward from its full line position in Fig. 2 to its dotted line position, closing the bore through the washing tool 9. The force of the fluid acting on the check valve 14 will cause downward movement of the sleeve valve 14 against the shoulder 16, which will open the ports 13 and discharge the washing fluid therethrough in the form of jets against the side walls of the well bore 1 with sufficient force to remove therefrom any adhering debris or cuttings. The drill stem may be moved up and down relative to the well bore and turned relatively thereto for effectively washing the bore throughout the major portion thereof for removing the debris therefrom. After this washing action by the jets, the normal direction of circulation is resumed downward through the casing and upward through the drill stem for carrying off the debris and cuttings thus washed down from the side walls of the bore.

The pressure of the washing fluid is removed from a downward direction on the check valve 19, and the normal direction of circulation is resumed whereby fluid is forced upward under pressure through the drill stem, this upward direction of circulation will act against the under side of the check valve 19 turning it from the dotted line position in Fig. 2 to the full line position therein, opening the bore through the tool and the drill stem, and allowing the spring 17 to move the sleeve valve 14 to its closed position, as shown in Fig. 2.

A modified form of the invention is shown in Figs. 4 to 6 in which a collar 25 is provided with an axial bore 26 therethrough. A plug 27 extends radially through a side of the collar 25 beyond the axial bore 26 therein, and is fixed in position in the collar by being screw-threaded thereto as at 28. The plug 27 may also be welded at 29, if desired, to hold it securely in set position, in proper relation to the axial bore 26 in the collar. Spanner wrench holes 30 are provided in the outer end of the plug 27 to facilitate the screwing of the plug into the side of the collar 25.

The plug 27 has a transverse passageway 31 therethrough of a size and shape substantially corresponding with the axial bore 26 in the collar, passageway 31 is preferably arranged in longitudinal alignment with said axial bore, as shown in Fig. 4, the plug 27 being turned to proper position therefor and securely held in place by the screw-threaded connection 25 alone or with the welded connection 28. The plug 27 has a longitudinal opening 32 extending transversely from a side of the passageway 31, adapted to form a discharge port for the washing fluid, which opening 32 is preferably of frusto-conical shape with the larger end 33 inward for concentrating the discharge port for increasing the velocity of the fluid therethrough. This opening 32 may be bored out in this shape from the inner end of the plug upon removal of a closure 34 inserted therein.

A check valve 34 is mounted in the passageway 31 through the plug 27, being pivoted thereto at 35, and having an offset flanged edge 36 in position to engage a pin 38 extending into the passageway 31 on the opposite side from the pivot 35 when the check valve 34 is turned downward from its full line position in Fig. 4 to its dotted line position therein. The check valve 34 carries a valve plug 39 on the back face thereof which seats in the inner end of the opening 32 when the valve 34 is raised to its open position, thereby closing the discharge opening or port 32 against the outward passage of fluid therethrough from the well bore 1 of within the bore of the plug 27.

The outer end of the port 32 is closed against the inward flow of fluid therethrough, by a check valve 40 which is pivoted at 41 in a recess 42 formed in the end of the plug 21. The check valve 40 is adapted to seat in the end of the
opening 32 when it is suspended in its full line position in Fig. 4, from which it may swing upward to its dotted line position therein.

One or more additional plugs may be provided in the collar 35 with valves for controlling discharge ports therein, as may be desired. One additional plug is shown at 45 screw-threaded into the opposite side of the collar 35, and hav- ing a discharge port or opening 46 of frusto-

conical shape, similar to the opening 32 de-
scribed above. The port 46 is adapted to be closed at its inner end by a check valve 47 hav-
ing its lower edge pivoted against the outside of the end of the plug 45, while the upper edge thereof has an inturmed flange 49. The outer end of the port 46 is closed by a check valve 50 pivoted at 51 at its upper edge within a recess 52 in the outer end of the plug 45.

During the normal washing operation in which the washing fluid is forced downward through the casing and upward through the drill stem, the force of the liquid flowing upward through the collar 35 will hold the check valve 47 open in the port 46 allowing substantially full flow of fluid therethrough. The flow of fluid will also act against the flange 49 on the check valve 47 to close the latter in its full line position in Fig. 4. This will close both of the cesses 42 and 52 for protection against being broken or injured by stones or other forces sur-

rounding the washing tool. These valves are shown as square in outline although they may be of any desired shape.

It may be pointed out further that when the ports 32 and 46 are open under fluid pressure, they will ejet a solid, unbroken stream of wash-

ing fluid to effect the washing of the walls of the well. Any valve which diverts the direction of the stream or breaks the flow in any manner has a tendency to cause atomization of the fluid and thereby lose the effect of the solid stream ejection against the walls of the well.

I claim:

1. A well washing tool comprising a body hav-
ing an axial opening therethrough and adapted for connection with a string of pipe, said body having a lateral opening in position for com-

munication with said axial opening, and means mounted in the body in position for movement to a closed position in the axial opening below the lateral opening in response to downward fluid flow in the lateral opening and directing the fluid through the lateral opening, said means being constructed for movement laterally of the body out of the path of fluid flow through said axial opening.

2. A well washing tool comprising a body hav-
ing an axial opening therethrough and adapted for connection with a string of pipe, said body having a lateral opening in position for com-

munication with said axial opening, and a check valve mounted in the body at one side of the axial opening below the lateral opening in posi-

tion for movement to a seated position in said axial opening in response to downward flow of washing fluid therethrough.

3. A well washing tool comprising a body hav-
ing an axial opening therethrough and adapted for connection with a string of pipe, said body having a lateral opening in position for com-

munication with said axial opening, a check valve mounted in the body at one side of the axial opening below the lateral opening in position for movement to a seated position in said axial opening for upward flow of fluid therethrough, and means for closing said lateral opening when the valve is in a normal position retracted from the axial opening.

4. A well washing tool comprising a body hav-
ing an axial opening therethrough and adapted for connection with a string of pipe, said body having a lateral opening in position for com-

munication with said axial opening, and a check valve pivotally mounted in the body at one side of the axial opening in position for swinging movement substantially out of said axial opening for upward flow of fluid therethrough and for movement to a closed position in the axial opening preventing downward fluid flow therethrough, said check valve being in position for movement in response to the fluid flow through the axial opening to said respective positions.

5. A well washing tool comprising a body hav-
ing an axial opening therethrough and adapted for connection with a string of pipe, said body having a lateral opening in position for com-

munication with said axial opening, a check valve pivotally mounted in the body at one side of the axial opening in position for swinging movement substantially out of said axial opening for upward flow of fluid therethrough and for movement to a closed position in the axial opening preventing downward fluid flow there-
through, said check valve being in position for movement in response to the fluid flow through the axial opening to said respective positions, and a check valve in position for controlling the lateral opening and constructed and arranged for movement in response to the first-mentioned check valve for opening the last mentioned check valve when the first-mentioned check valve is in said closed position for flow of fluid through said lateral opening.

6. A well washing tool comprising a body having an axial bore therethrough and adapted for connection with a string of pipe, said body having a lateral opening therein in position for communication with the axial opening, means mounted in said body normally in a retracted position out of closing relation with the axial opening and movable to a closed position in said axial opening to prevent downward circulation therethrough, and means connected with said closing means for closing said lateral opening when said closing means is in a retracted position and for opening said lateral opening when said closing means is in a closed position in the axial opening.

7. A well washing tool comprising a body having an axial opening therethrough and having a lateral opening in position for communication with said axial opening, a check valve pivotally mounted in the body at one side of the axial opening, said check valve being constructed of arcuate cross-section substantially corresponding with the curvature of the axial opening in position to be disposed at one side of said opening in a retracted position and having an offset flange thereon opposite the pivot in position to be acted on by the fluid flow through the axial opening for moving the check valve to a closed position.

8. A well washing tool comprising a body having an axial opening therethrough for flow of fluid therethrough and having a lateral opening in position for communication with said axial opening, a sleeve valve mounted in the body in position for controlling the lateral opening, and a check valve pivotally connected with the sleeve valves for movement into said opening for closing the same and causing movement opening of the sleeve valve by the pressure acting thereon.

9. A well washing tool comprising a body having an axial opening therethrough, a plug inserted radially in said body and having an opening therein in position for communication with the axial opening, a valve pivotally connected with the plug and supported thereby in position for controlling the opening therein, and means mounted in the body below said opening for closing the axial opening and directing fluid flow therethrough.

10. A well washing tool comprising a body having an axial opening therethrough, a plug extending radially in said body and having a longitudinal opening therein in position for communication with the axial opening forming a lateral discharge port therefor, a valve pivotally mounted on the plug above said port in position for controlling fluid flow therethrough and being mounted for outward swinging movement by fluid pressure through said port, and a valve pivotally mounted on the plug at one side of the axial opening in position for swinging movement to a closed position in said opening for directing fluid flow laterally through the port.

11. A well washing tool comprising a body having an axial opening therethrough, a plug extending radially in said body and having a longitudinal opening therein in position for communication with the axial opening forming a lateral discharge port therefor, a valve pivotally mounted for outward swinging movement by fluid pressure through said port, and a valve pivotally mounted on the plug above said port in position for controlling fluid flow therethrough and being mounted for outward swinging movement by fluid pressure through said port, and a valve pivotally mounted on the plug at one side of the axial opening in position for swinging movement to a closed position in said opening for directing fluid flow laterally through the port.

12. A well washing tool comprising a body having an axial opening therethrough, a plug extending radially in said body and having a longitudinal opening therein in position for communication with the axial opening forming a lateral discharge port therefor, a valve pivotally mounted for outward swinging movement by fluid pressure through said port, and a valve pivotally mounted on the plug at one side of the axial opening in position for swinging movement to a closed position in said opening for directing fluid flow laterally through the port.