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STEAM CONTROL OF ROTARY FEEDING MEANS

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2 Sheets-Sheet 2

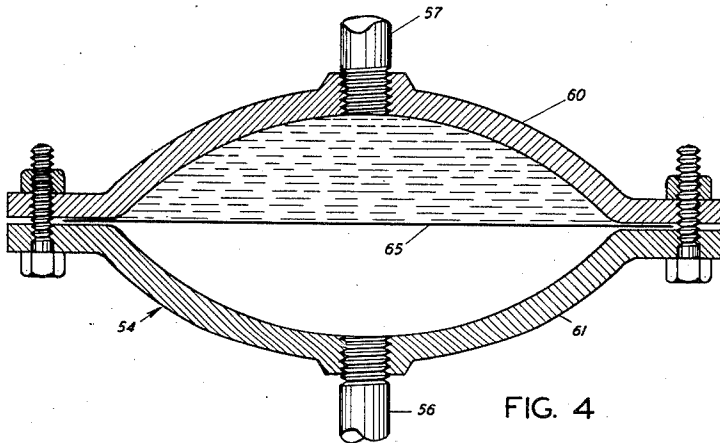


FIG. 4

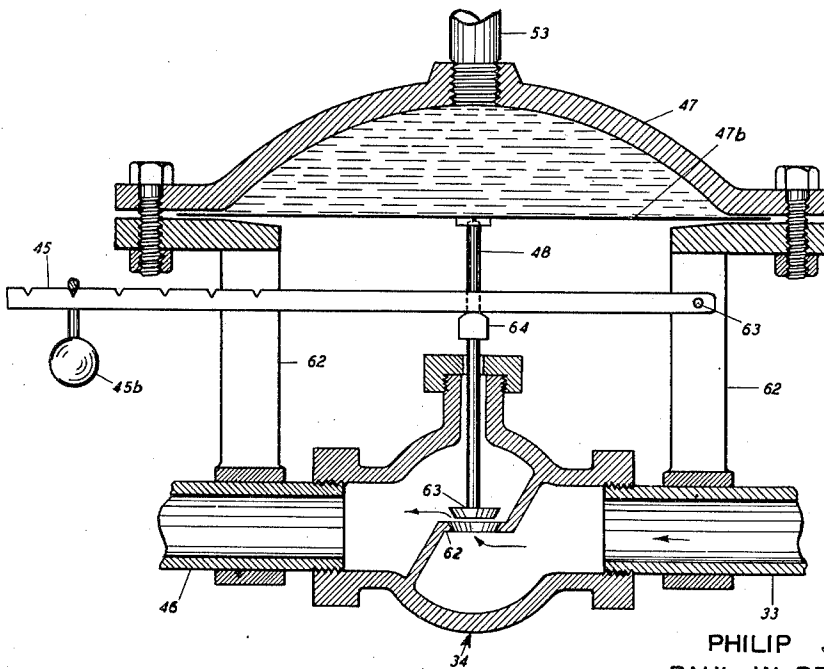


FIG. 3

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STEAM CONTROL OF ROTARY FEEDING MEANS

Application filed June 24, 1929. Serial No. 373,374.

Our invention pertains to the art of drilling wells by the rotary method and particularly to a manner of regulating the feed of the tools, as drilling progresses, by means actuated by the torque placed on the drill pipe.

It is well known that in the rotary method the drilling is accomplished by means of a bit which comes in contact with the bottom of the hole, the bit being at the end of a string of pipe commonly known as the drill string. When deep wells are being drilled the weight of this string of pipe, if allowed to rest on the bit, would be so great that it would be impossible to revolve it and the string would be broken or the bit twisted off.

It is therefore necessary to provide means by which the pipe may be partially supported on the drilling line or cable by which the tools are raised and lowered in the hole, and it is further desirable to make this supporting means responsive to the torque placed on the pipe. Such torque-responsive means are actuated by the torsional stress which the pipe momentarily undergoes and are so arranged that if this torque exceeds a predetermined maximum the drill string will be automatically lifted for a sufficient distance to relieve the pressure of the bit on the bottom of the hole. By this means the torsional stress on the pipe is immediately reduced and is automatically kept below the point at which a twist-off would be likely to occur.

Many such devices have been proposed and we do not claim the invention of torque-responsive means in general, but only the certain torque-responsive means about to be described.

The apparatus required for the practice of our invention consists of three elements: (1) a rotary drilling rig of any type in which the tools are revolved by means of a steam engine or an engine operated by gas pressure (not an explosion engine), (2) a means for raising and lowering the tools in the hole (hereinafter termed a feeding means) associated with the drilling line, (3) a torque-responsive means associated with the driving engine and the feeding means.

The rotary drilling machine (1) is the object to the control of which our invention is

applied and is in no other sense a part of our invention.

The particular feeding means (2) here shown is of our invention but is separately described and claimed in a companion application entitled Power actuated means for feeding rotary drills, filed June 24, 1929, Serial No. 373,372.

The torque-responsive means (3) disclosed in combination with the feeding means for the control thereof is the invention which we here claim.

In the attached drawings, to which reference is made

Fig. 1 shows in elevation a complete assembly containing the three units above described.

Fig. 2 is a longitudinal section through the motor 31 indicated in Fig. 1.

Fig. 3 shows a section through the automatic control valve 34 and the diaphragm unit 47.

Fig. 4 shows a section through the diaphragm unit 54.

Describing element 1, the drilling rig, and referring to Fig. 1, 10 is a derrick; 11 the upper squared end of the drill string, no details being shown; 12 indicates the travelling block; 13 the drilling line and 14 the crown block sheave; 15 the main reel on which the drilling line is wound and 16 the rotary table by which the tools are revolved. These arrangements are entirely conventional. The drilling rig shown also includes the engine 17, the sprockets 18, 19, 20 and 21 and the chains 22 and 23, the chains driving the rotary table by means of the usual rack and pinion, not shown, in the usual manner. The above is entirely illustrative and any other manner of and means for transmitting power from the engine to table may be used, provided only that the prime mover be a fluid-expansion engine.

Describing element 2, the feeding means, and referring solely to Fig. 1, 24 is a pump which is shown as a direct acting steam pump, but which may be a rotary or power pump driven by any throttling type of engine. This pump or its driving engine is supplied with steam or other compressible fluid

through a pipe 25, controlled by a manual valve 26.

The pump withdraws, through a pipe 27, a stream of liquid from a tank 28, this liquid being water or, preferably, a more viscous liquid such as lubricating oil or glycerine. The liquid discharged by the pump passes through a pipe 29 which divides into two branches. Branch 30 leads to the intake of a liquid-actuated motor 31, the liquid passing through this motor flowing through a pipe 32 into the lower portion of tank 28. Branch 33 is provided with an automatic control valve 34, which will be later described, and discharges preferably into the upper portion of tank 28.

The motor 31 may be any liquid-actuated motor which is capable of maintaining a constant torque at constant liquid pressure and which may be reversed in direction without change in torque. We prefer to use for this purpose a rotary pump of either the mesh-gear or the sliding-vane type, these devices, as is well known, functioning as pumps when driven by applied power and acting as prime movers when supplied with liquid under pressure. A machine particularly suitable for this use is fully described in the companion application above referred to and is shown in longitudinal section in Fig. 2.

Referring to Fig. 2, 35 is a case having flat sides 36 and two closely fitted and meshing gears 37 riding on roller bearings 38, which are carried in bosses on the flat faces of the case. One of the shafts 39 projects through the face and carries the smallest gear 40 as shown in Fig. 1.

Liquid under pressure entering pipe connection 41 revolves the gears in the direction indicated by arrows A—A and escapes through pipe connection 42, while if the gears are revolved in a contrary direction liquid will be drawn into the device at 42 and forcibly discharged at 41.

The drive shaft of this motor is connected through a gear train 43, or its equivalent, with a feeding reel 44 on which the free end of the drilling line is wound. This reel, when revolved in the direction indicated by arrow B, takes in line and tends to lift the tools free from the bottom of the hole, while if it revolves in a reverse direction it pays out line and feeds the drill string downwardly.

Describing element 3, the torque-responsive means for controlling the feeding means, we have first the regulating valve 34 (see Fig. 3), which should be a safety or relief valve having a lever 45 and ball 45b and the usual seat 62 and disc 63. These should be so arranged that the pressure of liquid in pipe 33 comes below the disc 63. When the disc drifts, the liquid flows through pipe 46 into the upper part of tank 28.

Above valve 34 and affixed thereto as by the

standards 62, by one of which an end of the lever 45 may be pivotally supported as at 63, is a diaphragm unit 47 comprising a rigid shell 47 and a flexible diaphragm 47b arranged to press on a pin 48. When the diaphragm is forced downwardly by pressure of liquid within shell 47 the pin tends to force down the valve disc and to increase the pressure in pipe 33 required to lift the disc off its seat. Lever 45 bears downwardly on this pin as indicated at 64, which is a block affixed to the pin, and thus the constant weight of the ball is added to the varying pressure exercised by the diaphragm to resist opening of the valve.

The engine 17 is supplied with steam or other compressible fluid through a pipe 49 communicating with a boiler or other source of supply not shown. This pipe is controlled by a manual valve 50 communicating with a pipe 51 which in turn communicates with the steam end 52 of the engine 17.

This engine being used to drive the rotary table and the steam supply being controlled by adjustment of the valve 50, the steam pressure in pipe 51 will be less than the pressure in pipe 49 (unless inlet valve 50 is wide open, which is not permissible under our method of operation) and will depend on the speed of the engine and the opening given the valve. So long as valve 50 remains at a constant opening the pressure in pipe 51 will be constant at constant engine speed, will increase as the resistance to rotation (pipe torque) increases and the engine slows down, and will decrease as the engine speeds up on reduction of pipe torque.

A pipe 53, of relative small diameter, affords communication between the diaphragm shell 47 and pipe 51. Through this pipe 53 changes in pressure in pipe 51 are transmitted to the control of valve 37. Thus, as the pressure in 51 increases, the pressure required to lift the disc in 34 increases and thus an increased pressure is thrown on the inlet opening 41 of motor 31. Lowering of pressure in pipe 51 correspondingly lowers the inlet pressure on the motor.

The functioning of the feeding unit in feeding and retrieving the tools is as follows. Valve 26 is so adjusted by hand as to affect a moderate circulation of liquid from tank 28 through pipes 27, 29 and 33 when the ball and lever control of valve 33 is so adjusted by hand as to support a desired porportion of the weight of the tool string. This support is afforded by motor 31 acting through the gear train 40—43 on the feeding reel. The pressure in pipe 29 being communicated to the motor through pipe 33 revolves it in a reeling-in direction (arrow B) until the motor stalls by reason of the weight on line 13 balancing the torque of the motor at the set liquid pressure. This stalling point may be varied, to alter the amount of supported

weight, by hand adjustment of the ball along the lever 45.

This stalling point having been reached, if or when the bit drills itself free an increased weight is thrown on the drilling line, the torque of the motor at fixed inlet pressure is overbalanced, and the motor runs backward, drawing liquid from tank 28 through pipe 32 and discharging it through pipes 30 and 33 and valve 34, thus feeding the tools downwardly against the braking force of the motor.

If or when the torque on the pipe increases above a predetermined value, due to drilling into hard formation or too rapid feeding, the engine slows down, the increased steam pressure in pipe 51 is transmitted to shell 47 and through the diaphragm and pin 48 to valve 34, thus adding to the liquid pressure in pipe 33 required to lift the disc at the valve. The inlet pressure on motor 31 is thus increased and the motor runs forward until the excess torque is removed by reeling in of line and lifting of the bit. When the bit is thus freed the engine speeds up, pressure in pipe 51 falls to normal and the added weight on valve 34 is removed, leaving the fixed weight to again control the feeding movement.

If the diaphragm unit 47 is far removed from the engine and pipe 51 it may be undesirable to actuate the diaphragm by steam pressure transmitted through pipe 53 or by a variable and uncertain quantity of water condensing in this pipe. In such case we prefer to introduce a second diaphragm unit 54 into the pressure transmitting system. For this purpose we introduce a valve 55 into pipe 53 and provide branch lines 56 and 57 communicating with pipe 53 below and above this valve. These branch lines may have the stop valves 58 and 59.

The unit 54 illustrated in Fig. 4 consists of two rigid shells 60 and 61 with a flexible and impervious membrane or diaphragm 65 separating them. The lower shell 61 is in direct communication with pipe 51, valve 59 being open, and is thus filled with steam at the pressure existing momentarily in pipe 51. The upper shell 60, that portion of pipe 53 above valve 55 (which should be closed) and the shell 47, are filled with any convenient liquid. A movement of the diaphragm between the shells 60 and 61 actuates the said liquid in pipe 53, and thus changes in pressure in pipe 51 may be transmitted instantly and positively to shell 47 and to the control of valve 34.

While we have described a highly specific embodiment of our invention in a preferred form we do not limit ourselves to the exact details shown, nor even to the use of diaphragm chamber means. We prefer such means as they require no packing and are free from leakage and friction, but if preferred,

hydraulic cylinders having pistons therein may be substituted for the diaphragm means.

We claim as our invention:

1. Apparatus for automatically controlling the feed of a rotary well drilling bit, comprising: a steam-actuated engine for rotating said bit and means for supplying said engine with steam under pressure; a secondary feeding means including a liquid-actuated motor and a winding drum driven thereby; means for supplying said motor with liquid under pressure; valve means for controlling said liquid pressure; pressure-responsive means associated with said valve means adapted to continuously regulate said valve means, and means for continuously equalizing the pressure in said pressure-responsive means with the steam pressure at the intake side of said engine.

2. Apparatus for automatically controlling the feed of a rotary well drilling bit, comprising: a steam-actuated engine for rotating said bit and means for supplying said engine with steam under pressure; a secondary feeding means including a liquid-actuated motor and a winding drum driven thereby; means for supplying said motor with liquid under pressure; valve means for controlling said liquid pressure; diaphragm means associated with said valve means adapted to continuously regulate said valve means, and means for continuously equalizing the pressure in said diaphragm means with the steam pressure at the intake side of said engine.

3. In apparatus for automatically controlling the feed of a rotary well drilling bit including a steam-actuated engine, a liquid-actuated motor, a winding drum driven by said motor, means for supplying liquid under pressure to said motor and means for regulating the pressure of said liquid: automatic control means comprising a pressure-responsive means associated with and adapted to control said pressure-regulating means, said pressure-responsive means being adapted to respond to changes in steam pressure at the intake side of said engine.

In witness that we claim the foregoing we have hereunto subscribed our names this 19th day of June, 1929.

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