June 23, 1959 A. A. ASHTON 2,891,771

HYDRAULICALLY DRIVEN ROTARY MACHINE

Filed July 5, 1955 2 Sheets-Sheet 1

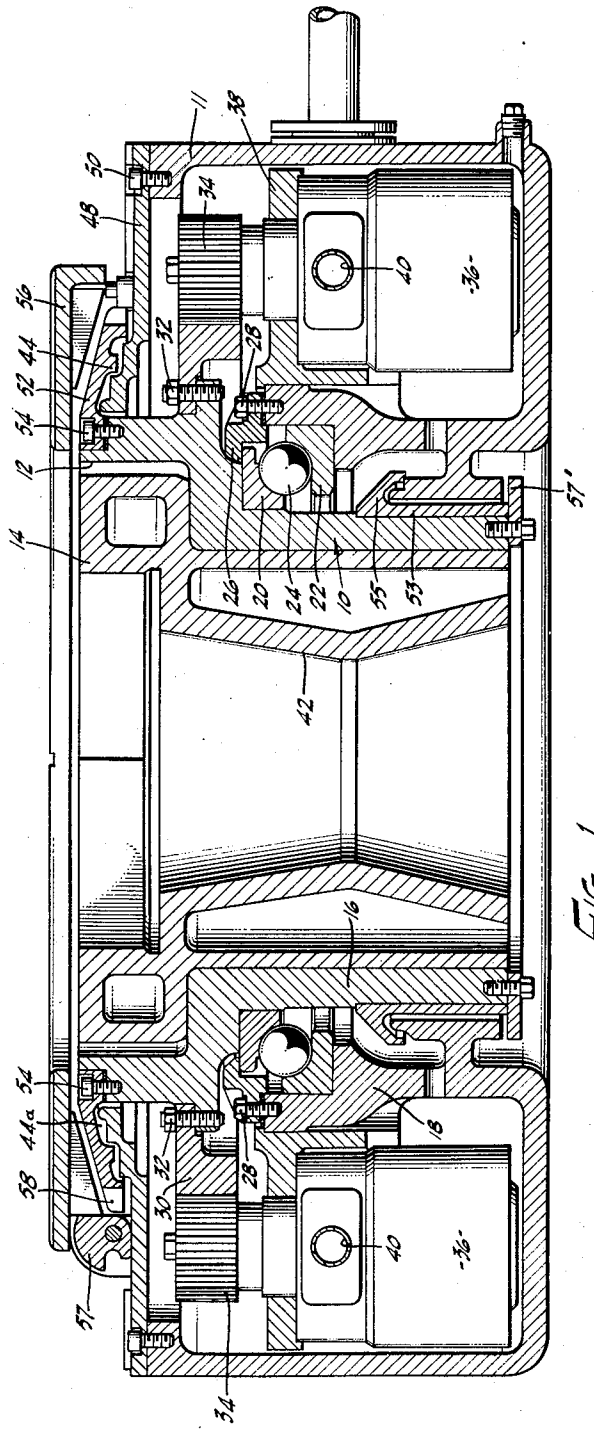

FIG. 1.

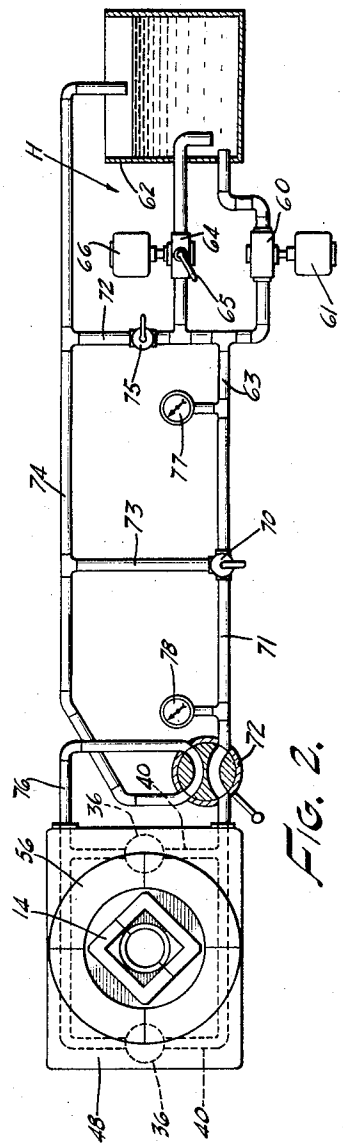

FIG. 2.

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HYDRAULICALLY DRIVEN ROTARY MACHINE

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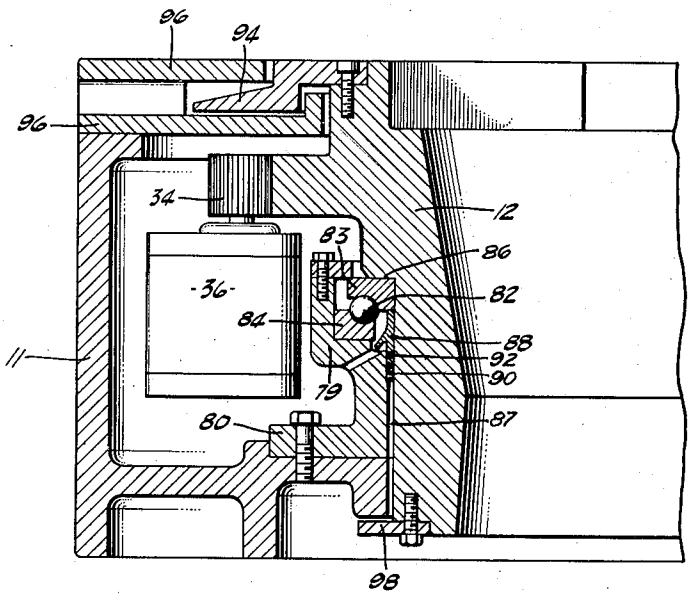

FIG. 3.

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2,891,771

HYDRAULICALLY DRIVEN ROTARY MACHINE

Albert A. Ashton, Houston, Tex., assignor, by mesne assignments, to The Youngstown Sheet and Tube Company

Application July 5, 1955, Serial No. 519,936

5 Claims. (Cl. 255—23)

My invention relates to an improved system for the rotation of the drilling string employed in rotary well drilling equipment, and relates to a system wherein important advantages are achieved in part by the provision of hydraulic means for driving the table of the rotary machine forming a part of the system.

It is an object of the invention to provide a hydraulic well drilling system wherein the torque applied to the drill string may be limited to a value which will not exceed the safe working strength of the drill pipe employed in the drill string, thereby avoiding or minimizing the possibility of twisting off of the drill pipe due to the application of excess torque.

A further object of the invention is to provide a hydraulic system for rotating the drill pipe wherein both the torque and the speed of rotation are subject to control and to variation without the necessity of resorting to complicated procedures.

A further object of the invention is to provide a system for rotating a string of drill pipe having hydraulic motors supported by the housing of the rotary machine which carries the rotary table and means for feeding hydraulic fluid to these motors at a controlled rate so that the speed of rotation of the rotary table is thereby determined, the fluid feeding means having a wide variation of the fluid volume delivered and utilizing a constant displacement hydraulic pump and also a variable displacement hydraulic pump, arranged to be employed singly or in combination in accordance with the volume of hydraulic fluid required. This accomplishes a material reduction in the original cost and the cost of upkeep of the hydraulic pumping equipment.

It is a further object of the invention to provide a rotary machine wherein the rotary table is supported in a housing which has chambers therein containing hydraulic motors for driving the rotary table. A powerful device is thereby provided which is of compact form and wherein the hydraulic motors are concealed and protected.

A further object of the invention is to provide in the rotary machine a simple and rugged means for transmitting power from the hydraulic motor or motors including a large gear connected directly to the rotary table and drive pinion means mounted on vertical shafts and in driving engagement with the ring gear.

Another object of the invention is to provide a rotary machine wherein the rotary table and its main bearing can be assembled as a unit externally of the housing of the rotary machine and as a unit installed in operative position in the housing, engagement of the drive and driven gears of the machine being thereby effected.

Further objects and advantages of the invention may be brought out in the following part of the specification wherein many details have been described for the purpose of competence of disclosure, without intending to limit the scope of the invention which is defined by the accompanying claims.

Referring to the accompanying drawings:

Fig. 1 is a cross-sectional view of a preferred form of my new hydraulically operated rotary machine.

Fig. 2 is a schematic view showing the new system for rotating a string of drill pipe.

Fig. 3 is a partial cross-sectional view showing a modified form of bearing for the rotary table.

Referring now to Fig. 1 of the drawings, the rotary machine includes a rotary table **10** and the support or housing **11**. The rotary table **10** is of generally cylindrical form, enlarged at its upper end and having an opening **12** to receive a table bushing **14** which has a tapered seat **42** and which is adapted, as well known in the art, to receive a Kelley drive bushing, not shown, through which rotation is imparted to the upper end of a drill string. The rotary table has depending skirt portion **16** disposed adjacent the internal structure **18** of housing **11** which serves to support the main bearing for the rotary drill table. The main bearing comprises upper and lower ball races **20** and **22** and ball bearings **24**. The lower ball race **22** is supported adjacent the skirt **16** by the internal structure **18** of the housing **11**. The upper ball race **20** fits an external shoulder of the rotary table **12**. The main bearing assembly is held in place by a clamping ring **26**, as shown, which is attached to the upper part of the structure **18** by cap screws **28**, as shown.

A large internally flanged spur gear **30** surrounds the intermediate upper part of the table **12** and is attached to the table **12** by cap screws **32**. The table **12** is driven by hydraulic motors **36** having pinion gears **34** arranged to rotate on vertical axes and to mesh with the gear **30**, as shown. These motors **36** are disposed in balanced relation. That is to say, they are evenly spaced or diametrically opposed around the exterior of the gear **30**. In Figs. 1 and 2 the two motors are shown in opposite sides of the housing **11** and mounted upon the transverse structure **38** within the housing **11**. The inlets to the motors are shown at **40** in Fig. 1, the motors being connected in parallel as may be seen in Fig. 2.

The upper part of the housing **11** around the table rotor **12** is closed by a cover **48** attached to the housing by screws **50**. The cover **48** adjacent to table bushing **12** has a stepped conformation, as shown, which lies under a ring member **52** attached to the upper part of the rotary table **12** by screws **54**, the ring member **52** having a downward slant, as shown, and having an annular rib **44** adjacent the intermediate step of the cover **48**. A labyrinth passage **44***a* is formed between the cover **48** and member **52** which resists entrance of drilling mud into the housing **11**. A stationary cover ring **56** is provided, which is attached to the housing **11**. At one side of the cover ring **56** there is a latch **57** arranged to be swung in clockwise direction to engage any one of a plurality of notches **58** in the ring member **52** whereby the table **12** may be locked against rotation. Numeral **53** designates a sleeve around the skirt **16** of the rotary table **12** closely adjacent a part of the structure **18** and having a lip **55** overhanging the adjacent structure **18** as shown to provide a seal against the escape of lubricating oil. Ring **57'** is attached to the bottom of table **12** and it extends below the adjacent housing structure.

As shown in Fig. 2, a source of hydraulic fluid is provided which comprises positive displacement pumping means of adjustable or variable output, whereby any rate of flow of hydraulic fluid may be delivered to the motors **36** within the operative range of the equipment. The hydraulic pumping means comprises a constant speed positive displacement pump **60** shown as being driven by a constant speed alternating current motor **61**. Being of positive displacement type, well known to the pumping art the pump **60** delivers a constant, predetermined rate

of flow of hydraulic fluid from a reservoir 62 to piping 63. A variable rate positive displacement pump 64, also well known to the art, is arranged in parallel relation to the pump 60 so as to deliver from the reservoir 62 to the piping 63 a constant rate of flow of hydraulic fluid of magnitude determined by the setting of the adjustment means of the pump 64 schematically represented by the control handle 65. The input shaft of the pump 64 is driven by a constant speed motor 66, and when the control 65 is in its first position the displacement of the pump 64 will be at substantially zero value. When the control 65 is moved to its other extreme, the displacement of the pump 64 will be the same as or nearly the same as the displacement of the positive displacement pump 60.

The piping 63 is connected to a main control valve 70 which is a three way valve adapted to deliver the hydraulic fluid either through delivery piping 71 to a reversing valve 72 or to a pipe 73 which is connected to return piping 74, through which the hydraulic fluid is returned to the reservoir 62. A pressure relief valve 75 of manually adjustable type connects the piping 63 with the return piping 74, thereby making it possible to limit the pressure of the hydraulic fluid in the piping 63 which is delivered to the hydraulic motors 36. The return piping 74 is connected to the reversing valve 72 in the manner shown, and the reversing valve 72 is connected to the fluid inlet members 40 leading to the hydraulic motors 36. The opposite ports of the hydraulic motors 36 are connected to the reversing valve 72 through piping 76.

With the reversing valve 72 in its normal position, as shown in Fig. 2, adjustment of the control valve 70 so as to deliver the hydraulic fluid into the piping 71 will result in this hydraulic fluid passing through the valve 72 to the inlet members 40, to drive the hydraulic motors 36 in their forward directions so that the rotary table 10 will be driven in forward rotation, or clockwise. Rotation of the plug of the valve 72 through an angle of approximately 90° will change the connections of the pipes which lead from the valve, so that the pressure fluid will be delivered through the piping 76 to the rear ports of the hydraulic motors 36, and the members 40 will be connected to the return piping 74, so that the motors 36 will be operated in reverse direction, to reversely turn the rotary table 10. Pressure gages 77 and 78 are respectively connected so as to show the pressures existing in the piping 63 and in the piping 71.

When both of the pumps 60 and 64 are in operation, and with the pump 64 adjusted for full capacity operation, the rotary table 10 will be driven at its highest speed. Operation of the pump 60 alone will effect operation of the rotary table at half speed, and the use of the variable capacity positive displacement pump 64 obtains all intermediate speeds of rotation for the rotary table 10. With the pump 60 idle, the pump 64 may be used to obtain table speeds between zero and one-half speed, and with the pump 60 also in operation the pump 64 will give speeds of rotation for the rotary table between half and full speeds.

Fig. 3 of the drawings shows a modified form of the invention wherein the rotary table 10 and its main bearing may be assembled as a unit outside of the gear box or housing 11 and thereafter lowered thereinto and bolted in place. Additionally, a sealing arrangement is provided to prevent the escape of lubricating oil from the main bearing. The main bearing structure comprises the circular member 79, having an extending flange 80 which may be bolted to the interior of the housing 11, as shown. The main bearing comprises balls 82 which cooperate with races 83 and 84 arranged between a shoulder 86 on the rotary table 10 and the member 79. There is an annular space 87 between the member 80 and the outside of the skirt of the table 10 and in this annular space is a bronze oil seal ring 88 which is urged by a spring 90

upwardly into engagement with the lower surface of the race 83. The ring 88 also has an O-ring 92 which seals against the surface of the member 79. By this arrangement the escape of lubricating oil from the main bearing is effectively prevented. Entrance of drilling mud to the bearing is prevented by baffle ring 98 attached to the bottom of table 10 as shown.

A flinger 94, is attached to the drill table 12, and resists entry of mud into the upper part of the housing 11. The flinger 94 tapers to its outer edge and it is disposed between dual baffles 96 extending from the housing 11 and disposed on opposite sides of the flinger, so that any mud entering into the spaces is thrown outwardly and is prevented from travelling inwardly to the interior of the gear box or housing 11.

I claim:

1. In a system for rotating a drilling string, a rotary table, a housing supporting said table for rotation, hydraulic motor means enclosed within said housing and geared to said table for rotation of the same, bearing means enclosed within said housing and mounted about said table for reducing rotational friction thereof, sealing means associated with said table and said housing for excluding drilling mud from the inside of the housing, a variable capacity, positive displacement pumping means for delivery of hydraulic fluid to said motor means, said pumping means comprising a constant volume positive displacement pump and a variable capacity positive displacement pump, both of said pumps having means for connecting their outlets to said hydraulic motor means to drive the same, means for selectively driving said variable capacity pump, and means for varying the capacity of said variable capacity pump.

2. In a system for rotating a drilling string, a rotary table, a housing supporting said table for rotation, hydraulic motor means enclosed within said housing and geared to said table for rotation of the same, ball bearing means enclosed within said housing and mounted around said table for reducing rotational friction thereof, sealing means associated with said table and said housing for excluding drilling mud from the inside of the housing, a variable capacity, positive displacement pumping means for delivery of hydraulic fluid to said motor means, said pumping means comprising a constant volume positive displacement pump and a variable capacity positive displacement pump, both of said pumps having means for connecting their outlets to said hydraulic motor means, means for selectively driving said variable capacity pumping means, means for varying the capacity of said variable capacity pump, bypass means connecting the outlets of said pumps with their inlets, and reversing valve means connected to the inlet and outlet of said hydraulic motor means for reversing the flow of hydraulic fluid through said motor means.

3. In a system for rotating a drilling string, a rotary table, a housing supporting said table for rotation, a large spur gear on said table concentric to the axis of rotation of the table and enclosed within said housing, a plurality of pinion gears supported for rotation on vertical axes engaging said large spur gear and enclosed within said housing, hydraulic motor means enclosed within said housing connected to said pinion gears so as to drive the same, bearing means enclosed within said housing and mounted around said table for reducing rotational friction thereof, means for sealing lubricant within said housing, sealing means associated with said table and said housing for excluding drilling mud from the inside of the housing, a variable capacity, positive displacement pumping means for delivery of hydraulic fluid to said motor means, said pumping means comprising a constant volume positive displacement pump and a variable capacity positive displacement pump, both of said pumps having means for connecting their outlets to said hydraulic motor means, means for selectively driving said variable capacity pump, means for varying

the capacity of said variable capacity pump, bypass means connecting the outlets of said pumps with their inlets, and valve means connected to the inlet and outlet of said motor means for reversing the flow of hydraulic fluid through said motor means.

4. In a system for rotating a drilling string, a rotary table, a housing supporting said table for rotation, hydraulic motor means enclosed within said housing and geared to said table for rotation of the same, bearing means enclosed within said housing and mounted about said table for reducing rotational friction thereof, sealing means associated with said table and said housing for excluding drilling mud from the inside of the housing, a variable capacity, positive displacement pumping means for delivery of hydraulic fluid to said motor means, said pumping means comprising a constant volume positive displacement pump and a variable capacity positive displacement pump, both of said pumps having means for connecting their outlets to said hydraulic motor means to drive the same, means for selectively driving said variable capacity pump, means for varying the capacity of said variable capacity pump, and adjustable relief valve, connected to the outlets of said pumps for selectively limiting the maximum fluid pressure deliverable to said hydraulic motor means.

5. In a system for rotating a drilling string, a rotary table, a housing supporting said table for rotation, hydraulic motor means enclosed within said housing and geared to said table for rotation of the same, ball bearing means enclosed within said housing and mounted around said table for reducing rotational friction thereof, sealing means associated with said table and said housing

for excluding drilling mud from the inside of the housing, a variable capacity, positive displacement pumping means for delivery of hydraulic fluid to said motor means, said pumping means comprising a constant volume positive displacement pump and a variable capacity positive displacement pump, both of said pumps having means for connecting their outlets to said hydraulic motor means, means for selectively driving said variable capacity pumping means, means for varying the capacity of said variable capacity pump, bypass means connecting the outlets of said pumps with their inlets, reversing valve means connected to the inlet and outlet of said hydraulic motor means for reversing the flow of hydraulic fluid through said motor means, and adjustable relief valve connected to the outlets of said pumps for selectively limiting the maximum fluid pressure deliverable to said hydraulic motor means.

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