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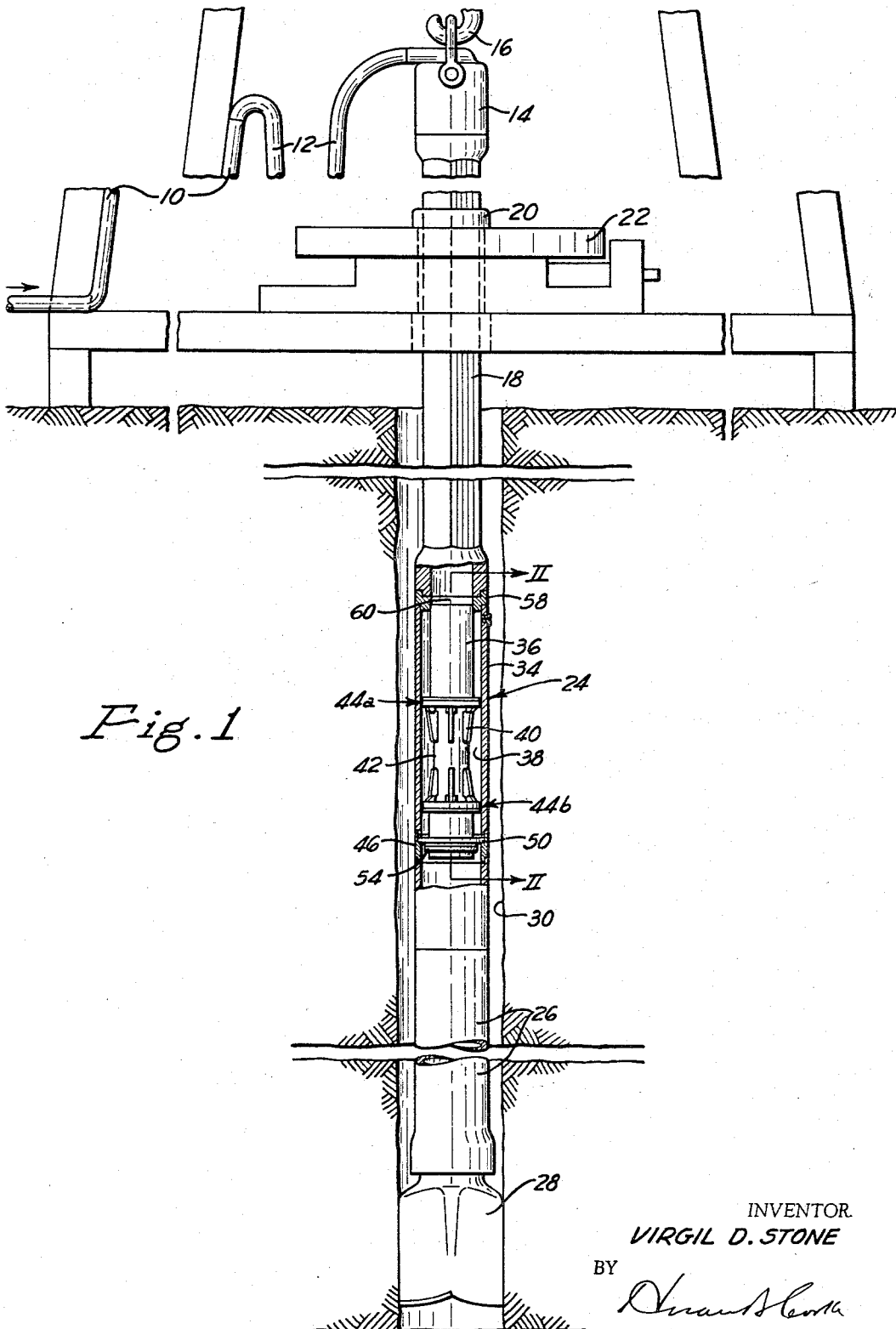
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3,292,718

AUTOMATIC KELLY VALVE

Filed Jan. 29, 1963

3 Sheets-Sheet 1



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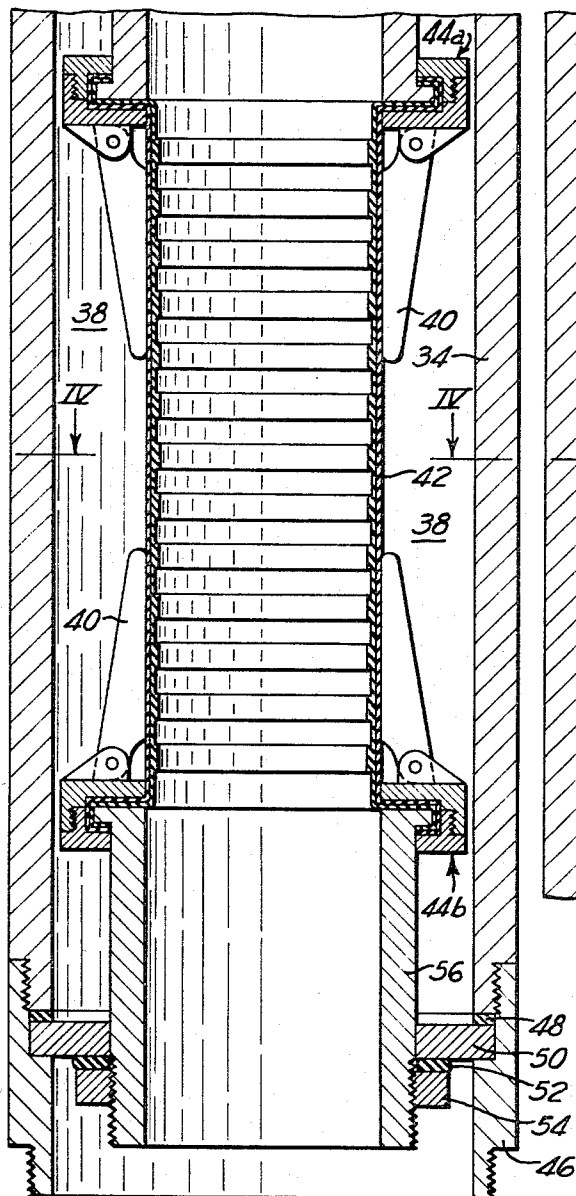
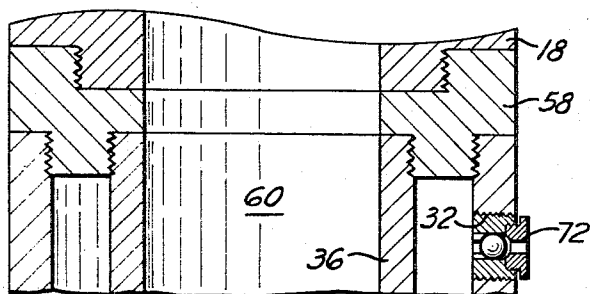


Fig. 2

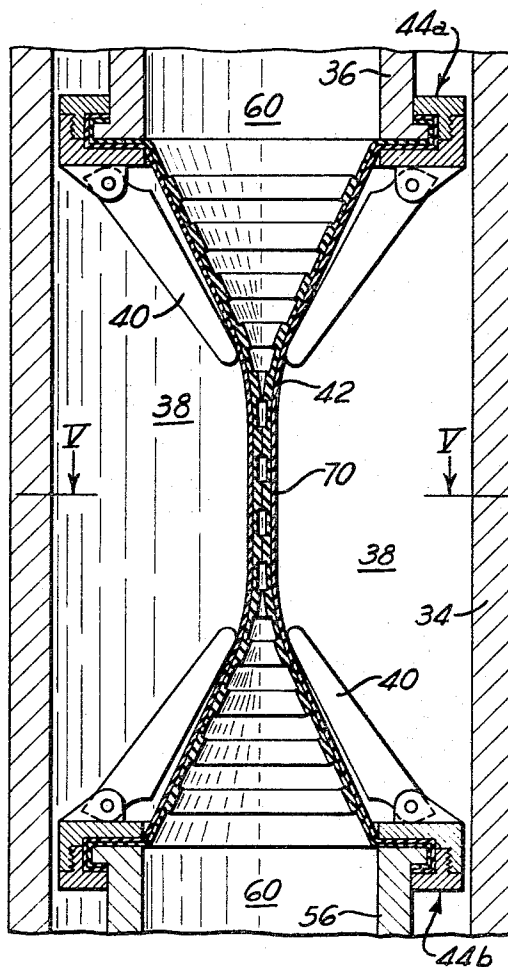


Fig. 3

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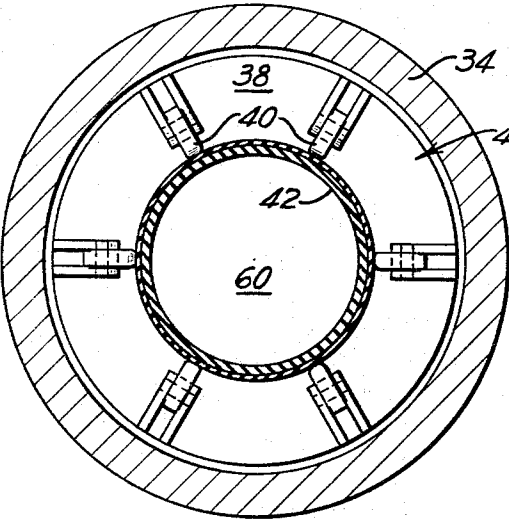


Fig. 4

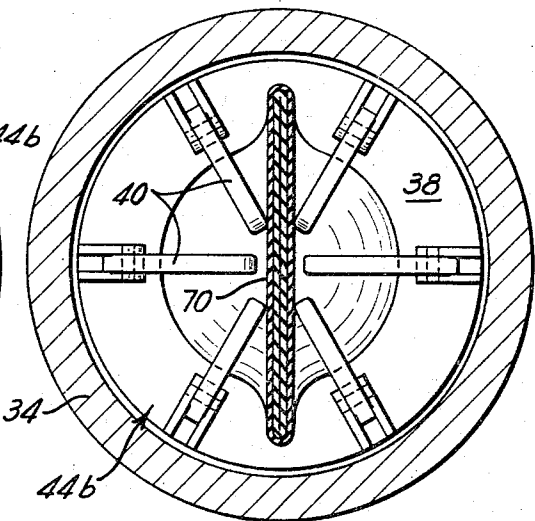


Fig. 5

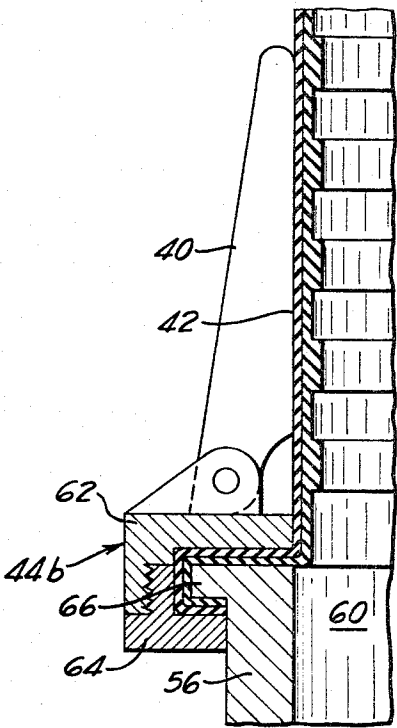


Fig. 6

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AUTOMATIC KELLY VALVE

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12 Claims. (Cl. 175-318)

This invention relates to a valve to prevent the loss of drilling fluid during rotary drilling operations.

In the drilling of oil wells with rotary drilling equipment, a circulating liquid, commonly referred to as drilling mud, performs many necessary functions such as the rapid, continuous removal of rock cuttings from the well-bore, the prevention of caving and sloughing of poorly consolidated or friable rock formations, the maintenance of a sufficient pressure on the walls of the well-bore to prevent a blow-out and well damage when unexpected high pressure reservoirs are encountered, and the cooling and lubricating of the drill pipe and bit as they rotate against the abrasive rock formations. The satisfactory performance of these several functions requires that the physical properties of the mud be closely controlled. Ordinarily, the drilling mud comprises a suspension of natural clays in water, oil, or an emulsion of water and oil. The addition of varying amounts of mud chemicals or wetting agents is determined by the specific requirements regarding viscosity, density, thixotropy, acidity, gel strength, shear strength and any other properties that might be required in a particular case. The volume of mud required for the drilling of a 15,000 foot well would be approximately one to two thousand barrels and might constitute as much as 20 percent of the total drilling costs; therefore, any innovation that reduces the expenditure made in maintaining a suitable mud program will be a significant improvement in rotary drilling practice.

When drilling is in progress, the mud is pumped from a surface reservoir, called a mud pit, to a swivel suspended from the draw works of the rotary drilling apparatus and downwardly from the swivel through a string of drill pipe to a rotary bit at the bottom of the well-bore. The mud is ejected at high velocity through a number of ports extending through the walls of the bit and is circulated up the annulus between the drill pipe and wall of the well-bore and back to the mud pit for recirculation.

The force rotating the string of drill pipe is provided by a rotary table located on the rig floor. In order that the rotary table will have a positive grip on the drill string, the upper end of the string is provided with a joint of pipe called a kelly, having a polygonal cross-section designed to fit a similarly shaped opening in a kelly drive bushing of the rotary table. The kelly, which is approximately 50 feet long, is connected in the drill string from the swivel suspended from the draw works and passes through the kelly bushing in the rotary table to the upper joint of drill pipe. Each time a joint of pipe is added to the drill string, the mud pumps are shut down and the lower end of the kelly is lifted above the rig floor and disconnected from the drill string. The column of mud that was contained in the kelly when circulation was halted then flows onto the rig floor and creates a safety hazard for the drilling crew as well as wasting the expensive mud. During the drilling of a 15,000 foot well, the operation is performed approximately five hundred times, with a loss each time of over one-half barrel of mud and the cost of idle rig time and wasted man-hours while the mud is washed from the rig floor.

It is the object of this invention to provide a kelly valve assembly which is internal to the drill string and has no external connections, and which will prevent the loss of drilling mud when the kelly is disconnected from the

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drill string. Such an embodiment of this invention is illustrated in the accompanying drawings.

FIGURE 1 is an elevational view of rotary drilling apparatus, partially in cross-section, showing the valve assembly connected between the kelly and the upper joint of drill pipe.

FIGURE 2 is a vertical, cross-sectional view taken along the line II-II in FIGURE 1 showing the valve in open position.

FIGURE 3 is a vertical, cross-sectional view similar to FIGURE 2 but showing the valve in closed position.

FIGURE 4 is a transverse, cross-sectional view taken on the line IV-IV of FIGURE 2 with the valve in open position.

FIGURE 5 is a transverse, cross-sectional view taken on the line V-V of FIGURE 3 with the valve in closed position.

FIGURE 6 is an enlarged vertical sectional view of the assembly for connecting the kelly valve of this invention in the drill string.

FIGURE 1 illustrates a rotary drilling apparatus which comprises a circulatory system for the drilling mud as it is pumped from a mud pit, not shown in the drawing, through a stand pipe 10 to a rotary hose 12 which is connected to a swivel 14. The mud then passes through the swivel 14 hanging from a hook 16 which is connected to a traveling block and draw works not shown in the drawing. The bottom of the swivel 14 is joined to a kelly 18 which passes through a kelly bushing 20 in a rotary table 22 rotated by a motor and suitable gearing, not shown in the drawing. Connected to the lower end of the kelly 18 is a kelly valve assembly 24, which is shown in the open position and which is connected to the upper end of a string of drill pipe 26 in a well-bore 30. A rotary bit 28, connected to the lower end of the string of drill pipe 26, has ports through which the mud flows into the well-bore 30 and up through the annulus surrounding the drill pipe to the mud pit, not shown, at the surface.

FIGURES 2 through 6 show in detail the construction of a kelly valve assembly comprising an outer tubular casing 34 connected by a bushing 58 to the bottom of the kelly 18. An inner tubular pipe 36 within the casing 34 extends downwardly from the bushing 58 through the casing 34 to a flexible tubular diaphragm 42 of elastic material such as rubber. The top of the diaphragm 42 is joined to the pipe 36 by a diaphragm connector 44a. A similar connector 44b joins the bottom of the diaphragm 42 to another inner tubular pipe 56. Thus a valve conduit 60 comprising a pipe 36, a diaphragm 42, and a pipe 56 forms a cylindrical fluid passage with a diameter preferably substantially equal to the internal diameter of the kelly 18 and extending through the casing 34.

An annular chamber 38 extending throughout the length of the valve assembly is formed between the casing 34 and the elements forming the valve conduit 60. The chamber 38 is sealed at the bottom by means comprising a ring seal 48 and an annular metal disk 50 which slip over the pipe 56 and seat against the bottom of the casing 34. A fluid tight seal between the casing 34 and the ring seal 48 is obtained by tightening a threaded collar 46 against the casing 34. A fluid seal along the surface of the pipe 56 is obtained by a ring 52 which slips over the pipe 56 and is compressed against the metal plate 50 by a nut 54.

The manner of obtaining a fluid seal around the edges of the diaphragm 42 is illustrated in FIGURE 6 which shows the detailed construction of the diaphragm connector 44b similar in design to an ordinary pipe union. The fluid seal is completed by tightening the threaded members 62 and 64 to compress the diaphragm against a flange 66 on the end of the pipe 56.

The diaphragm 42 is reinforced at both ends by a plurality of rigid rib supports 40 spaced around the circumference of the diaphragm 42 and pivotally mounted on the upper member 62 of the diaphragm connectors 44a and 44b. FIGURE 3 illustrates the extension of the supporting ribs 40 along the diaphragm 42 for part of the distance from each end, thus leaving the intermediate portion 70 of the diaphragm 42 to form a constriction of the valve conduit 60 when the diaphragm 42 is collapsed, thereby closing the valve.

The casing 34 forming the outer wall of the valve assembly has a port 32 permitting the introduction of air or other gas into the chamber 38. When the gas within the chamber reaches a desired operating pressure, the port 32 is sealed by a suitable one way valve indicated by reference number 72.

In operation, when the pumps are circulating mud through the system as illustrated in FIGURE 1, the pressure exerted upon the internal wall of the diaphragm 42 is greater than the pressure in the chamber 38. In this condition, the valve remains fully opened as shown in FIGURES 2 and 4, permitting unrestricted flow of drilling mud through the valve conduit 60. When it becomes necessary to change the bit 28 or to add a joint of pipe to the drill string 26, the pumps are shut down and the kelly 18 and valve assembly 24 are withdrawn from the well-bore 30 through the rotary table 22. Because the valve assembly 24 is free of external connections, it will pass readily through the rotary table 22 and may remain connected to the kelly 18 while the work of adding a joint of pipe or changing bits is being performed. While the pumps are shut down, the pressure exerted upon the internal wall of the diaphragm 42 by a column of mud supported in the kelly 18 and rotary hose 12 is less than the gas pressure in the chamber 38. This higher pressure in the chamber exerts a force which collapses the diaphragm 42 as illustrated in FIGURES 3 and 5 and thereby forms a fluid seal to prevent the loss of drilling mud while the kelly 18 and the valve assembly 24 are disconnected from the drill string.

The type of material comprising the diaphragm 42 will depend upon the specific requirements of a particular use. Rotary drilling mud ordinarily contains an appreciable amount of abrasive sand particles which do not settle out in the mud pit but remain suspended in the mud and circulate throughout the system. In a preferred form the diaphragm 42 illustrated in FIGURES 1 through 6 comprises two concentric rubber tubes, the inner tube being composed of a hard, durable type of rubber that will withstand abrasion by the sand particles in the mud, and the outer tube consisting of a pliable type of rubber that is highly impervious to the passage of gas. As shown in FIGURES 2 and 3 the harder material of the inner tube contains a number of expansion grooves to permit a positive seal along the constriction when the valve conduit 60 is closed.

The foregoing description illustrates the embodiment, as an integral and permanent part of a rotary drilling apparatus, of a kelly valve assembly that prevents the loss of drilling mud when the kelly and valve assembly are disconnected from the drill string and that has no external members so that the valve assembly will pass freely through the rotary table.

Therefore I claim as my invention:

1. Apparatus for the rotary drilling of wells comprising a drill string, means for rotating the drill string, and pumping means for circulating a drilling mud downwardly through the drill string to the bottom of the well, said drill string comprising a kelly, drill pipe in the drill string below the kelly, a drill bit at the lower end of the drill string, and a valve in the drill string between the kelly and the drill pipe, said valve having a diaphragm therein defining a conduit communicating with the kelly and the drill pipe for the circulation of drilling mud therethrough, a chamber within the valve surrounding the dia-

phragm, and a gas within the chamber under a pressure lower than the pressure of mud circulated through the valve and adapted to collapse the diaphragm and close the conduit when the pumping means for circulating the mud are stopped.

2. Apparatus for the rotary drilling of wells comprising a drill string, means for rotating the drill string, and pumping means for circulating a drilling fluid downwardly through the drill string to the bottom of the well and upwardly through the well around the drill string, said drill string comprising a kelly, drill pipe in the drill string below the kelly, a drill bit at the lower end of the drill string, and closure means in the drill string between the kelly and the drill pipe to prevent the flow of the drilling fluid from the lower end of the kelly when the pumping means for circulating the drilling fluid are stopped, said closure means comprising a tubular casing connected to the lower end of the kelly and the upper end of the drill pipe and having an outer diameter substantially equal to the outer diameter of the drill pipe, a flexible diaphragm extending longitudinally within the casing and defining a fluid passage therethrough, means securing the diaphragm within the casing, a totally enclosed chamber between the diaphragm and the casing, and resilient means within the chamber urging the diaphragm transversely across the passage whereby upon stopping the pumping means for circulating the drilling fluid the passage is closed to prevent flow therethrough.

3. Apparatus for the rotary drilling of wells comprising a drill string, means for rotating the drill string, and pumping means for circulating a drilling fluid downwardly through the drill string to the bottom of the well and upwardly through the well around the drill string, said drill string comprising a kelly, drill pipe in the drill string below the kelly, a drill bit at the lower end of the drill string, and a valve in the drill string between the kelly and the drill pipe, said valve having a flexible tubular diaphragm therein defining a conduit communicating with the kelly and the drill pipe for the circulation of drilling fluid therethrough, a chamber within the valve around the diaphragm, and a gas sealed within the chamber under a pressure lower than the pressure of the drilling fluid circulated through the valve and adapted to collapse the diaphragm and close the conduit when the pumping means for circulating the drilling fluid are stopped.

4. Apparatus as described in claim 3 in which the flexible tubular diaphragm comprises an inner and an outer concentric tube, the inner tube consisting of a hard abrasion resistant material, and the outer tube consisting of a pliable impervious material.

5. Apparatus as described in claim 3 in which a plurality of vertically spaced expansion grooves extend circumferentially around the inner surface of the diaphragm.

6. Apparatus for the rotary drilling of wells comprising a drill string, means for rotating the drill string, and pumping means for circulating a drilling fluid downwardly through the drill string to the bottom of the well and upwardly through the well around the drill string, said drill string comprising a kelly, drill pipe in the drill string below the kelly, a drill bit at the lower end of the drill string, and a valve in the drill string between the kelly and the drill pipe, said valve comprising a tubular casing joined to the lower end of the kelly and having an outer diameter substantially equal to the outer diameter of the drill pipe, a flexible tubular diaphragm extending longitudinally within the casing, said diaphragm having an outer diameter less than the inner diameter of the casing and thereby defining a chamber between the casing and diaphragm, connecting means joining the ends of the diaphragm to the inner wall of the casing and providing a fluid-tight seal around the chamber, and a gas sealed within the chamber at a pressure lower than the pressure of the drilling fluid circulated through the valve and adapted to constrict the diaphragm and close the valve when the pumping means for circulating the drilling fluid are stopped.

7. Apparatus according to claim 6 in which the con-

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necting means at the ends of the diaphragm comprises conduit means at each end of the casing adapted to provide a fluid conduit from the ends of the casing to the ends of the diaphragm, unions securing the ends of the diaphragm to said conduit means within the casing, said unions each having an externally threaded member engaging said conduit means and an internally threaded member engaging the externally threaded member and adapted to compress the ends of the diaphragm between the union members and said conduit means.

8. Apparatus according to claim 7 in which a plurality of rigid ribs are pivotally connected to the internally threaded member of the union and extend therefrom longitudinally along the outer surface of the diaphragm to support said diaphragm.

9. Rotary drilling apparatus having a kelly, drill pipe connected below the kelly, and pumps to circulate drilling fluid through the kelly and the drill pipe, a valve at the lower end of the kelly providing a conduit between the kelly and the drill pipe during circulation of the drilling fluid therethrough and adapted to close the conduit when the pumps are stopped, said valve comprising a tubular casing secured to the lower end of the kelly and having an outer diameter substantially the same as that of the drill pipe, said conduit extending through said casing and defined therein by the combination of an inlet passage in the upper end of the casing and an outlet passage in the lower end of the casing with a constrictive passage formed by a flexible tubular diaphragm secured within the casing between the inlet and outlet passages, said diaphragm having an outer diameter smaller than the inner diameter of the casing, connecting means providing fluid-tight seals between the ends of the diaphragm and the inner wall of the casing to form a totally enclosed chamber between the diaphragm and the casing, and a fluid sealed within the chamber at a pressure lower than the pressure of drilling fluid circulated through the diaphragm and adapted to constrict the diaphragm and close the conduit therethrough when the pumps are stopped.

10. Rotary drilling apparatus having a kelly, drill pipe connected below the kelly, and pumps to circulate drilling fluid through the kelly and drill pipe, a valve connected to the lower end of the kelly and the upper end of the drill pipe, said valve comprising a tubular casing having an outer diameter substantially equal to that of the drill pipe and forming a substantially even outer surface with the kelly and drill pipe, an inlet tube secured within the upper end of the casing, an outlet tube secured within the lower end of the casing, a flexible tubular diaphragm extending longitudinally within the casing and joined to the ends of the inlet and outlet tubes thereby defining a fluid conduit communicating with the lower end of the kelly and the upper end of the drill

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pipe, a chamber around the diaphragm totally enclosed within the casing, and a fluid sealed within the chamber under a pressure greater than the hydrostatic pressure exerted on the diaphragm by a column of the drilling fluid supported in the drilling apparatus above the valve but less than the pressure exerted on the diaphragm by the drilling fluid circulated therethrough by the pumps.

11. A self-acting direct passage valve for connection between a kelly and drill pipe of rotary drilling apparatus, said valve comprising a tubular casing having an outer diameter substantially equal to that of the drill pipe and forming an even outer surface between the kelly and drill pipe, threads at each end of the tubular casing for connection to the kelly and the drill pipe, a flexible tubular diaphragm extending longitudinally within the casing and secured therein by connecting means, said flexible tubular diaphragm defining a fluid passage longitudinally through the valve, a totally enclosed chamber between the diaphragm and the casing, the outer surface of the tubular diaphragm forming at least a portion of the inner wall of the chamber, and a gas sealed within the chamber at a pressure greater than the hydrostatic pressure of a drilling fluid contained in said drilling apparatus above the valve but less than the pressure of said drilling fluid as it is circulated through the drilling apparatus.

12. A self-acting valve for connection between a kelly and drill pipe of rotary drilling apparatus, said valve adapted to respond automatically to changes in fluid pressure of a drilling fluid contained in the valve and comprising a tubular outer casing forming a smooth even surface between the kelly and the drill pipe, said casing being threaded at each end for connection to the kelly and the drill pipe, a tube extending longitudinally within the casing and communicating with the kelly and the drill pipe and having a flexible center portion, the outer diameter of the tube being smaller than the inner diameter of the casing to form a chamber totally enclosed between the tube and the casing, and a gas sealed within the chamber, at a pressure adapted to constrict the flexible portion of the tube when circulation of the drilling fluid therethrough is stopped.

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