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Cannon et al.

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[45] **Nov. 4, 1975**

[54] **UNDERGROUND BLAST HOLE DRILLING MACHINE**

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[73] Assignee: **Cannon & Associates,** Hibbing, Minn.

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[52] **U.S. Cl.** **173/23;** 173/28; 173/147; 173/43

[51] **Int. Cl.²** **E21C 11/02**

[58] **Field of Search** 173/147, 28, 23, 43; 64/26

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Assistant Examiner—Richard E. Favreau
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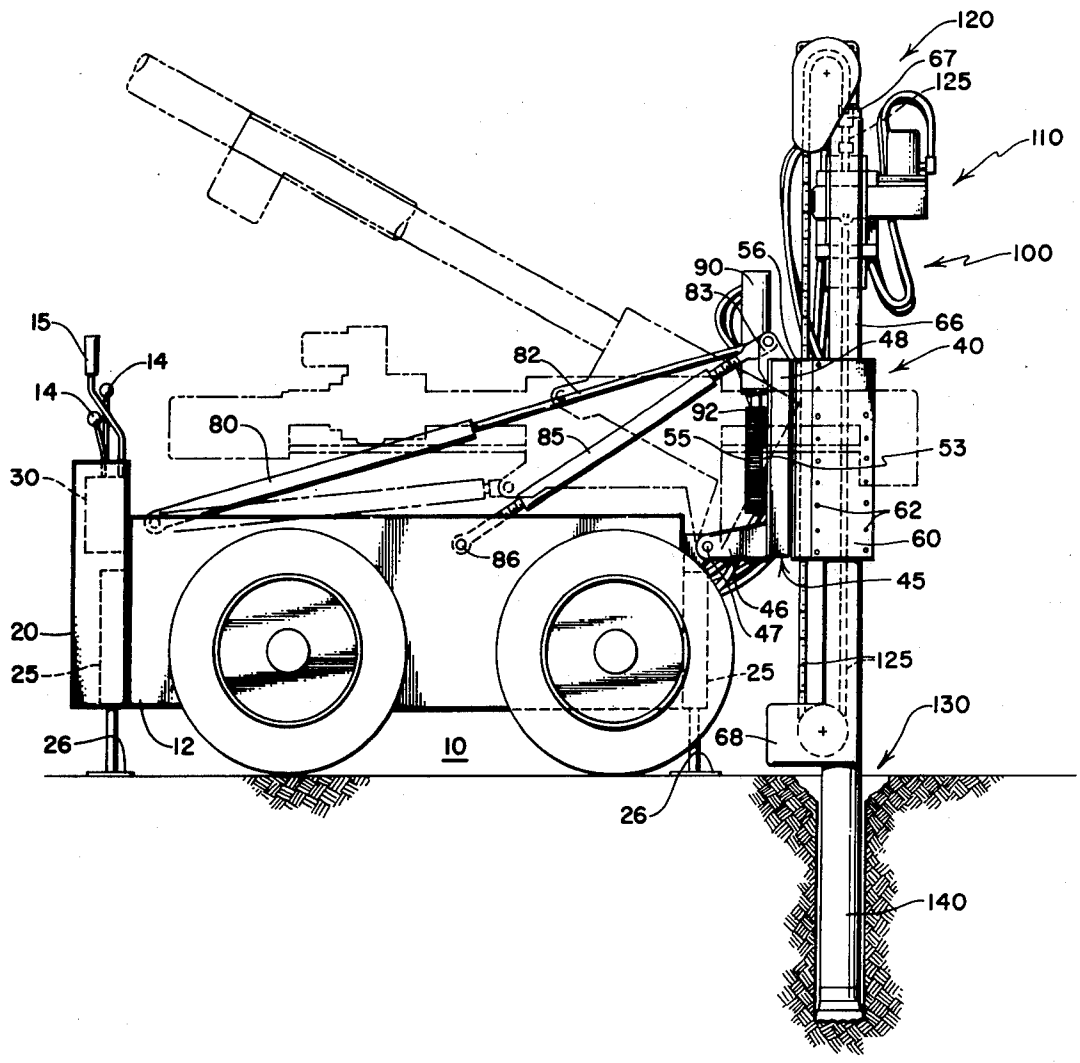
[57] **ABSTRACT**

A mobile drilling machine in which a mobile support vehicle of the hydrostatic type provides the power supply for the majority of the hydraulic components on the drilling head frame, the latter being adjustable through two axis of pivot with its mounting on the head frame for any angle of drilling. The head frame mounts the drill head which advances and withdraws drill rods or a drill string in a drilling operation. It supplies the rotational torque to the drilling string and provides pneumatic air passage therethrough to a drill tool at the end of the drill string at which the major portion of the drilling force is applied. This isolates these drill forces from the drill head and head frame to minimize wear on the drilling apparatus.

16 Claims, 7 Drawing Figures



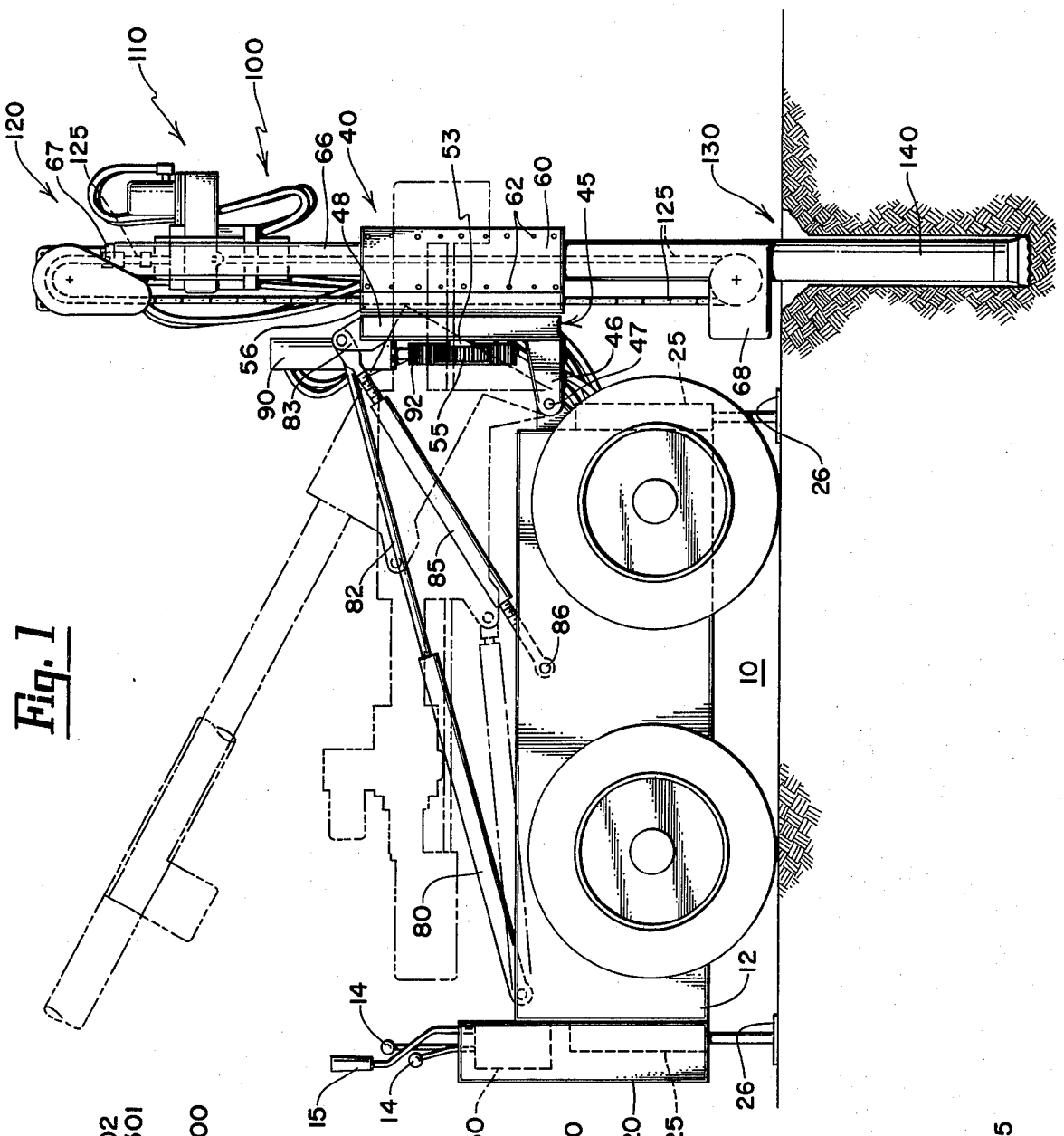

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Fig. 1

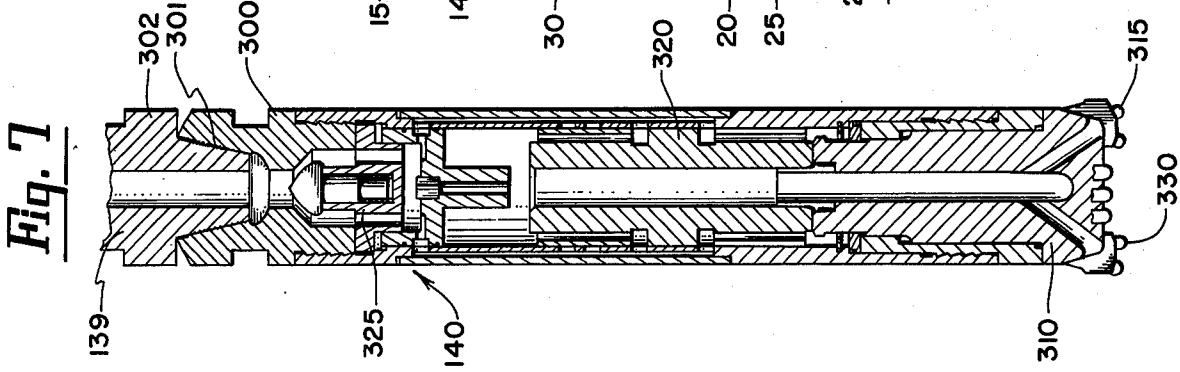
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Fig. 7

Fig. 2

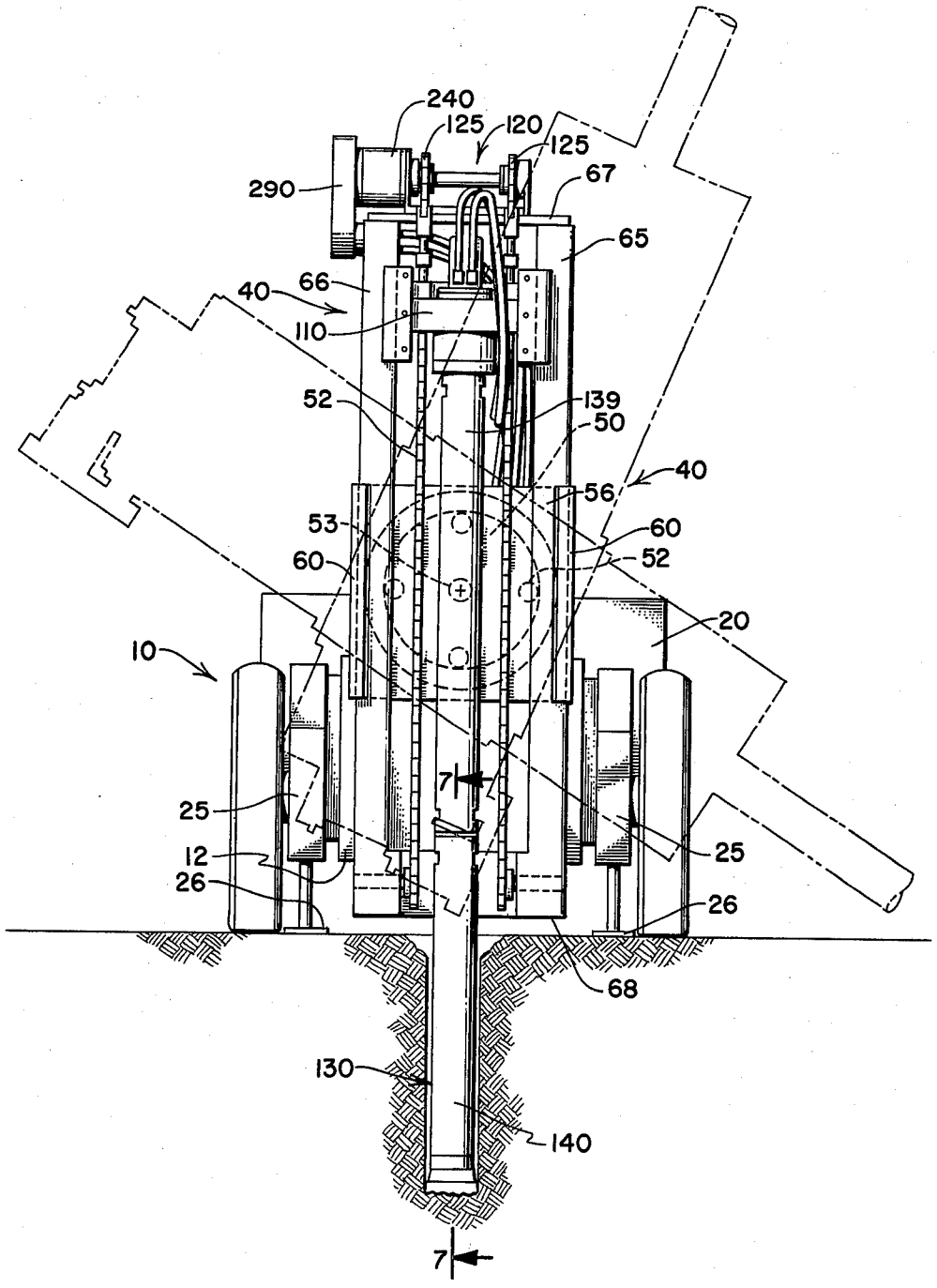
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Fig. 3

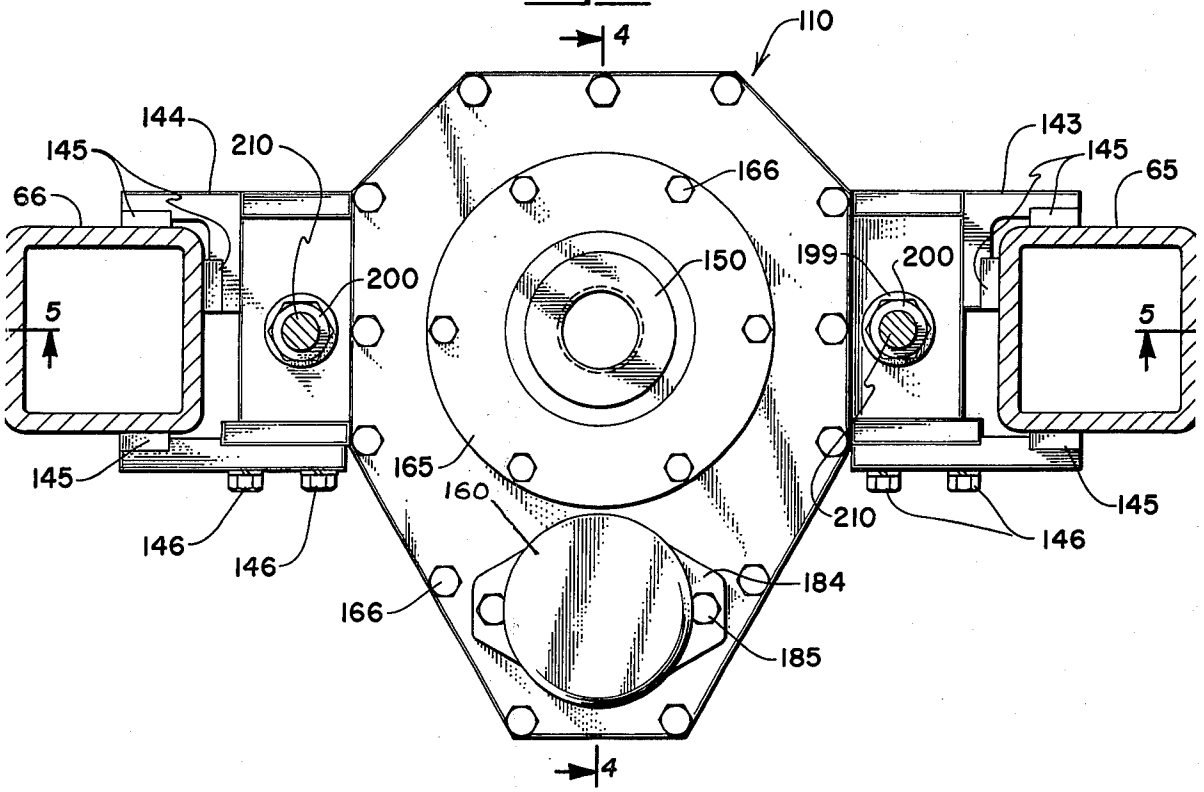
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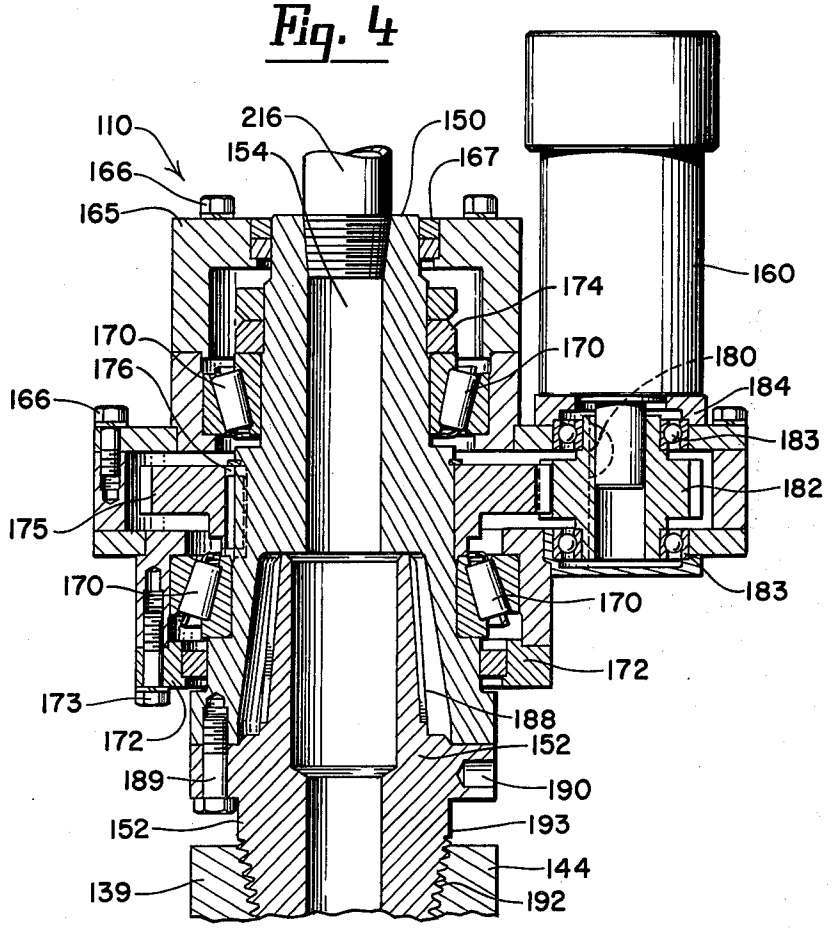
Fig. 4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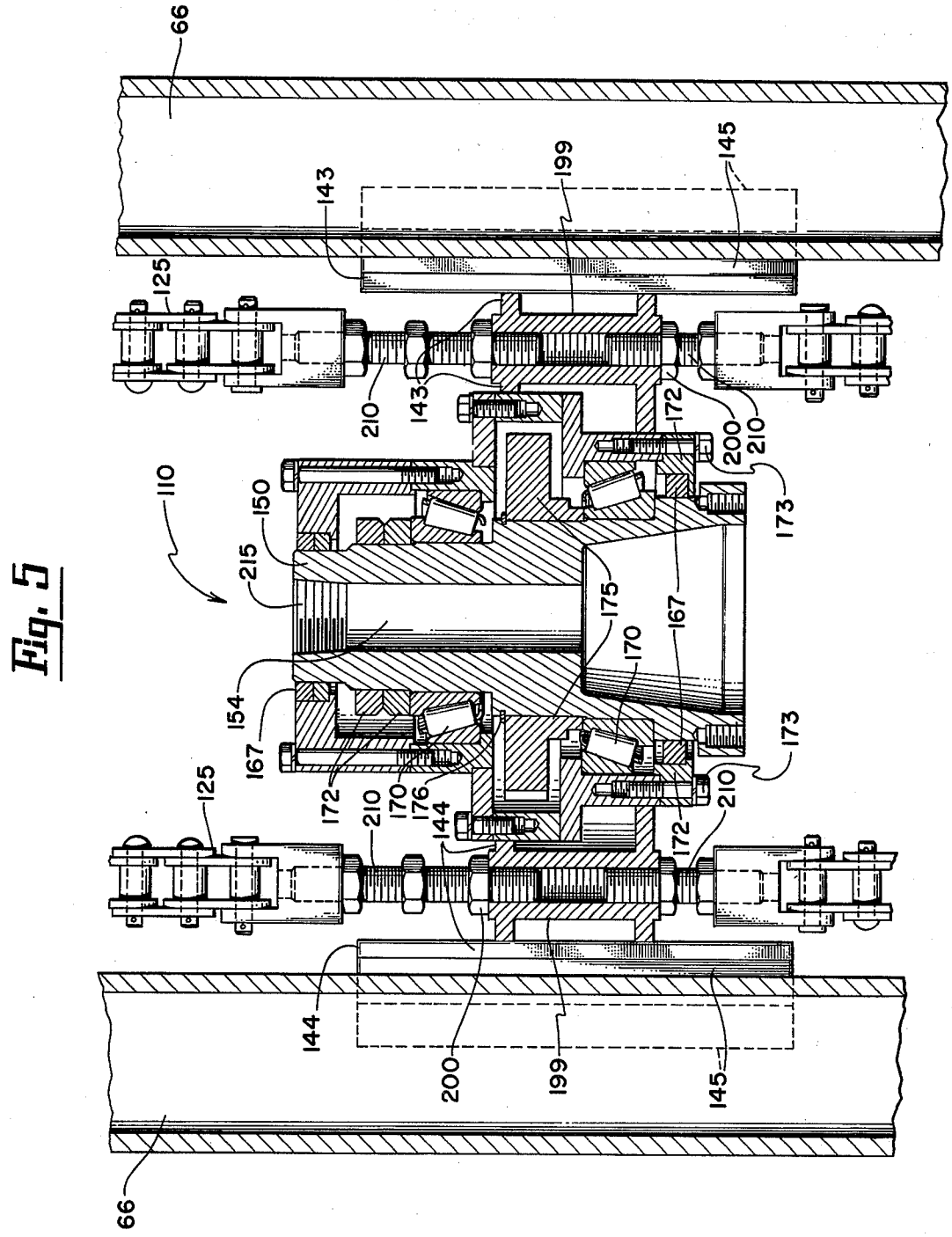
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Fig. 5

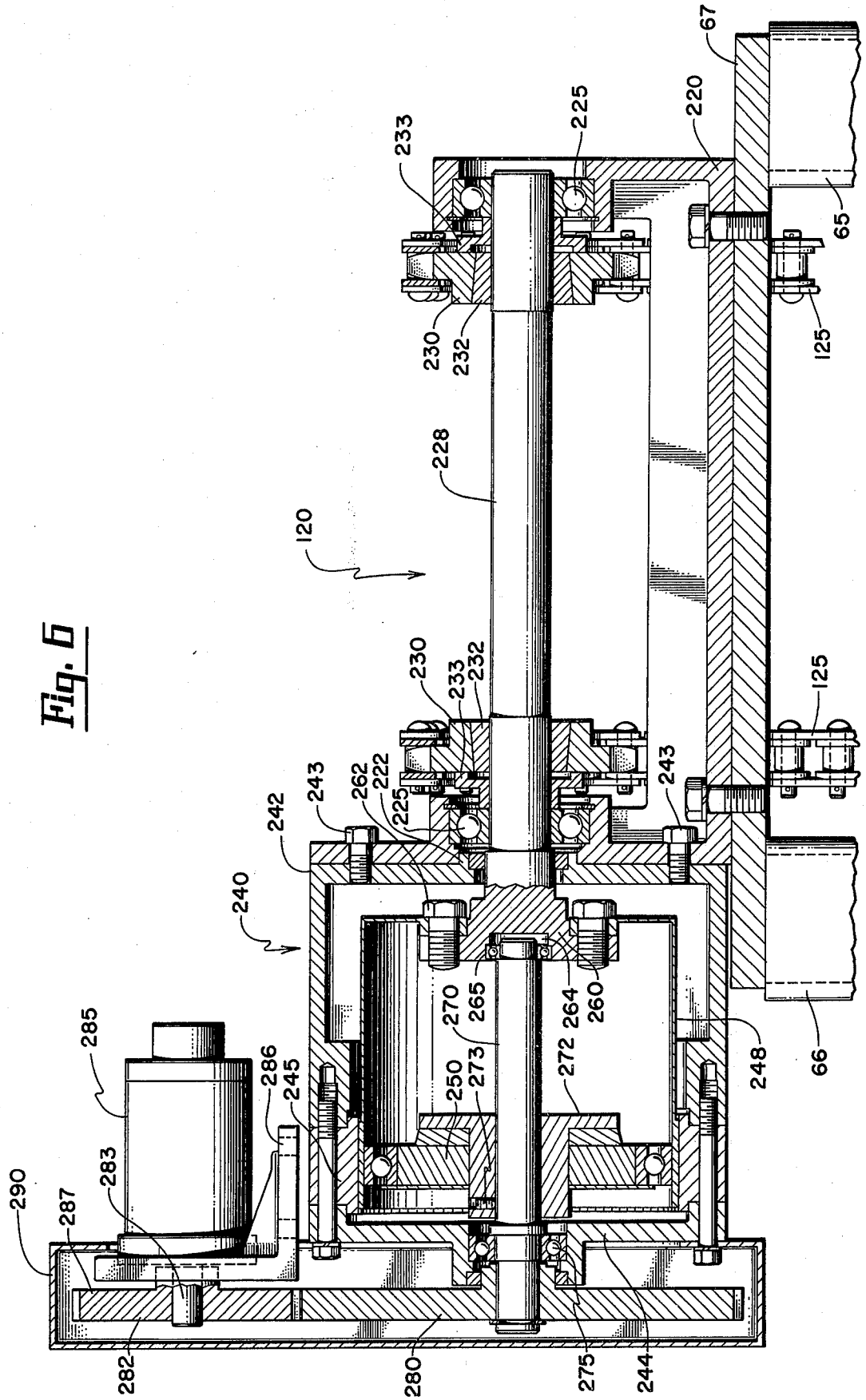
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Fig. 6

UNDERGROUND BLAST HOLE DRILLING MACHINE

Our invention relates to drilling machines and more particularly to an improved mobile drilling machine having particular application as an underground blast hole drilling machine of the mobile type.

At the present time, drilling machines of varying designs are known and recognized. The particular configuration of such prior machines are dictated by the application of the same for varying types of mining, tunneling or equivalent operations. In general, above ground type drills or drilling apparatus, while being portable or maneuverable are generally of size and cost as to limit the application of the same to shaft boring and the like. Smaller machines are known to have application for blast hole drilling, both above and below ground, but generally their complexity, maneuverability, and arrangement of parts dictate high maintenance cost, excessive setup time and take down time, and restricted maneuverability particularly in underground applications. Similarly, such machines are not normally self-contained from a self-powered standpoint in the sense that they require external power sources and/or motive sources for positioning the same. In general, all such drilling machines, whether impact or torsional type drilling, are of such physical size and employ feed and torsion power requirements that power sources for the same or the majority of components thereof, must be externally supplied to limit maneuverability of the same, and the forces thereon dictate secure anchoring of the machine to absorb the forces, increased setup time and high maintenance cost because of excessive wear and breakage of the same.

The present invention is directed to an improved drilling machine having particular application as a mobile self-contained blast hole drilling machine which is highly maneuverable and is applicable for above and below ground applications. The machine is compact, and is for the most part self-contained except for the requirement of an impact power source such as not to restrict application of the same. The improved drilling machine incorporates a conventional four wheel drive vehicle with a head frame mounted thereon in which a drill head is slidably positioned through a conventional rotary motor coupled through an efficient speed reducer to accurately control infeed time and permit more rapid outfeed, and in which torsional input power is supplied from the vehicle with the impact power and tool being removed from direct mounting on the machine so as to minimize shock of the same and eliminate the requirement of anchoring the machine during drilling. This significantly reduces the cost of the machine and the maintenance thereof and permits greater maneuverability of the same with reduced setup and take down time and with a higher degree of versatility for angle drilling in blast hole operations. In the improved drilling machine, the rotary motor is coupled through a speed reducer or harmonic drive to accurately control infeed at a desired speed rate with a capability of increased outfeed of the drill string, rapid interchange in extension and reducing of the drill string and increased maneuverability of the drilling angle with respect to the supporting vehicle for increased versatility of the same. The machine employs an isolated and effective drilling tool at the end of the drill rods which substantially removes impact forces from the machine.

It also permits the application of an isolated power source for the same, minimizing the size and the overall power requirements for the self-contained machine, except for the impact portion of the same. The improved machine employs a harmonic drive coupling the infeed motor to the infeed drive shaft and the chains coupling the drill head on the head frame in an arrangement which provides a compact high torque machine design. Similarly, the separation of torsional input to the drill string from impact input permits the drill head to be supplied from the self-contained power supply on the vehicle for infeed and torsional input power sources. Effective and more rapid drilling is obtained through the use of a separate drill tool or impact tip which is coupled to the drill head and whose power is supplied through the drill head to permit power supply of the same from an external source while minimizing effective impact shock on the drill head to reduce maintenance and wear on the machine.

It is therefore the principle object of this invention to provide a mobile drilling machine particularly suitable for underground blast hole drilling operations.

Another object of this invention is to provide in a mobile drill machine of this type of apparatus, which is capable of drilling at any angle to the supporting mobile vehicle for blast hole type drilling.

A further object of this invention is to provide in a mobile drilling machine, a self-contained power source enabling maneuverability of the machine and the application of power to most of the components thereof so that only a compressed air source at a drill site is required for the impact portion of the drilling operation.

A still further object of this invention is to provide in a mobile drilling machine, an improved speed reducer with variable infeed and withdrawal speeds through the use of an improved harmonic drive, coupling a rotary input motor to the drive feed shaft of the drill head.

Another object of this invention is to provide in a mobile drilling machine, a drill motor on the drilling head which provides the torsional input to the drill string and couples the impact portion of the drilling tool so that it may be powered through the drill head to minimize shock on the machine.

A further object of this invention is to provide an improved mobile drilling machine of this type in which the impact portion of the drilling machine is separately powered and removed from the drilling head to minimize impact and maintenance of the same.

A still further object of this invention is to provide a machine of this type which is easy to use, is relatively low in cost, and requires a minimum of setup and drilling time.

These and other objects of this invention will become apparent from the reading of the attached description together with the drawings wherein;

FIG. 1 is a side elevation view of the improved mobile drilling machine with alternate positions of the head frame for drilling or transit shown in phantom.

FIG. 2 is a front elevation view of the mobile drilling machine in a drilling mode of operation with alternate positions of the drill head and frame being shown in phantom.

FIG. 3 is a sectional view of a portion of the drilling machine shown in FIG. 2 and taken along the lines 3—3 therein disclosing the drill head portion of the machine.

FIG. 4 is a sectional view of the drill head portion of the drilling machine of FIG. 3 taken along the lines 4—4 therein.

FIG. 5 is a sectional view of the drill head portion of the drilling machine of FIG. 3 taken along the lines 5—5 therein.

FIG. 6 is a sectional view of the drilling machine shown in FIG. 2 and taken along the lines 6—6 therein and showing the feed drive portion thereof, and,

FIG. 7 is a sectional view of the drill tool portion of the drilling machine as shown in FIG. 2 and taken along the lines 7—7 therein.

Our invention in a mobile drilling machine is shown in the drawings in FIGS. 1 and 2 in connection with a wheel support vehicle indicated generally at **10.** The support vehicle is a steerable unit which may take a variety of forms and we have found that a mobile hydrostatic drive type tractor is suitable for this application. It includes a gasoline or diesel drive motor (not shown) which drives hydrostatic pumps and motors for powering wheels on each side of the vehicle frame **12** simultaneously and independently through chain drives which enables steering as well as high degrees of maneuverability. The details of the machine are omitted for simplicity since the support vehicle may take varying forms and many employ treads instead of wheels. In addition to the drive for the wheels on each side of the vehicle, the power supply is provided with a separate self-contained hydraulic source for the purpose of providing a hydraulic fluid through separate controls such as is indicated at **14** to drive various components on the drilling machine, as will be hereinafter indicated. The normal steering and speed control levers are indicated at **15** and they are contained in a console **30** in an operator platform **20** at the rear of the vehicle. The vehicle further includes hydraulic cylinders, such as is indicated at **25,** mounted on the front and back or the sides of the frame at each end of the vehicle with suitable stabilizing shoes **26** mounted at the shaft extremities of the same for the purpose of stablizing the vehicle during a drilling operation. These are similarly controlled by one of the various control valve levers in the control console **30** and controlling hydraulic fluids from the supply to the hydraulic actuators or stablizers. The individual hydrostatic drives to the wheels permit forward and reverse speed for the wheels on each side of the vehicle and independent suspension of the same for extreme maneuverability and stability in rough terrain surfaces such as found at mining sites.

Mounted on the frame **12** of the vehicle, and at the front end of the same, is a head frame, indicated at **40.** The head frame **40** is attached to the frame **12** at the front end of the vehicle through a suitable U-shaped mounting bracket assembly **45** having bifurcated arms **46** which pivot on the front end of the vehicle frame and indicated at **47.** The bracket includes a plate-like structure, as indicated at **48,** extending across the front end of the vehicle to which the arms **46** are connected for the purpose of supporting the head frame and drill head as will be hereinafter noted. Positioned in a cylindrical recess of the plate **48** is a cylindrical portion **50** which is journaled therein through suitable bearing means, such as is indicated in phantom at **52,** and which has a shaft, indicated in phantom at **53,** which extends through the plate **48** and mounts a pinion **55** on the vehicle side of the same. The shaft and bearing means support the cylindrical portion **50** in the recess for pivotal movement about an axis normal to the pivot axis defined by the pivot points **47** of the bracket on the front end of the support vehicle **10.** Attached to the cylindrical portion **50** is a plate-like structure **56** having the same rectangular configuration as the plate-like member **48** with the plate-like member **56** having the general U-shaped configuration with forward extending sides directed away from the plate-like member **48.** The sides are formed by a pair of L-shaped mounting plates **60** attached to the structure **56** through suitable bolt means, indicated at **62,** and these include inwardly directed shoulders (not shown) which fit around the outer edges of the column members **65, 66** of the head frame **40** and are secured thereto by additional bolt means **62** and clamping plates (not shown). The head frame is completed by a top plate **67** and a bottom plate **68** which are suitably welded to the side of the column members **65, 66,** to form a generally rectangular structure carried by the plate-like member **56** and its connecting side plates **60** to mount the head frame **40** on the bracket assembly **45** for pivotal movement about the axis of the shaft and the pivot arms formed in the bracket assembly to provide for two axis of movement of the head frame relative to the support vehicle. The articulation about axis is shown in FIGS. **1** and **2,** in which the head frame may be pivoted to varying positions for storage and drilling. This allows for drilling to be carried on from the head frame in a vertical plane or from a position of true vertical to a position of generally horizontal. The head frame is connected intermediate its extent through the support mounting bracket assembly and is pivoted about the pivot axis of the plate **56** on the plate **48** through an angle substantially equal to 360° or approximately 180° either side of a reference position. Such positioning is shown in phantom in FIG. **2.** This will enable the drill or head frame to be rotated on the plate **48** in a plane parallel to the extent of the plate **48** for varying angular positions of the drilling head on the front end of the vehicle. Composite motion about the two axis will enable the drill head to be so positioned for any number of angular relationships with the perspective support vehicle for versatile drilling. The mounting bracket is positioned on the support vehicle and about the pivot axis defined by the pivot pins **47** through a hydraulic actuator indicated at **80** whose cylinder extremity is pivoted on the frame **12** of the support vehicle and whose shaft extremity, as indicated at **82,** is pivotally connected to an upstanding flange **83** on the plate **48.** Suitable threaded locking rods **85** which are pivotally connected to the vehicle frame, as at **86,** and to the flange **83** of the plate **48,** employ threaded coupling members which permits adjustment of the angular position of the head frame **40** with respect to the support vehicle through the operation of the actuator **80** and with operation of the threaded parts provide a rigid locking coupling between the mounting bracket **45** and the support vehicle when a desired angular position has been reached. For the purpose of pivoting the plate **56** on the plate member **48,** a second hydraulic actuator **90,** whose shaft extremity carries a rack member **92,** cooperates with the pinion **55** on the shaft **53** of the plate **56** to position the same with respect to the plate **48** for positioning the head frame **40** about the second axis of pivot. A second locking member (not shown) cooperates with the rack member **92** and the pinion **55** to lock the plate member **56** about this second axis of pivot and hence to secure

the position of the head frame **40** with respect to the support vehicle about this axis of pivot whenever a desired angular position of the drilling has been reached.

The head frame **40** is basically composed of the guide or side frame members **65, 66,** with the top and bottom plates **67,** and **68** to provide the generally rectangular configuration upon which the drilling head, indicated generally at **110,** is slidably mounted and adapted to be reciprocated or advanced from one end to the other in a drilling operation. Mounted on the top of the head frame **40** is a feed drive assembly, indicated generally at **120,** which is coupled to the drill head **110** through feed chains **125.** It moves the drill head **110,** which is slidably mounted and guided on the side column members **65, 66,** of the head frame **40** from an elevated position to extreme feed position in which the drill head is adjacent the bottom plate **68** of the head frame and with reciprocation of the drill head to add additional drill rods to a drill string in a series of steps to drill to a desired depth. In the withdrawal mode of operation, the head frame is driven through the feed drive assembly **120** to retract the drill head in a series of steps of reciprocation of the drill head permitting withdrawal of the drill string, indicated generally at **130,** from a bore hole or blast hole site. The drill rods **139** or sections in a drill string **130** which are coupled to the drilling head, mount a drilling tool **140** at the end of the same with the cutting teeth thereon and as the bore hole is deepened or extended, the individual drill rods or sections, such as is indicated at **139,** are added to the drill tool to make the overall drill string which is operatively positioned from the drill head both in a rotational manner and in a feed manner. A recessed surface in the lower plate **68** permits the drill string to pass along the edge of the same so that it is supported by the drill head which is carried by the head frame for feeding purposes.

As will be hereinafter indicated, the motors associated with the drill head and the feed drive assembly along with the actuators **90** and **80** for positioning the drill head or head frame with respect to the support vehicle and the stabilizing actuators **25** as well as the drive mechanism within the support vehicle will all be powered hydrostatically from a hydraulic source driven by the power plant of the support vehicle. Suitable flexible pipe or conduit supply fluid power to these various actuators to permit rotation of the same where rotary fluid motors are used and for extending and retracting the hydraulic rams or cylinders where linear type actuators are used with the fluid lines providing supply and return passages to the hydraulic power system associated with the support vehicle.

Considering the drill head which will be seen in plan and sectional views of FIGS. **3, 4,** and **5,** it will be seen that the drill head **110** is formed basically of a plural part casing member which is guided on the columns **65,** 66, of the head frame **40,** through flange portions which have generally U-shaped extremities and mount suitable guide material or bearing blocks **145** which engage and space the case of the head frame on the column member **65, 66,** for sliding motion. I have found that Nylitron guide inserts suitably attached to the flange portions are suitable for this purpose in providing load bearing and guiding means with a minimum of friction. One of the sides of the flange portions **143,** 144, is suitably bolted to the case member as indicated at **146,** to permit assembly and removal of the drill head **110** from the head frame **40** for installation and/or maintenance purposes. Within the multipart case structure is mounted a drive spindle, indicated at **150,** which couples to the drill rods or bits **139** through a coupling member **152.** The case of the drill head also mounts a drive motor **160** which will be hereinafter noted, provide for rotation of the spindle, the latter being hollow as at **154** to provide fluid passage or air passage through the spindle for purposes to be later noted. The case of the drill head has a top removable cover portion, indicated at **165,** which is secured thereto through bolt means **166,** this cover portion having rotary seal members **167** at the upper surface of the same and around the spindle which in turn is journaled in the case through bearing means **170** formed by conical roller bearings at the upper side of the same. A similar set of conical roller bearings **170** are mounted on the lower side of the same and are installed through a removable plate portion **172** on the case which is similarly bolted to the case proper through bolt means **173.** Within the case member or drill head **110,** shoulder portions provide for positioning of at least one portion of the bearing means **170** and the parts of the case member forming the same, where not held together by bolts, are suitably welded to provided an integral structure. The top bearing mounts for the spindle **150** are secured to the spindle through pressure nuts **174** and a suitable drive gear **175** is positioned at the center of the spindle **150** and locked therein through key members **176** to be integral with the spindle member and drive the same. The front portion of the case member or drill head includes the mounting for the fluid motor or torque motor **160** whose output shaft **180** carries a pinion **182** which meshes with the teeth of the drive gear **175,** the shaft **180** being suitably journaled through ball type bearing members **183** at the top and bottom of the case member to mount and journal the same thereon. The housing of the motor **160** includes flange sections **184** through which apertures permit mounting bolts **185** to extend for the purpose of securing the rotary fluid motor **160** to the case member or drill head. The coupling member **152** has a splined outer surface fitting into a cooperating splined surface in the drive spindle **150,** as indicated at **188** for the purpose of providing a positive rotating torque to the drill string **130.** This coupling member **152** is secured to the underside of the case through bolt means **189** and suitable transversely extending apertures or recesses **190** permit the entrance of the tool after the bolts have been removed to remove the coupling member when adding additional drill rods or removing the same from a drill string. The individual drill rods proper **139** have a threaded upper extremity **192** which permits connection to the coupling member **152** or adjacent rods. A spacing **193** between the threaded extremity of the coupling member **152** and the ends of the rods **139** provide access to the mounting bolts of the coupling **152** for installation and removal of the same.

In FIG. **5,** it will be seen that the flange portions **143** and **144** of the drill head or case member include cylindrical coupling members **199** by means of which the chains **125** connect to the drill head **110** for the purpose of slidably positioning the same on the head frame **40.** The chains **125** terminate in threaded bolt sections **210** and these threaded bolt sections thread into the cylindrical members **199** in the drill head **110** to secure the chains **125** thereto. Suitable locking nuts **200** lock

this threaded connection. As will be seen in FIGS. 4 and 5, the upper end of the rotary drive spindle **150** in the drill head includes internal threading **215** and a suitable pipe type connector member **216** is threaded into the same for the purpose of introducing air under pressure to feed the drill tool **140** through the hollow drill rod for operation of the drill tool. The pipe **216** is connected to flexible hosing through a rotary coupling member (not shown) to permit rotation of the pipe member **216** with the spindle **150** and an air tight fitting at this point.

The drill head **110** is positioned along the extent of the column **65, 66,** of the head frame **40** in the withdrawal and feed mode of operation through the feed drive apparatus, as best seen in FIG. **6.** The upper connecting plate **67** of the head frame **40** mounts a generally U-shaped frame member **220** which has apertures or recesses through the upstanding sides of the same, as indicated at **222,** in which are positioned bearing members **225** for the purpose of supporting a drive shaft **228** therein. The drive shaft mounts drive sprocket members **230** over which the chains **125** are positioned. The sprocket members **230** are held in position on the shaft **228** through conical keys and locking members **232** and spacers **233.** This portion of the mounting frame **220** mounts the outer case **242** of a speed reducer, indicated generally at **240,** the outer cylindrical case **242** being secured to the member **220** through suitable bolt means **243.** This speed reducer is called an harmonic drive and is the product of United Shoe Machinery Corporation. It includes basic parts identified as an outer circular spline **245** which is bolted to the outer case **242** through a suitable cover plate **244.** Positioned adjacent with the outer circular spline and meshing with the teeth of the circular spline is a flexible spline or cup shaped structure **248** with a wave generator member **250** positioned interior thereof. The cup shaped flexible spline **248** with its toothed surface is connected by bolts **262** to an enlarged flange portion **260** on the end of the shaft **228** which is formed integral with shaft **228.** The enlarged flange portion **260** of the shaft **228** has a recess **264** at the exposed end of the same in which bearing means **265** are positioned for the purpose of mounting an input shaft **270** of the feed drive assembly. The input shaft **270** mounts the wave generator member **250** of the harmonic drive through a suitable positioning spacer member **272** which is keyed to the shaft through a bolt means **273.** The shaft **270** is journaled near its opposite extremity through bearing means **275** mounted in the cover plate **244** of the outer cast **242** of the harmonic drive to support the shaft **270** at two points along its extent with an overhang extending beyond the cover member **244** which mounts a further speed reducing gear **280** meshing with a pinion **282** carried by the output shaft **283** of the rotary fluid variable speed drive motor **285** of the feed assembly. The latter is carried by a mounting flange **286** which is secured to the outer case **242** of the speed reducer to support the same at the end of the head frame **40** through the frame member **220** connected thereto. Thus, the speed reducer basically has its input section suspended cantilever fashion on the end of the chain drive shaft **228** and through the supporting casing **240** of the harmonic drive attached thereto to provide an overall compact structure attached to the head frame **40.** A suitable enclosing cover **290** fits over the gears **280** and **282** to protect the same. The rotary fluid motor **285** may take varying forms and is of the type which has variable speed from 0 to 360 rpm's to cooperate with the speed reduction of the pinion **282** and drive gear **280** and the further reduction in the harmonic drive wherein a fixed speed reduction commensurate with the specifications of the speed reducer or harmonic drive is added to reduce the ultimate speed of the drive shaft **228** driving the sprockets **230** for the chains at a relatively slow speed and high thrust for the feed purposes. As an example, the drive shaft **228** has a maximum speed of approximately 7 rpm to provide a feed rate through the rotary fluid motor **285** at a drive speed of approximately 100 to 300 rpm input for 3 inches to 10 inches feed rate for the drill head **110.** This drive assembly permits a high thrust infeed to the drill string and a more rapid withdrawal after a drilling operation by increasing the speed of the motor **285** from the range of 300 rpm to 3600 rpm to increase the withdrawal rate or chain speed rate from 10 inches to 115 inches per minute. Fluid input through the hydraulic motors **285** to **160** are variably controlled through the control valves (not shown) incorporated into the control console **30** of the vehicle. The valving of the fluid through the flexible conductors leading to the rotary fluid motors provides for varying the input speeds for feed rate and withdrawal rate with varying torque output in terms of the feed drive assembly on the head frame and for variable torque or rotation of the spindle in the drill head **110** for drilling purposes. Thus, the torque range of the drive motor **160** has a rotational speed from 0 to 50 rpm and a torque rate from 600 to 8000 inch pounds of torque for normal drilling purposes.

We have found that a rotary fluid motor of the type manufactured by Vickers Manufacturing Co., Model MFBS piston motor is suitable for the feed assembly drive motor **285** while a rotary fluid motor of the type manufactured by Char-Lynn Manufacturing Co., of Minneapolis, Minnesota, Type DPS and having a maximum torque of 3000 inch pounds and a maximum speed of 137 rpm is suitable as the torque drive motor for the drill head **110.** Similarly, the harmonic drive component or speed reducer **240** is of the type manufactured by the Harmonic Drive Division of the United Shoe Machine Company of Beverly, Mass., and we have found that the type No. HDUC 80 258 1 is suitable for this application to provide for the rates identified above when coupled with the Vickers drive motor.

At the end of the drill rod is mounted the drill tool **140** which is shown in FIG. **7.** This is a special drill manufactured by the Mission Manufacturing Co. of Houston, Tex., under the trade name Megadril, Model A 53-15. Since its details form no part of the present invention, it will be described only generally as a pneumatically operated bottom hole drilling tool whose piston blows at the end of the drill bit are transmitted directly to the cutting surface and without loss of energy through the drill rods supporting the same. The air for operating the drilling tool **140** is fully used for rapid impacting or providing the percussive action of the drilling tool and for lifting cuttings from the drill hole. Thus, as shown in FIG. **7** at **140,** this drilling tool includes an outer drill casing structure **300** having a tapered adaptor type fitting **301** at the upper end of the same in which a tapered extremity **302** of the threaded extremity of the drill rod **139** fits for providing the air

passage or air inlet into the same. The casing is a plural part structure with an impacting tool portion **310** having cutting teeth **315** mounted at the end of the same. Internally, a slidable piston member **320** provides the impact action to the impacting end of the cutting tool, with the cutting tool or impact portion being slidably mounted in the casing as is the piston **320.** Suitable air diverting or valving means **325** positioned internally with the drilling tool provides the percussive action of the air and air passage, such as is indicated at **330,** provide excape of the used air through the impact end **310** for the purpose of removing particles cut by the end drill teeth. In addition to the percussive action, the rotary action of the spindle **150** and the drill string or drill bits coupled to the tool **140** will rotate the entire assembly in a drill cutting operation. With the improved drill tool separated from the drill string **130,** impact forces are removed from the drilling head **110** and the head frame **40** so that the drilling forces applied from the drill head **110** are the feed force at a relatively low speed and the rotational torque applied from the drilling head **110** through the drill string to the drilling tool **140.** This significantly simplifies the power train which must be connected to the drilling head **110** and the power source which is supplied from the support vehicle. It further eliminates the requirement of securing the machine in place during a drilling operation. In operating the drill tool **140,** normal compressed air pressure at a mine site permits coupling of a flexible hose (not shown) to the pipe **216** of the rotary spindle **150** in the drill head **110** so that compressed air may be fed to the drill tool directly and apart from the support vehicle **10** for the drilling operation. All of the other power from the support vehicle is utilized for positioning the head frame **40** positioning the support vehicle **10,** infeed and withdrawal of the drilling head **110** and the rotation of the drill tool **140** through hydraulic self-contained power supply on the support vehicle and powered from the diesel or gasoline engine plant or in the case of an electric drive from the electric source of power coupled thereto. This provides for increased mobility at a drill site with a minimum amount of setup time and a minimum in drilling time.

Therefore, in the operation of the improved mobile drilling machine or blast hole drill apparatus, whether above or an underground operation, the self-contained structure may be readily positioned at a desired drilling site in the head frame **40** pivoted to varying angles and positioned for any desired of drilling angle or mode with respect to a particular location. The stabilizing actuators **25** are extended to rigidly support the vehicle at a particular drilling location and when the head frame **40** is positioned for the desired drilling angle with respect to any surrounding terrain, the lock mechanism, such as is indicated at **85,** secures the head frame **40** in the desired position with respect to the support vehicle **10** eliminating the effect of hydraulic creepage. Hydraulic fluid power can then be utilized for feeding or operating the feed assembly **120** and the torque motor **160** on the drill head **110** for performing the drilling operation. Initially, the drilling tool is coupled to the spindle **150** for the initial penetration and as increased depth is required, additional rods **139** are added to the string **130** by the removal of the connection between the drilling tool **140** and the drilling head **110** after maximum infeed so that the length of the drill string may be increased. The hollow passages through the drill rods provide the air flow conduit to the drill tool **140** from the drilling head **110** and the rapid retraction rate of the drill head **110** on the head frame **40** insures the reduction of the overall drilling time as additional rods are added in a drilling operation. Similarly, after the drill hole has been completed, the process is reversed and the individual rods **139** are removed by withdrawal at a higher withdrawal rate than at an infeed rate to cut down on withdrawal time and to permit rapid disassembly of the drill string to enable a more rapid drilling operation. Our improved drilling machine provides a controlled infeed rate at a desired speed level or effective drilling through a combination of a fluid drive motor **285** and speed reduction couplings which minimize gearing and provide for low speed high powered input movements to the drill head or drive shaft **228** on the head frame **40** for infeed and withdrawal purposes.

In considering this invention, it should be remembered that the present disclosure is illustrative only, and the scope of the invention should be determined by the appended claims.

What we claim is:

1. A mobile drilling machine comprising, a mobile steerable support vehicle, a head frame, means pivotally mounting the head frame on one end of the support vehicle at a point intermediate the extent of the head frame and through at least one pivot axis, a drill head slidably mounted in the head frame and adapted to be reciprocated from one end of the head frame and to the other, said drill head including flanged extremities at the edges of the same and bearing material mounted in the flanged extremities on three sides thereof and bearing against three surfaces of each side of the head frame for slidably mounting the drill head on the head frame, a drive shaft positioned on said one end of the said head frame and having a reversible drive motor and a speed reducer attached to one end of the shaft thereof, sprocket wheels mounted on the shaft, stud shafts positioned at the other end of the head frame and mounting sprocket wheels thereon, said reversible drive motor including a rotary hydraulic motor and a harmonic speed reducer connected thereto and coupling the rotary drive motor to the drive shaft to impart reduced and variable and reversible rotation to the drive shaft and the sprocket wheel thereon, drive chains positioned over the sprocket wheels at the ends of the head frame and connected to the drill head for reciprocating the same in the head frame, an offset drilling motor mounted on the drill head and adapted to mount and rotate the drill rod thereon to extend toward said other end of said head frame, a drill tool means having additional drive means mounted on the rod for providing impact action to a portion of the drill rod, and means connected to the head frame and the support vehicle for pivoting the head frame through varying drilling angles with respect to the support vehicle and for locking the head frame in the various pivoting positions to effect drilling through the drill motor and the motor driving the drive shaft on the head frame.

2. The mobile drilling machine of claim **1** and including stablizing jack means positioned at the four corners of the support vehicle for stablizing the same in a drilling operation.

3. The mobile drilling machine of claim **1** in which means is connected to the head frame and the support vehicle for pivoting the head frame includes a single hy-

draulic actuator for pivoting the head frame and an adjustable screw shaft for locking the same.

4. The mobile drilling machine of claim **2** in which the bearing material mounting the drill head on the head frame is composed of a plastic antifriction material.

5. The mobile drilling machine of claim **4** in which the separate drill tool means mounted on the drill rod includes a separate drilling tool powered through the drill rod and providing oscillating impact action to a portion of the drill tool defining the cutting surface of the drill tool.

6. The mobile drilling machine of claim **1** in which the harmonic speed reducer is a three part element including an outer part mounted through bracket means on the end of the head frame and including the drive shaft with the sprockets thereon being journaled in the mounting flange carrying the outer part and having an inner part mounted on an input shaft which is journaled in part on the outer part and in part on the drive shaft and having a rotary drive motor connected thereto with a flexible coupling which couples the outer and inner parts and is mechanically connected to the drive shaft for imparting rotational output of the speed reducer to the drive shaft.

7. The mobile drilling machine of claim **6** in which the flexible coupling and the drive shaft provide the journaling for the input shaft which is mounted cantilever fashion with the drive motor on the bracket means and coupled thereto by additional speed reducing gearing.

8. The mobile drilling machine of claim **7** in which the support vehicle includes a motive source for providing hydraulic fluid power to drive the support vehicle and to provide through flexible connections a source of motive power to the drill motor mounted on the drill head and the drive motor on the head frame.

9. The mobile drilling machine of claim **8** in which the mobile steerable support vehicle is a wheeled self-propelled unit.

10. The mobile drilling machine of claim **1** in which the means pivotally mounting the head frame on the support vehicle includes bracket means having a first pivot axis coupling the bracket means to the support vehicle about a first axis of pivot and a second pivot axis normal thereto coupling the head frame to the bracket means.

11. The mobile drilling machine of claim **10** in which the means on the head frame and support vehicle and connected there between for connecting the head frame includes separate motive means for pivoting the head frame about the pair of axis on the support vehicle and independent of one another.

12. The mobile drilling machine of claim **11** in which the two axis of pivots of the means pivotally mounting the head frame includes separate hydraulic actuators and means for locking the head frame in a pivoted position on the support vehicle.

13. The mobile drilling machine of claim **10** in which the means pivotally mounting the head frame on the support vehicle includes bracket means having a first pivot axis coupling the bracket means to support vehicle through a first axis of pivot and a second pivot axis normal thereto coupling the head frame to the bracket means about the second pivot axis and including means on the bracket means and on the support vehicle for positioning the head frame about said first and second pivot axis selectively and independently of one another.

14. The mobile drilling machine of claim **13** in which the drill tool includes impact motor means mounted on the end of the drill rod and adapted to receive a source of motive power coupled through flexible connections from the support vehicle to the drill head and through hollow drill rod to the impact tool.

15. The mobile drilling machine of claim **1** in which the drill tool means mounted on the end of the drill bit includes a drilling tool having an impact motive means and in which the drill rods are hollow and the drill head includes a hollow coupler means adapted to be connected to a pneumatic source for powering the motive of the drill tool to provide the impact action of the end of the drill rod with the drill tool thereon.

16. The mobile drilling machine of claim **15** in which the steerable vehicle includes motive means driving a hydraulic pump with a self-contained hydraulic source and including hydraulic motors coupled to steerable wheels for driving the same and additional fluid connections connected to the drill motor and the drive motor on the drive shaft of the head frame, with a separate pneumatic source for imparting motive power to the impact means of the drill tool for drilling operation.

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