Sept. 2, 1969 R. W. AGETON 3,464,502

HYDRAULIC-DRIVE DRILLING

Filed Nov. 6, 1967 3 Sheets-Sheet 1

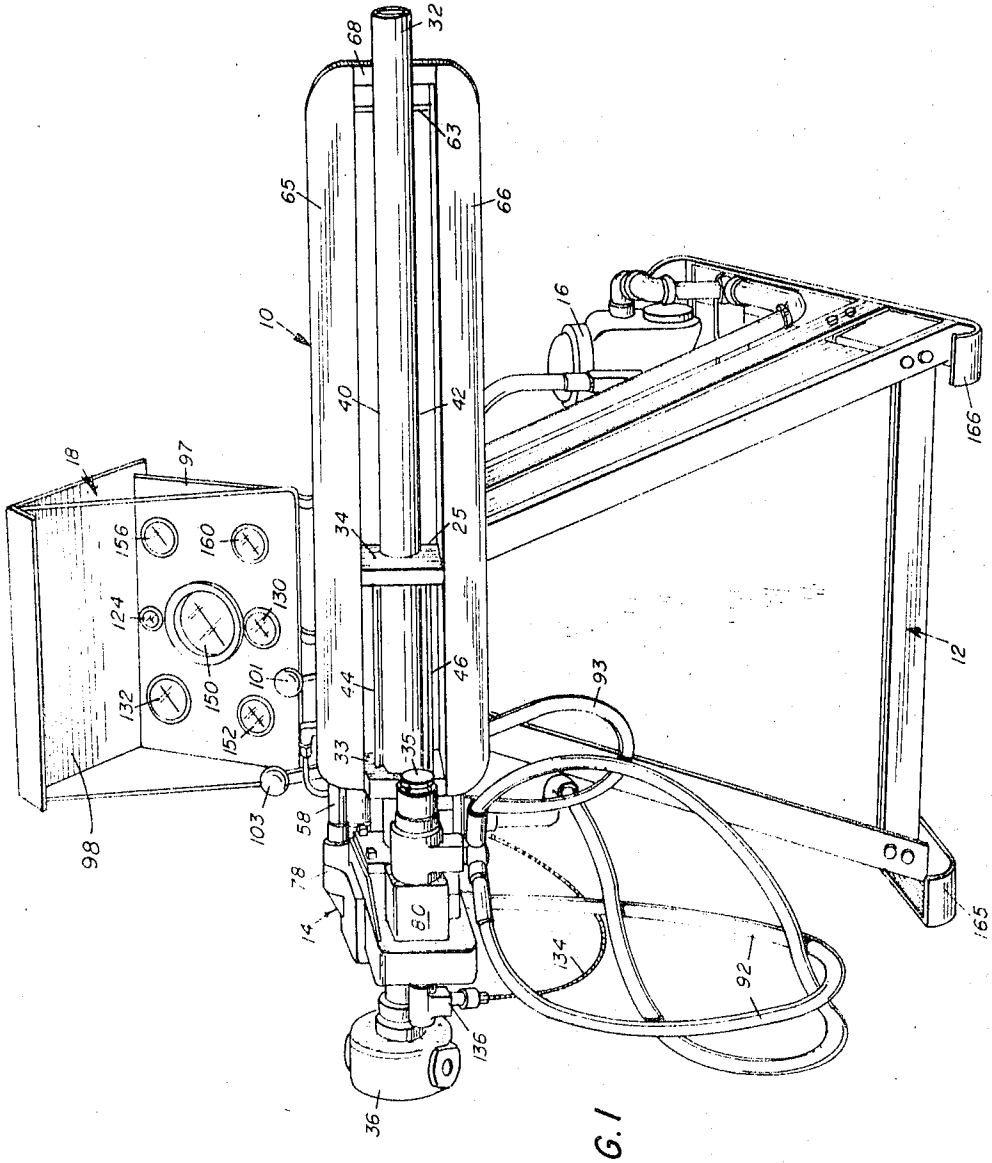


FIG. 1

INVENTOR
ROBERT W. AGETON
Ernest S. Cohen
BY Gersten Sadowsky
ATTORNEYS

Sept. 2, 1969 R. W. AGETON 3,464,502

HYDRAULIC-DRIVE DRILLING

Filed Nov. 6, 1967 3 Sheets-Sheet 2

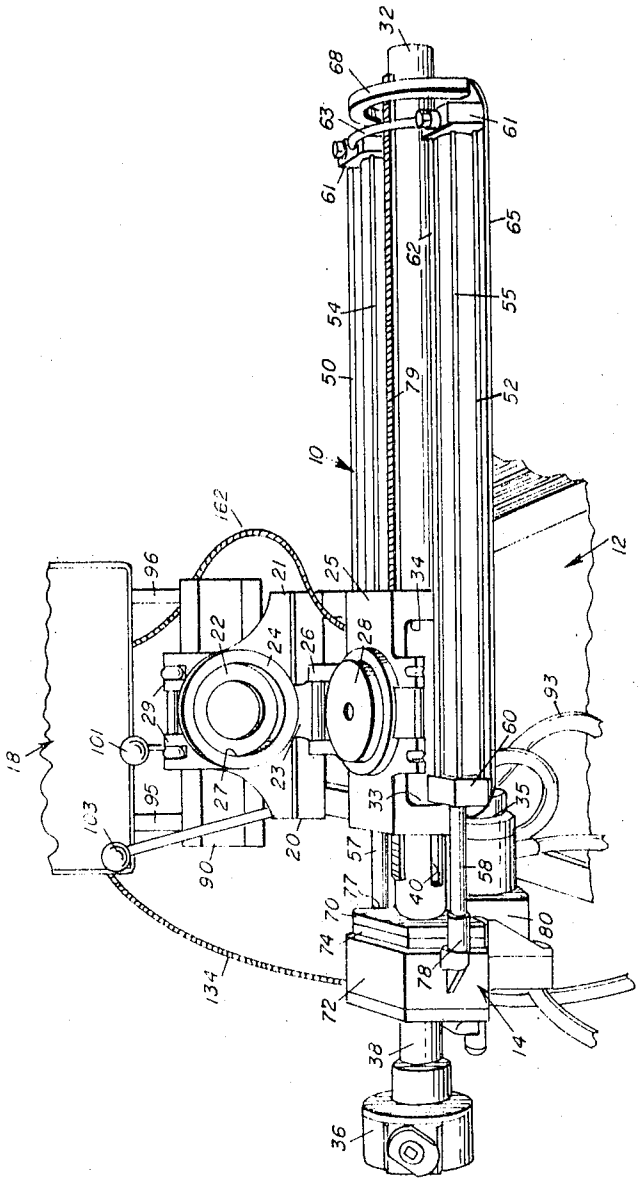


FIG. 2

INVENTOR
ROBERT W. AGETON

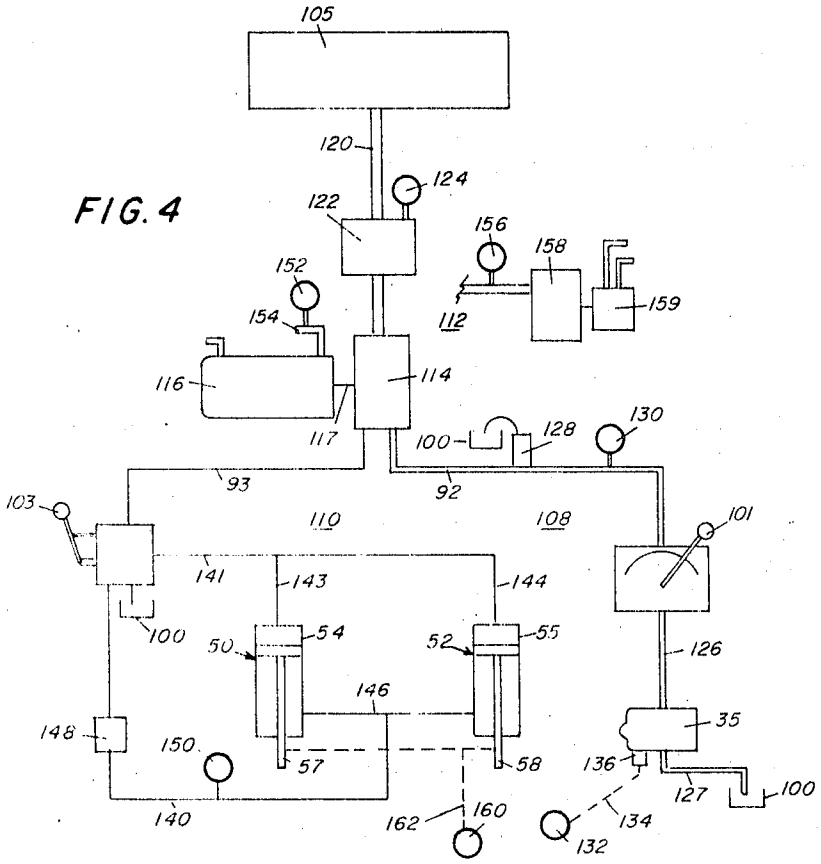
BY Ernest S. Cohen
Gerstein Sadowsky
ATTORNEYS

Sept. 2, 1969 R. W. AGETON 3,464,502

HYDRAULIC-DRIVE DRILLING

Filed Nov. 6, 1967 3 Sheets-Sheet 3

FIG. 4



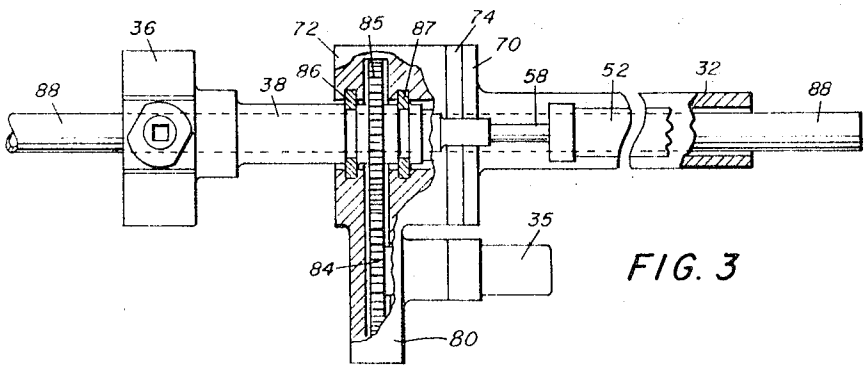


FIG. 3

INVENTOR
ROBERT W. AGETON
Ernest S. Cohen
BY Gersten Sadowsky
ATTORNEYS

United States Patent Office

3,464,502
Patented Sept. 2, 1969

3,464,502

HYDRAULIC-DRIVE DRILLING

Robert W. Ageton, Spokane, Wash., assignor to the United States of America as represented by the Secretary of the Interior

Filed Nov. 6, 1967, Ser. No. 680,616
Int. Cl. B23q 5/06; E21c 11/00, 9/00
U.S. Cl. 173—20 5 Claims

ABSTRACT OF THE DISCLOSURE

Drilling cores of hard, fractured quartzite is accomplished by separately applying sensitively controlled high pressure hydraulic forces to rotate and advance a drill. Applicable drilling apparatus includes a gear drive housing which is attached to a centrally supported torque guide tube, and supports a bit chuck for a rotational drive by a hydraulic motor and longitudinally displacement by hydraulically driven pistons affixed to the housing. Independently controlled hydraulic pressure circuits variably activate the pistons and produce high torque at low r.p.m.'s in the motor. A console adjacent the pressure controls contains instrumentation allowing concurrent observations of all important operational parameters during controlled drilling.

This invention resulted from work by the Bureau of Mines of the U.S. Department of the Interior, and the domestic title to the invention is in the government.

The invention relates to an improved method and apparatus for controlled drilling in hard rock. In particular, the invention concerns ways and means to secure the most effective utilization of coring and overcoring drills made operable by hydraulic power mechanisms.

Since meeting drilling requirements in mining activities and mineral exploration constitutes a major cost item, improved efficiency in drilling operations yields significant economic advantages. Important considerations in promoting such efficiency as the reduction of power consumption needed for drilling, and minimization of wear and tear on drilling equipment. Accordingly, more efficient drilling operations are made possible by applying procedures and equipment thereto which facilitate close control of such factors as the power inputs to the drives rotating the drill bit and advancing it into the rock, as well as maintaining lubricating water pressure. Instrumentation of the present invention functions therein to monitor the operational characteristics of its component parts whereby improved operations can be readily achieved by providing a requisite control in response to the conditions indicated by the instrumentation. Damage to bits, rods and other items of equipment in the event the bit is retarded or blocked in a hole can be more easily prevented when appropriate corrective action is taken in light of instrument data. Thus, monitoring the drilling performance assists the drill operatior in anticipating trouble and making corrections before critical malfunctions cause operational shutdown. Monitoring investigations of diamond drilling which activates instrumentation needed to determine rock stress in mine walls permits recovery of more useful cores and increases footage of the cores drilled. The invention further concerns equipment wherein a sensitive and responsive control of drilling is effectively accomplished in a reliable manner. Accurate

monitoring of drill bit r.p.m. for deriving meaningful torque-horsepower relationships can be accomplished in accordance with the present invention using a hydraulic motor to drive the drill.

The best combination of factors for optimum drilling rates and efficiencies for all types of rock drilling can be determined from consideration of drilling parameter data such as is made easily accessible and conveniently applicable by the present invention. It is therefore a primary objective of the present invention to provide a method for accomplishing exactly controlled drilling operations utilizing observable data to determine drilling parameters. A further important objective of the present invention is to provide an improved drilling apparatus having instrumentation, constituting an integral cooperative part thereof, for monitoring operational characteristics of the apparatus.

The manner in which these and other objects of the invention are attained will become clear from the detailed description which follows and the drawing in which:

FIG. 1 is a pictorial representation of a generally elevational front view of the apparatus according to the invention;

FIG. 2 is a pictorial representation partially showing the apparatus of FIG. 1, in an inactive condition wherefore it is open to reveal internal mechanisms thereof;

FIG. 3 is a partially schematic showing of a structural support and driving connections for a drill bit rod used in the invention; and

FIG. 4 is a schematic representation of operational arrangements for the apparatus shown in FIGS. 1 to 3, including the various drives, drive controls, and the instrumentation involved therewith.

An apparatus according to the invention is shown in FIGS. 1 and 2 as an integral structure wherein a drill rig **10** is securely maintained upon a truncated pyramidal stand **12**. The more comprehensive constituent parts of rig **10** include a hydraulic drill drive mechanism **14**, a drill drive power unit **16**, an operation monitoring console **18**, and an intermediate support assembly **20** affixed to stand **12** and constituting a connective body structurally associating rig **10** and console **18** to stand **12** and power unit **16**. Assembly **20** comprises a stanchion part **21**, whose base is bolted to the top of stand **12**, and up-right face carries centrally located thereon a collar-like extension **22**. A hanger structure **23** having a relatively wide yoke-like ring **24** is mounted in assembly **20** so as to be rotatable completely around on collar extension **22**, and a housing structure **25** of the assembly is pivoted to ring **24** by rugged hinge connection **26**. Complementary circular conformations **27** and **28** in ring **24** and on housing **25**, respectively, are adapted to fit together, whereby they can be held clamped by pivotal latch members **29**. Housing structure **25** is thus adapted to function as a retainer device maintaining drill drive mechanism **14** operably positioned in a manner hereinafter more fully explained.

Drill drive mechanism **14** includes components which render a drill bit operable to rotate and move longitudinally during drilling action. A sturdy tubular member **32** disposed centrally within mechanism **14**, and projecting out the rearward end thereof, functions to guide the drill bit in its longitudinal displacement, and to absorb torque produced by a hydraulic motor **35** transmitting a rotational drive to the drill bit which is held in a chuck **36** attached to the forward projecting end of a relatively short length quill **38**. Torque tube **32** is supported in axially aligned conforming openings through parallel side walls

33 and 34 of retainer housing 25. Along an extended portion of the outer surface of torque tube 32 there are formed on opposite sides thereof elongated channel-like grooves constituting keyseats 40 and 42. Spline-like keys 44 and 46 are secured between walls 33 and 34 of retainer housing 25, and suitably spaced apart to slidably fit within keyseats 40 and 42, respectively, whereby in restraining torque tube 32 to have only longitudinal displacement with respect to its support openings in retainer housing walls 33 and 34, the engaged parts constitute torque absorbing structure.

Retainer housing 25 is situated between a pair of hydraulic ram mechanisms 50 and 52, which comprise elongated cylinders 54 and 55, respectively, in which piston rods 57 and 58, respectively, are displaceable by hydraulic fluid pressure applied thereto. A pair of rectangular blocks 60 and 61 are prrovided for each hydraulic cylinder whereon the blocks constitute closures for the opposite end openings of the respective cylinders. Passages through these blocks communicate with the cylinders and hydraulic fluid piping such as is designated by numerals 62 and 63 in FIG. 2. Corresponding elongated plates 65 and 66 are affixed at side edges on the extended ends of housing walls 33 and 34, by welding or the like, whereby a plate projects outwardly and rearwardly from each side of the housing to form support ledges thereon. Blocks 60 and 61 are securely fastened to these ledges near the far ends thereof whereby the hydraulic ram mechanisms are operatively oriented to the drill drive components, as will be hereinafter more fully explained. A semi-circular reinforcing brace 68 for rig 10 is anchored on rearwardly extending portions of plates 65 and 66, so as to span across torque tube 32. The forward end rim of torque tube 32 is welded, or otherwise fastened by a rugged connection within a conforming opening through a flange plate 70 whereby the torque tube is made integral therewith.

A generally rectangular casing 72, is provided as a housing for the drive trains which operatively associate quill 38 and drill chuck 36, attached thereto, with the displacing forces produced in the special hydraulic circuits of the invention to be hereinafter more fully explained. Casing 72 is equipped with an apertured face block 74 to which torque tube flange plate 70 is securely bolted. A generally cylindrical protuberance on each of two opposite sides of casing 72 project rearwardly therefrom and constitute socket-like brackets 77 and 78. Alignment of piston rods 57 and 58 with the bracket sockets 77 and 78, respectively, when the hydraulic ram mechanisms are located by the arrangement of their end closure blocks 60 and 61 on flange plates 65 and 66, facilitates securing the firm couplings joining the piston rods to the sockets aligned therewith, which appear best in FIGS. 1 and 2. Casing 72, thus supported by these couplings and the connection of its face block 74 to torque tube flange 70, responds to longitudinal displacements by pistons 57 and 58 of the hydraulic ram mechanisms to move torque tube 32 therewith. When the torque tube is driven as indicated, it is steadied and guided for reciprocality by the openings of the retainer housing walls 33 and 34, and by housing keys 44 and 46 upon which keyseats 40 and 42 in the torque tube are adapted to ride, as was hereinbefore explained. An elongated narrow rack 79, attached to torque tube 32 along the outer surface thereof and parallel to its longitudinal axis, passes through conformable slots in both end walls of retainer housing 25 when moved along with the torque tube for purposes to be hereinafter explained.

Referring particularly to FIG. 3, casing 72 is seen as supporting hydraulic motor 35 by attachment thereof in the wall of a reduced part 80 of the casing. A shaft from the motor projecting into part 80, maintains a gear 84 affixed thereto in mesh with a corresponding gear 85 secured to the cylindrical outer surface of quill 38. Thrust applied to casing 72 by ram mechanisms 50 and 52 is transferred to the drill bit through conventional bearing collars 86 and 87 affixed to quill 38 on the opposite sides of gear 85. Drill rod 88, shown extending through torque tube 32 and the quill, emerges from drill chuck 36 wherein it is secured in a conventional manner so that it rotates therewith when the quill is driven to turn the chuck. It is evident that drill rod 88 is thus rotatable by a drive from gears 84 and 85 in a 1:1 ratio when this drill rod extends through the openings in torque tube 32 and casing 72. Therefore, since quill 38 is journaled within casing 72, longitudinal displacement of the casing by the hydraulic ram mechanisms 50 and 52, as was hereinbefore explained, moves the drill therewith as it rotated by the gear drive from hydraulic motor 35.

Drill power drive unit 16 comprises a control compartmentation 90, and a plurality of drive source components which are partly visible in FIG. 1, and more fully explained in connection with the hydraulic circuitry represented in FIG. 4. These drive source components are arranged as a compact grouping by fastenings securing them to framing structure bolted to a side of stand 12 at the rear of console 18, whereon they are conveniently positioned for operational connections by way of hydraulic fluid carrying hoses 92 and 93 to motor 35 and ram mechanisms 50 and 52. Monitoring console 18 is maintained above and rearwardly of control compartmentation 90, supported on stand 12 by a pair of upstanding strap-like posts 95 and 96. A plurality of meters mounted within openings through a panel 97 of the console, are protected under a partial hood 98 attached around the top and side edges of the panel. A pair of manually positionable control levers 101 and 103 are operable through compartmentation 90 to determine the speed of motor 35, and the force applied to displace the pistons 57 and 58 of the ram mechanisms, respectively.

The aforementioned principal parts of the apparatus are illustrated in FIG. 4 in association with the fluid and mechanical drive connections operatively interrelating such parts. Provisions for maintaining an operationally effective flow of driving fluid, such as oil, between an oil reservoir 105 and hydraulic motor 35 and ram mechanisms 50 and 52, include parallel hydraulic circuits 108 and 110 supplied from a common pump system 112. Fluid pressure for supply system 112 is derived in a pump 114 whose unitary casing encloses dual feed vanes. In the simplified construction characterizing the apparatus of the invention, pump 114 has two fully balanced pump sections which are driven by an air motor 116 mechanically coupled to the drive shaft 117 of this double pump arrangement. A pipe 120 having a suitably large diameter, provides a conduit for oil flowing from a connection thereof to reservoir 105, conveniently located within the space framed by the structure of stand 12, to a connection coupling the pipe to a single inlet of pump 114. Oil conduit 120 is equipped with an oil filter 122 having connected thereto an oil pressure gage 124. The simultaneously operable pump sections of pump 114 feed oil at different rates to hose conduits 92 and 93, respectively coupled to separate outlet connections on the pump. Hose 92 conducts oil to hydraulic circuit 108 and hydraulic motor 35 therein by way of a throttle valve 101, and hose 93 conducts oil to hydraulic circuit 110 and hydraulic ram mechanisms 50 and 52 therein by way of a valve control device 103. A larger diameter characterizes hose 92 since the larger vane of pump 114 feeds oil to this hose at a rate double that at which oil is fed to hose 93 by the smaller vane of pump 114.

Hydraulic circuit 108 is completed through further hoses 126 and 127 coupling throttle valve 101 to motor 35, and the motor to reservoir 105 by way of a return line coupling, designated 100 at the several points it is shown in FIG. 4. Hose 92 is protected by a hydraulic pressure relief valve 128, connected to return coupling 100, which functions to prevent the pressure delivered by hydraulic pump 114 from exceeding the recommended

pressure to be applied to the connecting hoses. Also responsive to the hydraulic pressure in hose **92** is an oil pressure gage **130**. Hydraulic motor **35** is driven at a speed which is a function of the flow feed pressure registered on gage **130** and oil quantity, and is modified by the throttling action set by valve control **101**. Motor speed is indicated on a r.p.m. meter **132** linked by a speedometer cable **134** to an auxiliary drive attachment **136** having gearing engaging the motor drive shaft.

Hydraulic circuit **110** is completed through hoses **140** and **141** coupling a parallel connection, including tubing **143**, **144**, and **146**, between hydraulic cylinders **50** and **52** to cylinder valve **103** and reservoir **105** through return line coupling **100**. Hose **140** is equipped with a flow control valve **148** to determine the flow of oil applicable to drive pistons **57** and **58** of the hydraulic ram mechanisms, and a duplex pressure gage **150** which as will be explained permits monitoring of the bit force. Other indicators made operable in the apparatus are a gage **152** connected in an air hose line **154** for measuring the pressure of air delivered to air motor **116**, and a gage **156** measuring pressure of water delivered by a pump **158**, driven by air motor **159**, to the drilling zone. In addition, the apparatus includes a bit advance gage **160**, driven by the displacement of rack **79** as it moves with the torque tube. One end of the flexible drive cable **162** is provided with a small wheel drivingly engaged by rack **79** such that a connection from the other end of the cable to a gear mechanism in gage **160** indicates the advance of the drill bit with chuck **36**. The clustered arrangement of the aforementioned gages and meters in panel **97** of console **18**, which appears in FIG. 1, places these indicators close at hand to controls **101** and **103**, and others at the operator's position where all their readings are easily discernible to the operator.

When readied for operation, the apparatus is firmly held immobile by hydraulic jacks extended between runners **165**, **166**, on the base frame of stand **12**, and surfaces of adjacent walls or roof in the mine. Oil pressure applied to brace the apparatus is indicated on pressure gages conveniently placed on the jacks. Monitoring the oil pressure improves safety since it permits checking the stability of the braces whereby any pressure drop noted may be corrected quickly by repressuring. A drill string is passed into the apparatus through the tail end opening of torque tube **32**. Chuck **36** is adjusted to securely clamp the drill string emerging from the head end of the torque tube so as to provide an extended portion of drill string on whose end is connected the drill bit. Drill drive mechanism **14** is thereafter swung upwardly bringing conforming parts **27** and **28** into contact to facilitate clamping retainer housing **25** to stanchion **21** whereby the drill mechanism is maintained in operable position. Air, oil and water valves are adjusted open to bring the pressures in the associated lines and hoses to appropriate levels. Throttle **101** is adjusted open to set the pressure of the fluid flow from pump **114** which passes through hydraulic motor **35**. Quill **38** is rotated accordingly, carrying with it chuck **36** and the drill string secured by the chuck. A directional adjustment of valve control **103** is then made to admit hydraulic fluid into piston chambers **54** and **55** by way of lines **141**, **143** and **144** with the result that pistons **57** and **58** move forwardly carrying casing **72**, and the rotating drill parts therewith. Hydraulic pressure thus advances the rotating drill bit against the rock being drilled.

When piston rods **57** and **58** are fully extended, throttle **101** is reset to stop the rotational drive from motor **35** to the drill bit, and the drill string is released from the grip of chuck **36**. The drill string is thus left supported by the disposition of its bit end in the drill hole and the rod thereof extending through the chuck and torque tube. Subsequent readjustment of valve **103** redirects hydraulic fluid to piston chambers **54** and **55** by way of lines **140** and **146** enabling piston rods **57** and **58** to effect return of casing **72** toward retainer housing **25** whereby torque tube **32** and chuck **36** are withdrawn therewith back over the drill string. Further drilling is accomplished by repeating the operational sequence wherein chuck **36** is clamped on the drill string, hydraulic motor **35** is brought up to an appropriate speed by adjustment of throttle **101**, and a further reversal of valve control **103** brings an advancing force from the hydraulic pistons **57** and **58** to bear on the rotating bit. After the drill string is disconnected at some point forwardly of chuck **36**, drill drive mechanism **14** can be swung down around its hinged connection to stanchion **21**, to facilitate unimpeded withdrawal from the drilled hole of the drill rod and bit placed therein by the drilling operation.

In the utilization of the apparatus, manipulation of throttle control **101** and valve control **103** can at all times be fully coordinated to comport with all current operational conditions of the apparatus since only a quick glance at the clustered indicators openly displaced on console **18**, is necessary to gain immediate observation of all such conditions. Check for leaks or obstructions in the hydraulic system return and feed are obtained by observing oil pressure gage **124**. Drill drive r.p.m. monitored on meter **132** is utilized to maximize drilling or cutting speed for a bit size and to estimate the torque-horsepower being applied or used, particularly when related to the fluid pressure in drill driving hydraulic motor **35**, as will be hereinafter more fully explained.

Readings on gage **130** of the oil pressure in the fluid delivered to hydraulic motor **35**, provides a parameter with which to estimate torque-horsepower being applied. In this connection, a table of precalculated data based on correlating motor oil pressure readings and the characteristic rate of fluid flow values for a selected motor running at a predetermined r.p.m., could be used to directly give specifications on the torque of the motor for the indicated speed. Moreover, increasing readings on gage **130** may also indicate a pressure build-up in line **92** due to abnormal resistance to the drill bit which may eventually stop rotation when the by-pass pressure set on relief valve **128** is reached, and oil is by-passed through return **100** at the valve. Since motor restart and resumption of drilling usually follows pull back of the bit, the measure of increased torque or horsepower needed to overcome repeated sticking becomes apparent from adjustment made to achieve steady drilling. Accordingly, there are determinable thereby the parameters for horsepower needed to drill in a particular rock with a specific bit.

Oil pressure gage **150** responds to pressure sensed in hydraulic circuit **110** whereby it indicates the force which the operation of ram mechanisms **50** and **52** develop for application to the drilling bit. The p.s.i. readings from the gage are merely converted to pounds force based upon a calibration of the hydraulic cylinder system. Monitoring the bit pressure on gage **150** is of special value in forestalling excessive bit force which acts to slow down the drilling. The preliminary warning given by the increasing bit force is accompanied by a pressure buildup in hydraulic circuit **108** wherefore gage **130** indicates the need for the application of more torque. Air pressure readings on gage **152** can also provide a clue to the cause for poor cutting response not due to a mechanical malfunction. Lack of air to efficiently operate oil pump **114** results in less horsepower available for the drilling work. An indication of high water pressure on gage **156** provides further evidence of poor drilling response which could stall the drilling. The water pressure gage also serves as a constant reminder that water is still being pumped through to the drilled hole. As was previously explained, gage **160** provides data from which can be determined increments of depth to which initial and repeated drilling operations have been carried. For example, actual cuttng might start at a gage reading of 14 inches and stop at gage reading 29 inches to indicate an

advance of 15 inches for the period monitored. Typical data derived in applying the invention to investigating drilling performance is presented in the following table of results obtained using an EX bit (1.5 inches diameter).

Depth	R.p.m.	Oil, p.s.i.	Bit force	Penetration rate, in./min.	Torque, inch/lbs.	H.P.
0'10"-3'2"	155	400	1,410	1.33	511	1.0
4'2"-5'5"	170	350	1,460	1.25	379	1.0
6'11"-7'4"	150	300	1,360	1.67	372	0.9
7'9"-8'11"	150	350	1,820	2.00	412	1.0
9'0"-9'8"	140	400	1,830	2.00	519	1.1
10'5"-12'10"	170	350	1,360	1.62	429	1.1

The instant apparatus is particularly useful in overcoring operations wherein deformation characteristics of a mine wall may be monitored. Such operations require the implanting of a borehole pressure cell, or sensor, in the mine wall, followed by the cutting of a core around the sensor so as to centrally contain it. Overcoring thus obtains stress relief in a selected area within a rock mass so that this relief, characterized by deformation, may be monitored on a meter responding to the sensor output. The data gathered thereby can be converted into usable information regarding directions of maximum and minimum stress in the rock mass of the mine wall. A more complete description of the operations involving stress relief is available in the U.S. Bureau of Mines' Reports of Investigations No. 6887, "Deep Mine Stress Determinations Using Flatjack and Borehold Deformation Methods," and No. 6997 "Stress Ellipsoid Determination in a Rock Burst Prone Area at 4000 Foot Depth," Galina Mine, Wallace, Idaho, by the inventor herein, published in 1967. As explained in these R.I.'s, only uniform, vibration-free overcoring allows reception of reliable borehole deformation readings in extremely hard substances such as fractured quartzites. The exceptionally close, and careful control of operational parameters enabled by the present invention permits low speeds of rotation of the quill and the bit which is a most important factor in obtaining deformation readings. For example, vibration of a six inch diameter bit due to high r.p.m. can cause significant lateral displacements, and sudden violent stops which in turn can break the core prior to obtaining stress-relief readings. Moreover, a core break piece which continues turning at a high r.p.m., endangers the integrity of any intelligence cables attached to the borehole deformation gage by entangling and frequently breaking the cables. A positive control over the overcoring process at low r.p.m. avoids damage to the cables.

While the preferred embodiment of the invention has been described and illustrated, it is to be understood that the invention is not limited thereby but is susceptible to changes in form and details.

What is claimed is:

1. A drilling apparatus comprising a drill rig and a stand constituting a base therefor, and having means affixed thereto adapted to coordinate the disposition of said drill rig with respect to said stand, said drill rig comprising aligned elongated plates having formed integral with one end thereof a housing structure, an elongated hollow element aligned with said plates and extending through end openings in said housing structure, said hollow element having formed thereon a means coupling with keying means in said housing whereby said element is restrained to follow longitudinal displacements with respect to said housing structure, a drill bit drive mechanism operatively disposed on an extended end of said hollow element and including a drive transmitting element having affixed to an extended end thereof a means securing a drill bit therein, and a power supplying component applying a driving force to said transmitting element wherefore torque arising at said drill bit is absorbed in said restrained hollow element, further power supplying components fixedly mounted on said elongated plates and having extensible elements thereof secured to said drill bit drive mechanism and effective when concurrently driven to project from said further power supplying components to longitudinally displace said hollow element with respect to said housing structure, a power deriving unit supported on said stand, control devices cooperatively interrelating said power deriving unit with said power supplying components, a drill rig operation monitoring means affixed to said coordinating means, an angularly adjustable connective assembly having separable mating parts respectively secured to said coordinating means and said housing structure, said mating parts being pivotally connected whereby said connective assembly functions when said respective parts are separated to maintain said drill rig suspended from said stand and when mated to maintain said drill for operation in an adjusted position whereat said control devices are situated adjacent said drill bit drive mechanism and said monitoring means is disposed with respect to said drill rig so as to allow unobstructed observation of said monitoring means when said control devices are manipulated.

2. The drilling apparatus of claim **1** wherein said hollow element is a cylindrical tube, said further power supplying components comprise piston cylinders having closure blocks attached to opposite ends thereof, said blocks being affixed to said elongated plates, said extensible elements comprising displaceable piston rods, said drill bit mechanism comprising a casing made integral with said torque absorbing and guiding tube, said means securing a drill bit therein comprising a chuck adapted to rotate with respect to said casing, said piston rods having their extended ends affixed to said casing, said powered component supplying driving force to said transmitting element comprising motor means supported in said casing, said motor means and piston means having drive power connections to said power deriving unit whereby power is transmitted to longitudinally displace said casing by said piston means during rotation of said chuck by said motor means.

3. The drilling apparatus of claim **1** wherein said drill bit power deriving unit comprises a duplex power source concomitantly functioning to transmit different power quantities to said motor and piston means, respectively, whereby separate ones of control devices are operative to regulate the transmission of said power quantities between said power source and said respective power supplying components.

4. The drilling apparatus of claim **3** wherein said motor means is a hydraulic motor and said piston means comprises hydraulic cylinders, and said duplex power source is a hydraulic pump having one fluid inlet and first and second pump compartments each having a fluid outlet, a first hydraulic circuit connecting said first compartment outlet to said hydraulic motor, and a second hydraulic circuit connecting said second compartment outlet to said hydraulic cylinders, said first hydraulic circuit having operable therein a first of said control devices comprising a throttle component, and said second hydraulic circuit having operable therein a second of said control devices comprising a reversible hydraulic valve, a reservoir of hydraulic fluid, and further hydraulic circuits connecting said reservoir to said hydraulic pump inlet and to return outlets in said first and second hydraulic circuits.

5. The drilling apparatus of claim **4** wherein said monitoring means comprises a console panel, a plurality of data indicating mechanisms and means affixing said

mechanisms in said panel to allow said observation thereof when manipulating said control devices, a first of said mechanisms connected in said reservoir circuits to indicate a measurement of fluid pressure in said circuits, a second and third of said mechanisms connected in said first and second hydraulic circuits, respectively, to indicate measurements of fluid pressures in said circuits, a fourth of said mechanisms connected to a drive from said motor means to indicate a measurement of the rotational speed of said motor, and a fifth of said mechanisms connected to a drive connection on said torque tube to indicate a measurement of the longitudinal displacement of said torque tube and the advance of said drill bit therewith.

References Cited

UNITED STATES PATENTS

2,000,975	5/1935	Mitchell	173—35 X
2,265,987	12/1941	Anderson et al.	173—159
3,107,738	10/1963	Osborn	173—149 X
3,324,717	6/1967	Brooks et al.	173—152

ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

173—1, 35, 152