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[54] APPARATUS FOR CONTROLLING THE ROTARY SPEED OF A DRILL

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[52] **U.S. Cl.** **173/1,** 137/49, 137/51, 173/12

[51] **Int. Cl.** **E21b 3/04**

[58] **Field of Search**.....73/136 R, 136 A, 151.5, 73/518–520; 137/47–51; 173/1, 4, 9, 12; 175/40, 39, 24, 50

[56] **References Cited**

UNITED STATES PATENTS

1,976,277	10/1934	Blackmon	73/136 R
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[57] **ABSTRACT**

The rotary speed of a rotary drive system, including a rotary engine, for a drill in a well is maintained at a predetermined value and is sensed by a tachometer. An electrical signal from the tachometer is converted to a pneumatic signal by an electro-pneumatic transducer which is applied to a receiver-controller receiving a supply of filtered air at a predetermined pressure. When the electrical signal from the tachometer changes due to a change in the rotary speed of the rotary drive system from the predetermined value, the pneumatic output from the receiver controller changes accordingly until the rotary speed of the rotary drive system is once again at the predetermined value. The pneumatic output from the receiver controller remains at the pressure which returned the rotary speed to its predetermined value.

In achieving speed control, the pneumatic output from the receiver controller is effectively amplified by a booster relay receiving filtered air at a second predetermined pressure to provide a pneumatic signal. The pneumatic signal from the booster relay is applied to the throttle of the rotary engine to control the engine's rotary speed and hence the rotary speed of the rotary drive system and drill.

10 Claims, 2 Drawing Figures

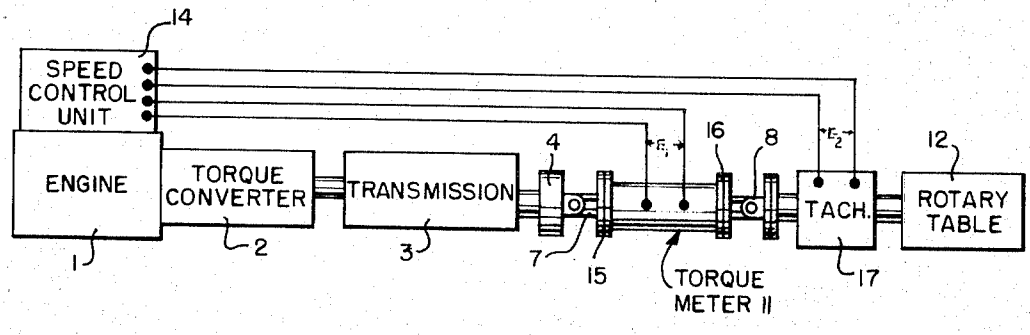


FIG. 1

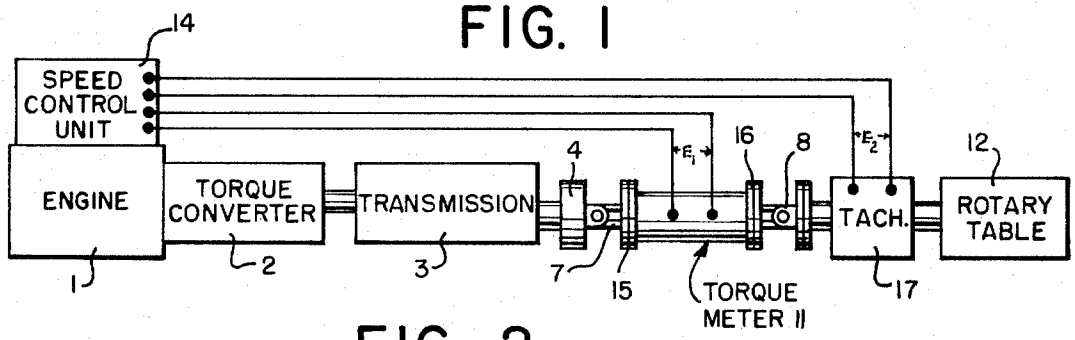
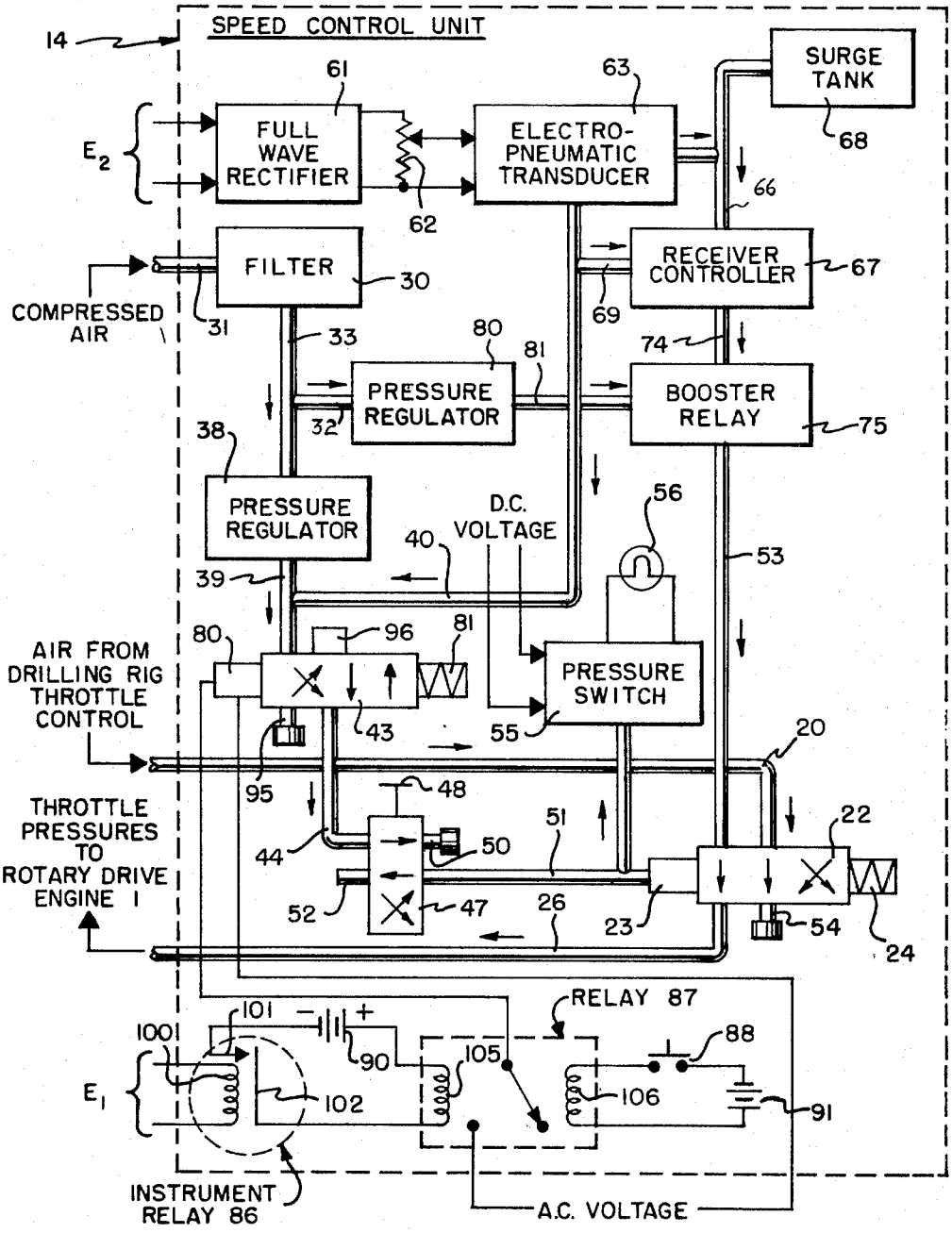

14
SPEED CONTROL UNIT
ENGINE
1
TORQUE CONVERTER
2
TRANSMISSION
3
4
7
15
E_1
16
8
TORQUE METER II
E_2
TACH.
17
12
ROTARY TABLE

FIG. 2


14
SPEED CONTROL UNIT
61
63
SURGE TANK
68
E_2
FULL WAVE RECTIFIER
62
ELECTRO-PNEUMATIC TRANSDUCER
66
FILTER
30
31
COMPRESSED AIR
RECEIVER CONTROLLER
67
69
33
80
81
74
PRESSURE REGULATOR
32
BOOSTER RELAY
75
38
PRESSURE REGULATOR
39
D.C. VOLTAGE
40
56
53
AIR FROM DRILLING RIG THROTTLE CONTROL
80
96
81
PRESSURE SWITCH
43
55
20
95
48
THROTTLE PRESSURES TO ROTARY DRIVE ENGINE 1
44
50
51
22
52
47
26
23
54
24
RELAY 87
101
100
90
105
88
E_1
102
106
91
INSTRUMENT RELAY 86
A.C. VOLTAGE

APPARATUS FOR CONTROLLING THE ROTARY SPEED OF A DRILL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to control systems in general and, more particularly, to a speed control system for an engine.

2. Description of the Prior Art

Heretofore, the rotary speed of a drill in a well drilling operation was controlled manually at the drilling rig. As the drill experienced different load factors resulting from changes in the earth's formation, the rotary speed of the drill changed. It is highly desirable to maintain a constant rotary speed. However, there is a substantial time delay in the manual system in recognizing that the drill's rotary speed has changed and restoring the desired rotary speed. Furthermore, due to size of the typical drilling rig throttle control, the desired rotary speed may not be achieved precisely.

The control system of the present invention maintains the rotary speed of the drill irrespective of change in the earth's formation. The control system allows greater sensitivity in rotary speed selection for a drill than heretofore achieved by manual throttle control.

SUMMARY OF THE INVENTION

A control system controls the rotary drilling speed of a drill being driven by a rotary drive system including rotary engine. The control system includes a sensor sensing the rotary speed of the drill and providing an electrical signal representative of the drill's rotary speed. A transducer converts the electrical signal to a pneumatic signal. Apparatus receiving air at a predetermined pressure provides a pneumatic control output, in accordance with the pneumatic signal, to a device which controls the rotary engine in accordance with the pneumatic control output. The rotary engine is controlled to maintain a predetermined constant rotary speed for the rotary drive system and the drill.

One object of the present invention is to provide a system for controlling the rotary speed of a drill while drilling into the earth's surface.

Another object of the present invention is to maintain the rotary speed of a drill while drilling in the earth irrespective of changes in the earth's formation.

Another object of the present invention is to provide a system for maintaining the rotary speed of a drill while drilling in the earth until the torque experienced by the rotary drive system exceed a maximum permissable torque.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter in consideration of the detailed description which follows and together with the accompanying drawings wherein one embodiment is illustrated. It is to be especially understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing a deep well drilling rotary power unit with the engine connected directly, via rotary power shaft type couplings to the rotary table.

FIG. 2 is a detailed diagram, in partial schematic form and partial block form, of the speed control unit, constructed in accordance with the present invention, shown in FIG. 1.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there in schematically indicated a rotary drive system for well drilling rig. The system includes an engine 1 for driving the rotary table of the direct coupled rotary drilling rig which includes a derrick (not shown). The driving engine power may be derived from various types of engines, having pneumatically controlled trottles, e.g., a caterpiller engine.

Engine 1 is connected via a torque converter 2, which in turn is connected to a transmission 3 that reduces the speed of revolution of the drive shaft output relative to the input from converter 2. The output of transmission 3 is carried along via direct shaft coupling, which may include a brake unit 4 located close to transmission 3.

Since there is usually a change in the vertical level from engine 1 to the drilling rig (not shown), there are a pair of universal joints 7 and 8 connected into the direct rotary drive at both ends of a torque meter 11. Torque meter 11 is the torque meter; disclosed in U.S. Pat. No. 3,295,367 issued on Jan. 3, 1967 to Mr. H. A. Rundell, inventor of the present invention, and is assigned to Texaco, Inc. The power drive connection terminates at a rotary table 12 which is a standard element employed with a drill rig for applying rotary power to the drill string, which in turn connects to the drill bit at the bottom of the hole.

Engine 1 is controlled by a speed control unit 14 receiving signals E_1, E_2 from torque meter 11 and from a conventional alternating current tachometer 17, respectively, air from the drilling throttle control (not shown) and from a compressor (not shown). Signal E_2 corresponds to the rotary speed of the drill. Speed control unit 14 maintains the rotation of the drill at a substantially constant speed, which may be selected by an operator, when it is operative and permits rotary speed control at the drilling rig when it is not operative.

Referring to FIG. 2 when speed control unit 14 does not control engine 1, air in a line 20 in speed control unit 14 passes through a directional control valve 22, having a pneumatic operative piston 23 and a spring 24, and through a line 26 to engine 1. The air pressure in line 26 is used to position the throttle of engine 1 to control the rotary speed of engine 1. The air pressure is controlled by the drilling rig's throttle control.

Speed control unit 14 includes a filter 30, which may be of the type manufactured by the Fisher Governor Company as part number 316, receiving compressed air from a source (not shown) through a line 31. The filtered air from filter 30 passes through lines 32, 33 to a pressure regulator 38, which may be a series 76 regulator made by the Fisher Governor Company, providing air in lines 39, 40 at a reduced pressure. By way of example, the reduced pressure may be 35 psi. The air in line 39 passes through a directional control valve 43, which may be of the type made by AAA Products, Inc. as their part number 503, to a line 44. Valve 43 is a safety device which effectively returns control of engine 1 to the drilling rig when the power drive system for the drill experiences a torque exceeding a predetermined safe level, as hereinafter explained.

The air in line 44 is applied to a manually operative directional control valve 47, such as the type made by AAA Products, Inc. as part number KE3. The state of valve 47 determines whether speed control unit 14 or the drilling rig throttle control controls engine 1. Valve 47 has a knob 48 for actuating valve 47. When knob 48 is pushed in, the air in line 44 is dead-ended into a capped line 50, while the air in a line 51, which was actuating piston 23 of valve 22, is vented to the outside through a line 52. Spring 24 then actuates valve 22 so that the air from the drilling rig throttle control in line 20 passes through valve 22 to line 26 to engine 1 throttle while the air in a line 53 is dead-ended in a capped line 54. When the pressure in line 51 drops due to the venting of line 51, a conventional pressure switch, receiving a direct current voltage, blocks the voltage so that an indicating lamp 56 is not lit indicating that engine 1 is being controlled by the drilling rig throttle control.

When air at 35 psi pressure is provided in line 51, piston 23 activates valve 22 to dead-end the air in line 20 in a capped line 54 and to pass the air in line 53 to line 26 so that speed control unit 14 controls engine 1 to control the rotational speed of the drill. Switch 55 passes the voltage to lamp 56 causing lamp 56 to light. When lit, lamp 56 indicates that engine 1 is being controlled by speed control unit 14.

In controlling engine 1, a full wave rectifier 61 receives signal E_2 from tachometer 17 and provides a rectified voltage corresponding to the rotary speed of the drill across a potentometer 62. The position of the wiper arm of potentometer 62, which may be adjusted by an operator, determines the rotary speed of the drill. Potentometer 62 permits the rotary speed to be selected with greater accuracy than with the drilling rig throttle control. A portion of the rectified voltage, determined by the position of the wiper arm, is applied to an electro-pneumatic transducer 63, which may be of the type manufactured by Fisher Governor Company as type 546 electro-pneumatic transducer. Transducer 63 controls the air it receives from line 40 in accordance with the rectified voltage from potentiometer 62 to provide air in a line 66 whose pressure corresponds to the drill's rotational speed.

The air in line 69 is applied to a receiver controller 67 which receives air from line 40 by way of line 69. By way of example, receiver controller 67 may be a type 2516 receiver controller made by Fisher Governor Company. A surge tank 68 connected to line 66 smoothes out abrupt changes in the air pressure in line 66 to prevent damage to receiver controller 67. Receiver controller 67 uses the air in line 69 to control the pressure of the air provided to a booster relay 75 through a line 74 in accordance with a change in the air pressure line 66. Booster relay 75 may be of type manufactured by Moore Product Corporation as their part number 66BAH4.

Booster relay 75 receives air from a pressure regulator 80 through a line 81. Regulator 80, which may be a series 95 pressure regulator made by Fisher Governor Company, provides air at a reduced pressure from line 32. By way of example, the air pressure in line 81 may be 130 psi. Booster relay 75 in effect amplifies the air pressure in line 74 in providing air to valve 22. The air pressure in line 74 is used to control the air entering line 53 from 81 through booster relay 75. A small change in the air pressure in line 74 causes a larger change in the air pressure in line 53. With valve 22 being activated by piston 23, the change in air pressure in line 53 results in a change in the rotary speed of engine 1 and hence the drill's rotary speed.

In operation, when the drill's rotary speed decreases, as the drill enters a hard formation, signal E_{12} from tachometer 17 decreases causing the rectified voltage to transducer 63 to decrease. Transducer 63 decreases the air pressure in line 66. Controller 67 increases the air pressure in line 74 in response to the decrease in air pressure in line 66 from the set point position of controller 67 causing relay 75 to amplify the increase pressure by substantially increasing the air pressure in line 53. The increase of line 53 air pressure causes engine 1 to drive the drill at a faster rotary speed until the air pressure in line 66 is in accord with the set point of controller 67. Controller 67 then maintains the air pressure in line 74 that helped achieve the desired rotary speed. An opposite operation occurs when the drill's rotary speed increases as the drill enters a soft formation.

As previously stated, valve 43 acts as a safety valve when the rotary drive system experiences excessive torque. Valve 43 includes a solenoid 80 and a spring 81. During normal operation, solenoid 80 of valve 43 is energized which permits valve 43 to pass the air in line 39 to line 44. A circuit, which includes an instrument relay 86, a self-latching relay 87, a switch 88 and batteries 90, 91 removes the alternating current voltage to solenoid 80 causing valve 43 to dead-end the air in line 39 into a capped line 95 and to vent the air in line 44 through a line 96. The venting of the air in line 44 results in valve 22 returning the control of the rotary speed of the drill to the drilling rig throttle control, as heretofore explained.

The alternating current voltage is removed from solenoid 80 of valve 43 as a result of signal E_1 from torque meter 11 exceeding a predetermined level corresponding to a maximum permissable torque. Signal E_1 energizes a coil 100 of relay 86 when its amplitude exceeds the predetermined level. Energized coil 100 closes contacts 101,102 of relay 86 which permits battery 90 to energizes a coil 105 of relay 87. Relay 87 removes the alternating current voltage applied to solenoid 80 once coil 105 has been energized until another coil 106 is energized as hereinafter explained.

Valve 43 is reset by manual activation of switch 88 which momentarily applies a direct current voltage from battery 91 across coil 106 of relay 87 to momentarily energize coil 106. After coil 106 is energized, relay 87 provides the alternating current voltage to solenoid 80 of valve 43 over riding spring 81 to control valve 43.

The system of the present invention controls the rotary speed of a drill while drilling in the earth's surface so as to maintain a constant rotary speed irrespective of changes in the earth's formation. The system maintains the rotary speed until the torque experienced by the rotary drive system a maximum permissable torque.

What is claimed is:

1. A system for maintaining the rotary speed of a drill, irrespective of changes in the earth's formation, said drill being driven by a rotary drive system including a rotary engine, comprising means for sensing the rotary speed of the rotary drive system and providing

an electrical signal representative thereof, a transducer connected to the sensing means for converting the electrical signal to a pneumatic signal, means connected to the transducer and receiving air at a predetermined pressure for providing a pneumatic control output in accordance with the pneumatic signal, and means connected to the output means and to the rotary engine for controlling the rotary engine in accordance with the pneumatic control output from the output means to maintain the rotary speed of the rotary drive system and of the drill.

2. A system as described in claim 1 further comprising switching means connecting the control means to the rotary engine and receiving a supply of air at a pressure which may be manually adjusted for providing either the pneumatic control output or the received air to the rotary engine to control the rotary engine.

3. A system as described in claim 2 in which the switching means is manually operated to accomplish its switching function.

4. A system as described in claim 2 further comprising means for sensing the torque experienced by the rotary drive system and providing an electrical torque signal corresponding thereto, and means connected to the torque sensing and to the switching means for providing an electrical output to the switching means when the amplitude of the torque signal exceeds a predetermined value corresponding to a maximum permissable torque and no electrical output when the amplitude of the torque signal is equal to or less than the predetermined value; and in which the switching means provides the pneumatic control output from the output means to the rotary engine when the electrical output means provides no electrical output and provides the received air to the rotary engine when the electrical output means provides an electrical output.

5. A system as described in claim 4 in which the switching means may also be manually operated to accomplish its switching function.

6. A system as described in claim 4 in which the electrical output means continues to provide no output after the torque signal amplitude drops below the predetermined value until the electrical output means receives a reset signal, and manually operative means connected to the electrical output means for providing a reset signal to the electrical output means when operated.

7. A system as described in claim 6 in which the output means includes a receiver controller having a set point and receiving air at a predetermined pressure and connected to the transducer for providing air at a pressure controlled by a change in the pneumatic signal with respect to the position of the set point, and a booster relay connected to the receiver controller and receiving air at a second predetermined pressure for control output which is in effect an amplification of the pressure of the air from the receiver controller.

8. A method for maintaining the rotary speed of a drill, irrespective of changes in the earth's formation, being driven by a rotary drive system including a rotary engine, which comprises sensing the rotary speed of the rotary drive system, providing an electrical signal representative of the rotary speed of the rotary drive system, converting the electrical signal to a pneumatic signal, providing a pneumatic control output in accordance with the pneumatic signal, and controlling the rotary engine in accordance with the pneumatic control output to maintain the rotary speed of the rotary drive system and of the drill.

9. A method as described in claim 8 which further comprises providing a second pneumatic control output whose pressure does not correspond to the rotary speed of the rotary system and may be manually controlled, and in which the second mentioned providing step includes providing the second pneumatic control output, when desired, in lieu of the first pneumatic control output so that the rotary engine may be controlled manually.

10. A method as described in claim 9 which further comprises sensing the torque experienced by the rotary drive system, and providing an electrical torque signal corresponding to the sensed torque; and in which the second mentioned providing step includes providing the second pneumatic control signal in lieu of the first pneumatic control signal once the torque signal exceeds a predetermined value, corresponding to a maximum permissable torque, until a reset signal occurs and then providing the first pneumatic control output in lieu of the second pneumatic control output so as to prevent failure of the drill or the rotary drive system due to excessive torque, and providing a reset signal when the first pneumatic control output may be safely used to control the rotary engine.

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