United States Patent

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Division of Ser. No. 787,113, Dec. 26, 1968

[54] REVERSIBLE FLUID-DRIVEN MOTOR
7 Claims, 15 Drawing Figs.

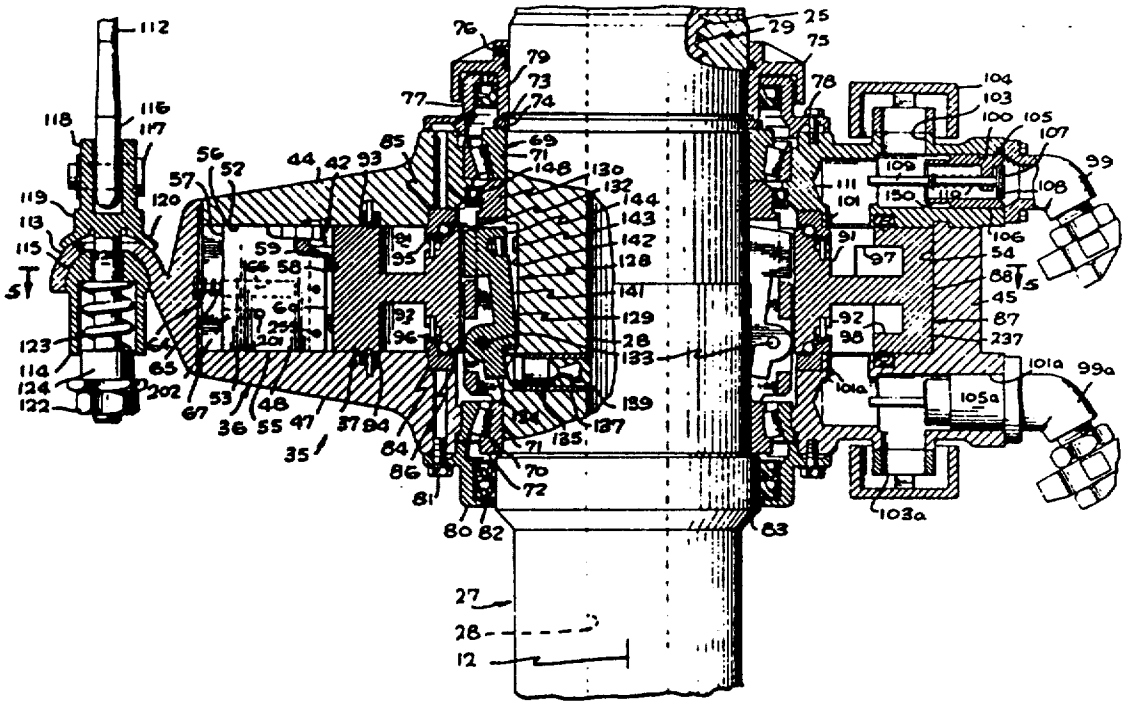
[52] U.S. Cl. 418/186, 91/464, 418/248
[51] Int. Cl. F01c 1/00
[50] Field of Search 418/186, 243, 244, 245, 246, 247, 248, 249, 250, 251, 270; 417/315, 518; 91/464, 469

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ABSTRACT: A reversible fluid-driven motor having two selectively usable fluid inlet passages for introducing pressure fluid to the motor to drive it in two opposite directions, with each passage being vented to atmosphere during periods when fluid is being admitted to the motor through the other passage, and with two valve units being provided between a source of pressure fluid and the two passages respectively and each operable automatically when pressure fluid is supplied thereto to close off a vent to atmosphere from the associated passage.



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SHEET 1 OF 4

Fig. 1

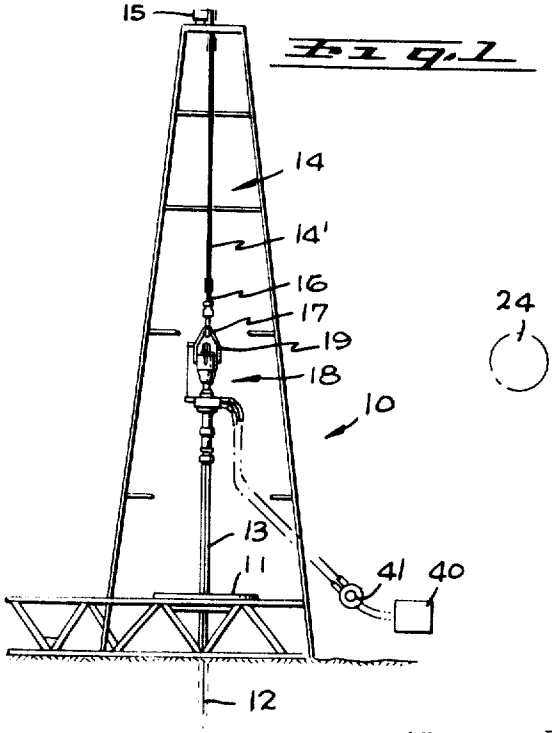


Fig. 2

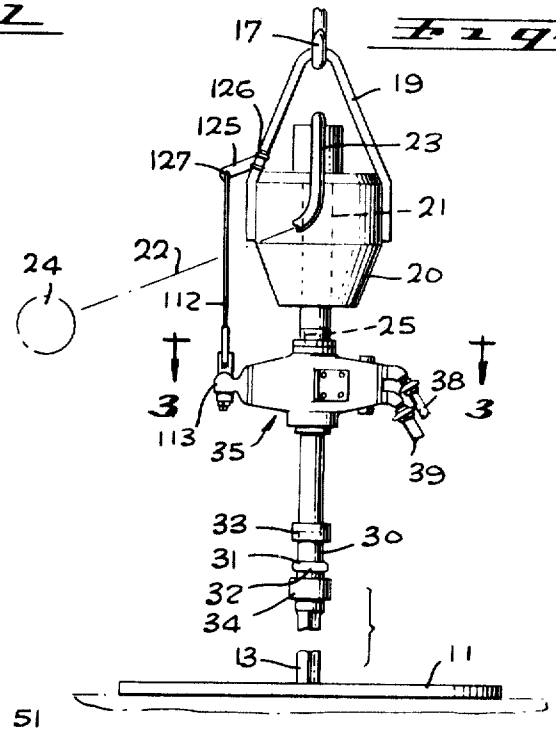
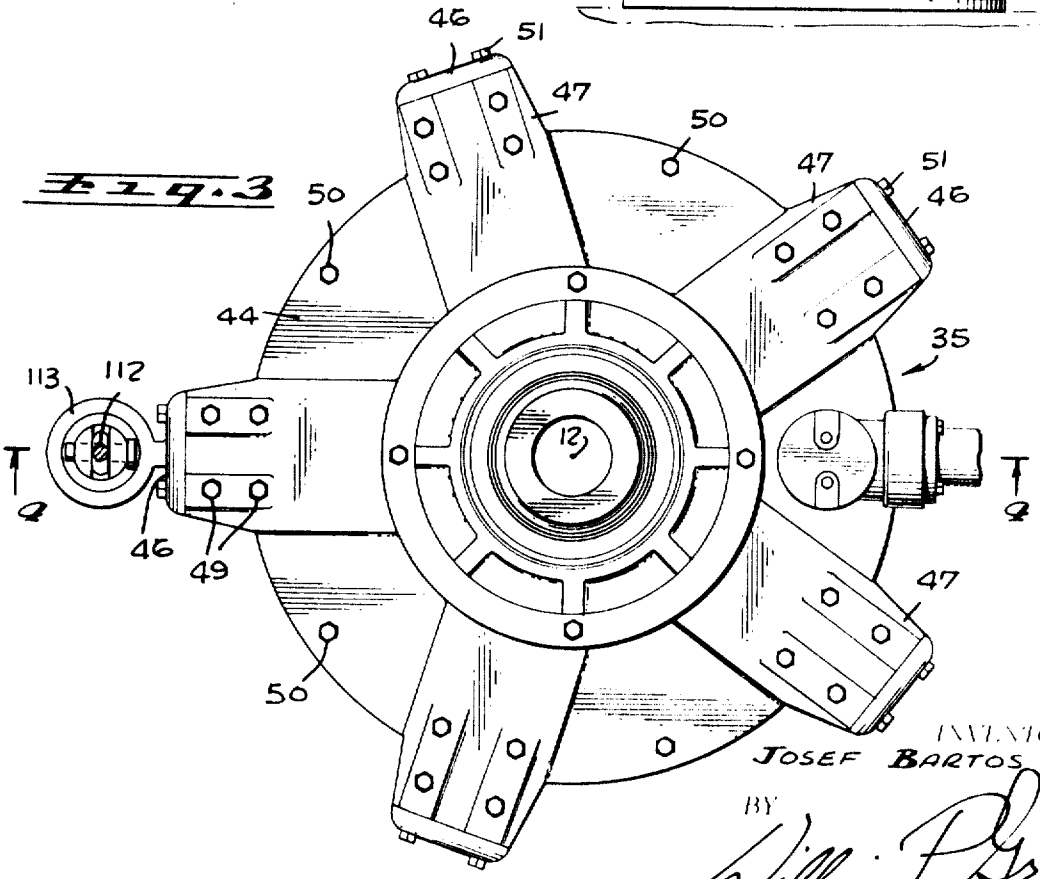


Fig. 3



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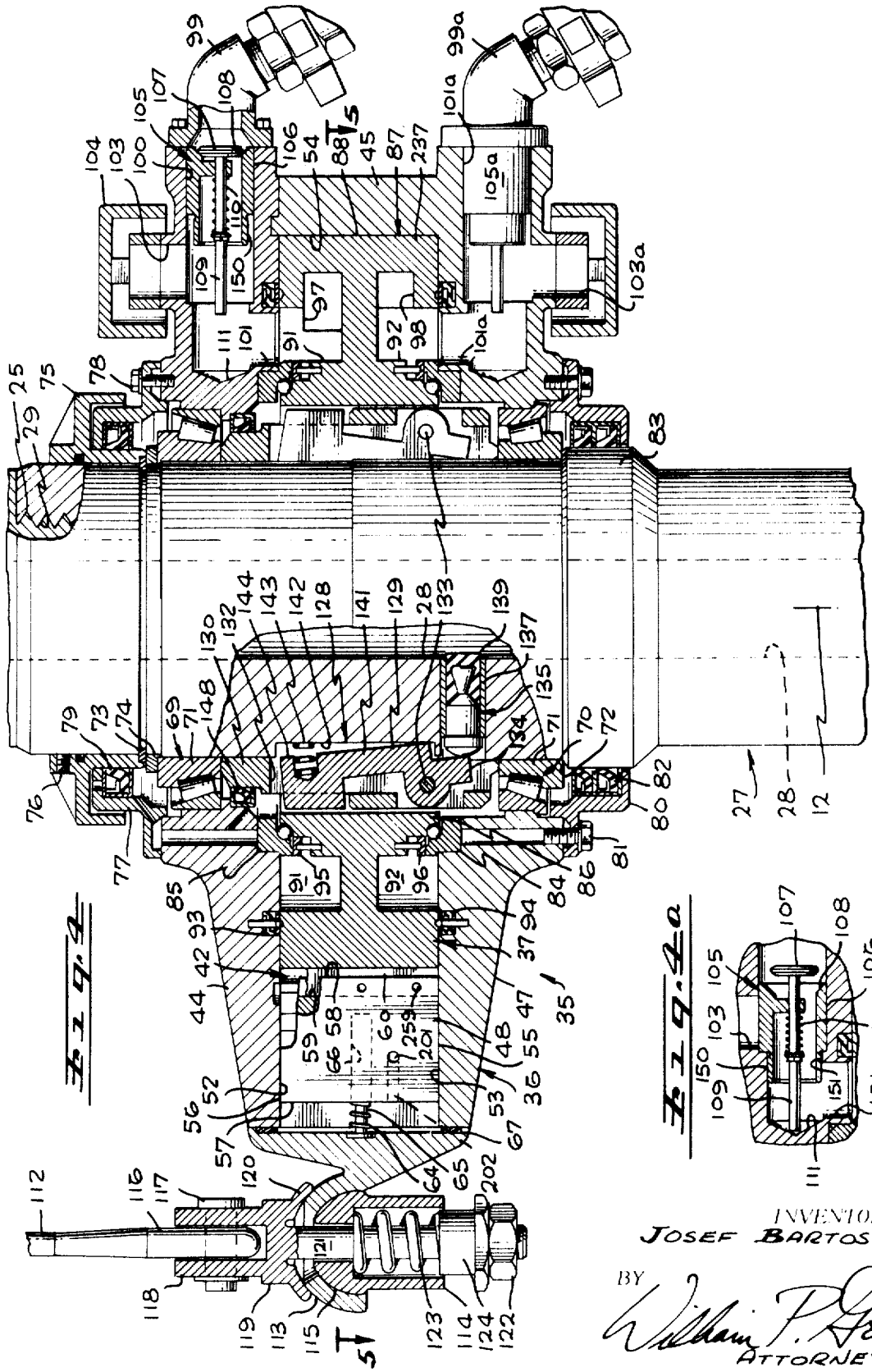
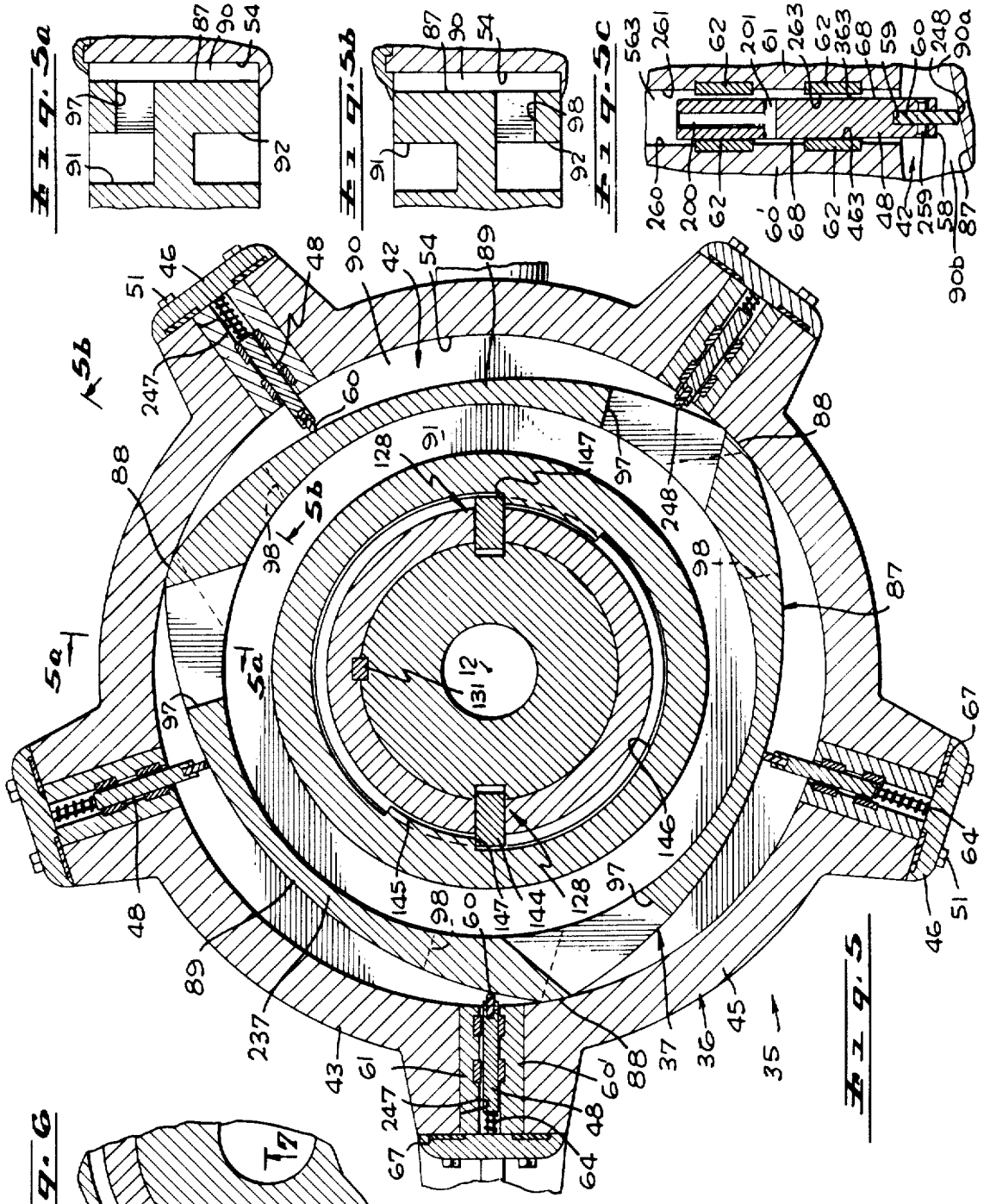


Fig. 4

Fig. 4a

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Fig. 7

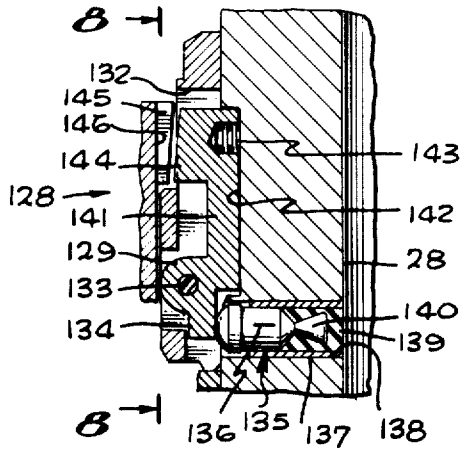


Fig. 8

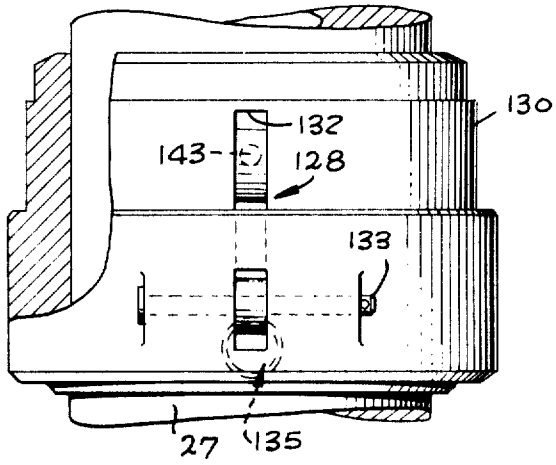


Fig. 9

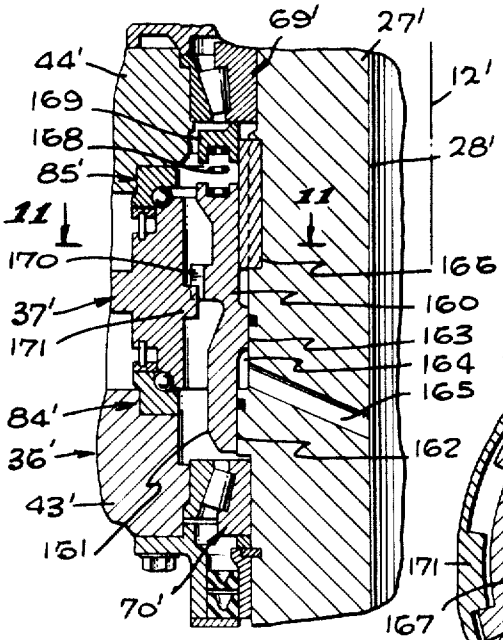


Fig. 10

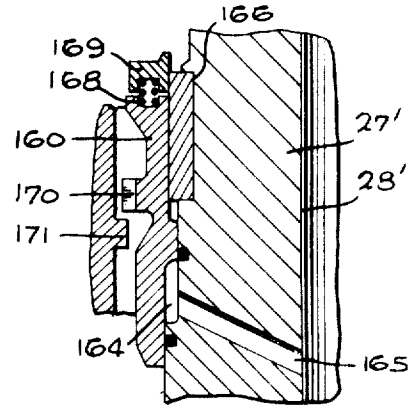
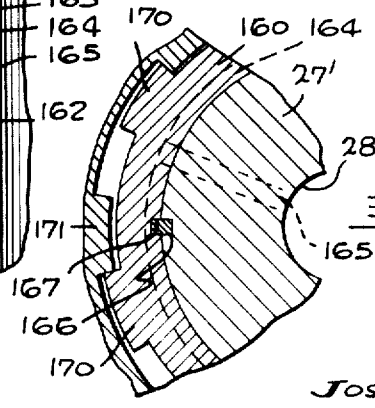


Fig. 11



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REVERSIBLE FLUID-DRIVEN MOTOR

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a division of my prior copending application U.S. Pat. Ser. No. 787,113, filed Dec. 26, 1968 on "Vane Type Rotary Fluid Handling Mechanism," which in turn was a division of and copending with my prior U.S. Pat. application Ser. No. 648,913, filed June 26, 1967 on "Spinner Device For Turning Well Pipe or the Like," now U.S. Pat. No. 3,461,974. Certain features of the apparatus of the present invention have been disclosed and claimed in my U.S. Pat. No. 3,381,584, issued May 7, 1968 on "Vane Type Rotary Device."

BACKGROUND OF THE INVENTION

This invention relates to fluid-driven motors of a reversible type adapted to be driven rotatively in either of two opposite directions, and preferably also of the vane type in which one or more vanes define a compartment or compartments which change in size as the motor turns.

In devising a reversible rotary fluid-driven motor, it is frequently relatively difficult to provide completely effective and yet structurally simple valving means for controlling the flow of pressure fluid to and from the motor in its two different direction conditions, and also in a stopped condition. This is particularly true in situations where the motor is to be controlled remotely, and especially where the volume of air or other pressure fluid required to drive the motor is relatively large. Particularly difficult under those conditions is the maintenance of positive and reliable fluid seals in the valving structure under all conditions of the motor.

SUMMARY OF THE INVENTION

The present invention teaches an improved valving arrangement for attaining the above discussed purpose of controlling the flow of pressure fluid to and from a reversible fluid motor. For this purpose, I provide means which are capable of introducing pressure fluid selectively into either of two different inlets, to drive the motor in its two opposite directions respectively, with the inactive one of the inlets serving as an outlet passage. In each of the inlet lines, there is provided a unique valve unit which is automatically actuable from a fluid discharging condition to a position for closing off an associated outlet passage in response to the introduction of inlet pressure to that line. This valve unit may include a slide valve element which is actuable by the inlet pressure to a position closing off the discharge or outlet passage, and which carries a second valve element spring urged to a closed position and adapted to be automatically opened by the inlet pressure fluid to a position passing such pressure fluid to the motor. These two automatic valve units may then be controlled very effectively and positively but from a remote location by actuation of a remote control valve or valves which act merely to admit pressure fluid to a pair of supply lines leading to the two automatic valve units respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which the invention is typically illustrated as applied to a fluid motor utilized as the driving force in a well pipe spinner, and in which drawings:

FIG. 1 is a somewhat diagrammatic side view of a drill rig having a spinner which contains a motor embodying the invention;

FIG. 2 is an enlarged fragmentary representation of a portion of FIG. 1;

FIG. 3 is a further enlarged view taken on line 3–3 of FIG. 2;

FIG. 4 is an enlarged view taken primarily on the vertical sectional line designated 4–4 in FIG. 3;

FIG. 4*a* is a fragmentary representation of one of the valve units of FIG. 4, in a changed position;

FIG. 5 is a horizontal section taken on line 5–5 of FIG. 4.;

FIGS. 5*a* and 5*b* are fragmentary vertical sections taken on lines 5*a*–5*a* and 5*b*–5*b* respectively of FIG. 5;

FIG. 5*c* is an enlarged horizontal section through one of the vanes of the device;

FIG. 6 is a fragmentary view representing a portion of FIG. 5, but with the clutch in its released condition;

FIG. 7 is a fragmentary vertical section taken primarily on line 7–7 of FIG. 6;

FIG. 8 is a fragmentary elevation, partially broken away in section, taken on line 8–8 of FIG. 7;

FIG. 9 is a view similar to FIG. 7, but showing a different form of clutch mechanism;

FIG. 10 shows a portion of FIG. 9 in a position in which the clutch is released; and

FIG. 11 is a fragmentary horizontal section taken on line 11–11 of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Attention is first directed to FIG. 1, in which there is shown a conventional well drilling rig **10** having a rotary table **11** which turns about a vertical axis **12**, and is adapted to drive rotatively about that axis the usual noncircular 'kelly' section **13** of the drill pipe. The rest of the drill string is of course connected to the kelly and extends downwardly into the well. The entire drill string is suspended by the usual elevator assembly designated **14** in FIG. 1, which includes a block and tackle assembly **14'** driven by a motor **15**, with the cable **16** of the block and tackle carrying a hook **17**. The swivel is illustrated at **18**, and has an upwardly projecting bail **19**, which engages and is suspended by hook **17** of the elevator assembly. The swivel of course includes an outer body **20**, having a tubular vertically extending spindle or stem **21** mounted in the body for rotation about the vertical axis **12**, with drilling fluid or 'mud' being fed to the upper end of the tubular spindle **21** from an appropriate supply hose **22** through the usual goose neck **23**. The circulating fluid is pressurized by a pump represented at **24**, which is in operation during rotation of the well string to produce circulation of drilling fluid downwardly therethrough, but which is stopped whenever a joint in the string is to be made or broken.

The spindle **21** of the swivel projects downwardly a short distance beneath the lower end of the nonrotating body **20**, and has external threads **25** connectable to a spinner **26**. This spinner includes a vertically extending short pipe section **27** (see FIGS. 2 and 4), containing a passage **28** through which drilling fluid passes downwardly from swivel stem **21** to the kelly. The upper end of pipe section **27** is internally threaded at **29**, to form a 'box' end into which the threads **25** of the swivel stem or spindle are connectable. Alternatively, there may be connected between the swivel stem and section **27** of the spinner an intermediate short pipe section or 'sub'. The lower end of pipe section **27** may have an externally threaded downwardly projecting end **30** which may be connected to the kelly through a conventional kelly cock section **31** having a kelly cock valve **32** for closing off the flow of fluid through the string when necessary. The kelly cock section in turn is connected to the upper end of the kelly **13** by an appropriate threaded connection, with section **31** of course containing a passage forming a continuation of the passage **28** in pipe section **27** of the spinner, so that fluid may flow downwardly through section **31** to the kelly and into the well. The joint between sections **27** and **31**, as well as the joint between section **31** and the kelly, may be locked against accidental detachment by appropriate external locking rings **33** and **34** suitably connected to the joined parts.

In addition to the central tubular pipe section **27** of the spinner, this device includes and forms, about section **27**, a vane-type fluid driven motor **35**, with whose construction the present invention is primarily concerned, this motor including

an outer nonrotating housing or body **36**, and a rotor **37** which in one condition of the apparatus acts to drive pipe section **27** and the connected parts rotatively about vertical axis **12**. The rotor is capable of driving the well pipe in either rotary direction, and for this purpose two flexible fluid inlet hoses **38** and **39** may be provided, to lead actuating pressure fluid, typically compressed air, into housing **36**, for driving the rotor in its opposite directions. The fluid may be delivered to hoses **38** and **39** from a source **40** of compressed air or other pressurized fluid, through a three-way valve **41**, which is actuable to three positions, for admitting air selectively to either of the two hoses, or closing off all air to both hoses.

Housing **36** contains and forms an inner annular chamber **42** (FIGS. **4** and **5**) within which rotor **37** is mounted to turn. The housing may be formed sectionally or several parts, including a generally annular main section **43**, a generally annular top wall or section **44**, and a series of radially outer cover plates **46**. At a series of evenly circularly spaced locations (desirably five such locations), the sections **43** and **44** have radially outwardly projecting portions or enlargements forming outwardly projecting portions **47** of the housing, within which a series of radially movable vanes **48** are slidably received. Sections **43** and **44** are secured rigidly together in any suitable manner, as by several sets of screws **49** extending downwardly through top section **44** and into bottom section **43** at the locations of the outwardly projecting enlargements **47**, and by several similar screws **50** extending through section **44** and into section **43** at a number of circularly intermediate locations (FIG. **3**). Outer cover plates **46** extend across the radially outer extremities of sections **43** and **44** at the locations of outwardly projecting portions **47**, and are secured thereto by bolts **51**.

The previously mentioned rotor chamber **42** in the housing is defined at its top and bottom by two annular parallel horizontal surfaces **52** and **53**, formed on the underside of section **44** and the upper side of section **43** respectively, and both disposed perpendicular to axis **12**. The radially outer extremity of chamber **42** is defined by a generally annular wall **45** projecting upwardly from and desirably integral with section **43** of the housing, and having an inner cylindrical wall surface **54** centered about axis **12** and extending vertically from surface **52** to surface **53**. Wall **45** is circularly continuous except at the locations of outwardly projecting enlargements **47** on the housing, at which locations wall **45** is interrupted to provide radially extending slots or guideways **247** within which vanes **48** and their guiding parts are received.

Vanes **48** are rectangular flat elements of a height corresponding to the vertical distance between the two top and bottom wall surfaces **52** and **53** of chamber **42**, to be slidably received therebetween. More specifically, as seen in FIG. **4**, one of the vanes is there illustrated as having a bottom horizontal edge **55** slidably engaging surface **53** of housing section **43**, and a top horizontal edge **56** slidably engaging surface **52** of top section **44**. The radially outer extremity of the vane may be defined by a vertical edge **57**, while the radially inner extremity of the vane may be defined by a vertical edge **58**, desirably containing a vertical groove **59** (see FIGS. **4** and **5**) within which there is retained by rivets or screws **259** a seal element **60** formed of nylon or other sealing material and extending vertically between surfaces **52** and **53**. The vane **48** may be formed of any suitable preferably rigid material, such as an appropriate metal, and may be slidably confined between two bearing carrier plates **60'** and **61** (FIG. **5**), confined within one of the housing slots **247**. Plates **60'** and **61** may be formed of an appropriate metal, such as steel, and be welded to section **43** or otherwise permanently secured in the illustrated positions. Plates **60'** and **61** have parallel opposed vertical planar surfaces **260** and **261**, extending substantially radially with respect to axis **12**, and containing vertical grooves within which there are loosely received vertical bearing inserts **62** of an appropriate bearing material (such as nylon or aluminum bronze) for minimizing the frictional resistance to motion of the vanes. The two elements **60'** and **61**, and their inserts **62**, form together the opposed vertical sidewalls of a guideway within which the vane **48** is mounted for sliding movement directly radially with respect to the main axis **12** of the spinner.

Each of the vanes is spring urged radially inwardly against the rotor by a coil spring **64**, which may be received about a pin **65** projecting radially inwardly from the associated cover plate **46**, with the spring projecting into a suitable passage **66** in the vane (FIGS. **4** and **5**), and bearing against a shoulder at the end of that passage. The radially outer end of the vane receiving guideway may be sealed by provision of an appropriate seal between each of the cover plates **46** and the other housing parts (sections **43** and **44**), peripherally about the vane area, and more specifically by providing an endless typically rectangular gasket **67** (FIGS. **4** and **5**) for preventing leakage of air from the housing. The radially inner extremities of the two bearing carrier plates **60'** and **61**, at each of the vane locations, may have arcuate surfaces which form continuations of the cylindrical surface **54** of housing wall **45**.

The opposite side surfaces **68** of each of the vanes are parallel to one another, and extend vertically, but are spaced apart a distance somewhat less than the space between the opposed parallel planar vertical surfaces **263** of each pair of bearing elements **62**, to provide a clearance space between each of the vanes and one of the surfaces **263** (as at **363** in FIG. **5***c*) through which some of the air from within chamber **42** may flow radially outwardly to a location outwardly beyond the vane. This air always flows radially outwardly at the pressure side of the vane, while the latter is maintained by the pressure in sealing engagement with the bearing surfaces **263** at its opposite side (as at **463** in FIG. **5***c*).

The entire housing **36** is mounted rotatably to the central tubular main pipe section portion **27** of the spinner, since pipe section **27** is to turn with the rest of the drill string while the housing remains stationary. For this purpose, there are provided two bearings **69** and **70** about pipe section **27**, and at the upper and lower ends of the housing. Each of these bearings may have inner and outer races with rollers **71** received therebetween, and disposed at inclinations enabling bearings **69** and **70** to function as thrust bearings, so that in addition to mounting section **27** for rotation within the housing, they also retain the housing against both upward and downward movement relative to pipe section **27**, and in fact serve to support the weight of the housing and its contained rotor from pipe section **27**. The inner race of bearing **70** may engage against and be supported by an upwardly facing annular shoulder **72** formed on pipe section **27**, while the inner race of bearing **69** is retained against upward movement by a snap ring **73** received within a groove in pipe section **27**, and acting against bearing **69** through a washer **74**.

Roller bearing **69** may be protected against contamination by a shield ring **75** disposed about pipe section **27** and secured thereto by setscrews **76**, with this shield ring coacting with another ring **77** of the configuration illustrated in FIG. **4**, secured to upper wall **44** of the housing by bolts **78**, and containing an annular deformable seal element **79** engaging a depending skirt on ring **75**. The lower roller bearing **70** may be protected by connection of a shield ring **80** to the housing through screws **81**, with ring **80** containing seal elements **82** engageable with an annular surface **83** on pipe section **27**.

The rotor **37** is mounted rotatably within chamber **42** by means of two ball bearings **84** and **85** (FIG. **4**), whose outer races engage and are confined by housing sections **43** and **44** respectively. The rotor itself has surfaces **86** which define the inner races of these ball bearings, with the ball contacting surfaces all being disposed at such an angle as to give the bearings a capacity to function as thrust bearings, in addition to merely mounting the rotor for turning movement. The rotation of the rotor is of course about main axis **12** of the apparatus.

The radially outer portion **237** of the rotor occupies the entire vertical distance from bottom wall surface **53** of chamber **42** to top wall surface **52** of the chamber, and has a radially outer surface **87** which is circularly continuous about axis **12**,

and which has the noncircular horizontal cross-sectional configuration illustrated in FIG. 5. This cross section continues for the entire vertical extent of chamber **42**, to define a series of evenly circularly spaced radially outwardly projecting lobes **88** on the rotor, and circularly intermediate portions **89** of surface **87** which, in advancing circularly from one of the lobes to the next lobe, first progressively decrease in radius, and then progressively increase in radius to the next lobe. The lobes **88** are of a diameter corresponding substantially to the diameter of internal surface **54** of the housing, to engage or substantially engage that surface continuously, and move therealong, so that there are formed between successive lobes, a series of air compartments **90**, forming portions of chamber **42** which are isolated from one another. These compartments in effect vary progressively in size as the rotor turns, since vanes **48** also form sides of the compartments. As the rotor turns, the vanes of course move inwardly and outwardly, to always contact the outer surface **87** of the roller in sealed relation.

The radially inner portion of rotor **37** contains two annular fluid inlet and fluid outlet passages **91** and **92**, which have the vertical cross-sectional shape illustrated in the left-hand portion of FIG. 4 except at the locations of certain later-to-be-described openings by which these passages communicate with the exterior of the rotor. More specifically, the upper passage **91** opens upwardly, while the lower passage **92** opens downwardly. Annular seal elements **93** and **94** may be contained within annular grooves in the housing to annularly engage the upper and lower surfaces of the rotor radially between passages **91** and **92** and the outer compartments **90**, to thus form a seal therebetween. Also, the bearings **84** and **85** may be sealed by annular seal rings **95** and **96** (FIG. 4) to prevent escape of any of the air from passages **91** and **92** into or through the bearings.

As seen in FIGS. **5** and **5*a***, the upper fluid inlet and outlet passage **91** in the rotor communicates with compartments **90** through a series of openings **97** extending radially through the outer wall of the rotor at first sides of the lobes **88**. Similarly, lower passage **92** communicates with compartments **90** through a series of openings **98** (see broken lines in FIG. **5** and see showing of FIG. **5*b***), at the opposite sides of lobes **88**.

The first air inlet hose **38** communicates with the upper interior portion of the housing through a fitting **99** (FIG. 4), which opens into a cylindrical radially extending passage **100** in upper wall **44** of the housing, the opposite end of which passage communicates downwardly at **101** with the discussed upper passage **91** in the rotor.

Passage **100** in the upper portion of the housing also communicates with the atmosphere through a vent outlet **103**, past a shield cap **104**, with vent outlet **103** opening into the side of the cylindrical passage **100**. A slide valve element **105** is slidably mounted within passage **100** for movement between the positions of FIGS. **4** and **4*a***. In the position of FIG. **4*a***, the tubular sidewall **106** of the slide valve element extends across and closes vent outlet opening **103**, to prevent the loss of any air from passage **100** to the atmosphere.

Element **105**, in addition to serving as a slide valve element, also functions as a portion of a shiftable two valve assembly, and for this purpose contains a second valve element **107**, adapted to seal annularly against a valve seat surface **108** formed at the end of the tubular sidewall **106** of the slide valve element. The second valve element **107** has a stem **109** which is slidably guided to mount element **107** for only axial movement, and about which there is received a coil spring yieldingly urging element **107** to its closed position of FIG. **4**. Stem **109** projects leftwardly beyond the end of slide valve element **105**, for engagement with a transverse surface or shoulder **111** in the housing, in a manner automatically shifting the second valve element **107** to its opened position of FIG. **4*a*** in response to leftward movement of element **105** under the influence of compressed air admitted through fitting **99**. Spring **110** is of a strength or force enabling such compression of the spring, for opening of valve element **107**, in response to the application of air pressure to the slide valve element **105**.

The second air inlet line **39** communicates through a fitting **99*a*** with a passage **100*a*** corresponding to upper passage **100**, and containing a second slide valve element **105*a*** corresponding to upper valve **105** and containing a spring-pressed valve corresponding to valve **107**. This lower valve assembly is constructed and functions in the same manner as the upper valve assembly to control the flow of air between inlet line **39**, a vent outlet opening **103*a***, and a passage **101*a*** leading into passage **92** in the rotor.

The outer housing **36** of the spinner and its motor is retained against rotation about axis **12** by connection to the upper bail **19** of swivel **18** through a flexible vertically extending cable **112**. The lower end of this cable may be connected to the housing by forming one of the outer cover plates **46** of the housing to have an integral radially outwardly projecting partial spherical socket portion **113** (FIGS. **3** and **4**), within which there is received a mating part **114** having a spherically curved ball portion **115** forming a universal connection with socket **113**. The lower end of the cable may have an eye portion **116** forming an opening through which a connector pin **117** extends, with that connector also extending through openings in a pair of upwardly projecting ears **118** on a part **119**, which has a partial spherical portion **120** engaging the upper surface of socket **113**, and a downwardly projecting shank **121** to which a nut **122** is connected. A spring **123** bears downwardly against an element **124** retained by the nut, and upwardly against part **114**, to yieldingly retain the parts in their FIG. **4** relative positions, while allowing limited resilient upward movement of the lower end of the cable relative to the housing in response to excessive forces. The upper end of the cable is connected to the bail by means of a connector bracket **125**, detachably secured in any suitable manner to bail **19**, as by a clamp structure represented at **126** and extending about a portion of the bail, with bracket **125** projecting outwardly far enough for connection to the cable at a location **127** positioned so that the cable may extend directly vertically past the main body of the swivel. As will be apparent, the cable **112** does not support the weight of housing **36** or the rest of the spinner structure, but rather merely retains the housing against rotation about axis **12**, while at the same time allowing some limited rotary motion of the housing about that axis in response to excessive torsional forces, to thus introduce a certain amount of resiliency into the structure for holding the housing against rotation. The actual support of the weight of the housing and other parts of the spinner is effected through the central pipe section **27** and the various bearings which mount the spinner on that section, as has been previously indicated.

When the spinner is in use, rotor **37** is connected in driving relation to pipe section **27** by means of a clutch mechanism represented generally at **128** in FIG. **4**. This mechanism includes two diametrically opposite clutch levers or elements **129**, which are movably carried by a ring or sleeve **130** disposed about and rigidly connected to pipe section **27**. Internally, this ring **130** is a close fit on the outer surface of pipe section **27**, and keyed thereto for rotation with the pipe section by a key represented at **131** in FIG. **5**. The levers are mounted pivotally to ring **130** within two vertically elongated slots **132** in the ring, and by a pair of horizontal pivot pins **133** extending through the keys and into the material of the ring. Beneath the level of pivot pin **133**, each lever **129** has a downwardly projecting arm portion **134**, which is engaged by a pressure actuated piston or plunger element **135** mounted for movement directly radially of axis **12**, and along a radial axis **136**, relative to pipe section **27**. This piston **135** may be slidably mounted within a cylinder sleeve **137** which is a pressed fit within a cylindrical opening **138** extending through the sidewall of pipe section **27**. To seal piston **135** with respect to cylinder **137**, the radially inner end of the piston may carry an externally cylindrical seal element **139** of rubber or other resilient material, which is a tight slightly compressed fit within the sleeve, and which desirably projects slightly inwardly beyond the wall or passage **28** in the FIG. **4** position of the clutch. Seal element **139** may be secured to piston **135** by

molding it about a head or projection **140** formed on the piston. As will be apparent, when pressure is applied to the radially inner end of the seal portion **139** of the piston, by drilling fluid or 'mud' within passage **28**, the piston is actuated by that pressure radially outwardly from the FIG. **4** position to the FIG. **7** position, to thereby swing lever **129** to its FIG. **7** position.

Upwardly above the level of pivot pin **133**, each of the clutch levers **128** has an upwardly projecting arm portion **141**, which may be offset slightly radially inwardly and be received partially within a vertically extending groove or recess **142** in the outer surface of pipe section **27**, and which is yieldingly urged radially outwardly by a coil spring **143** to normally retain the lever in its FIG. **4** position. The upper end of arm **141** forms a radially outwardly projecting clutch lug **144**, which is engageable in rotary driving relation with one of two diametrically opposite clutch lugs **145** projecting radially inwardly from the otherwise straight cylindrical inner surface **146** of rotor **37**. As seen best in FIG. **5**, the driving surfaces or shoulder surfaces **147** through which rotary forces are transmitted between levers **129** and rotor lugs **145** lie within planes which extend substantially radially and axially with respect to axis **12**. In the FIG. **7** position of each of the clutch levers **129**, these levers are moved out of driving engagement with rotor lugs **1145**, so that pipe section **27** may turn freely without corresponding rotation of the rotor. A seal may be provided annularly between the upper end of ring **130** and the upper portion of the housing, at a location beneath bearing **71**, by a seal element **148** (FIG. **4**).

To now describe the operation of the apparatus of FIGS. **1** through **8**, assume that the spinner **26** is connected into the drilling apparatus at the location illustrated in FIGS. **1** and **2**, beneath swivel **18**, and that the rig is initially being utilized in an actual drilling operation, with the kelly section **13** of the pipe string being driven rotatively by rotary table **11**, to thus drive the rest of the string and the drill bit for deepening the well. During such rotation of the string by the rotary table, drilling fluid or mud is supplied to the swivel through line **22** of FIG. **2**, and flows downwardly under pressure through the stem **21** of the swivel, and through pipe section **27** of spinner **26**, to then enter and flow downwardly through the kelly and into the lower portion of the string. The pressure of this drilling fluid acts against the seal portion **139** of piston **135** in FIG. **4**, to force that piston radially outwardly from its FIG. **4** position to its FIG. **7** position, and thus pivot the clutch lever **129** to its FIG. **7** position in which it does not transmit rotary motion between pipe section **27** and the rotor **37** of the spinner. Thus, pipe section **27** of the spinner is free to turn with the stem of the swivel and with the kelly and the remainder of the well string, without turning motion of the rotor or any other portion of the spinner. Such disconnection of the spinner or rotor from the turning parts prevents damage to the rotor by unnecessary turning, and also prevents any possibility of the string being retained against rotation by binding of the rotor **37** within the spinner housing, such as might occur for example if particles of dirt or other foreign materials were in some way to lock the rotor or its bearings against rotation. This binding is not a major factor, but could be so disastrous to all of the equipment in the vicinity, and even to persons working in the area, as to render it desirable to take every precaution against the possibility.

When it is desired to utilize the spinner for driving the kelly and pipe string, this will always occur after mud pump **25** has been deenergized, to stop the flow of circulating fluid through the string, and thereby reduce the pressure within passage **28** of pipe section **27** (FIG. **4**). As soon as the mud pressure is reduced, springs **143** will actuate the two clutching levers **129** to their active FIG. **4** positions, in which they become effective to transmit rotation from rotor **37** to pipe section **27**. If it is then desired to turn the pipe section **27** and kelly **13** in a clockwise direction, selector valve **41** of FIG. **1** is actuated to a position to admit compressed air through hose **38** to the spinner. This compressed air moves slide valve element **105** from its FIG. **4** position to its FIG. **4***a* position, to thereby close off communication through outlet **103** to the atmosphere, and with the final portion of this motion serving to open valve **107** so that the compressed air may enter passage **91** of the rotor, and from that passage discharge through openings **97** in the rotor into the variable sized compartments formed between the rotor and the housing. The compressed air within these compartments drives the rotor in a clockwise direction, as viewed in FIG. **5**, since the compartments into which the air is admitted will increase in size progressively during such right hand rotation. The vanes **48** engage the rotor in a valving relation, so that until a particular one of the openings **97** reaches one of the vanes, that opening admits air to a compartment at a first side of the vane, but after passing the vane the air is admitted to the opposite side of the vane.

While the rotor is turning in a clockwise direction, the openings **98** act as outlet openings, through which the air is forced into passage **92** of the rotor, for discharge through outlet **103***a* of FIG. **4** to atmosphere. If it is desired to reverse the rotation of the rotor, this may be effected by actuating selector valve **41** to a position in which the air to hose **38** is shut off, and compressed air is admitted instead to hose **39**. This air will actuate the lower valve **105***a* leftwardly to a position corresponding to that shown for the upper valve in FIG. **4***a*, while the upper valve returns rightwardly to its FIG. **4** position under the influence of air discharging from passage **91** to the atmosphere through outlet **103**. That is, the reduced diameter portion **140** of slide valve **105** acts within reduced portion **151** of the passage **100** as a piston, which is forced rightwardly by the discharging air, with this piston effect being enhanced in the final portion of the travel by confinement of the larger diameter portion of slide valve element **105** within the larger diameter portion of passage **100**. During the reverse or counterclockwise rotation, the air which enters bottom annular passage **92** of the rotor flows outwardly into the compartments between the rotor and housing through openings **98**, while the discharging air leaves those compartments through openings **97** and passage **91** of the rotor to actuate the upper valve element **105** to open position as previously discussed, and thus discharge to atmosphere.

When drilling is again to be resumed, this will only be done after pump **24** of FIG. **2** has again been energized to produce a flow of drilling fluid and to produce a pressure within passage **28**, to thus return the clutch levers **129** to their FIG. **7** inactive or released positions, so that the drill string may then be turned without rotation of rotor **37**. Desirably, the clutch elements and their springs **143** are so designed as to be actuable from their FIG. **4** positions to their FIG. **7** positions by a pressure of between about 200 and 500 pounds per square inch within passage **28**. The seal element **139** prevents access of any of the drilling fluid to the clutching parts.

During rotation of rotor **37**, vanes **48** are continuously held radially inwardly against outer surface **87** of the rotor by the combined action of springs **64** and air pressure exerted radially inwardly against the vanes. To bring out the manner in which the pressure of the air exerts a radially inward force against the vanes, reference is made to FIG. **5***c*, in which it may be assumed that compressed air at relatively high pressure is contained within the compartment **90***a* to the right of the vane, while air is being discharged from the compartment **90***b* to the left of the vane, and is therefore at a reduced pressure in compartment **90***b*. Because of the greater pressure in compartment **90***a*, vane **48** of FIG. **5***c* is urged leftwardly by the air pressure and into tight-sealing engagement with the two left-hand seal strips **62**, as indicated at **463**, while a gap is left between the two right-hand seal elements and the vane, as indicated at **363**. Thus, the high-pressure air from compartment **90***a* can flow radially outwardly through the gaps at **363** and into the space **563**, to exert a radially inward force against the vane. This force is partially counteracted by the exertion of a radially outward force against the inner extremity of the vane (toward the bottom of FIG. **5***c*), but because the vane assembly contacts outer surface **87** of the rotor at **248**, the out-

ward force against the vane can be exerted against only one-half of its inner extremity, that is the portion to the right of contact line **248** but not the portion to the left of that contact line. Thus, there is a net differential pressure tending to urge the vane radially inwardly, and coacting with spring **64** in assuring that the vane will continuously contact the rotor. When conditions reverse and the pressure in compartment **90***b* of FIG. **5***c* exceeds that in compartment **90***a*, the vane shifts rightwardly to contact the bearing elements at its right, and provide air leakage gaps at the left side of the vane, so that in all conditions the high-pressure side of the vane is in communication with the radially outer space **563**, to attain the desired result of exerting a net differential force radially inwardly against the vane. It is also noted that each vane may contain a passage **200** (FIGS. **4** and **5***c*) through which air may flow through the interior of the vane past the radially outer pair of bearing elements **62**, to reduce the resistance to flow of air outwardly past those elements, but with the passage **200** being so located as to never move far enough radially inwardly to bypass the two radially inner bearing elements **62**, so that a seal will always be formed with one of these inner elements. The passage **200** may consist of a transverse opening **201** extending entirely through the thickness of the vane, to communicate with both sides of the vane, and leading into a radially extending passage **202** extending outwardly to the radially outer extremity of the vane.

FIGS. **9**, **10**, and **11** represent fragmentarily a variational form of the invention, which may be considered as identical with the arrangement of FIGS. **1** through **8** except as to the construction of the clutching mechanism for operatively connecting the rotor of the vane type motor to the central pipe section of the spinner device. Fig. **9** shows this changed mechanism in a view very similar to the FIG. **7** showing of the first arrangement. In FIG. **9**, the central pipe section of the spinner is designated **27'** (corresponding to section **27** of FIGS. **4** and **7**), and contains a passage **28'** (corresponding to passage **28** of the first form of the invention) through which drilling fluid flows downwardly under pressure during a drilling operation. The rotor of the vane type motor is shown fragmentarily at **37'**, with the outer housing being designated **36'**, and more particularly with the housing having a lower wall section **43'** and an upper wall section **44'** corresponding to sections **43** and **44** of FIG. **4**. The bearings **69'**, **70'**, **84'**, and **85'** serve the same function as in the first form of the invention.

Instead of the two clutching levers **129**, the apparatus of FIGS. **9** to **11** includes a clutching ring **160** which is annular about pipe section **27'** and about axis **12'** of the apparatus. This ring is constructed to function as a vertically movable piston, and for that purpose has a lower enlarged diameter annular portion **161** having an internal cylindrical surface slidably engaging a corresponding external cylindrical surface on pipe **27'** at **162**. Above its portion **161**, ring **160** has a reduced diameter portion having a cylindrical internal surface slidably engaging a reduced diameter external cylindrical surface on pipe sections **27'** at **163**, to form an annular pressure fluid chamber **164** between the ring and pipe section **27'** to which the pressure of the pump of the drilling fluid within passage **28'** is communicated through a passage or opening **165** in the sidewall of pipe **27'**. The ring is retained against rotation relative to pipe **27'**, while permitting axial movement of the ring, by one or more keys or splines **166**, which may be secured in fixed position within grooves or recesses in pipe **27'**, and be slidably received within opposed axially elongated and axially extending grooves **167** formed in the inner surface of the upper portion of ring **160**. The ring is yieldingly urged downwardly by a number of evenly circularly spaced coil springs **168**, which may be partially received within opposed recesses in an upper retaining ring **169** and the upper surface of movable ring **160**. Retaining ring **169** may be located against upward movement by engagement against the inner race of roller bearing **69'**.

Externally, the ring or piston **160** has a series of evenly circularly spaced clutch teeth or lugs **170** projecting radially outwardly to a position in which they can mesh with inwardly projecting evenly circularly spaced lugs **171** carried by and formed in rotor **37'**. These teeth are movable out of their driving interfitting engagement by upward movement of ring **160** from the FIG. **9** position to the FIG. **10** position.

When superatmospheric pressure is applied to drilling fluid or mud within the interior of passage **28'**, that pressure is communicated through passage **165** to the underside of the annular piston or ring **160**, to actuate that piston upwardly to its FIG. **10** position, in which it cannot transmit rotation between pipe **27'** and rotor **37'**, to thus enable free rotation of the entire drill string and pipe section **27'** without corresponding rotation of the rotor. When the drilling fluid pressure is reduced, preparatory to an operation in which the spinner may be used, the ring **160** is moved downwardly to its FIG. **9** position by springs **168**, to engage teeth **170** and **171** in a manner enabling rotor **37'** to turn pipe section **27'** and the connected kelly or other pipe section therebeneath, to make or break a joint in the string. The operation of the remainder of the apparatus is the same in FIGS. **9** through **11** as in the other form of the invention.

I claim:

1. The combination comprising a fluid motor adapted to be driven in two opposite directions and having a first passage which serves as a fluid inlet when the motor is turning in a first direction and as an outlet when the motor turns in the opposite direction, and a second passage which serves as a fluid outlet when the motor turns in said first direction and as an inlet when the motor turn in said opposite direction, and two valve units interposed between a source of pressure fluid and said passages respectively and each operable automatically when pressure fluid is supplied thereto to close off communication between the associated one of said passages and a vent outlet to atmosphere.

2. The combination as recited in claim **1**, in which each of said valve units includes a hollow slide valve element actuable slidably within a valve body structure by said pressure fluid, said structure having said outlet to atmosphere in a wall thereof positioned to be closed by said sliding pressure fluid induced actuation of said element, each of said valve units also including a second valve movably carried by said slide valve element and spring urged to a closed position in which it closes off the flow of pressure fluid to one of said passages through the interior of said slide valve element, said second valve being actuable automatically to open position upon said actuation of the slide valve element.

3. The combination as recited in claim **2**, in which said second valve has a stem engageable with a shoulder in said valve body structure in a relation opening said second valve upon said actuation of the slide valve element.

4. The combination as recited in claim **1**, in which said motor includes a body containing a chamber, a rotor mounted in said chamber to rotate in said two opposite directions relative to the body, said rotor having at least one lobe projecting toward a wall of said chamber and having portions at the leading and trailing sides of the lobe which are spaced farther from said wall to vary the spacing between said rotor and said wall as the rotor turns, at least one vane movably carried by said body and projecting from said wall into said chamber and into engagement with said rotor and forming with said body and rotor at least one compartment which varies in size as the rotor turns, said first fluid passage being formed in the rotor and communicating with said compartment through a first opening at a first side of said lobe and being operable when the rotor is turning in said first direction to admit pressure fluid into said compartment for driving the rotor, and when the rotor is turning in the second direction to discharge fluid through said opening and passage to atmosphere, said second fluid passage being formed in the rotor and communicating with said compartment through a second opening at a second side of said lobe and being operable when the rotor is turning

in said compartment to atmosphere, and when the rotor is turning in said second direction to admit pressure fluid into the compartment for driving the rotor in that direction.

5. The combination as recited in claim 1, in which said motor includes a body containing a chamber, a rotor mounted in said chamber to rotate in said two opposite directions relative to the body, said rotor having at least one lobe projecting toward a wall of said chamber and having portions at the leading and trailing sides of the lobe which are spaced farther from said wall to vary the spacing between said rotor and said wall as the rotor turns, at least one vane movably carried by said body and projecting from said wall into said chamber and into engagement with said rotor and forming with said body and rotor at least one compartment which varies in size as the rotor turns, said first fluid passage being formed in the rotor and communicating with said compartment through a first opening at a first side of said lobe and being operable when the rotor is turning in said first direction to admit pressure fluid into said compartment for driving the rotor, and when the rotor is turning in the second direction to discharge fluid through said opening and passage to atmosphere, said second fluid passage being formed in the rotor and communicating with said compartment through a second opening at a second side of said lobe and being operable when the rotor is turning in said first direction to discharge pressure fluid from said compartment to atmosphere, and when the rotor is turning in said second direction to admit pressure fluid into the compartment for driving the rotor in that direction, there being two passages in said body communicating in sealed relation with said two rotor passages respectively, and control valve means for supplying pressure fluid to said two body passages selectively, said two valve units being located in said two body passages respectively.

6. The combination as recited in claim 5, in which each of said valve units includes a hollow slide valve element actuable slidably within said body passage by said pressure fluid and operable upon such actuation to close a venting outlet in a wall of the passage, a second valve movably carried by said slide valve element and spring urged to a closed position in which it closes off the flow of pressure fluid to one of said rotor passages through the interior of said slide valve element, and means forming a shoulder for actuating said second valve element to open position upon movement of the slide valve element to its position for closing said venting outlet so that said pressure fluid may flow to the rotor.

7. The combination as recited in claim 5, in which said rotor has a plurality of said lobes, there being a plurality of said vanes and compartments, said first passage being generally annular and communicating with said compartment through a plurality of said first openings at first sides of the lobes respectively, said second passage being generally annular and communicating with said compartments through a plurality of said second openings at second sides of the lobes respectively.