United States Patent [19]

Gaylord

[11] **3,907,046**

[45] **Sept. 23, 1975**

[54] **RECLOSABLE DOWNHOLE BYPASS VALVE**

[75] Inventor: **Eber W. Gaylord,** Pittsburgh, Pa.

[73] Assignee: **Gulf Research & Development Company,** Pittsburgh, Pa.

[22] Filed: **Dec. 16, 1974**

[21] Appl. No.: **532,749**

[52] **U.S. Cl.** **175/235;** 175/317

[51] **Int. Cl.²** **E21B 27/00;** E21B 41/00

[58] **Field of Search** 175/317, 318, 235

[56] **References Cited**

UNITED STATES PATENTS

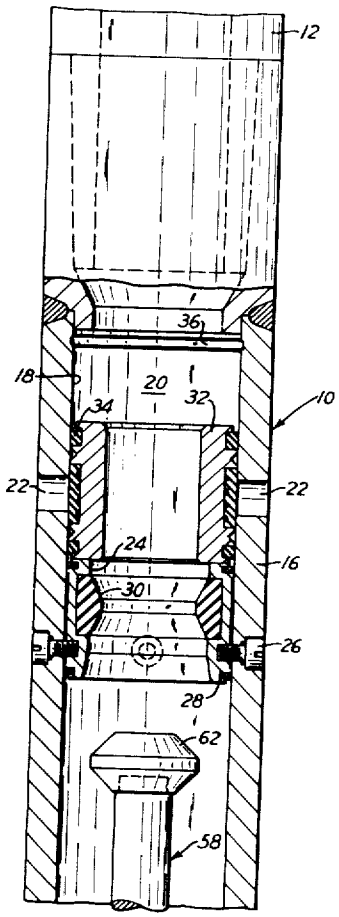
1,619,328	3/1927	Benckenstein	175/317
1,888,814	11/1932	Abercrombie	175/235
2,776,817	2/1957	Gregory et al.	175/48
3,205,955	9/1965	Whittle	175/318
3,369,619	2/1968	Brown	175/317

Primary Examiner—James A. Leppink

[57] **ABSTRACT**

A reclosable bypass valve for installation in the lower end of a drill string for the drilling of wells. A mandrel slidable in the lower end of the drill string can be moved upwardly by application of weight to the drill bit whereby the mandrel engages the lower end of a valve head and moves it upwardly against a sleeve to move the sleeve upwardly to uncover ports allowing liquid pumped down the well to bypass the drill bit. The valve head includes a deformable valve plug that can be forced upwardly through a valve seat to move the sleeve to uncover the ports and then moved downwardly to engage the valve seat and prevent flow to the drill bit during circulation through the bypass valve.

9 Claims, 6 Drawing Figures



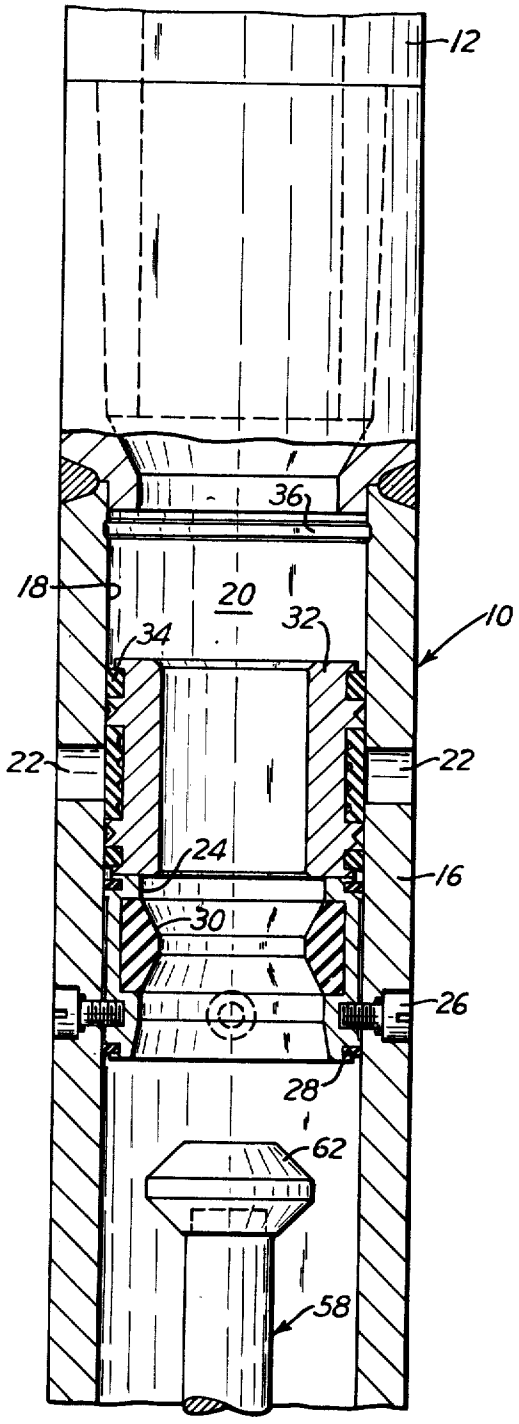

12
36
18
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32
10
34
22
22
24
16
30
26
28
62
58

Fig. 1a

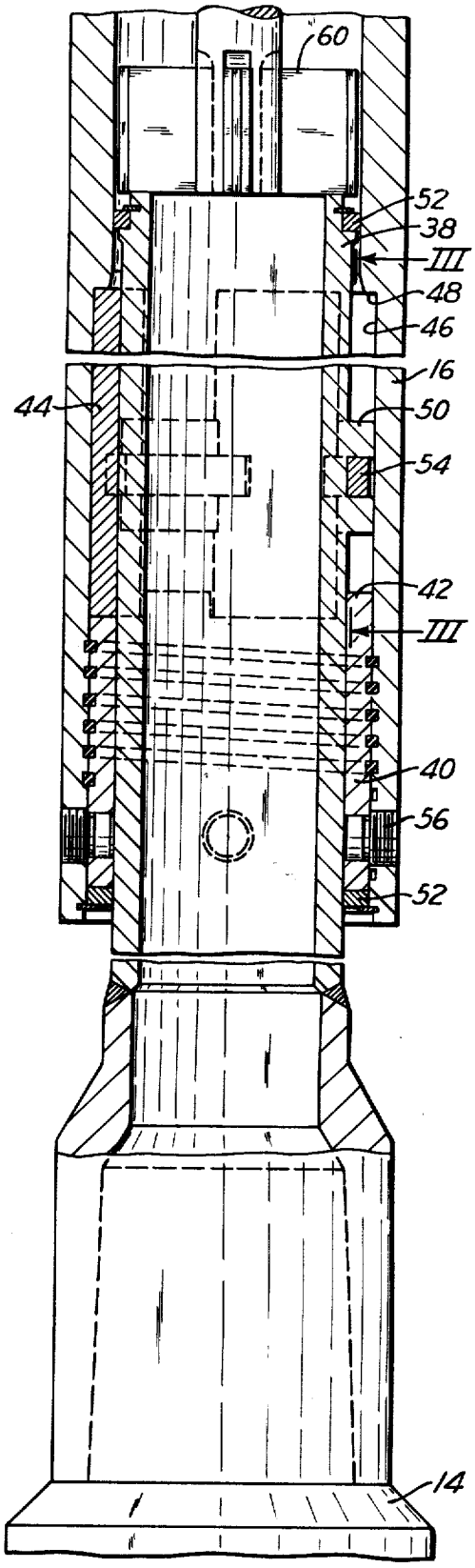

60
52
38
III
48
46
16
44
50
54
42
III
40
56
52
14

Fig. 1b

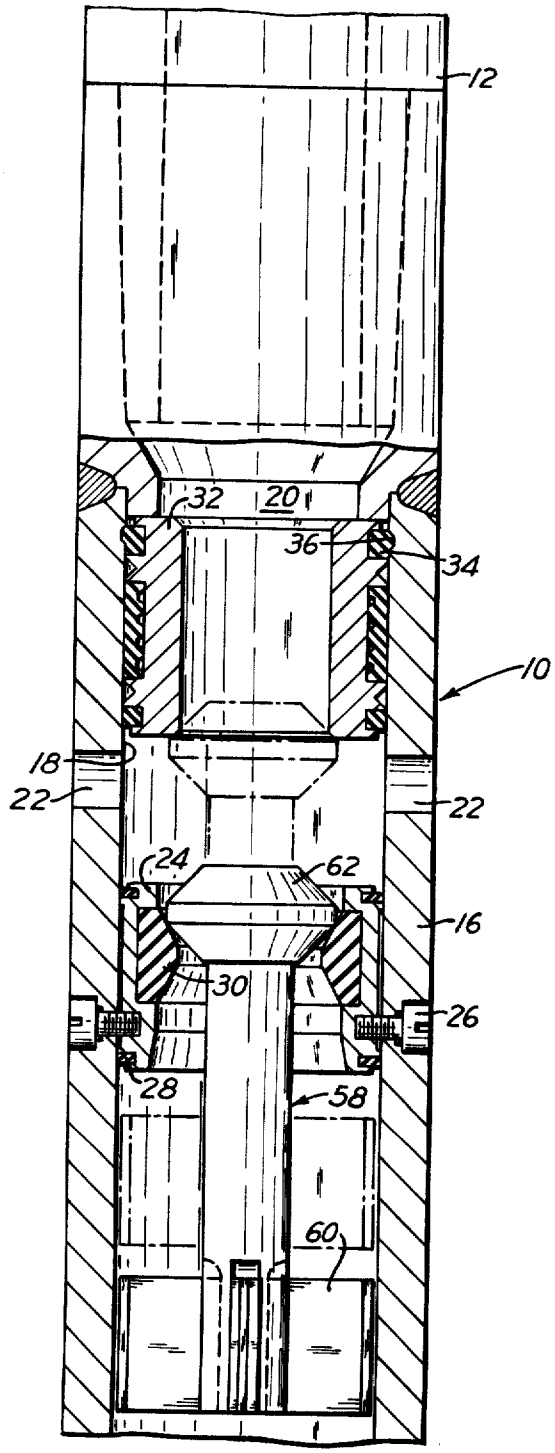

12
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Fig. 2a

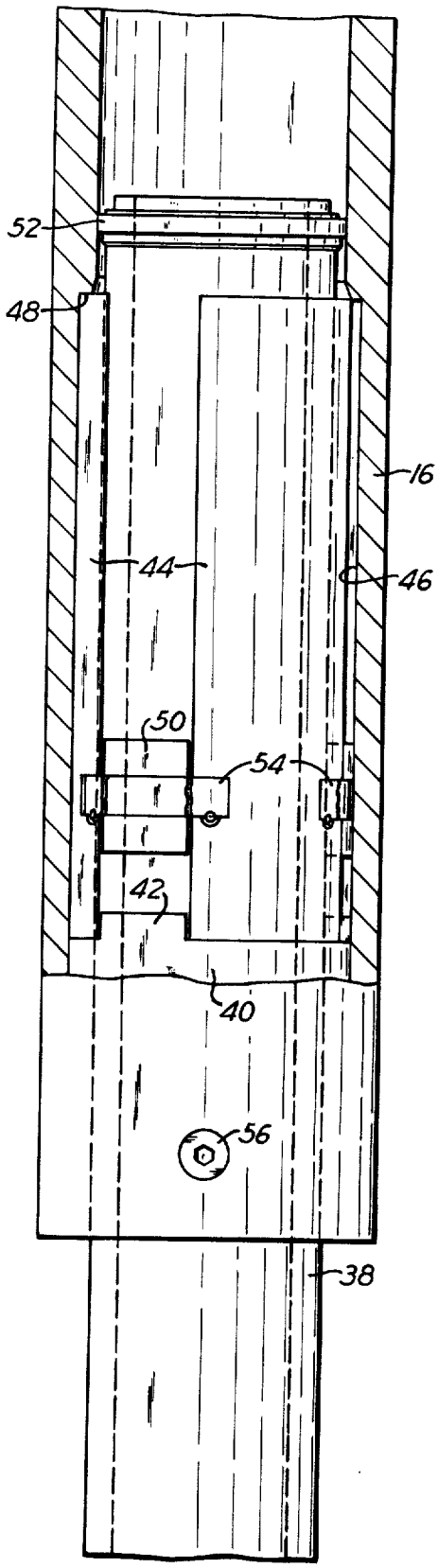

52
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16
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38

Fig. 2b

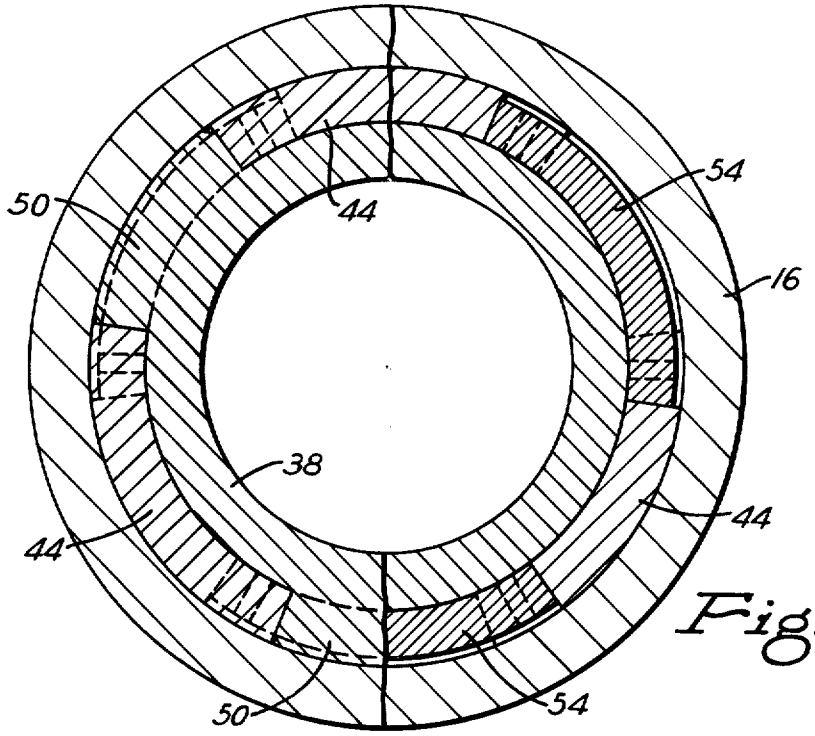


Fig. 4

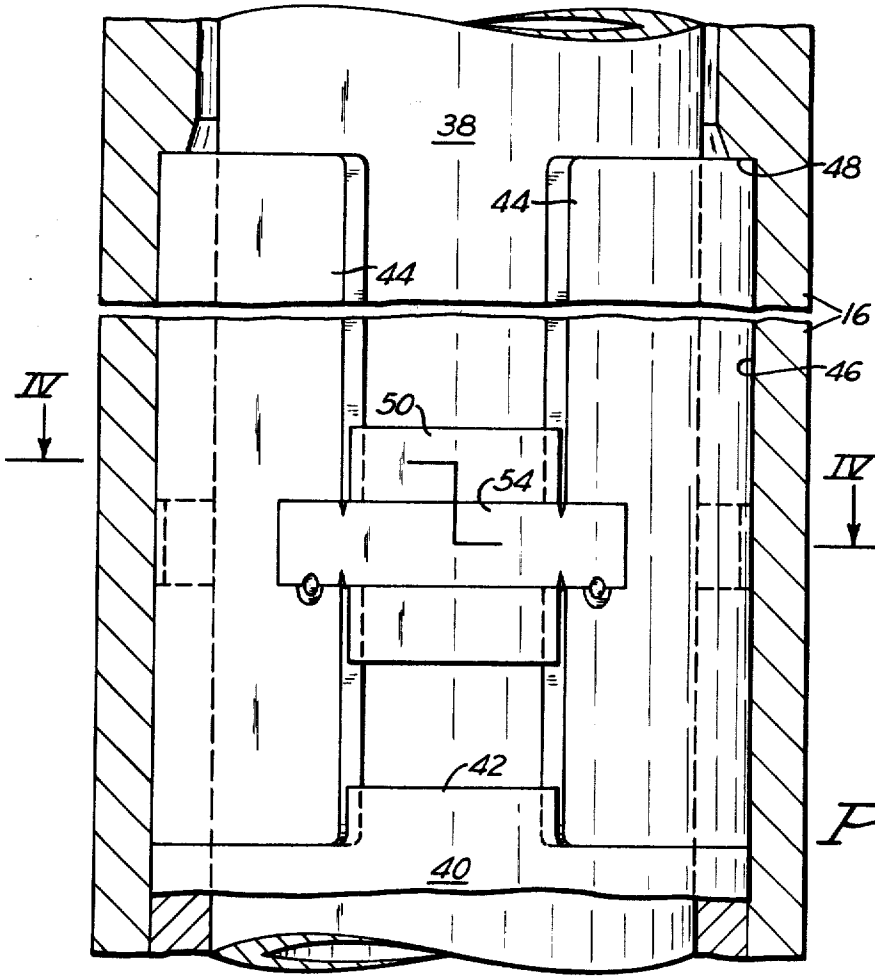


Fig. 3

RECLOSABLE DOWNHOLE BYPASS VALVE

This invention relates to the drilling of wells and more particularly to a downhole bypass valve which allows circulation of liquids through the well without passing through the drill bit.

In the rotary drilling of wells, a bit at the lower end of a drill string is rotated in contact with the bottom of the borehole to break rock from the bottom and thereby deepen the hole. A liquid, ordinarily referred to as a drilling mud, is circulated down the drill string and discharged through nozzles in the drill bit. The drilling mud washes the bottom of the borehole to speed the drilling process and carries the cuttings of rock upwardly through the annulus surrounding the drill string to the surface. Rock particles are separated from the drilling mud at the surface to recondition the drilling mud for recirculation through the well.

An important function of the drilling mud is to maintain a hydrostatic pressure in the hole higher than the pressure of formations penetrated by the well. Sometimes there is a loss of circulation of drilling mud caused by drilling mud flowing into highly permeable or fractured formations penetrated by the borehole. The loss of circulation may cause a drastic reduction of the hydrostatic pressure in the well by reducing the height of the column of drilling mud in the well. Such reduction in the hydrostatic pressure may result in a blowout if the well should penetrate formations containing fluids under high pressure.

One method of correcting loss of circulation is to add lost circulation agents to the drilling mud and circulate them through the well. The lost circulation agents are ordinarily granular or fibrous materials that are filtered from the drilling mud entering the formations causing the loss of circulation and form a barrier to the flow of additional drilling mud into such formations. The size of the lost circulation materials is such that they may plug the nozzles in drill bits and for that reason it is desirable to provide means for circulating them through the well without passing through the drill bit.

One method of drilling that has been developed recently is abrasive jet drilling. In that method, drilling mud containing abrasive particles, preferably iron or steel particles having a size in the range of 20 to 80 mesh, is discharged from the drill bit at extremely high velocities to erode the bottom of the borehole. A pressure drop of at least 5000 psi through the nozzles of the drill bit is required to impart the necessary high velocity to the drilling mud. In order to obtain the requisite high velocity without excessive rates of circulation of the drilling mud through the hole, the diameters of the nozzles in drill bits used for the abrasive jet drilling are very small. Because lost circulation additives would quickly plug those nozzles, it is particularly desirable to provide means for bypassing the drill bit during abrasive jet drilling operations.

Several types of apparatus for permitting circulation of drilling mud or other liquids in a well without passing through a drill bit are disclosed in the following United States patents:

Patent No.	Patentees	Issued
2,776,817	Gregory et al	1-57
3,205,955	Whittle	9-65
3,369,619	Brown	2-68

This invention resides in a reclosable bypass valve for installation at the lower end of the drill string in which a tubular body is secured to and forms a part of the drill string and a tubular mandrel slidable in the tubular body extends from the lower end of the tubular body for suspension of the drill bit. Spline means are provided to prevent rotation of the tubular mandrel relative to the tubular body. A port extending through the well of the tubular body is covered by a sleeve slidable in the tubular body during normal drilling operations and is uncovered when it is desired to bypass the drill bit. A deformable valve head is supported by a spider which can be engaged by the upper end of the mandrel to force the valve head upwardly through a valve seat below the port and against the lower end of the sleeve to move the sleeve to an upper position uncovering the port. The deformable valve head can be moved downwardly by liquid pressure in the drill string against the valve seat for bypassing the drill bit, or through the valve seat for resumption of drilling.

In the drawings:

FIG. **1***a* is a longitudinal sectional view of the upper end of the downhole bypass valve of this invention with the valve in the closed position.

FIG. **1***b* is a longitudinal sectional view of the lower end of the bypass valve in the closed position.

FIG. **2***a* is a longitudinal sectional view of the upper end of the bypass valve in position for bypassing the drill bit.

FIG. **2***b* is a longitudinal view, partially in vertical section, of the lower end of the bypass valve in the bypass position.

FIG. **3** is an elevational view showing means for preventing rotation of the mandrel of the bypass valve relative to the body.

FIG. **4** is a transverse sectional view along the section line IV—IV in FIG. **3**.

Referring to FIGS. **1***a* and **1***b*, the downhole bypass valve indicated generally by reference numeral **10** is shown connected between the lower end of drill string **12** and the upper end of drill bit **14.** Bypass valve **10** includes a tubular body **16** connected at its upper end to the lower end of drill string **12.** The inner wall **18** of the tubular body **16** surrounds a central bore **20** which extends longitudinally through the tubular body **16.** A plurality of ports **22** extend through the wall of the tubular body near its upper end.

Below the ports **22** and extending around the inner wall **18** of the tubular body **16** is an annular valve seat assembly **24** secured in position by shear bolts **26.** Sealing means **28** engage the outer surface of the valve seat assembly and the inner wall **18** to prevent leakage therebetween. In the preferred form of the invention illustrated in FIG. **1***a*, a valve seat **30** is of a deformable material such as polyurethane for the reasons hereinafter described.

Slidable in the bore **20** of the tubular body **16** above the valve seat assembly **24** is a sleeve **32.** Sleeve **32** is movable from a lower position illustrated in FIG. **1***a* in contact with the upper end of the valve seat assembly **24,** at which position the sleeve covers ports **22,** to an upper position illustrated in FIG. **2***a* at which the ports **22** are uncovered. Seal members **34** around the outer surface of the sleeve engage the inner wall **18.** When the sleeve is in the upper position, the upper seal member **34** extends into a retaining groove **36** to aid in holding the sleeve at the upper position.

Below the valve seat assembly **24** is a tubular mandrel **38** which during the drilling operation is vertically slidable, as hereinafter described, to operate the bypass valve. Mandrel **38** extends from the lower end of the tubular body for connection, directly or indirectly through suitable subs, to drill bit **14.** Holding tubular mandrel **38** in the tubular body **16** is a retaining bushing **40** which is threadably connected in an enlarged central opening at the lower end of the tubular body **16.** Shear pins **56** extending through the wall of tubular body **16** and the wall of retaining bushing **40** prevent rotation of the bushing relative to tubular body **16.** Leakage between the outer surface of the mandrel and the inner surface of the tubular body **16** is prevented by suitable sealing means **52.**

Spline means are provided to prevent rotation of the mandrel **38** relative to the tubular body **16.** For that purpose in the embodiment illustrated, the upper end of bushing **40** has a plurality of spaced-apart, upwardly extending shoulders **42.** Positioned in recesses in the upper end of the bushing **40** between the shoulders **42** are torque bars **44** that extend upwardly between the outer surface of the tubular mandrel **38** and the inner wall **46** of the enlarged portion of the central bore. The upper ends of torque bars **44** engage a shoulder **48** at the upper end of the enlarged portion of the central bore **20** in the tubular body. Lugs **50** extend outwardly from the outer surface of the tubular mandrel **38** into the space between torque bars **44.** Lugs **50** limit the vertical movement of the tubular mandrel **38** relative to the tubular body **16** by engagement with the shoulder **42** at the lower limit of travel of the mandrel and shoulder **48** at the upper limit of travel of the mandrel.

It is desirable to lock the mandrel in position as the drill bit is run into the hole to prevent inadvertent opening of the bypass valve. For this purpose, shear segments **54** rest in a horizontal groove in the lugs **50** and extend into suitable recesses in the torque bars **44.** Shear segments **54** are designed to prevent vertical movement of the tubular mandrel **38** in tubular body **16** until a predetermined thrust has been exerted on the mandrel.

Movable within the central bore **20** above the mandrel **38** is a valve head indicated generally by the numeral **58.** Valve head **58** includes a spider **60** adapted to engage the upper end of tubular mandrel **38** and to permit flow of drilling fluid downwardly into the mandrel. A valve plug **62** at the upper end of valve **58** is adapted to engage valve seat **30** to prevent flow downwardly through the valve body and tubular mandrel during circulation through the bypass. Valve plug **62** is constructed of a deformable material such as polyurethane to permit the valve plug to be forced through the valve seat, as hereinafter described.

The bypass valve is run into the well in the condition shown in FIGS. **1***a* and **1***b* with the mandrel **38** held in an intermediate position by the shear segments **54** and the sleeve **32** in the lower position covering the ports **22.** Shear segments **54** are designed to withstand a predetermined thrust on the mandrel to prevent the mandrel accidentally moving the sleeve **32** to the open position by engagement of the tool with some obstruction as the tool is run into the hole. In a typical embodiment when the bypass valve is used in a jet drilling operation, the shear segments can be designed to withstand a thrust on the mandrel of 38,000 pounds, for example. When the drill bit has been run to bottom, it is lifted off the bottom of the hole and drilling mud pumped down the drill string at a pressure adequate to provide a downward thrust to shear the shear segments **54.** In the typical embodiment referred to above, a pressure of 4,000 psi is adequate to shear the segments **54.**

The net downward force exerted on the mandrel by the drilling mud during drilling exceeds the upward force on the mandrel resulting from the load placed on the bit. Thus, the bypass valve remains in the closed position during drilling. Before the pressure of circulating drilling mud on the bit is released during the drilling operation, the drill bit is lifted off bottom; hence, conditions during drilling are not such as to open the bypass valve.

When it is desired to open the bypass valve, for example when lost circulation material is to be circulated into the well or if it is desired to separate abrasive out of the well before pulling a drill bit, the drill string is depressurized and the bit lowered against the bottom. The weight on the bit is increased to a weight adequate to force the valve plug **62** on the valve head **58** against the valve seat **30** with sufficient force to deform the valve plug **62** and the valve seat **30** and move the valve head **58** upwardly through the valve seat **30.** Valve head **58** engages the lower end of sleeve **32** and moves it to the upper position illustrated by broken lines in FIG. **2***a* to uncover ports **22.** To circulate through the bypass valve, the bit is again lifted off bottom and circulation commenced down through the drill string and out through the ports **22.** Valve plug **62** engages valve seat **30** as shown in full lines in FIG. **2***a* to prevent flow to the drill bit, but the pressure on the upper surface of valve plug **62** is not adequate to force it through the valve seat. Engagement of sealing rings **34** with the walls of retaining groove **36** holds sleeve **32** in the upper position during circulation through the bypass valve.

When it is desired to close the bypass valve, a weight is applied to the drill bit to move the valve head **58** into engagement with the lower end of the sleeve to prevent flow through the sleeve and the drill string pressurized. The pressure of the drilling mud on the upper end of the sleeve and the valve head **58** overcomes the weight on the bit and moves the sleeve downwardly to the lower position, illustrated in FIG. **1***a*, covering the ports **22.** Continued application of pressure deforms the valve seat **30** and valve plug **62** to move the valve head downwardly below the valve seat. The drilling mud can then flow downwardly through the spider **60** to the drill bit.

The normal operation of the bypass valve allows the valve to be used repeatedly. If for any reason, such as inability to force the valve head **58** through the valve seat, it is not possible to open the bypass valve in the manner indicated above, a ball can be dropped down the drill string to engage the upper end of sleeve **32** and pressure is applied to the drill string. Increasing the pressure forces sleeve **32** against valve seat assembly **32** to shear bolts **26** and move the valve seat structure **24** and sleeve **32** downwardly below ports **22** to uncover the ports. Circulation can then be conducted through ports **22.** If a ball is used to open the bypass valve, it is not possible to close the bypass valve or circulate through the drill bit, and it is then necessary to replace the tool before drilling can proceed.

The reclosable bypass valve of this invention contributes to the safety of the drilling operation. If loss of cir-

culation should occur, lost circulation material can be quickly circulated through the bypass valve to the zone causing the loss of circulation to plug that zone. Thereafter, the bypass valve can be closed and drilling resumed. In jet drilling operations, the bypass valve has the further advantage of providing means for circulating abrasive from the hole before a round trip to replace a drill bit. While it is ordinarily expected that the mandrel of the valve will be located in the intermediate position as the drill bit is run into the hole, the bypass valve can be opened and circulation maintained through the bypass as the drill string is run into the hole by pressuring the drill string to rupture the shear segment at any stage during the running of the drill string into the hole.

I claim:

1. A downhole bypass valve for connection into the lower end of a drill string above a drill bit comprising a tubular body adapted to be connected into the drill string for rotation therewith, said tubular body having an inner wall surrounding a bore extending longitudinally therethrough, a port extending laterally through the tubular body, a tubular mandrel slidable in the tubular body below the port and extending from the lower end of the tubular body for suspension of the drill bit, spline means adapted to prevent rotation of the mandrel relative to the tubular body, a sleeve slidable in the tubular body above the mandrel from an upper position exposing the port to the bore of the tubular body to a lower position covering the port, a valve seat around the inner wall of the tubular body between the upper end of the mandrel and the port, and a valve head in the bore, said valve head being constructed and arranged to engage the valve seat to prevent flow through the bore and being deformable to pass through the valve seat on application of a predetermined force urging the valve head against the valve seat.

2. A bypass valve as set forth in claim **1** in which the valve head comprises a spider adapted to engage the upper end of the mandrel and a valve plug extending upwardly from the spider for engagement with the valve seat.

3. A bypass valve as set forth in claim **1** in which the valve seat is deformable.

4. A bypass valve as set forth in claim **1** in which shear bolts secure the valve seat to the tubular body, said shear bolts having a strength allowing the valve head to pass through the valve seat without shearing of the shear bolts.

5. A bypass valve as set forth in claim **1** in which shear segments engage the spline means to prevent longitudinal movement of the mandrel relative to the body.

6. A downhole bypass valve as set forth in claim **1** in which the spline means comprise spaced-apart, longitudinally extending torque bars on the inner wall of the tubular body and lugs extending outwardly from the mandrel into the spaces between the torque bars.

7. A downhole bypass valve as set forth in claim **6** in which shear segments engage the lugs and torque bars to prevent longitudinal movement of the mandrel relative to the body as the bypass valve is run into the hole.

8. A downhole bypass valve as set forth in claim **1** in which the bore is enlarged at the lower end of the valve body, a retaining bushing is threadably connected into the lower end of the body for rotation therewith, said retaining bushing extending into the body for a portion of the length of the enlarged bore, spaced-apart shoulders on the inner end of the retaining bushing, shear bars fitting between the shoulders and extending longitudinally to the upper end of the enlarged bore, and lugs extending outwardly from the tubular mandrel into the spaces between the shear bars.

9. A downhole bypass valve as set forth in claim **8** in which shear segments engage the lugs and bars to prevent rotation of the mandrel relative to the body.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,907,046

DATED : September 23, 1975

INVENTOR(S) : Eber W. Gaylord

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 9, "well" should be --wall--.

Column 3, line 48, after "valve", second occurrence, insert --head--.

Column 4, line 17, cancel "separate" and insert in lieu thereof --circulate--.

Signed and Sealed this

twenty-seventh Day of *January 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks