Oct. 11, 1966 E. V. BERGSTROM 3,278,235

VIBRATORY APPARATUS FOR PENETRATING EARTH MATERIAL AND THE LIKE

Filed Sept. 24, 1962 3 Sheets-Sheet 1

FIG. 3.

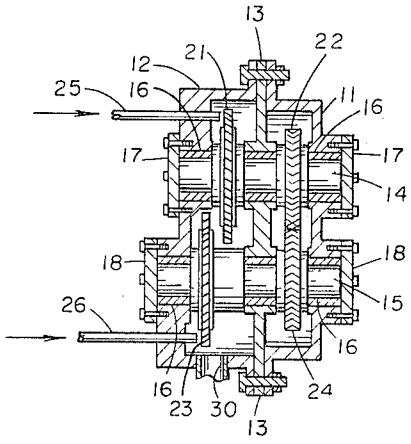


FIG. 4.

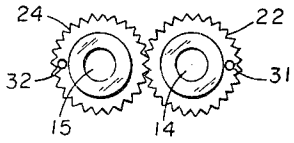


FIG. 1.

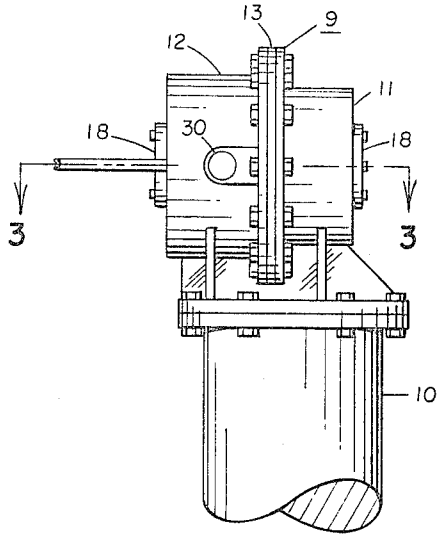
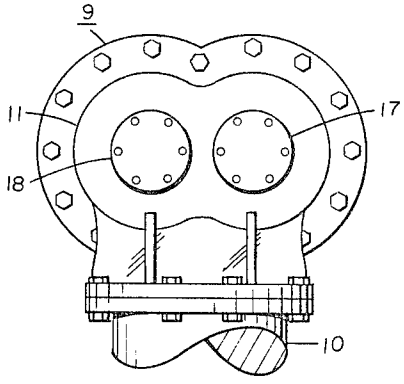


FIG. 2.



ERIC V. BERGSTROM
INVENTOR.

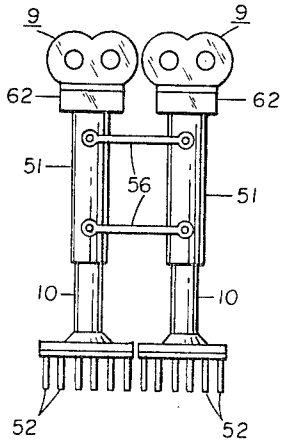
BY W. Mathews & Garland
ATTORNEY.

Oct. 11, 1966 E. V. BERGSTROM 3,278,235

VIBRATORY APPARATUS FOR PENETRATING EARTH MATERIAL AND THE LIKE

Filed Sept. 24, 1962 3 Sheets-Sheet 2

FIG. 6.



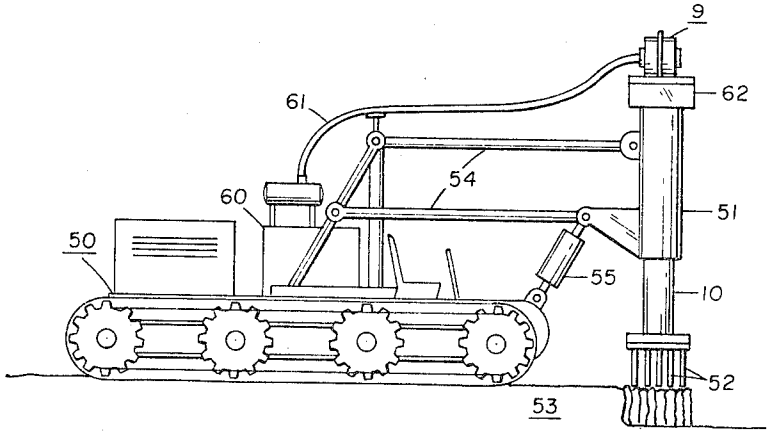


FIG. 5.

ERIC V. BERGSTROM
INVENTOR.

BY H. Matthews Garland
ATTORNEY.

Oct. 11, 1966 E. V. BERGSTROM 3,278,235

VIBRATORY APPARATUS FOR PENETRATING EARTH MATERIAL AND THE LIKE

Filed Sept. 24, 1962 3 Sheets-Sheet 3

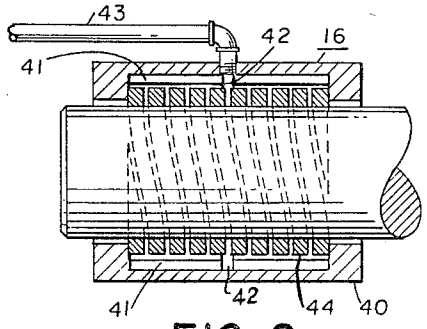


FIG. 9.

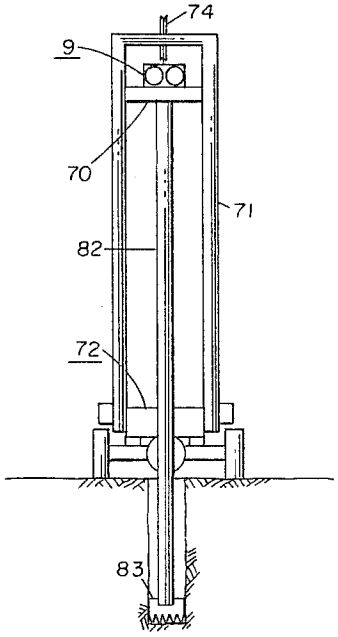


FIG. 8.

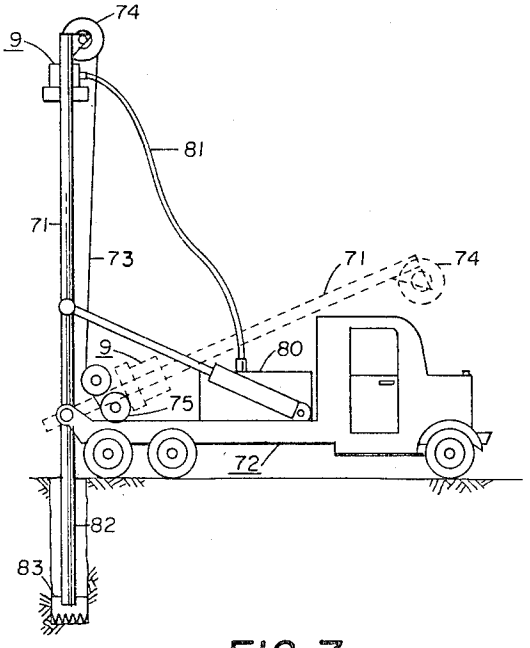


FIG. 7.

ERIC V. BERGSTROM

INVENTOR.

BY H. Matthews Garland

ATTORNEY.

United States Patent Office 3,278,235 Patented Oct. 11, 1966

3,278,235

VIBRATORY APPARATUS FOR PENETRATING EARTH MATERIAL AND THE LIKE

Eric V. Bergstrom, Byram, Conn., assignor to Mobil Oil Corporation, a corporation of New York

Filed Sept. 24, 1962, Ser. No. 225,585
5 Claims. (Cl. 299—37)

This invention relates to vibratory type apparatus which is useful in carrying out various methods of penetrating solid material. More specifically, this invention relates to fluid turbine actuated vibratory apparatus which is particularly suited to drilling or otherwise breaking up and pulverizing solid forms of material such as those which comprise the earth's structure.

The use of vibratory systems for solid material penetration has been suggested. The presently available vibratory mechanisms are, however, limited in their applications. Such systems are unnecessarily complicated in structure and do not have the frequency range desired for many operations carried out by the oil industry. Particularly, present systems are not capable of sustained operation in high frequency ranges, such as 2,000 to 30,000 cycles per minute. For example, portable, simply constructed vibratory mechanisms are desirable for such operations as shot-hole drilling in geophysical work and in the mining of oil shale. Oil shale is often a rather hard substance which must be broken up into relatively small pieces for the necessary processing operations to remove the oil from the shale.

It is one object of the invention to provide a mechanical vibratory prime mover which is simple in construction and which may be operated over a wide range of frequencies. It is another object of the invention to provide a mechanism for drilling wells which utilizes the vibratory principle. It is another object of the invention to provide a vibratory type mechanism for the mining of oil shale. It is a further object of the invention to provide a vibratory type prime mover which is actuated by a turbine type power source capable of operating in high frequency ranges. It is a still further object of the invention to provide a form of bearing which may be used under the rapidly fluctuating load conditions encountered by a vibratory type prime mover.

In accordance with one aspect of the invention, a housing is secured by relatively stiff connecting means to material cutting means. Positioned within the housing are two shafts which are aligned parallel to each other and perpendicular to the longitudinal axis of the connecting means. Secured on each of the shafts is at least one turbine wheel for rotating the shafts in response to fluid under pressure supplied to the turbine wheels through nozzles secured through the housing. The shafts are provided with meshing gears to synchronize the speeds of the shafts and turbine wheels. A condition of unbalance is established in each of the shaft-turbine wheel-gear assemblies in such a manner that the unbalance is additive in a direction along the longitudinal axis of the connecting means and is cancellative along a line transverse or perpendicular to the longitudinal axis of the connecting means. In accordance with another aspect of the invention, the vibratory system just described is employed with motive means which supports the system and moves it along the surface of the material to be penetrated. The connecting means may be provided with cutting means, such as a drill bit for drilling wells or chisel type elements for cutting and pulverizing relatively hard material, such as oil shale. In accordance with still another aspect of the invention, there is provided a journal type bearing which comprises a helical spring positioned in a chamber around the shafts employed. Oil is injected into the chamber to lubricate the surfaces of contact between the springs and the shafts.

Other objects and advantages of the invention will be evident from the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a side view in elevation of one embodiment of a vibratory type prime mover constructed in accordance with the invention;

FIGURE 2 is an end view of the prime mover illustrated in FIGURE 1;

FIGURE 3 is a view in cross section taken along the line 3—3 of FIGURE 1;

FIGURE 4 is a side view in elevation of the gears employed in the prime mover of FIGURES 1–3;

FIGURE 5 is a side view in elevation of an oil shale mining system in accordance with the invention;

FIGURE 6 is a front view in elevation of the vibratory assemblies employed with the mining system of FIGURE 5;

FIGURE 7 is a side view in elevation of a well drilling system in accordance with the invention;

FIGURE 8 is a rear view in elevation of the drilling system of FIGURE 7; and

FIGURE 9 is a longitudinal, cross-sectional view of a preferred form of sleeve type bearing assembly for use in the vibratory type prime mover illustrated in FIGURES 1–3.

Referring particularly to FIGURES 1 and 2, vibratory prime mover **9** is supported on the end of column **10** which, as illustrated, is a section of cylindrical pipe. Column **10** serves to support the prime mover and transmit vibrations from it to whatever cutting means are secured to the other end of the column. Obviously, column **10** may be constructed with other cross-sectional shapes and may also be a solid member. The housing of the prime mover comprises portions **11** and **12** which are secured together by any desired means, such as bolting. In joining portions **11** and **12** of the housing, an effective seal must be made between the two portions to contain the pressure of the turbine actuating fluid which will be exerted within the housing. Any effective means of securing the housing to column **10** may be employed, bolting having been chosen in the illustrated embodiment because of the ease of assembly and disassembly it provides. As may best be observed in FIGURE 3, a plate **13** is positioned between portions **11** and **12** of the housing. Plate **13** functions as a bearing support member and may serve to divide the housing into two compartments, one enclosing the turbine wheels and one enclosing the gears. Secured within the housing are shafts **14** and **15** which are supported by a plurality of bearings **16**. Secured to the housing over the ends of shaft **14** are closure members **17**, and secured to the housing over the ends of shaft **15** are closure members **18**. The longitudinal axes of shafts **14** and **15** are substantially parallel to each other and lie in a common plane which preferably is approximately perpendicular to the longitudinal axis of column **10**. Bearings **16** are of a type which are capable of withstanding high rotational speed and rapid vibratory impact, such, for example, as 30,000 revolutions per minute and 30,000 impact cycles per minute. One form of bearing **16** which may be employed is illustrated in FIGURE 9. Two of the bearings **16** are positioned through plate **13**, as shown in FIGURE 3. Secured on shaft **14** are turbine wheel **21** and gear **22**. Secured on shaft **15** are turbine wheel **23** and gear **24**. Turbine wheels **21** and **23** are identical to each other in all respects except that the blades in the wheels are positioned in opposite directions since the wheels must turn in opposite directions. In order to facilitate the compactness of the assembly and to avoid interference between the

two turbine wheels, the respective positions of the turbine wheels on the shafts are offset to provide a noninterfering overlap, as illustrated in FIGURE 3. It will be recognized that the apparatus may be constructed with shafts **14** and **15** spaced apart a greater distance to permit turbine wheels **21** and **23** to be located at the same respective position on the shafts without interference with each other. Nozzles **25** and **26** are secured through the housing to permit the introduction of fluid for driving the turbine wheels. Nozzle **25** provides fluid to drive turbine wheel **21**, and nozzle **26** provides fluid to drive turbine wheel **23**. While several types of fluids may be employed for actuating the turbine wheels, it is preferred that the vibratory prime mover illustrated be operated by compressed air which is supplied through the nozzles. Conduit **30** is connected into the casing to permit the actuating fluid to flow from the casing after striking the turbine wheels. Gears **22** and **24**, which in the preferred embodiment are provided with herringbone type gear teeth, are positioned at identical locations on their respective shafts so that they will mesh with each other. The sole function of the gears is to synchronize the speeds of the turbine wheels and their respective shafts.

In each of the turbine wheel-shaft-gear assemblies, turbine wheel **21**-shaft **14**-gear **22** and turbine wheel **23**-shaft **15**-gear **24**, there is established a condition of unbalance by the addition of weight to or the removal of weight from either the shafts or the gears. The conditions of unbalance are provided in such a manner that they will add to each other in a first direction and will cancel each other in a second direction which is perpendicular to the first direction. By way of example, one way of establishing the desired condition of unbalance in the assemblies shown is illustrated in FIGURE 4, which is a plan view of the meshing gears **22** and **24**. A small amount of metal is removed from each of the gears by drilling hole **31** in gear **22** and hole **32** in gear **24**. By positioning holes **31** and **32** as illustrated in FIGURE 4, the conditions of unbalance will be additive in a vertical direction and will cancel each other in a horizontal or lateral direction, since the holes will reach their maximum upper and lower limits of travel simultaneously and also will be at opposing positions in a horizontal direction at the same time. In other words, in a vertical direction the holes will move into phase, while in a horizontal direction the holes will be 180° out of phase so that the conditions of unbalance in the two assemblies are added together to drive the column **10** in a vertical direction but cancel each other out in a direction perpendicular to the longitudnial axis of column **10** so that there is no horizontal driving or movement of the column. Obviously, since the conditions of unbalance in each of the assemblies are intended to cancel each other out in a lateral or horizontal direction, the magnitude of the unbalance in each of the assemblies should be substantially equal to each other. It will be evident that the conditions of unbalance may be established by the removal of weight from either the shafts or the gears, or weight may be added to either the shafts or the gears, such as by welding a small spot of metal at the desired location on the assemblies. The magnitude of the driving force exerted on column **10** by the unbalanced condition in the assemblies will be dependent upon the amount of unbalance established, together with the rotational speed of the assemblies.

As previously indicated, bearings **16** must be of a type capable of withstanding substantial vibratory action at speeds ranging from 2,000 to 30,000 revolutions per minute. One preferred form of bearing **16** is illustrated in FIGURE 9. Referring specifically to FIGURE 9, a cylindrical housing **40** is positioned around a shaft, which in this particular application would be shaft **14** and/or shaft **15**. The housing **40** is provided with a plurality of oil grooves **41** which extend in the housing along the length of the shaft to facilitate distribution of lubricating oil. Also formed within the housing is an oil groove **42** which extends completely around the internal surface of the housing in a plane substantially perpendicular to the longitudinal axis of the shaft. Oil groove **42** communicates with each of the oil grooves **41** to facilitate distribution of the lubricating oil around the entire internal surface of the housing. Connected into the housing in communication with the oil groove **42** is a conduit **43** through which lubricating oil is supplied under pressure. Positioned within the housing around the shaft is a bearing **44** which is constructed in the form of a helical spring. The helical spring type bearing **44** is constructed of a spring type steel to provide a very hard bearing surface. If desired, two springs may be used having dimensions which will permit them to be threaded together in order to increase the bearing surface available and still provide ample openings through which oil may flow in between the surface of the shaft and the internal surfaces of the bearing element. The advantages inherent in the use of a helical spring type bearing element are severalfold. Such a bearing element may be readily constructed from available materials and by known production practices. Furthermore, such a bearing element, due to its helical spring type construction, provides a plurality of openings through which lubricating oil may readily flow to the surface of the shaft. It should be pointed out that no spring action is involved in the function of the bearing element. The spring configuration is merely a means of achieving simplicity of construction and thoroughness of lubrication. The oil enters the housing through conduit **43** and is evenly distributed throughout the internal surface of the housing through oil grooves **42** and **41**. Subsequent to performing its lubricating function, the oil may be permitted to flow around the shaft into the housing of the vibratory prime mover from which it may be conducted through a common line, not shown, to an oil sump, not shown. On the other hand, since a portion of the oil utilized in lubricating the bearings may become entrained in the air used to actuate the turbine wheels, it may be preferred that means be provided which will prevent any mixing of the oil and the air. In this latter case, it is preferred that an oil return line, not shown, be connected into each of the bearing housings to allow the oil from each of the bearings to be returned to a common oil reservoir or sump. Should the bearings be constructed with individual oil return lines, it is preferred that each of the bearings be provided with oil seals at the ends of housing **40** around the shaft. While such oil seals have not been illustrated in FIGURE 9, it will be obvious to those skilled in the art that many of the known type oil seals may be employed for this purpose.

Due to its simplicity of construction, the minimum number of moving parts utilized, and the reliability inherent in turbines, vibratory type prime mover **9** may be utilized in a number of systems in which vibratory action of the type provided by the prime mover is desired. Such a prime mover finds particular application in the material penetrating systems of the type illustrated in FIGURES 5–8.

In FIGURES 5 and 6 there is illustrated a system useful in the mining of oil shale, which is a relatively hard earth material from which oil may be refined after the material is removed from the earth and broken up. Referring specifically to FIGURE 5, tractor **50** may be any form of the commercially available tractors, particularly one of the crawler type which is equipped with an air compressor and may readily move along the surface of the material to be broken up. Vibratory type prime mover **9** is secured to the upper end of column **10** which is supported within a sleeve element **51**. Secured to the

lower end of column **10** are a plurality of chisels **52** which contact and break up the oil shale material **53**. Sleeve **51** is connected to tractor **50** by a plurality of elements which will be referred to collectively as support assembly **54**. Support assembly **54** is actuated by a hydraulic piston **55** connected between the support assembly and the frame of the tractor to allow the support assembly to be raised and lowered so that the chisel elements may be brought into contact with the oil shale material. An air compressor **60** mounted on the tractor is connected by line **61** to vibratory prime mover **9**. As illustrated in FIGURE 6, two vibratory systems, comprising prime mover **9**, sleeve **51**, column **10**, and chisel elements **52**, are mounted on the support assembly **54** of the tractor **50**. The vibratory systems are connected together by members **56**. It is to be understood, however, that the invention is not limited to the use of only two such vibratory assemblies.

Oil shale may often be mined in a manner requiring tunnels which will limit the size of the equipment which may be used. In this event, the tunnels will most likely be of a size which will limit the combined length of column **10** and chisels **52** to a range of about 10 to 15 feet. Such a length of vibrating systems will require a vibrating frequency of 20,000 to 30,000 cycles per minute for a condition of sonic resonance.

The device as shown in FIGURES 5 and 6 provides a very mobile mechanism for rapid pulverization of a floor of oil shale. The chisels **52** are lowered into contact with the surface of the oil shale and, by means of vibratory prime mover **9**, the chisels are rapidly driven into the oil shale to pulverize it. Once the chisels have reached the lower limit of their travel, they are lifted from the oil shale by means of piston **55** and support assembly **54** until they are at such an elevation above the oil shale floor that the tractor **50** may move to the next section to be pulverized. In working with the device, particularly on an oil shale floor, it may be preferred that weight be added to the vibratory system in addition to that provided by the weight of its several members. In such an event, weights **62**, as shown in FIGURES 5 and 6, may be secured between the prime movers **9** and columns **10**. It will be readily recognized that the use of a device as illustrated in FIGURES 5 and 6 is not limited to the pulverizing of a floor, but may also be used to break up vertical walls of the material which is to be pulverized. Support assembly **54** may be readily constructed such that the chisel elements **52** may be raised and directed against a vertical wall.

Another embodiment of a device utilizing vibratory action for material penetration is illustrated in FIGURES 7 and 8, which show apparatus for the drilling of wells, such, for example, as shot holes in geophysical operations and water wells. Referring specifically to FIGURES 7 and 8, a vibratory type prime mover **9** is supported on and secured to member **70** which is slidably mounted in an inverted U-shaped frame **71** secured to a movable vehicle **72** which may be a tractor or truck. Frame **71** is pivotally connected at its lower end to the vehicle such that the frame may be lowered, when not in use, into the position illustrated in the dotted lines in FIGURE 7. Prime mover **9** is movably suspended from a line **73** which extends over a sheave **74** mounted on the upper end of frame **71** and downwardly to a hoist **75** supported on the bed of the vehicle **72**. An air compressor **80** is mounted on the vehicle and is connected through hose **81** to the prime mover **9** to provide actuating fluid to the prime mover. Secured to the lower side of member **70** is drill pipe **82** which is provided with a drill bit **83**. Means, not shown, are provided for connecting drill pipe **82** to member **70** to facilitate easy disconnection of the drill pipe to allow the introduction of additional sections of drill pipe into the drill string as drilling progresses. It may be preferred that force be exerted on the drill bit in excess of that provided by the weight of the drill pipe and the prime mover **9**, in which event member **70** may be constructed of such a size and material to provide the desired weight, or additional weight or weights may be secured to member **70**. Drilling is carried out in much the same manner as with other types of drilling rigs. The drill bit **83** is placed in contact with the surface of the earth and air is supplied through hose **81** from compressor **80** to rotate the turbines within the vibratory prime mover **9**. The prime mover provides through the drill pipe **82** percussive blows on the drill bit to drive the drill bit into the ground. As the drill bit penetrates the earth, the prime mover and element **70** are lowered along with the drill pipe by means of hoist **75** and line **73**, with additional sections of drill pipe being added as necessary until the desired depth of well has been reached.

It will be readily recognized that the invention provides a highly versatile vibratory system which, due to the employment of fluid turbines, may be utilized over a wide range of operating speeds.

While the invention has been illustrated in connection with certain specific embodiments, it is to be understood that those applications shown are merely illustrative and various changes in design may be made within the scope of the following claims.

What is claimed is:

1. In a device for penetrating earth material and the like the combination which comprises:

(a) cutting means;

(b) a substantially rigid column secured at the lower end thereof to said cutting means;

(c) a housing secured to the upper end of said column;

(d) at least two shafts rotatably mounted in said housing, said shafts being positioned substantially parallel to each other and substantially perpendicular to the longitudinal axis of said column;

(e) bearing means secured between said housing and each of said shafts for supporting said shafts;

(f) a turbine wheel mounted on each of said shafts;

(g) means interconnecting said shafts to synchronize the speed of said shafts;

(h) means for effecting equal conditions of dynamic unbalance in each of the assemblies comprising a shaft and a turbine wheel, said conditions of unbalance being additive in a direction along the axis of said column and canceling each other in a direction perpendicular to the axis of said column;

(i) means for directing a fluid against each of said turbine wheels;

(j) motive means for moving said column along the surface of said material;

(k) means connected between said column and said motive means for supporting said column and moving said column relative to said material; and

(l) pump means for supplying said fluid under pressure to actuate said turbine wheels.

2. A device according to claim **1** wherein said cutting means comprises a plurality of chisel elements.

3. A device according to claim **1** wherein said cutting means comprises a drill bit and said rigid column comprises at least one section of drill pipe.

4. In a device for penetrating earth material and the like the combination which comprises:

(a) a housing;

(b) at least two shafts rotatably mounted in said housing, said shafts being positioned substantially parallel to each other;

(c) a turbine wheel mounted on each of said shafts;

(d) means positively interconnecting said shafts to synchronize the speed of said shafts;

(e) means for effecting equal conditions of dynamic unbalance in each of the assemblies comprising a shaft and a turbine wheel, said conditions of unbalance being additive in a first direction and cancelling

each other in a direction perpendicular to the first direction;

(f) means for directing a fluid against each of said turbine wheels;

(g) motive means adapted for movement along the surface of said material;

(h) a support frame supporting said housing upon said motive means;

(i) a drill pipe having its upper end connected to said support frame; and

(j) a drill bit connected to the lower end of said drill pipe.

5. In a device for penetrating earth material and the like the combination which comprises:

(a) a housing;

(b) at least two shafts rotatably mounted in said housing, said shafts being positioned substantially parallel to each other;

(c) bearing means secured between said housing and each of said shafts for supporting said shafts;

(d) a turbine wheel mounted on each of said shafts;

(e) means interconnecting said shafts to synchronize the speeds of said shafts;

(f) each shaft-turbine wheel assembly being provided with means to effect a condition of dynamic unbalance, the conditions of unbalance being additive in a first direction and cancelling each other in a second direction perpendicular to said first direction;

(g) means for directing a fluid against each of said turbine wheels;

(h) means for conducting said fluid away from said housing;

(i) motive means adapted for movement along the surface of said material;

(j) a support frame for supporting said housing upon said motive means;

(k) means for adjusting the position of said support frame into a substantially vertical position;

(l) a drill pipe having its upper end connected to said support frame; and

(m) a drill bit secured to the lower end of said drill pipe and adapted to penetrate said material.

References Cited by the Examiner

UNITED STATES PATENTS

1,454,682	5/1923	Layne	308—240
1,745,425	2/1930	Johnson	308—240
2,420,793	5/1947	O'Connor	259—1
2,491,558	12/1949	Hanson	308—240
2,840,354	6/1958	McKellar	74—61 X
2,904,320	9/1959	Salisbury	262—8
2,970,487	2/1961	Ongaro	74—61
2,975,846	3/1961	Bodine	173—49 X
3,008,776	11/1961	Love et al.	308—121
3,030,715	4/1962	Bodine	299—14 X

ERNEST R. PURSER, *Primary Examiner.*

BENJAMIN HERSH, CHARLES E. O'CONNELL, *Examiners.*