Jan. 12, 1971 P. E. CHANEY 3,554,602

EXCAVATING METHOD AND APPARATUS

Filed July 24, 1968

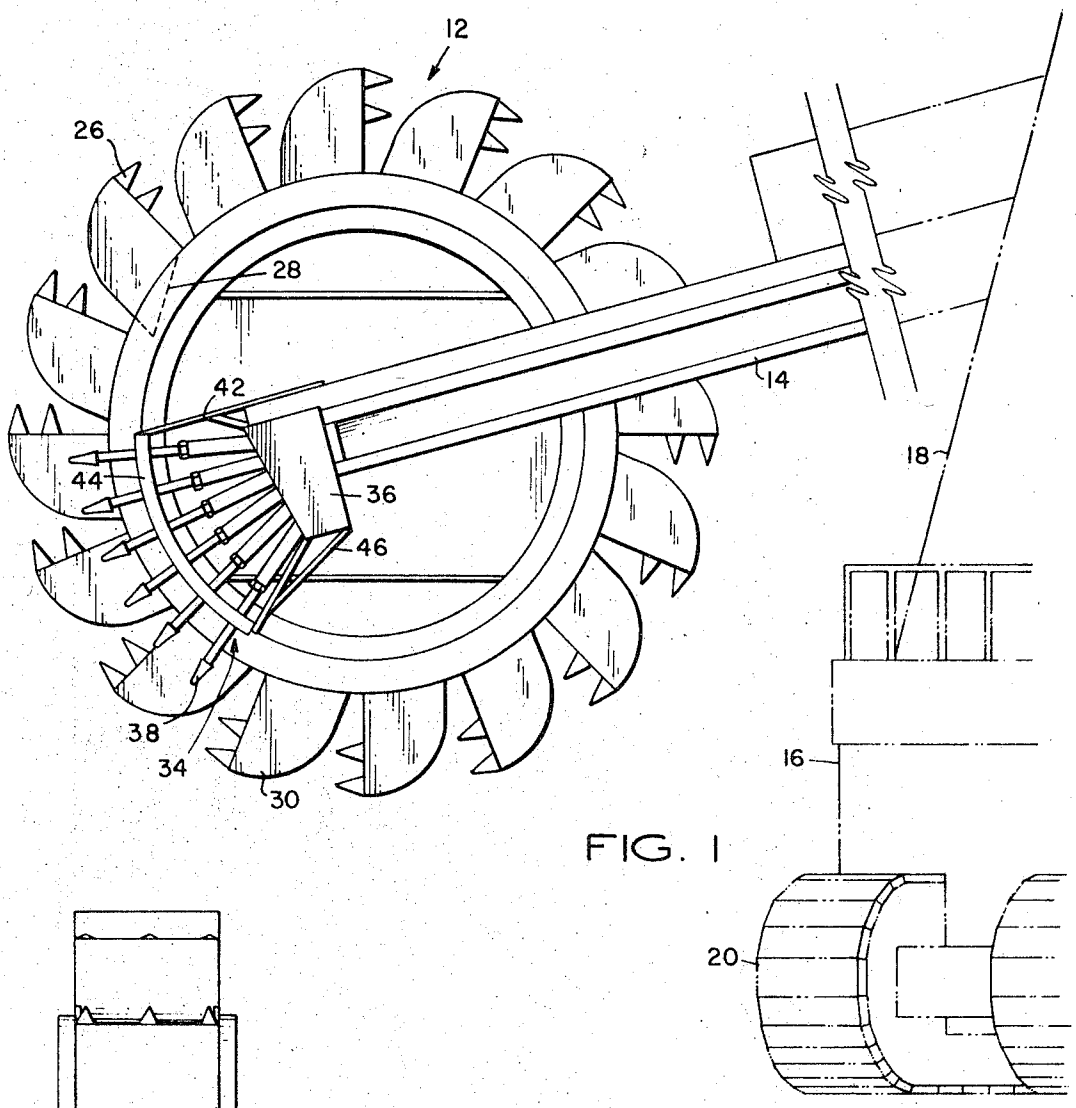


FIG. 1

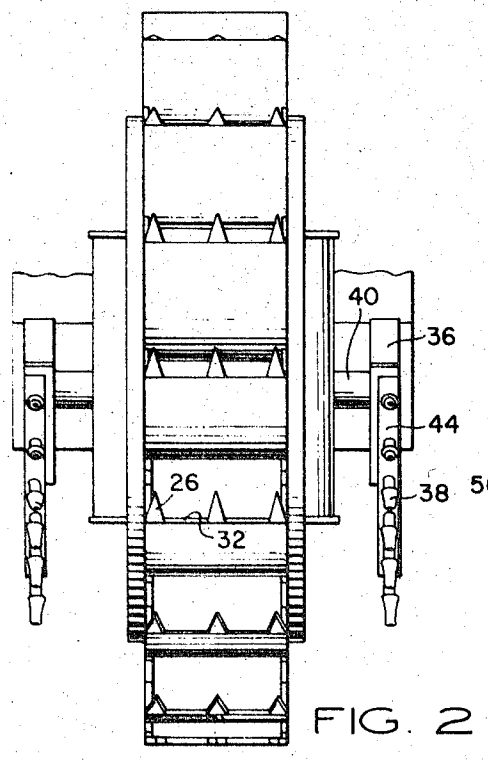


FIG. 2

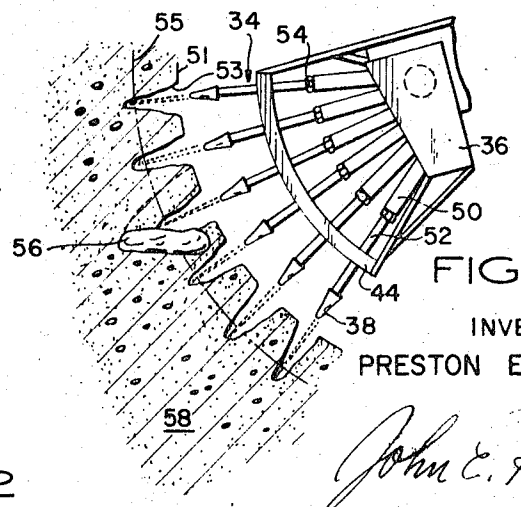


FIG. 3

INVENTOR
PRESTON E. CHANEY

John E. Holder

ATTORNEY

United States Patent Office 3,554,602 Patented Jan. 12, 1971

3,554,602

EXCAVATING METHOD AND APPARATUS

Preston E. Chaney, Dallas, Tex., assignor to Sun Oil Company, Philadelphia, Pa., a corporation of New Jersey

Filed July 24, 1968, Ser. No. 747,319
Int. Cl. E21c 25/60
U.S. Cl. 299—17 2 Claims

ABSTRACT OF THE DISCLOSURE

The embodiment of the invention described herein utilizes, in an earth excavating operation, fluid jets arranged to cut vertically spaced, horizontal recesses in the face of a formation being excavated. An earth excavating bucket engages the face of the formation after the recess has been cut therein.

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for excavating earth materials and more particularly, to an apparatus for excavating earth materials having hard materials embedded therein.

A problem associated with the excavating or mining of earth materials is the wear and breakage of earth contacting portions of excavating equipment. Such wear and breakage is normally the result of abrasion and impact with earth materials being excavted. An example of the problem involves the mining of bituminous tar sands.

The sands are composed of a siliceous material generally having a size greater than that passing a 325 mesh screen, saturated with a relatively heavy, viscous bitumin in quantities of from 5 to 21 weight percent of the total composition. The bitumin is quite viscous and contains typically 4.5% sulfur, and 38% aromatics. A specific gravity at 60% fahrenheit, ranges typically from about 1 to about 1.06. The tar sands also contain clay and slit in quantities from 1 to 50 weight percent of the total composition. Silt is normally defined as mineral which passes a 325 mesh screen, but which is larger than 2 microns. Clay is mineral smaller than 2 microns, including some siliceous material of that size. The composition described, together with the peculiar consistency due to its viscous nature, has been found to exhibit extreme wear properties on equipment normally used for excavating earth materials. Therefore it is desirable, in the design of such equipment, to use materials which exhibit good wear properties in such an environment. However, layers of hard rock material are often encountered in the formations containing the tar sands. Also, boulders or large rock masses are found embedded in the tar sands. Due to the encountering of such hard materials, it is costly to use some materials in the construction of excavating equipment which might otherwise be applicable, because of their wear properties. For example, tungsten carbide bucket teeth exhibit desirable wear properties for excavating the abrasive tar sand material, but are not compatible with the excavation of hard rock, because of the brittle nature of tungsten carbide.

The present invention is therefore directed to a method and apparatus for mining earth material, and in particular tar sands under the conditions described above.

At present, the Athabasca Tar Sand deposit is being mined by large bucket wheel machines. The bucket wheel is approximately 30 ft. in diameter and is mounted on the end of a boom which can be rotated about a vertical axis so as to move the bucket wheel horizontally. The boom is also capable of vertical motion so as to position the bucket at several elevations for working a mine face that is thicker than the cut of the bucket wheel. Specifically in this operation, the practice is to work about a seventy foot face in five horizontal passes of the bucket wheel. On each pass, the boom is rotated about the vertical axis through an angle of approximately 180°. At the end of one horizontal pass, the boom is moved vertically to the proper level for the next pass and the horizontal traverse is reversed so as to mine toward the starting point of the preceding traverse. After the five vertical cuts have been completed, the entire machine is advanced approximately two feet toward the working face and the entire process is repeated.

This is a very efficient and inexpensive mining technique for mining unconsolidated materials of moderately small particle size. While the bulk of the tar sand meets these requirements, there are unfortunately consolidated inclusions in the tar sand which seriously interfere with the operation of the bucket wheel machine. Some of these inclusions are in the form of horizontal lenses usually not more than twelve to eighteen inches thick and with horizontal dimensions in the order of ten feet. These lenses are composed principally of very fine grained silt stone cemented by minerals such as calcium, iron, or manganese carbonates. In addition to these lenses, there are boulders which may be roughly two feet thick and about three feet in each horizontal dimension.

While the lenses do interfere with the mining operation, they are less damaging to the equipment because they are generally thinner and also because their larger horizontal dimensions make it easier to detect their presence and adjust the speed of the machine to avoid damage. However, both the lenses and the boulders do serious damage to the bucket wheel under present operating conditions. Breakage of teeth is common, and buckling of the wheel itself has occurred in several cases.

The present invention contemplates an improvement in the bucket wheel machine to reduce the frequency and extent of damage resulting from either lenses or boulders encountered during the mining operation. The mechanism by which this modification reduces damage to the wheel is best understood from a study of what occurs when the bucket wheel encounters a ledge or boulder. First, we should note that the weight of a boulder of the dimensions described above is quite small compared to the capacity of the bucket wheel. Also, the lenses encountered in the tar sand, while they may cover a considerable horizontal area, are sufficiently thin that the bucket wheel would have no difficulty in breaking an unsupported section of the lens of a maximum size that could be encountered at the present cut depth and feed rate. The damage to the machine results not so much from the weight and hardness of the boulders and lenses, but rather from the fact that they are embedded in and supported by the surrounding tar sand.

When the bucket encounters either of these types of obstructions, the rock behaves somewhat like a piston which distributes the force of the bucket wheel from the small area of the wheel tooth to a very large area of tar sand surrounding the rock. This tar sand in turn supports the rock so as to minimize the bending stress which otherwise would be far in excess of that required to produce failure. The net result is that the bucket wheel is suddenly called upon to move the entire column of tar sand supporting the rock opposite the point of contact. Since the tar sand is only very slightly compressible and completely surrounds the rock, the resistance encountered by the wheel far exceeds its capacity and stalling or mechanical failure of some kind must result.

It is therefore an object of the present invention to provide a method and apparatus to reduce substantially the ability of earth formations to support hard objects, thus allowing the force of the bucket wheel to produce greater bending stresses and/or rotating moments in the hard

objects with the result that the hard object is either broken without damage to the wheel or is dislodged intact.

SUMMARY OF THE INVENTION

With this and other objects in view, the present invention pertains to a method and apparatus for excavating earth materials containing hard substances. An earth excavating apparatus is passed through a horizontal path while contacting the earth formation to be excavated prior to contact of excavator bucket members with the formation, jets of fluid are directed at the face of the formation. Such recesses provide relief in the over burden pressure which may be exerted on the hard materials embedded within the formation, so that upon contact of the excavating buckets with the hard materials, such materials are more easily dislodged from the formation.

A complete understanding of this invention may be had by reference to the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sied view of a bucket wheel excavator embodying principles of the present invention;

FIG. 2 is an enlarged front view of the bucket wheel excavator; and

FIG. 3 schematically illustrates the principle of operation of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, FIG. 1 shows a side view of an excavator wheel **12** mounted on a boom **14**. This structure forms a part of an excavator apparatus, including a support structure **16** adapted to rest on the ground, and a turn table structure **18** having a turning axis and rotatably supported by the support structure. The working boom **14** is connected at one end to the turn table structure and projects outwardly therefrom. The bucket wheel **12** is rotatably mounted at the outer end of the working boom. The support structure **16** is normally mounted on wheels or tracks **20** for moving the structure relative to the material being excavated. The apparatus also may include a conveying mechanism (not shown) for moving earth materials excavated by the buckets to a location adjacent to the excavator for removal. The bucket wheel is comprised of a circular frame **22** rotatably mounted at the end of the boom with buckets **24** having teeth **26** extending substantially outwardly from the periphery of the bucket for severing earth materials as the bucket wheel is brought into position for contacting the face of an exposed earth formation.

A convention bucket is generally V-shaped when viewed from the side, and consists of a solid arcuate back wall **28**, solid side walls **30**, and a cutting lip **32** at the leading edge of the back and side wall. The lip of each bucket projects beyond the wheel rim **22**, and the lower end of the bucket extends slightly inwardly from the rim of the wheel as shown by the dotted lines in FIG. 1.

A hydraulic jet system is positioned on the boom around each side of the wheel. The hydraulic jet system consists of hydraulic jet lines **34** which are preferably spaced radially to the axis of the rotation of the bucket wheel, but are fixed to the boom **14** and do not rotate with the wheel. The converging ends of the lines terminate in a manifold **36** for delivering a fluid to the lines. The opposite and outer ends of the lines are fitted with nozzles **38**. The number of jet lines is selected so as to provide a vertical spacing of the nozzle ends on the order of two or three feet measured along the sand face. The sizes of nozzles and the fluid pressure are selected so that the jet stream will cut a slot in the sand face preferably somewhat deeper than the selected depth of the cut of the bucket wheel.

Referring to FIG. 2 of the drawings, a delivery pipe **40** is shown extending outwardly from the wheel for delivering the fluid from a central source (not shown) to the manifold **36**. As shown in FIG. 2 duplicate arrangements of jet lines and nozzles are provided on each side of the wheel, with the sets of lines being used alternately so as to produce the desired recesses in the formation face prior to passage of the bucket wheel as the wheel is moved in alternate horizontal directions along the formation face. The jet lines are spaced horizontally away from the bucket wheel, so as to avoid damage. The spacing is not critical, but would normally be in the range of one to two feet. Referring both to FIGS. 1 and 2, a support structure is shown for mounting the hydraulic jet system, and includes a support **42** extending from the upper end of the boom and attached to the upper end of a spacer member **44**. The lower end of the spacer member **44** is held by support member **46** extending outwardly from the bottom of the boom. The spacer member **44** provides a means for maintaining the jet lines in a vertically spaced relationship relative to the face of the earth formation.

The hydraulic lines **34**, which are shown in somewhat greater detail in FIG. 3, include an enlarged conduit portion **50** extending from the manifold, which telescopingly receives a smaller conduit portion **52**. A locking collar **54**, which is positioned about the telescoping portions of the hydraulic line, provides means for locking the telescoping conduit portions **50**, **52** in a fixed relationship. The smaller conduit portions **52** of the hydraulic lines are slidably received in the spacer member **44** so that they may be moved back and forth when adjustments in the length of the hydraulic lines are necessary. Means (not shown) are provided for supplying a fluid under pressure to the delivery pipe **40**. Such fluid could be in the form of water and may be a mixture of water and steam to provide heat to the fluid for preventing freezing of the fluid after it is jetted onto the formation and before excavation of the formation takes place.

Referring to FIG. 3 of the drawings, the exposed face of a formation is represented by the arcuate lines which extend from the top of the formation shelf to a converging point at the bottom of a slope formed by the face. FIG. 3 should be viewed as if the excavator were moving away from the viewer into the page. For simplicity, the bucket is not shown. The outer arcuate lines **51** represents that portion of the formation face which has not as yet been excavated on the instant pass of the excavator. However, the outer formation face **51** has been exposed to the fluid jets and horizontal recesses **53** are shown penetrating into the face **51**. The inner arcuate line **55** represents that portion of the formation face which has been removed by the excavator subsequent to the hydraulic cutting action of the fluid jets.

The dotted lines in FIG. 3 show the probable lines of fracture in the surrounding earth materials which would result from encounter of a bucket wheel tooth **26** with a boulder **56**. In this case, the boulder would be dislodged from the formation matrix **58** by the first tooth encounter, after which it may land in the following bucket, or may be pushed aside, in which case it would fall to the bottom of the slope to be removed by auxiliary equipment. Under normal conditions, the over burden of the surrounding formation would support the boulder so as to minimize bending stresses in the boulder. Thus the excavator bucket would be called upon to move the entire column of material over the boulder opposite the point of contact. Since materials such as tar sands are very slightly compressible, the resistance encountered by the bucket may cause failure of some part thereof.

In accordance with the present invention, a fluid under pressure is circulated in the jetting system to direct a high velocity stream of fluid from the nozzle **38** against the formation face which will cause a plurality of the vertically spaced horizontal recesses **53** to be formed in the formation face just ahead of the rotating excavator bucket wheel. In such case, as shown in FIG. 3, the recesses **53** would be formed perpendicular to the formation face and

extend inwardly therefrom to provide a series of relief notches in the formation matrix. This in turn permits movement of boulders or the like embedded in the formation in response to contact by the bucket. Under such circumstances, contacting of the rock by the bucket causes a bending moment to be developed, so that the rock can be dislodged from its embedded position, and thereafter more easily removed. Any large boulders which enter the buckets must be screened before transferring the materials to conveyor belts. This can be done by passing the materials through large mesh (about 1 foot) screens made of steel bars.

Any water or other fluid remaining in the tar sand after the jetting operation described above, will serve as a lubricant and actually improve the performance of the bucket wheel. It is therefore desirable to operate the jets on the leading side of the bucket wheel as it moves laterally across the formation face so as to leave water in the freshly cut slots. On the other hand, if excess water is detrimental to bucket wheel performance, it may be desirable to operate the trailing edge jets so as to cut the recesses **53** for the next pass of the bucket wheel at that level. This would permit adequate time for the water to drain from the formation face.

In any event, the jetting systems must be operated on alternate sides of the bucket wheel in order to permit slotting of the formation face as the bucket wheel is moved horizontally in alternate directions in accordance with the method of mining tar sands as outlined above. If it is desirable to operate the jets on the trailing side of the bucket wheel, in order to permit water drainage or for other reasons, it would be necessary to extend the hydraulic lines outwardly a greater distance so as to position the nozzle ends of the tubes in a more proximate position relative to the face of the formation being excavated. In order to accommodate such adjustment of the length of the hydraulic tubes, provisions are made in accordance with the apparatus in FIG. 3 for extending the length of the tubes by loosening locking collar **54** on the tubes, and permitting telescoping members **50, 52** thereof to be adjusted in accordance with the desired position of the jets. The nozzles would be spaced so as to approach, but to avoid contact with the sand face.

In the apparatus presently being used for excavating tar sands, the rotation of the 30 ft. diameter bucket wheel is approximately nine revolutions per minute, and during one revolution of the wheel, the boom traverses along its horizontal path approximately five inches. Under such conditions, if the jet lines are spaced outwardly from the bucket wheel a distance of approximately one foot, such jet stream would impinge upon the formation approximately 16 seconds before the buckets themselves contacted the earth formation. Under these conditions, it may be possible for the operator to observe the exposure of a boulder by the impinging fluid jet or to observe a difference in the splash pattern of the impinging fluid jet as it strikes a hard substance. The operator could then react quickly enough to stop or slow down electric motors, which are used on the tar sand bucket wheel excavators. Such shut down of the equipment would prevent the apparatus from impacting the embedded rocks at full speed and thereby prevent excessive damage of the buckets.

While particular embodiments of the excavating apparatus disclosed herein have been described in conjunction with a bucket wheel excavator, it is readily seen that the disclosed method and apparatus would have application to other types of earth handling devices. In addition, while particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. In an earth excavating apparatus for excavating earth materials from the face of a formation, a boom mounted on a base, said boom being rotatable on said base about a vertical axis; a wheel on said boom and mounted for rotation about a horizontal axis; excavating buckets on said wheel, said buckets being arranged about the periphery of said wheel and arranged to sequentially contact said earth formation as said wheel is rotated in a vertical plane, said boom being rotated simultaneously with the wheel to move the rotating bucket wheel horizontally across the face of the formation; and a plurality of conduits arranged radially about the axis of rotation of said wheel in a plane spaced horizontally from said wheel, said radially arranged conduits being positioned on each side of said wheel, said conduits being longitudinally movable to permit adjustment of the spacing of said conduits relative to the face of said formation.

2. A method of excavating earth materials from an earth formation containing hard portions, comprising the steps of: passing a rotating bucket wheel horizontally across the substantially vertical face of an earth formation, with such bucket wheel rotating in a vertical plane to sequentially contact buckets thereon with the face of the earth formation; and prior to contacting the formation with the buckets, directing vertically spaced streams of fluid under pressure against the face of the formation for cutting continuous vertically spaced horizontal recesses in the face of the formation to relieve over burden pressure on hard portions embedded in the earth formation, such recesses being vertically spaced along the face of the formation through a segment of formation face which corresponds with an arc of contact of the rotating bucket wheel with the formation face.

References Cited

UNITED STATES PATENTS

657,247	9/1900	McDougall	299—17X
2,304,143	12/1942	Bigelow	299—17X
3,350,138	10/1967	Wilms	299—67

ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

37—189, 195; 175—67; 299—67