Aug. 1, 1967 R. C. ANDERSON 3,333,895

MINING MACHINE HAVING SYNCHRONIZED OSCILLATING CUTTER HEADS

Filed Sept. 25, 1964 5 Sheets-Sheet 1

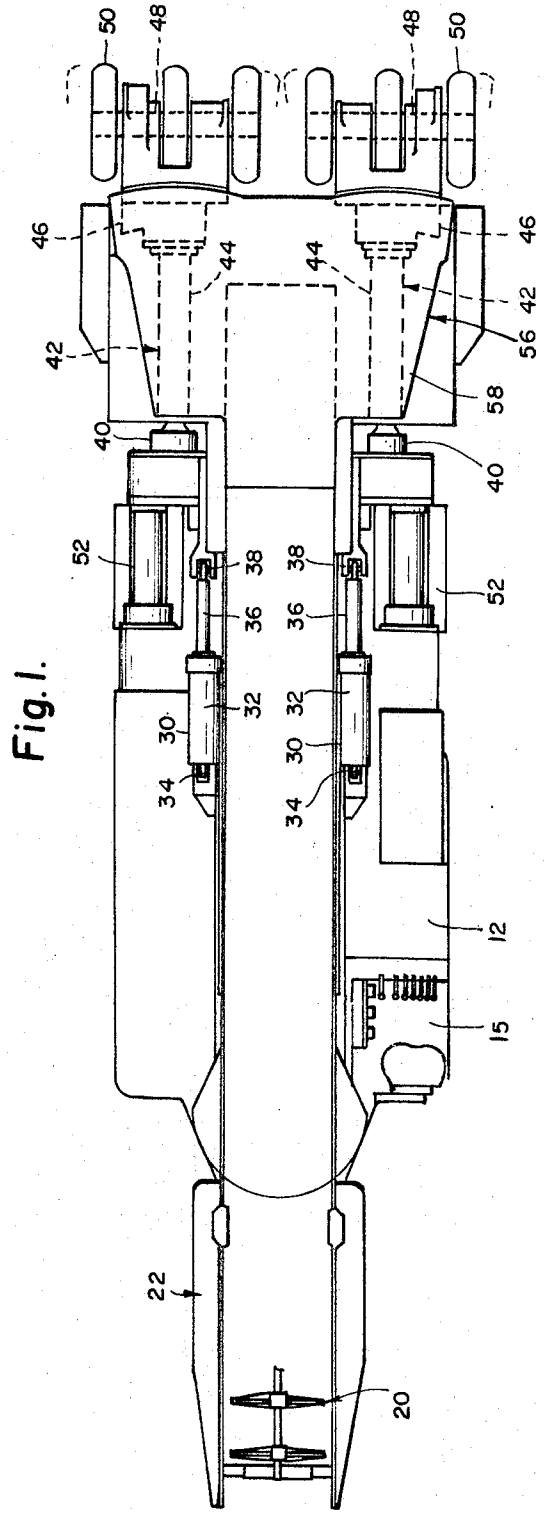


Fig. 1.

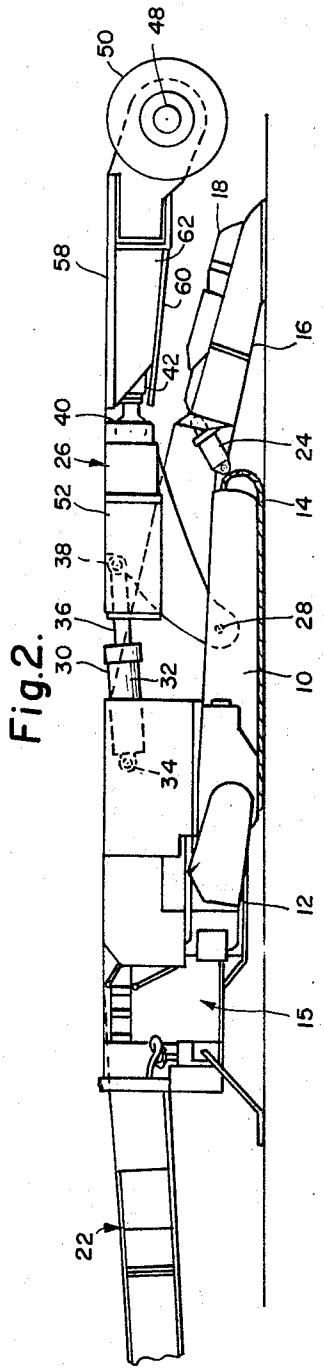


Fig. 2.

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Fig.3.

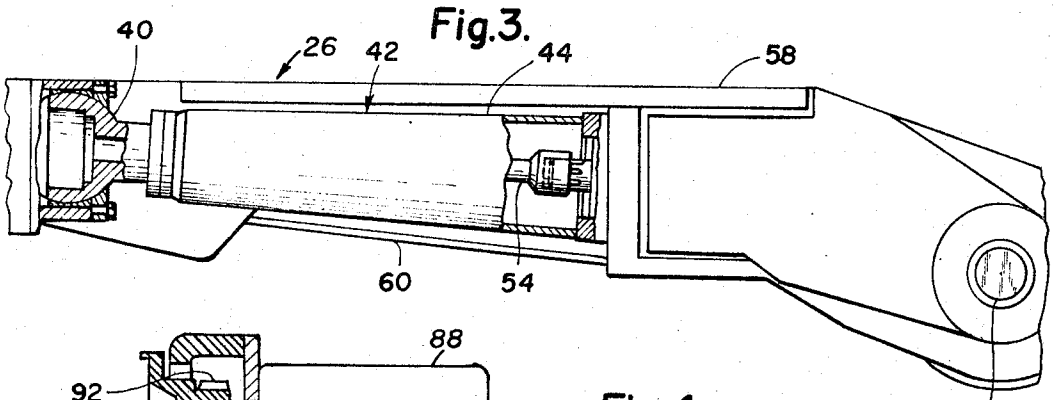


Fig.4.

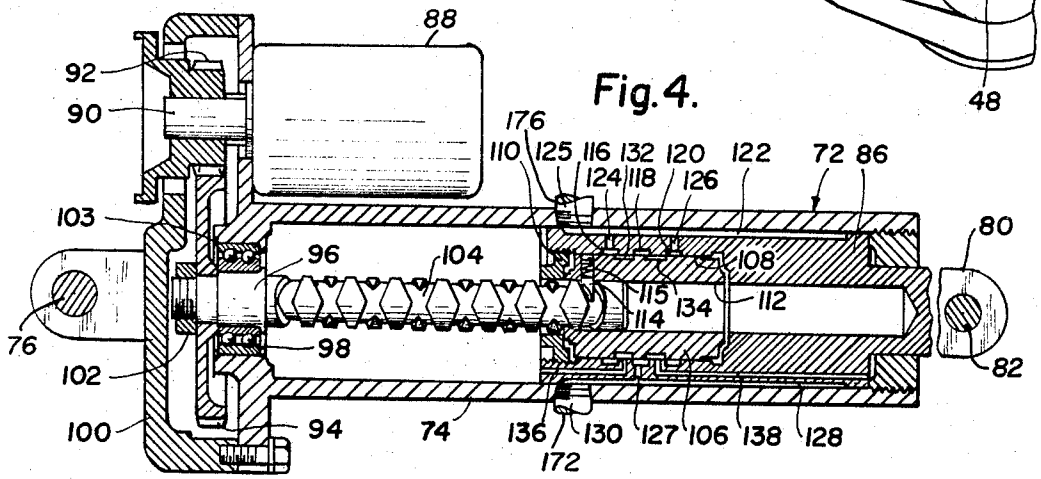
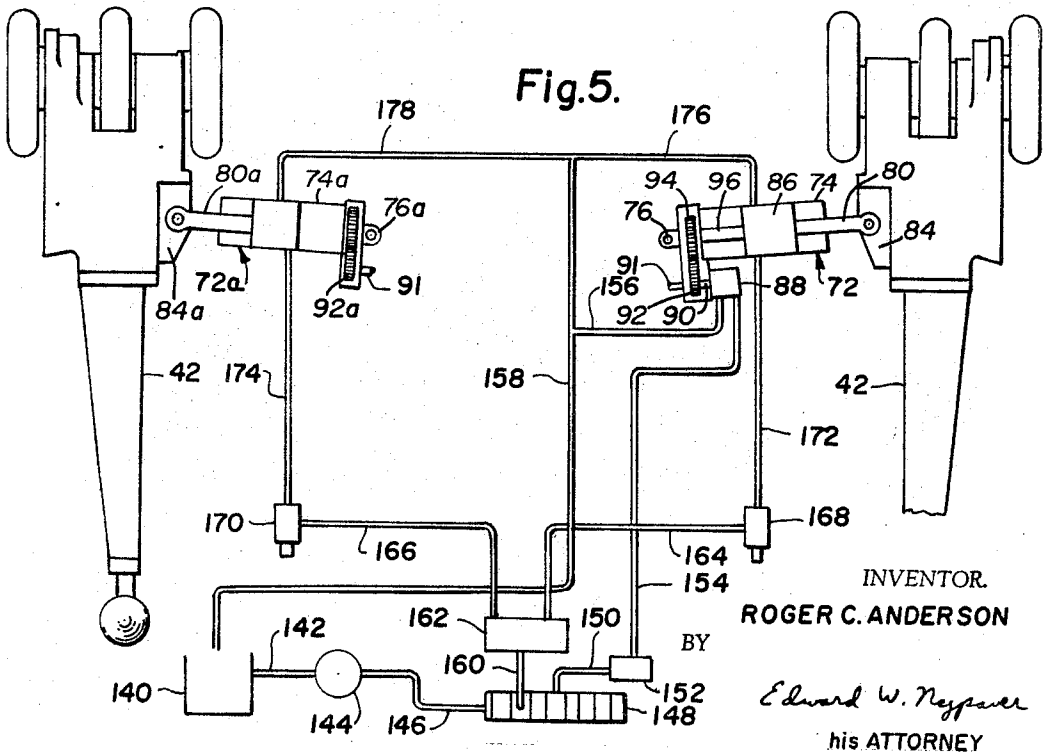


Fig.5.



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MINING MACHINE HAVING SYNCHRONIZED OSCILLATING CUTTER HEADS

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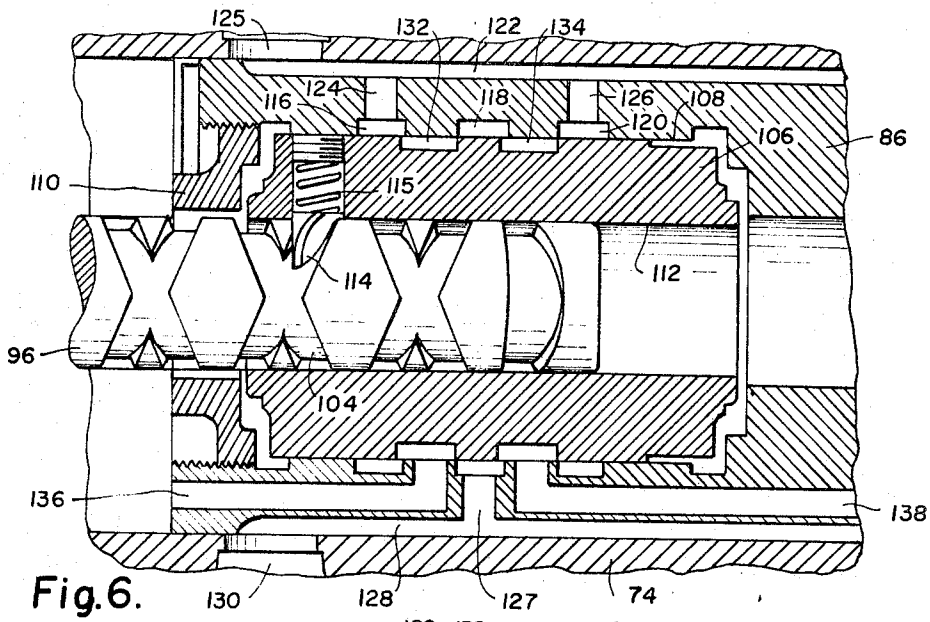


Fig.6.

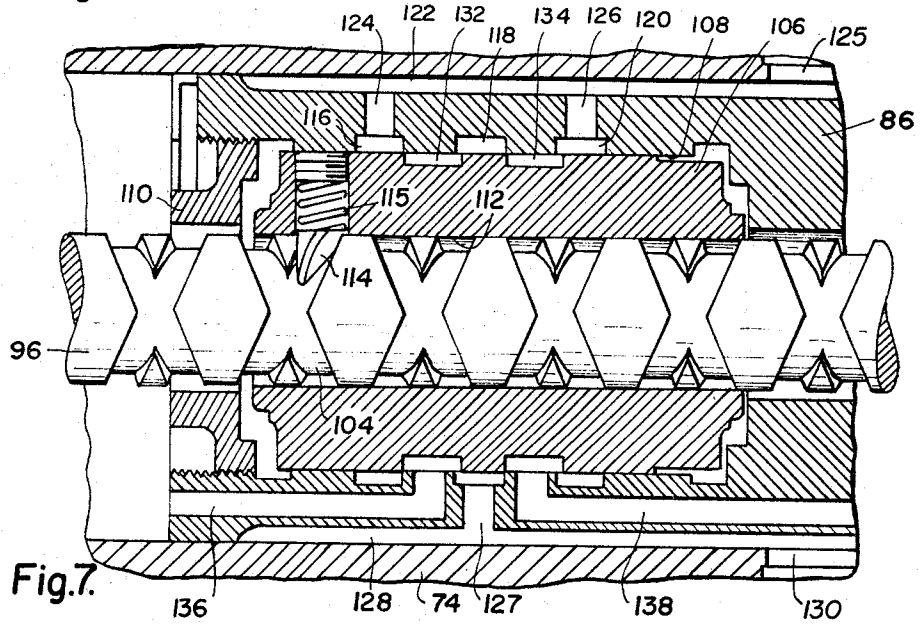


Fig.7.

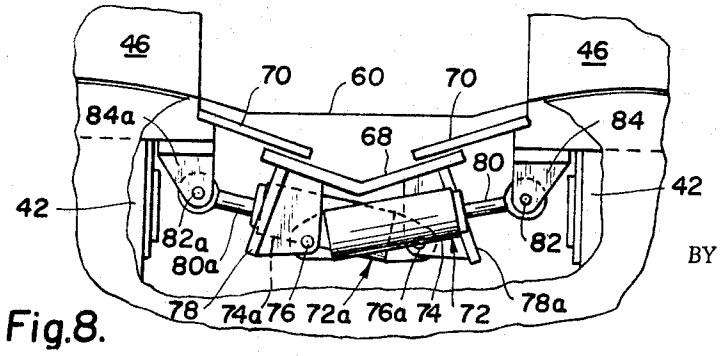


Fig.8.

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MINING MACHINE HAVING SYNCHRONIZED OSCILLATING CUTTER HEADS

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Fig. 9.

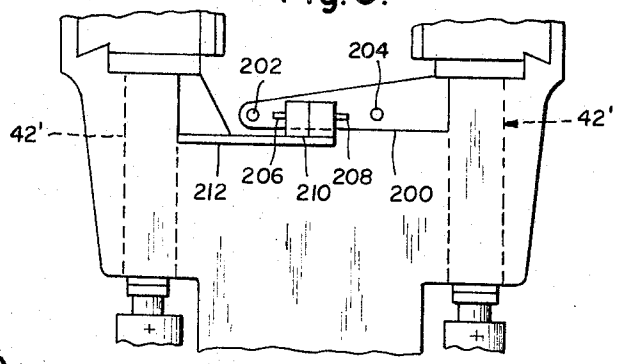


Fig. 10.

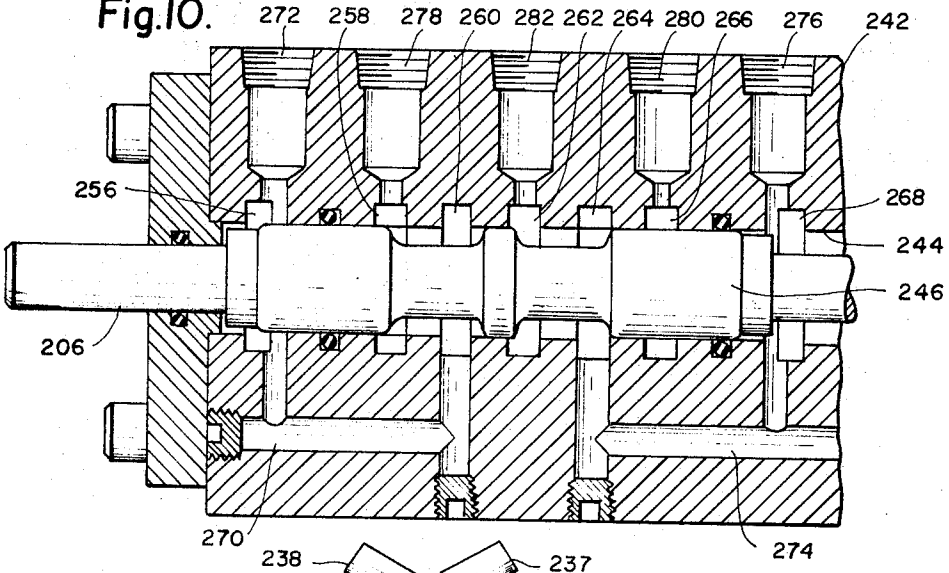
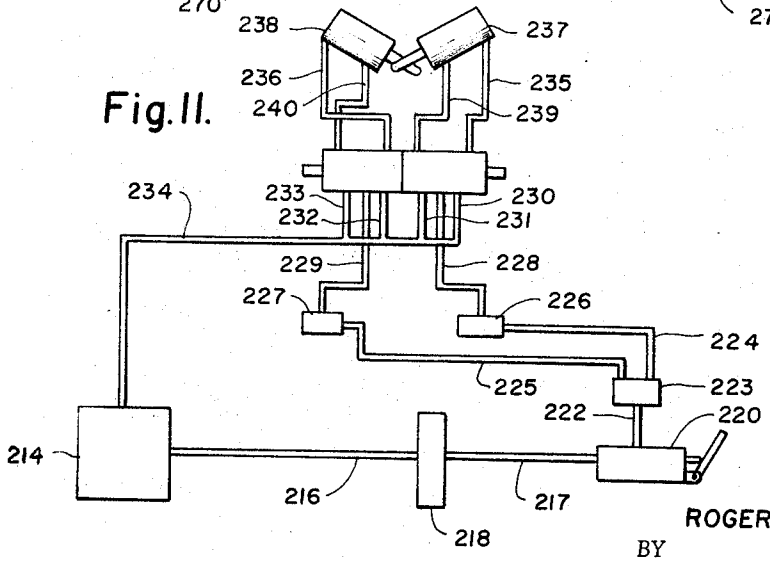


Fig. 11.



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MINING MACHINE HAVING SYNCHRONIZED OSCILLATING CUTTER HEADS

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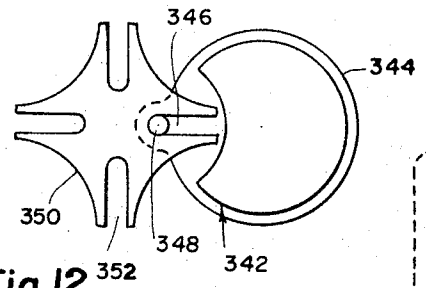


Fig.12.

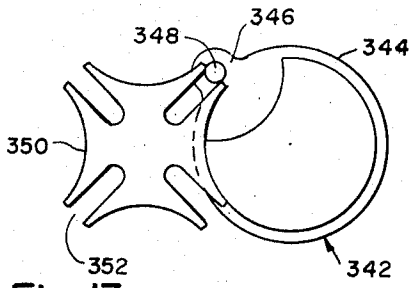


Fig.13.

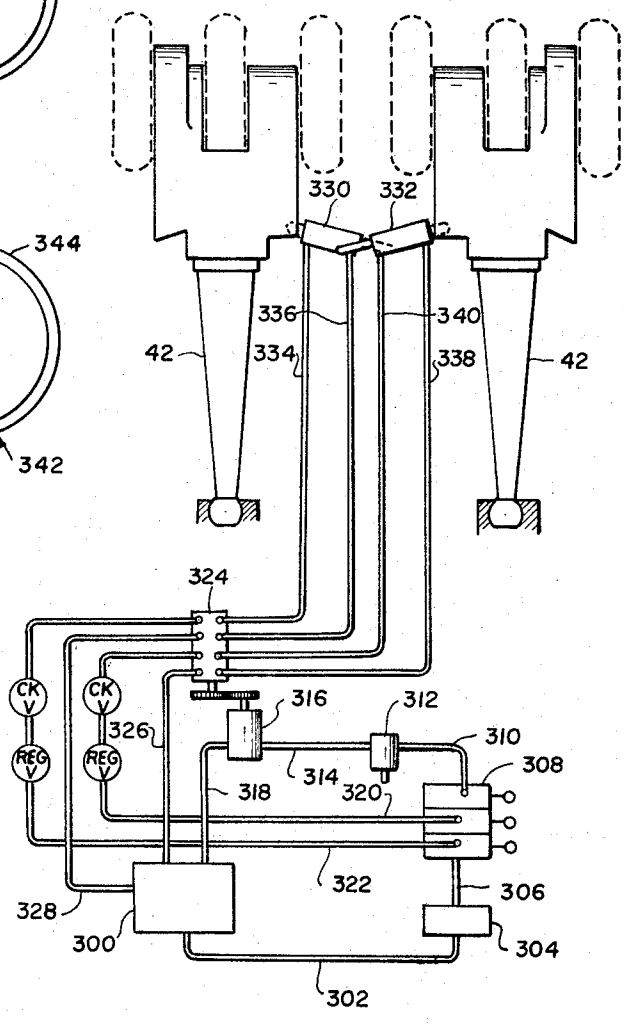


Fig.14.

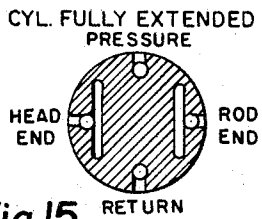


Fig.15.

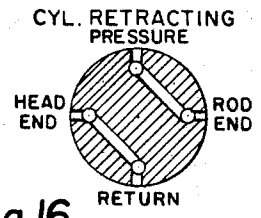


Fig.16.

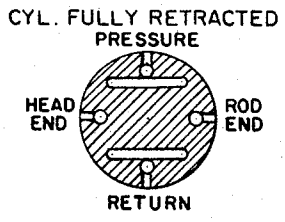


Fig.17.

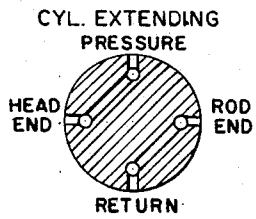


Fig.18.

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Patented Aug. 1, 1967

3,333,895

MINING MACHINE HAVING SYNCHRONIZED OSCILLATING CUTTER HEADS

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Filed Sept. 25, 1964, Ser. No. 399,178
5 Claims. (Cl. 299—1)

This invention relates to a continuous mining apparatus having a pair of mineral disintegrating or cutter heads and more particularly to a new and improved means for oscillating the cutter heads in opposite directions and in phase.

In a continuous mining apparatus of a known type, a pair of disintegrating heads are sometimes employed in dislodging mineral from the mine vein and are operable to provide a mine passageway or room into which the apparatus advances as mining progresses. The disintegrating head mechanisms are usually pivotally mounted on a mobile base to swing in a vertical plane between the mine roof and floor and may include rotary cutters arranged on horizontal transverse axes having teeth or bits which tear away and disintegrate the mineral. The apparatus also includes a conventional loading head for gathering the loose mineral on the mine floor and moving it inwardly toward the forward receiving portion of the conveying means of the apparatus. Such apparatus further includes a mechanical means for traversing or oscillating the cutter heads back and forth in a horizontal direction while rotating the cutters so that the total transverse distance over which the cutters operate is wider than the transverse distance of the apparatus to provide adequate clearance on each side of the apparatus.

The prior known devices employed common driving means for rotating the cutter discs and for oscillating the cutter heads by various gearing arrangements so that rotation of the cutters effected oscillation of the cutter heads. Accordingly, oscillation could not be interrupted at any intermediate position without terminating the operation of the rotary cutters, thereby restricting the overall efficiency of the machine. In the case of worm and crank arrangements, oscillation, velocity and acceleration were continuously variable. Furthermore, these devices required a multitude of moving parts which were subject to severe vibration, wear and excessive loads. Also, any adjustment with respect to the speed or rate of oscillation required a change in the ratio of the worm gears which necessitated the breakdown and replacement of parts.

The present invention as hereinafter described contemplates an improvement over such known type of mining apparatus and obviates the disadvantages set out above by employing a hydraulic or pressure fluid means for oscillating a pair of cutter heads which means is compact, simple in construction, requires only a minimum number of parts is reliable in operation.

Another advantage residing in the apparatus of this invention is that oscillation of the cutter heads is independent of the cutter drive means so that the cutter heads can be interrupted in various transverse positions without terminating the cutting operation, thereby facilitating rib slabbing turning cross cuts, and cutting large lumps of mineral resulting from roof falls.

A further advantage residing in the apparatus of this invention is that frequency of oscillation may be readily varied by changing the volume of oil delivered to the circuit without the need for replacing various parts in areas of limited accessibility.

It is therefore an object of this invention to provide a new and improved continuous mining apparatus.

It is another object of the present invention to provide

a new and improved continuous mining apparatus having novel cutter head oscillating means.

It is a further object of this invention to provide a new and improved continuous mining apparatus having hydraulic means for oscillating a pair of cutter heads at a uniform rate in a horizontal transverse direction.

It is a specific object of the present invention to provide a new and improved continuous mining apparatus having hydraulic means, independent of the cutter drive mechanism, for oscillating a pair of cutter heads so that oscillation of the cutter heads may be interrupted in any selected transverse position without terminating the cutting operation.

It is a more specific object of this invention to provide a new and improved continuous mining apparatus having hydraulic actuators for oscillating a pair of cutter heads in opposite directions and in step, said actuators having pistons with spool valves contained therein for controlling the movement and direction of the cutter heads.

It is another more specific object of this invention to provide a new and improved continuous mining apparatus having hydraulic means including a shifter valve mechanism for controlling the oscillation of a pair of cutter heads in opposite directions and in phase.

It is still another more specific object of this invention to provide a new and improved continuous mining apparatus having hydraulic means including an intermittently rotatable selector valve for controlling the oscillation of a pair of cutter heads in opposite directions and in phase.

These and other objects of this invention will become more apparent when taken in conjunction with the following detailed description and drawings, in which:

FIG. 1 is a top plan view of the mining apparatus constructed in accordance with the principles of this invention;

FIG. 2 is a side elevational view of the mining apparatus as shown in FIG. 1;

FIG. 3 is an enlarged elevational view of one of the oscillating arms with the side plate removed and a portion of the arm broken away;

FIG. 4 is an enlarged longitudinal sectional view of a hydraulic cylinder constructed in accordance with the principles of this invention;

FIG. 5 is a diagrammatic view illustrating the hydraulic circuit for the independent oscillating drive means;

FIG. 6 is an enlarged sectional view showing the pilot valve in one of its positions;

FIG. 7 is an enlarged sectional view showing the pilot valve in an alternate position;

FIG. 8 is an enlarged, partial, fragmentary top plan view of the apparatus of this invention with a portion of the cover plate broken away to show the mounting of the actuating cylinders with respect to the oscillating arms;

FIG. 9 is an enlarged, diagrammatic, plan view, with parts omitted, of another embodiment of the mining apparatus of this invention;

FIG. 10 is an enlarged central, longitudinal sectional view through one-half the pilot shifter valve mechanism of the embodiment shown in FIG. 9;

FIG. 11 is a diagrammatic view illustrating the hydraulic circuit for the embodiment of FIG. 9;

FIG. 12 is a diagrammatic view showing the Geneva stop mechanism of a third embodiment of the mining apparatus of this invention;

FIG. 13 is a view similar to FIG. 12 showing a second position of the Geneva stop mechanism;

FIG. 14 is a diagrammatic view showing the hydraulic circuit for the third embodiment;

FIG. 15 is a diagrammatic view illustrating the porting arrangement of the selector valve of the embodiment

shown in FIG. 14 with the actuating cylinder in the fully extended position;

FIG. 16 is a view similar to FIG. 15 showing the porting arrangement of the selector valve when the cylinder is retracting;

FIG. 17 is a view similar to FIG. 15 showing the porting arrangement of the selector valve with the cylinder in the fully retracted position; and

FIG. 18 is a view similar to FIG. 15 showing the porting arrangement of the selector valve when the cylinder is extending.

Referring to the drawings and particularly to FIGS. 1 and 2, it will be observed that a continuous mining apparatus constructed in accordance with the principles of this invention comprises a mobile base **10** having a frame **12** mounted on suitable self propelling and steering means **14**. Arranged rearwardly of the frame at one side thereof is an operator's control station indicated generally at **15** which is provided with a suitable control valve mechanism and other control appurtenances which need not be detailed here.

Carried by frame **12** at the forward end thereof is a suitable tiltable loading head **16** embodying conventional oscillatory gathering foldable arms **18** for gathering loose material on the mine floor and for moving the material so gathered onto the forward receiving portion of an endless flight conveyor generally indicated as **20**. Conveyor **20** extends substantially along the length af the apparatus and terminates at a discharge section generally designated **22**, which discharge section is swingable about a vertical axis and tiltable about a horizontal axis, respectively, as is well known in the art. The gathering head is tiltable about a horizontal axis by means of a pair of fluid jacks **24** (only one of which is shown in FIG. 2). Since the structure of the gathering mechanism and the conveyor mechanism is conventional and has been widely used in well known commercial structures by applicant's assignee, it is believed that no further illustration is required.

An elongated boom frame generally designated as **26** is pivotally mounted at its lower rear end on a horizontal axis **28** located on the main frame **12**. For purposes of this description, the forward end of the apparatus will be taken as the right hand side of the apparatus as seen in FIGURES 1 and 2. Frame **26** is of substantial width as shown in FIGURE 1 and projects forwardly over and beyond the tiltable loading head **16** in the manner shown in FIGURE 2.

The boom frame may be swung in vertical planes about its pivot by means of suitable extensible hydraulic jacks **30** comprising cylinders **32** suitably pivotally mounted at **34** on main frame **12** and these cylinders contain suitable reciprocable pistons having forwardly extending piston rods **36** suitably pivotally mounted at **38** to the rear portion of boom frame **26**. Thus when liquid under pressure is properly supplied to the hydraulic jacks **30**, the boom frame may be swung either upwardly or downwardly about its pivot to vary the elevation thereof and by trapping liquid within the cylinders at the opposite sides of the piston, the boom frame may be locked in any selected position.

Pivotally supported by universal connections herein preferably in the form of ball and socket pivotal mountings **40** (FIGS. 1 and 3) and projecting forwardly therefrom are a pair of elongated oscillating arms generally indicated as **42**. Each arm comprises an elongated hollow tubular member **44** having a cutter head or gear case housing **46** disposed at the forward end thereof for enclosing a suitable drive mechanism (not shown) for rotating a suitable transverse shaft **48**. A series of spaced rotary cutter discs **50** are rigidly secured to each shaft **48** and are rotatable therewith. Although preferably each cutter head has three rotary discs as illustrated, it will be obvious that, if desired, more or less than three discs may be utilized. As is well known in the art, a plurality of cutter bits (not shown) are rigidly secured to the cutter discs, respectively, adjacent the peripheries thereof in and desired pattern.

In order to effect rotation of rotary discs **50**, a pair of suitable motors **52** are mounted at the sides of boom frame **26** and are operatively connected through suitable associated gearing (not shown) to a suitable shaft **54** located in tubular member **44** as shown in FIGURE 3, which shaft is operatively connected to the drive mechanism (not shown) enclosed in housing **46**. Such gearing arrangements for driving the shaft **48** and thereby discs **50** may be of any conventional variety, and since many such arrangements are known in the art, no further illustration is believed necessary.

For the purpose of protecting the oscillation controls, hereinafter more fully described, and the cutter head gear cases, a massive shrouding generally designated as **56** is provided. Such shrouding comprises a top cover plate **58**, a bottom cover plate **60** and side cover plates **62** (only one of which is shown in FIGURE 2). Bottom plate **60** supports the forward ends of the oscillating arms and also the actuating cylinders, hereinafter more fully described. A front plate **68** is rigidly secured, as by means of welding for example, between the top and bottom cover plates **58** and **60** respectively (FIG. 8). A pair of movable plates **70** extend laterally inwardly from housings **46** respectively, and cooperate with front plate **68** to form a front face of the shrouding so that the oscillation controls and cutter head gear cases may be protected in any lateral position of oscillating arms **42**.

For the purpose of providing a continuous uniform oscillating motion to the oscillating arms, hydraulic means are provided, such means comprising a pair of hydraulic cylinders generally designated **72** and **72***a* (FIG. 8), each cylinder being connected between the boom frame **26** and an oscillating arm **42**.

Hydraulic cylinders **72** and **72***a* are arranged at the forward central portion of the shrouding **56** (FIG. 8) and comprise elongated hollow cylindrical bodies or casings **74**, **74***a*, pivotally mounted at their head ends at **76**, **76***a* respectively, to brackets **78**, **78***a* secured to front plate **68**. These cylinders contain pistons **86** (not shown in FIG. 8 but hereinafter more fully described) having laterally and outwardly extending piston rods **80**, **80***a* pivotally connected at **82**, **82***a* respectively, to brackets **84**, **84***a* secured to the inner sides of housings **46** of oscillating arms **42**.

Cylinders **72** and **72***a* are similar in construction with the exception of cylinder **72** having a conventional hydraulic motor **88** associated therewith as shown in the diagrammatic view of FIG. 5. Motor **88** drives an output shaft **90** (FIG. 4) having a small pinion gear **92** rigidly secured thereto. Output shaft **90** is adapted to receive a shaft (indicated diagrammatically as **91** in FIG. 5) for synchronously driving a small pinion gear **92***a* associated with cylinder **72***a*, said gear being identical to gear **92**. Since cylinders **72** and **72***a* are similar in construction, the description will be restricted to cylinder **72** as shown in FIGS. 4, 6 and 7.

Pinion gear **92** meshes with a larger gear **94** mounted on an elongated actuating shaft **96** which is suitably journalled within bearing **98**, such bearing being supported in the head **100** of casing **74**. A lock nut **102** is provided for holding the shaft **96** within bearing **98** and for retaining gear **94** on such shaft. Bearing **98** is held in position in head **100** by means of a snap ring **103**. A right and left hand diamond thread **104** is provided over that portion of shaft **96** which extends into the cylinder casing.

An actuating spool valve **106** is slidably contained within a bore **108** of piston **86** for limited linear movement relative thereto and is retained in the piston by means of a locking nut **110**. Actuating valve **106** has a central bore **112** for receiving shaft **96** and is provided with a pivotable tooth or projection **114** that is biased radially inwardly

by a spring **115** into such bore for engaging the thread of the shaft. Consequently, when the shaft is rotated, the valve travels back and forth in a linear direction over the threaded area of the shaft toward either end of casing **74**.

Bore **108** of piston **86** is provided adjacent the central portion thereof with three annular enlargements or grooves **116**, **118** and **120**, respectively. Grooves **116** and **120** are connected to an elongated exhaust passageway **122** by passages **124** and **126**, respectively. Exhaust passageway **122** is connected to exhaust port **125** which is connected to a return conduit leading to tank. A passage **127** connects groove **118** to an elongated pressure passageway **128** which in turn is connected to a pressure port **130**, which communicates with the pressure line.

Actuating spool valve **106** is provided adjacent the central portion thereof with two annular recesses **132** and **134**, respectively, which direct fluid flow through the piston and are alternately connected to pressure and exhaust. Passageway **136** connects recess **132** to the left side or head end of piston **86** as seen in FIGURES 4, 6 and 7 and passageway **138** connects recess **134** to the right side or rod end thereof.

Referring now to the diagrammatic showing of the hydraulic circuit in FIGURE 5, it will be observed that a source of hydraulic fluid is shown at **140** as, for example, a suitably disposed tank or receptacle to contain the necessary quantity of hydraulic fluid. The source **140** is connected by a suitable suction line **142** with a suitable pump **144** which is driven from any suitable source of power, not shown.

Pump **144** delivers fluid under pressure to a line **146** which is connected with the main hydraulic control valve **148**. Leading from the control valve **148** is a conduit **150** connected to a suitable pressure reducing valve **152** which in turn is connected by means of a conduit **154** to hydraulic motor **88**. Motor **88** is connected to a conduit **156** which leads back to the source **140** by means of return conduit **158**.

Also leading from the control valve **148** is a conduit **160** connected to a conventional flow divider **162**, which is connected by means of conduits **164** and **166** to suitable relief valves **168** and **170** respectively. Conduits **172** and **174** connect relief valves **168** and **170** respectively, to the pressure ports of actuating cylinders **72** and **72***a* respectively. Exhaust ports **125** of actuating cylinders **72** and **72***a* are connected with suitable conduits **176** and **178**, respectively, which lead back to the source **140** by way of return conduit **158**.

The general mode of operation of the improved mining apparatus above described is as follows: When the working face is reached with the cutter discs located at the face of the mine vein, the cutter discs may be raised or lowered into various selected fixed vertical positions or continuously raised and lowered by swinging boom frame **26** about horizontal axis **28** by means of hydraulic jacks **30**. Motors **52** may then be operated to rotate the two shafts **48** and cutter discs **50** secured thereto, and the conveying mechanism and gathering mechanism may be operated concurrently in the conventional manner, and the apparatus may be advanced by the tractor base bodily over the mine floor to feed the cutters toward the work to penetrate the latter thereby to effect the mining operation.

During the cutting operation cutter heads **46** may be oscillated in a horizontal or lateral direction with their direction of motion always opposite and in step in the following manner: Hydraulic fluid under suitably reduced pressure is applied to hydraulic motor **88** causing it to rotate actuating shafts **96** of cylinders **72** and **72***a*, respectively, while hydraulic fluid under suitable pressure is simultaneously applied to pressure ports **130** of hydraulic cylinders **72** and **72***a*. Assume that cutter heads **46** have completed one-half the cycle of oscillation whereat they are located in the laterally outwardly extended position and are about to be moved laterally inwardly. Rotation of shaft **96** effects linear movement of pilot valve **106** to the left with respect to piston **86** as illustrated in FIGURES 4 and 6. Pressure fluid flow is established through port **130** and passageway **128** between passages **127** and **138** by means of groove **118** and recess **134** and is directed to the rod or right hand end of piston **86** and will cause movement of the piston to the left carrying along with it oscillating arm **42**. Fluid existing on the left side of piston **86** will be exhausted by way of passage **136**, recess **132**, groove **116**, passage **124**, passageway **122** and exhaust port **125** to tank thus allowing movement of piston **86** to the left.

Slight movement of the piston **86** leftwardly tends to center the piston relative to the spool valve and establish a neutral position by uncovering both recesses **132**, **134** so that pressure fluid in groove **118** could be directed to passageways **136** and **138** via recesses **132**, **134** which would equalize the pressure on both sides of piston **86**. However, because spool valve **106** is continuously moving to the left, piston **86** does not move a sufficient distance relative to the spool valve **106** to effect such a neutral position until the spool valve **106** reaches the end of its travel at the left end of the thread **104**.

It will be evident that on the opposite movement of pilot valve **106** by means of continually rotating shaft **96**, alternate connections between pressure and exhaust will be effected so as to move oscillating arm **42** outwardly or to the right as viewed in FIGURES 1 and 5. Specifically, as shown in FIGURE 7, pressure fluid flow is established between passages **127** and **136** by means of uncovered recess **132** and is directed to the left hand side of piston **86** while fluid on the right side of piston **86** will be exhausted by way of passage **138**, recess **134**, groove **120**, passage **126**, passageway **122** and exhaust port **125** to tank.

Valve **106** has a relatively small linear motion within the piston, as for example, on the order of $\frac{1}{32}$ of an inch, permitting the edges of the recesses to seat against mating edges of the inside of the piston, thus directing flow to either end of the piston. The passages **136** and **138** of the piston serve two ways, either pressure or exhaust, depending on the position of the valve inside the piston. The valve and piston arrangement effect a sort of reflex action comparable to that of the human body in that the valve is the brain issuing orders and the piston is the muscle that does the work. Wherever the valve is located on the actuating shaft, the piston wants to follow. The piston always wants to center itself over the valve providing fast, accurate, linear travel. Of course, movement of piston **86** carries oscillating arm **42** in the same direction by means of piston rod **80**. Oscillating arms **42**, carrying cutter heads **46**, are oscillated in opposite horizontal directions in step by properly coupling flexible shaft **91** to cylinders **72** and **72***a*. The frequency of oscillation may be readily varied by changing the volume of fluid delivered to the circuit. As hereinbefore stated, oscillation can be stopped at any horizontal position within its cycle without terminating or affecting the cutting operation.

From the foregoing it is apparent that an improved mining apparatus is obtained by employing an independent pressure fluid means for oscillating a pair of cutter heads. Such means permits the use of a low pressure hydraulic circuit and requires only one pressure line per cylinder, resulting in lower initial costs and maintenance. Also, placing the spool valve within the cylinder piston eliminates hoses, line surges and lag or hesitation in oscillation.

FIGURES 9, 10 and 11 illustrate another embodiment of the continuous mining apparatus of this invention which is very similar to the general arrangement of the above described embodiment with the exception of the hydraulic circuitry and the mechanism for oscillating arms **42**. With reference to FIGURE 9, an elongated flat bracket **200** is rigidly attached, as by means of welding, for example, to the right oscillating arm **42'** as shown

in FIGURE 9. Extending vertically upwardly from bracket **200** are a pair of abutment pins **202** and **204**, which are adapted to engage extensions **206** and **208** respectively, of a pilot shifter valve mechanism designated generally as **210**, said shifter valve being rigidly mounted on a bracket **212** which is rigidly secured to the other oscillating arm **42'**.

With reference to the diagrammatic view of FIGURE 11, it will be observed that a source of hydraulic fluid is shown at **214**, as for example, a suitably disposed tank or receptacle to contain the necessary quantity of hydraulic fluid. Source **214** is connected by a suitable suction line **216** with a pump **218**, which is driven from any suitable source of power, not shown. Pump **218** delivers fluid under pressure by means of conduit **217** to the operator's control valve **220**. Leading from the control valve is a suitable pressure line **222** which is connected to a conventional flow divider **223**, which in turn is mounted by suitable pressure conduits **224** and **225** to suitable relief valves **226** and **227**, respectively. Leading from the relief valves are conduits **228** and **229** which are connected to the pilot shifter valve mechanism **210**. This valve mechanism is connected by conduits **230**, **231**, **232** and **233** to return line **234** which leads back to the source **214**. Conduits **235** and **236** connect the shifter valve **210** to the head ends of cylinders **237** and **238**, respectively, while conduits **239** and **240** connect the shifter valve to the rod ends of said cylinders.

Cylinders **237** and **238** are of the conventional double acting type and are mounted between the boom frame and the oscillating arms in the same manner as cylinders **72**, **72***a* of the embodiment first described with the exception that the head and rod ends are reversed. It is contemplated, however, that the mounting of cylinders **237** and **238** may be similar to that of the first embodiment, if desired.

Because the left hand portion of shifter valve **210** is identical to the right hand portion, the description will be restricted to the left hand portion only. The valve mechanism **210** includes a chest **242** having a bore **244** in which an elongated pilot valve element **246** is reciprocable. Element **246** has oppositely projecting extensions **206** and **208** (not shown in FIG. 10) which are adapted to be engaged by abutment pins **202** and **204** as oscillating arms **42'** move in opposite directions.

Bore **244** is provided between its ends with seven annular grooves or enlargements numbered **256**, **258**, **260**, **262**, **264**, **266** and **268** respectively. Grooves **256** and **260** are connected together by a passage **270** and groove **256** is connected with port **272** communicating with conduit **230**. Grooves **264** and **268** are connected together by a passage arrangement **274** and groove **268** is connected with port **276** communicating with conduit **232**. Grooves **258** and **266** are connected to exhaust lines **224** and **226** respectively, by ports **278** and **280** respectively. Groove **262** is connected to port **282** which in turn is connected to conduit **222** which serves to supply fluid under pressure to the shifter valve mechanism.

The mode of operation of this embodiment will be readily understood. Assume that arms **42'** have moved laterally inwardly so that pin **204** engages stem **208** to shift element **246** to the left, a condition which is shown in FIGURE 10. Pressure fluid flow is then established through port **282**, groove, **262**, groove **264**, passage **274**, groove **268**, port **276**, line **232** and is directed to the head end of cylinder **238**. Pressure fluid in bore **244** acts on the pilot valve element similar to a cylinder piston and forces the pilot valve element quickly in the leftward direction and holds it there. Of course, pressure fluid flow will be directed to the head end of cylinder **237** in the same manner.

Exhaust will be established through conduit **240**, conduit **230**, port **272**, groove **256**, passage **270**, groove **260**, groove **258**, port **278**, conduits **233** and **234** back to the source **214**. Since the piston rods of cylinders **237**, **238** are secured to the boom frame, the cylinder casings will move outwardly, causing arms **42'** to move outwardly in opposite directions. Upon reaching their laterally outwardly extended position, abutment pin **202** will engage extension **206** to shift valve element to the right, thus reversing pressure and exhaust flow to cause arms **42'** to move inwardly in opposite directions.

This embodiment has an advantage over the first embodiment described in providing the quick shift feature in order to minimize throttling and allow a quick reversal of movement of the arms.

It is to be realized that other means may be employed to effect such a quick shift for controlling alternate connections between pressure and exhaust to the cylinders. By way of example, a lost motion mechanical linkage adapted to be operated by the moving arms can be utilized to quickly shift a valve spool of a conventional hydraulic control valve and to hold such spool in the shifted position for a given portion of a cycle.

FIGURES 12, 13, 14, 15, 16, 17 and 18 illustrate still another embodiment of the continuous mining apparatus of this invention which is very similar to the general arrangement of the embodiment first described with the exception of the hydraulic circuitry for oscillating arms **42**.

Referring now to the diagrammatic showing of the hydraulic circuit in FIGURE 14, a source of hydraulic fluid is shown at **300**, as for example, a suitably disposed tank or receptacle to contain the necessary quantity of hydraulic fluid. Source **300** is connected by suitable suction line **302** with a suitable pump **304** which is driven from any suitable source of power, not shown.

Pump **304** delivers fluid under pressure to a line **306** which is connected with the hydraulic control valve **308**. Leading from the control valve **308** is a conduit **310** connected to a suitable pressure reducing valve **312** which in turn is connected by conduit **314** to a hydraulic motor **316**. Motor **316** is connected to a conduit **318** which leads back to the source **300**.

Also leading from control valve **308** are conduits **320** and **322** which are connected to a rotary selector valve **324** and direct fluid under pressure thereto. Conduits **326** and **328** connect rotary selector valve **324** to the source **300**.

A pair of conventional double acting hydraulic actuating cylinders **330** and **332** are mounted between the boom frame and oscillating arm in the same manner as cylinders **238** and **240** of the second embodiment described. Conduits **334** and **336** connect selector valve **324** to the head end and the rod end respectively of cylinder **330**. Conduits **338** and **340** connect selector valve **324** to the head end and rod end respectively of cylinder **332**.

Motor **316** drives a Geneva stop type mechanism **342** which comprises a circular disc **344** (FIG. 12) having an extension **346** extending from the periphery thereof, such extension having an elongated cylindrical pin **348** rigidly secured thereto. Disc **344** is continuously rotated by a power shaft which is driven by motor **316**. A rotatable star wheel **350** has four slots **352**, which are spaced 90° apart and are adapted to be engaged by pin **348** for the purpose of intermittently rotating said star wheel which in turn rotates the selector valve **324** by means of a shaft for controlling pressure and exhaust flow to and from the cylinders **330**, **332**. It is to be understood that the Geneva stop mechanism may be mounted in any convenient or desirable location on either frame **12** or boom frame **26**.

FIGURES 15, 16, 17 and 18 show the diagrammatic porting of one-half the selector valve **324** for cylinder **332**. It is to be understood that the other half of selector valve **324** has an identical porting arrangement for cylinder **330**.

The mode of operation is as follows: Assume that cylinders **330** and **332** are fully extended so that the oscillating arms are in the laterally outwardly extended position and the diagrammatic porting of selector valve **324** for cylinder **332** is as shown in FIGURE 15. Members **344** and

350 will be in the position shown in FIGURE 12. Member 344 is uniformly rotated through ⅛ of a revolution by motor 316. Wheel 350 is rotated with a variable angular velocity through ⅛ of a revolution by means of pin 348 and slot 352. Such rotation establishes a connection between fluid pressure and the rod end of cylinder 332 (FIGURE 16) while permitting exhaust of fluid from the head end of cylinder 332 to return. Wheel 350 is stationary while disc 334 rotates ¾ of a revolution and cylinder 332 retracts at a uniform rate carrying along with it the oscillating arms. Pin 348 then engages slot 352 to turn wheel 350 ⅛ of a turn to close the pressure and exhaust ports (FIG. 17) bringing the cylinder to rest. The following ⅛ of a turn of wheel 350 indexes the selector valve 324 to the position shown in FIGURE 18, which reverses the fluid pressure flow to the head end of cylinder 332 so as to extend the cylinder which carries the oscillating arm with it. It is to be noted that the cylinders are extended and retracted during ½ of a revolution of star wheel 350. The cycle is repeated to effect horizontal oscillating movement of the cutter heads in opposite directions and in phase.

This embodiment has the advantage of utilizing only one cylinder circuit, if desired, thereby permitting selective use of the cutter units. Also, abrupt changes in direction are eliminated by the acceleration and deceleration characteristics obtained by valve throttling when the end of the stroke is reached.

Preferred embodiments of the principles of this invention having been described and illustrated herein, it is to be realized that modifications thereof can be made without departing from the broad spirit and scope of this invention as defined in the appended claims.

I claim:

1. In a mining apparatus having: a mobile frame; a pair of forwardly extending elongated support arms mounted at one end thereof on said mobile frame for pivotal movement about spaced axes respectively; cutting means carried at the other end of each of said support arms the improvement comprising fluid operated drive means for said support arms for oscillating said support arms through a given cycle about said axes in opposite directions, respectively; said drive means having a pair of valves therein each having a member positionable to direct fluid flow through said drive means to synchronize the oscillations of said support arms; and control means cooperable with said valves operative to position said members relative to said valves in response to a variation in the oscillation rate of one of said support arms to direct the fluid flow to cause a like change in the oscillation rate of the other of said arms.

2. In a mining apparatus as specified in claim 1 the improvement as therein set forth wherein: another member of each valve is mechanically connected to a respective support arm and movable thereby.

3. In a mining apparatus having a mobile frame; a pair of forwardly extending elongated support arms mounted at one end thereof on said mobile frame for pivotal movement about spaced axes, respectively; cutter heads rotatably mounted at the other ends of each of said support arms; fluid operated drive means for each of said support arms for oscillating said support arms through a given cycle about said axes in opposite directions, respectively; the improvement comprising means for directing fluid flow to each of said drive means, individually, said directing means including a pair of servo valves and control means operative with said servo valves for positioning said servo valves for directing fluid flow through said drive means for oscillating said support arms, and said control means including means for shifting one of said servo valves in response to a decrease in the oscillation rate of one of said support arms for causing redirection of the fluid flow for oscillating the other of said arms.

4. In a mining apparatus having a mobile frame; a pair of forwardly extending elongated support arms mounted at one end thereof on said mobile frame for pivotal movement about spaced axes respectively; a cutter head rotatably mounted at the other end of each of said support arms, respectively; a double acting hydraulic cylinder connected between said mobile frame and each of said support arms for oscillating said support arms through a given cycle about said axes in opposite directions, respectively; a pair of servo valves mechanically connected to said support arms for regulating fluid flow through said cylinders, respectively, motor operated camming means rotatably mounted on said mobile frame; actuating means connected between said camming means and said servo valves to synchronize the oscillations of said support arms and to operate said servo valves in response to a decrease in the oscillation rate of one of said support arms to cause a like change in the oscillation rate of the other of said arms.

5. In a mining apparatus having a mobile frame; a boom frame mounted on said mobile frame for pivotal movement about a first axis; a pair of arms mounted on said boom frame for pivotal movement about spaced axes, respectively; cutter heads spaced from said spaced axes and supported by said arms respectively; means for actuating said cutter heads; and means for oscillating said arms about said spaced axes, respectively; the improvement in said oscillating means comprising: a fluid operated means operatively connected to each of said arms for oscillating said arms about said spaced axes, respectively; including a source of pressurized fluid; cylinder means connected with said source; piston means in said cylinder means operatively connected to one of said arms; valve means in said cylinder means movable relative to said piston means for causing pressurized fluid to selectively flow to either side of said piston means, said valve means and said piston means being in a neutral position with respect to each other when said arms are not oscillating such that the pressurized fluid flows to both sides of said piston means to cause an equal force on both sides of said piston means; actuating means for moving each of said valve means relative to said piston means such that pressurized fluid is directed to one side of each of said piston means to move said arms together in opposite directions; and fluid directing means operatively connecting said fluid operated means for changing the rate of oscillation of one of said arms in response to a change in the rate of oscillation of the other of said arms; said means for changing the oscillation rate including mechanical means connecting said actuating means to each other for changing the movement of one of said valve means in response to a change in movement of the other of said valve means such that said one of said valve means is in a neutral position with respect to said piston means associated with said one of said valve means.

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