Aug. 12, 1969 T. LUKSICH 3,460,868

MINING MACHINE HAVING OSCILLATING CUTTING ARMS

Filed May 11, 1967 3 Sheets-Sheet 1

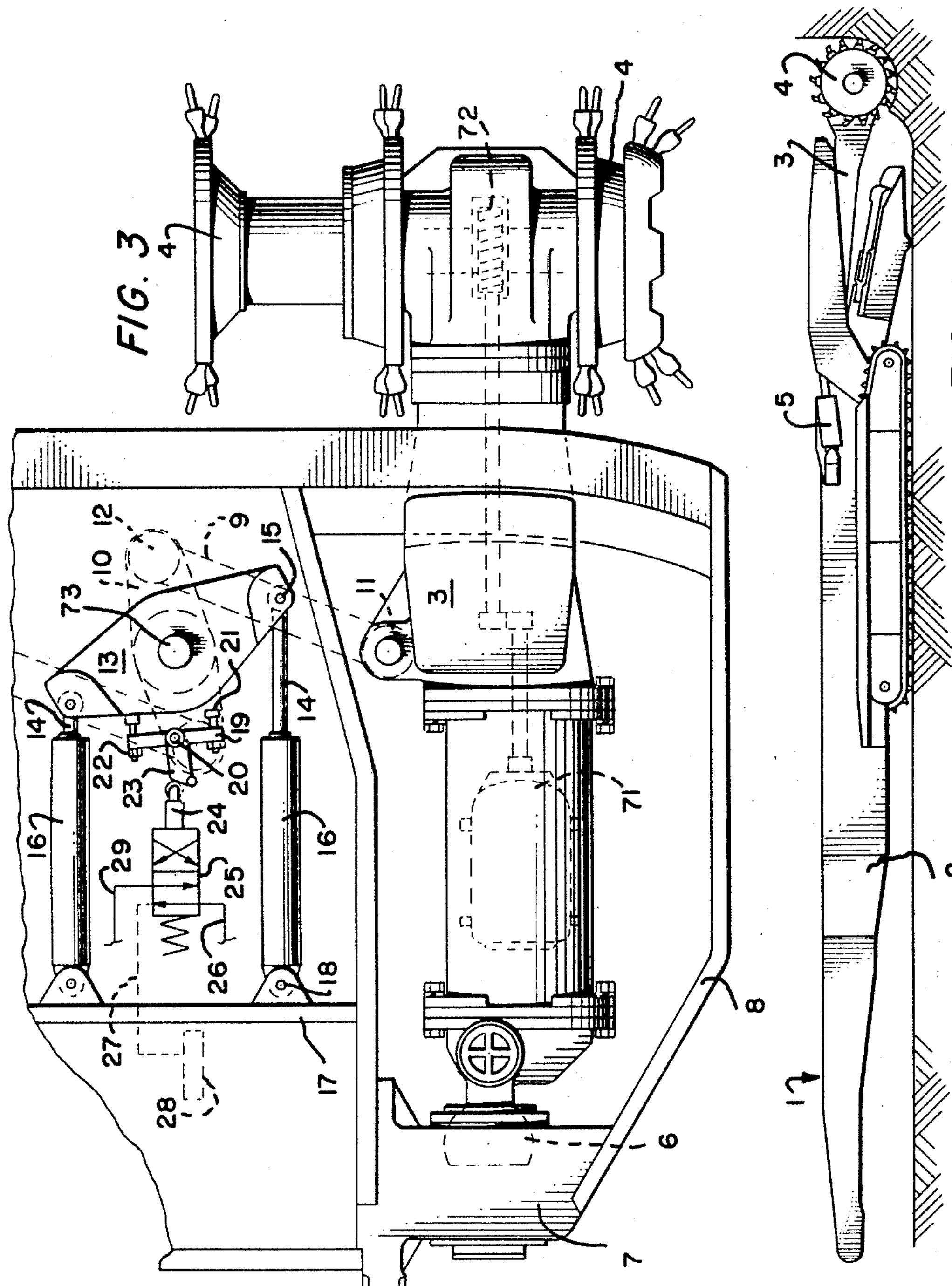

FIG. 3

FIG. 1

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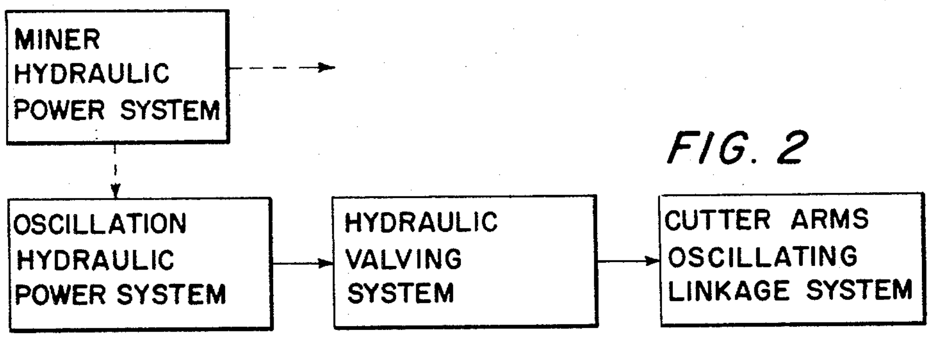

FIG. 2

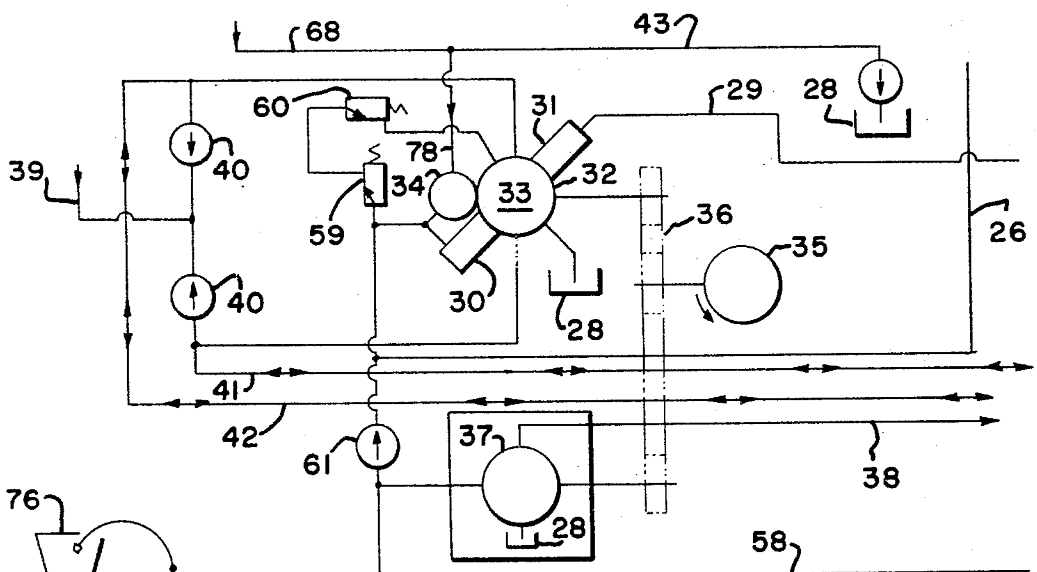

FIG. 4

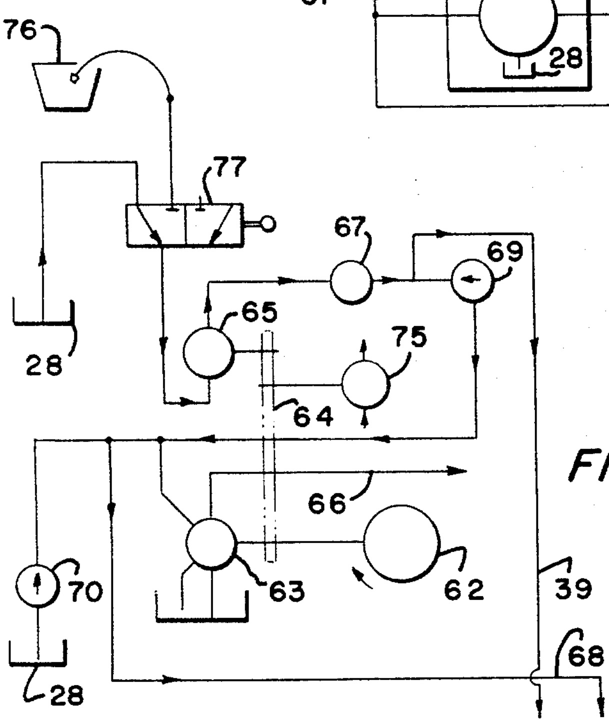

FIG. 6

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MINING MACHINE HAVING OSCILLATING CUTTING ARMS

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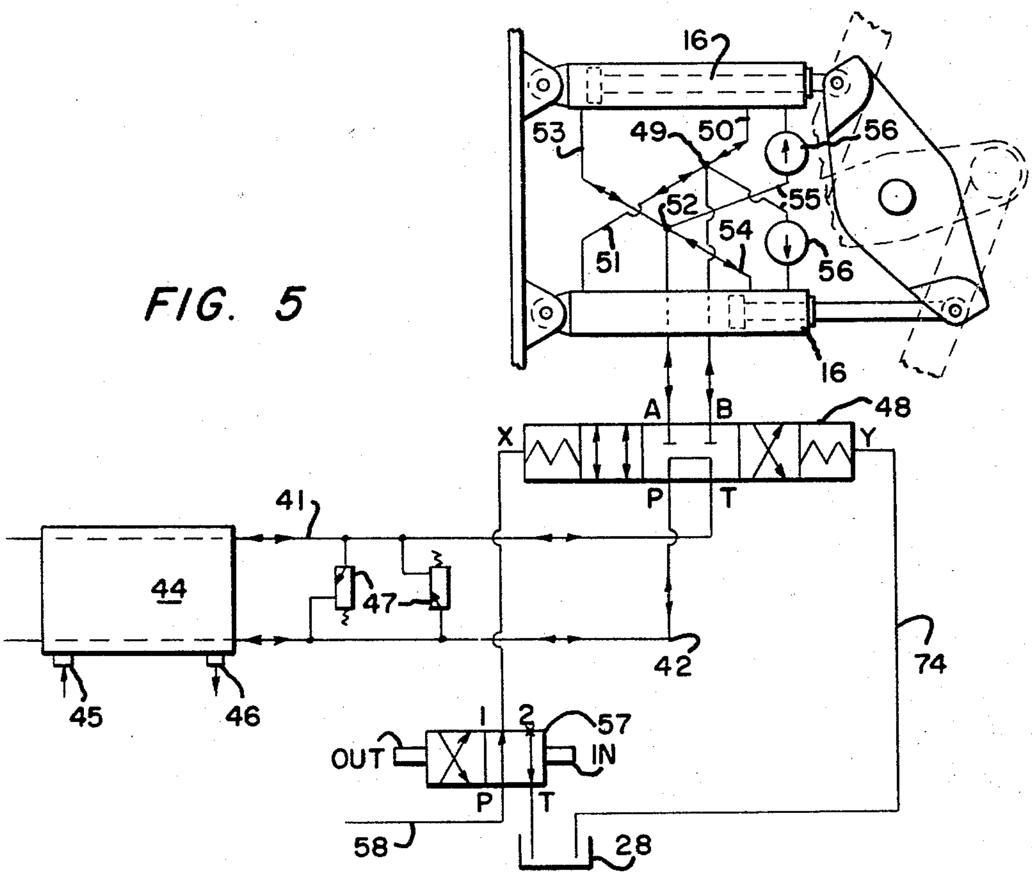

FIG. 5

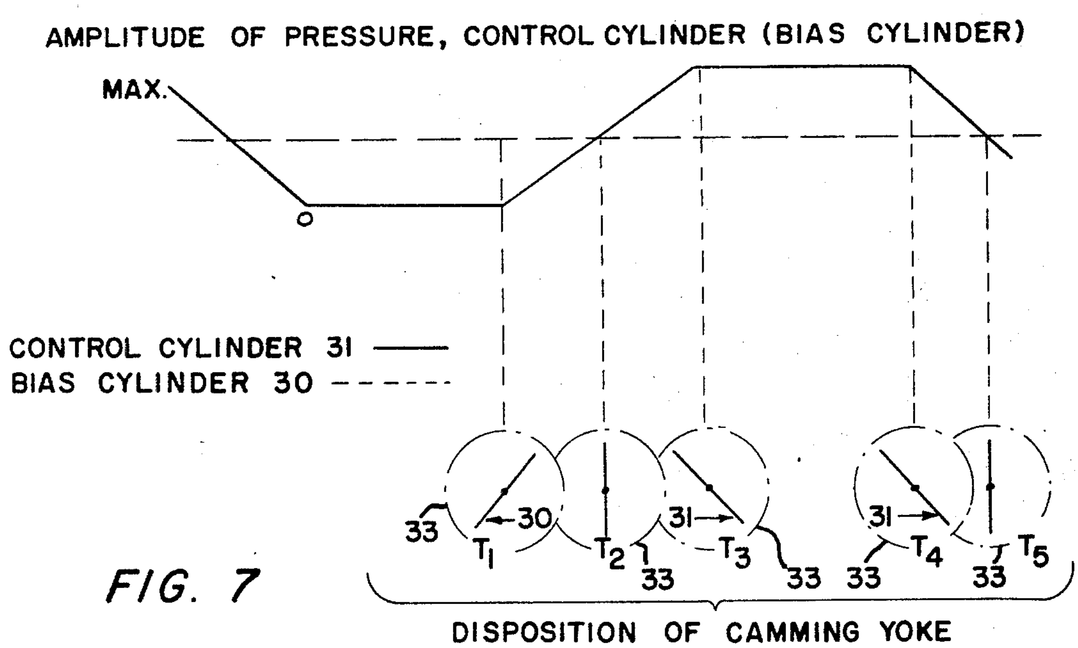

FIG. 7

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MINING MACHINE HAVING OSCILLATING CUTTING ARMS

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U.S. Cl. 299—71 14 Claims

ABSTRACT OF THE DISCLOSURE

A continuous mining machine using a variable-volume hydraulic pump to produce oscillation of forwardly extending cutting arms. The cutting arms support cutting discs which are rotated by electric motors wholly contained in the arms. The pump, a pilot-operated, camming-yoke-type, provides variable-pressure, hydraulic fluid flows of positive and negative values. A hydraulic oscillation system supplies these flows to oscillate cylinders, which are crank-coupled to the cutter arms, in cooperative and successive cycles. Camming means, operated by the cutter arms' crank, moves a pilot valve which, in turn, controls hydraulic fluid pressures used to move the pump camming yoke back and forth in alternating "over-center" positions.

This invention pertains to continuous mining machines and especially to such machines having oscillating cutting arms.

Continuous mining machines known in prior art have hydraulic means for oscillating the cutting arms which comprise pairs of cylinders which simultaneously move the pistons cotnained therein, the pistons being coupled to the arms and the arms being mounted in ball sockets and coupled to each other. The known devices oscillate the arms by addressing a high-volume, pressurized hydraulic fluid, which has a given direction, to one cylinder and an equal volume, pressurized fluid, which has an opposite direction to the other cylinder. With the bottoming of each piston, fluid having an alternate direction then must be addressed to each cylinder. These devices require hydraulic systems that will quickly decelerate and halt hydraulic fluid flow, and the abrupt deceleration causes excessive loading of the hydraulic components and loss of hydraulic fluid. The high-pressure fluid, having considerable mass, with each deceleration and/or redirection produces shock to the detriment of the hydraulic system and other servo-controls and relief valves used therein. These known, prior hydraulic oscillation systems employ constant volume pumps, and it is the constant volume, and the constant pressure developed thereby, which must be dealt with. Thus, these systems require means to shunt and switch the full pressures, from one cutting arm to the other. They must have valving to absorb the total mass and momentum of a given positive fluid force until associated system components can redirect this positive force and then introduce an equally-massive, negative fluid force of the same momentum. The constant volume pump arrangements, then, constantly have to handle equal, full, and opposing fluid pressure in rapid succession. To overcome this limitation, some prior continuous miners employ mechanical means to oscillate the cutting arms. In this it is known to use an eccentric and an associated bell crank to oscillate the arms in a sinusoidal profile. The limitations with the mechanical arrangement arise from their complex structure, the wearing of mechanical parts, the shearing of eccentric pins or other coupling components, and further they have "dead center" positions at which the oscillation can easily be stalled. Additionally, the devices known in the prior art dispose the motors for the rotation of the cutting discs on the chassis and couple the output shafts of the motors to the cutting discs by means of universal joints. This disposition of the motors accommodates the elevation and lowering of the cutting arms. However, these arrangements add to the vertical dimension of the miner, the very dimension which it is necessary to limit. Also, these universally-coupled power shafts have a very limited angle through which they can be directed, in order to satisfy necessary parameters of reliability and power. Further angulation introduces power limitations and a high mortality of components. Accordingly, it is an object of the present invention to provide a continuous miner having hydraulic means for effecting oscillation of the cutting arms without necessitating abrupt decelerations in the massive flow of pressurized hydraulic fluid. An object of this invention is to provide a continuous miner having hydraulic means for oscillation of the cutting arms which employ variable-pressure, hydraulic fluid flows of positive and negative values, and address them to oscillation system components in cooperative and successive cycles, diminishing the flow volumes to zero as they range between the positive and negative functions. Another object of this invention is to provide means for rotation of the cutting arms, which means are carried by the arms so as to minimize the vertical profile of the miner, and to obviate the arising therefrom of any limitation in the elevation of the arms. A feature of this invention is the use of a pilot-operated, camming-yoke-type, variable-volume hydraulic pump having means for smoothly and fully diminishing and then reversing the volumetric flow of pressurized fluid therefrom, continuously, to oscillate the cutting arms. Another feature of this invention comprises the containment of a motor, which provides for rotation of the cutting discs, wholly within the arms. Further objects and features of this invention will become more apparent by reference to the following description taken in conjunction with the figures, in which:

FIG. 1 is a side elevational view of a continuous miner according to the invention;

FIG. 2 is a block diagram of the several systems of the novel miner of FIG. 1;

FIG. 3 is a schematic and mechanical diagram of the cuter arms oscillating linkage system;

FIG. 4 is a schematic diagram of the oscillation hydraulic power system;

FIG. 5 is a schematic diagram of the hydraulic valving system;

FIG. 6 is a schematic diagram of the miner hydraulic power system; and

FIG. 7 is a chart of the functions of the fluid flow operation in the hydraulic oscillation arrangements.

The miner, shown generally at 1 in FIGURE 1 has a chassis 2 to the forward end of which are mounted cutter arms 3 having rotatable cutter discs 4 on the ends thereof. The chassis 2 mounts a hydraulic cylinder 5 for elevation and lowering of the cutter arms. An understanding of the novel oscillation system for the cutter arms is best understood by review of FIGURE 2. Here is shown the several systems which make up the inventive oscillation arrangement, and each is treated in turn in the succeeding figures. FIGURE 2 shows the cutter arms oscillating linkage system which derives its power from the oscillation hydraulic power system by way of the hydraulic valving system. The miner hydraulic power system is principally concerned with providing hydraulic power to the miner tram and other control systems not wholly and immediately pertinent to the present invention, yet the miner hydraulic power system has an ancillary association with the oscillation hydraulic system which will be discussed in the subsequent text.

FIGURE 3 again illustrates one of the cutting arms 3, and it will be seen that arm 3 has a ball socket mounting 6 secured in a gusset 7 of the cutter boom frame 8. A linkage 9 is connected to a lower crank 10 to which it is pivotally coupled by means of pivot couplings 11 and 12 at either ends thereof. The lower crank 10 is fixed to an upper crank 13 which has coupled thereto at the ends thereof piston rods 14 by means of pivoted couplings 15. Upper and lower cranks 10 and 13 are rotatably journaled on a trunnion 73 which is secured in the cutter boom frame 8. The piston rods 14 mount pistons on the ends thereof which operate in the oscillation cylinders 16. The oscillation cylinders 16 are pivotally mounted to a strut 17 of the cutter boom frame 8 by means of couplings 18. A trip lever 19 is pivotally mounted at 20 so as to follow the oscillation of crank 13. The trip lever mounts screw heads 21 which are adjustable in the trip lever by means of lock nuts 22. At one end of the trip lever, there extends therefrom a cam 23. The cam 23 cooperates with a cam follower 24 extending from a schematically shown four-way pilot valve 25. A control cylinder hydraulic line 26 is coupled to the pilot-valve, and a drain line 27 is directed to a reservoir tank 28. A bias cylinder hydraulic line 29 is also coupled to the pilot valve.

FIGURE 4 shows a bias cylinder 30 and a control cylinder 31 coupled to a dual pump 32 across a variable volume section 33 of the dual pump. Dual pump 32 has a vane section 34 which is driven in common with the associated variable volume section 33. Dual pump 32 is driven by a 50 HP motor 35 through gear train 36 which also drives a variable volume pump 37. Variable volume pump 37 produces a hydraulic pressure output which is communicated therefrom through miner operating control line 38. A supercharging line 39 is directed to the dual pump variable volume section 33 through two check valves 40. The output of the variable volume section 33 is conveyed by oscillation control lines 41 and 42. The input for the vane section 34 is received from reservoir tank 28 by way of the hydraulic fluid input line 43.

FIGURE 5 shows the oscillation control lines 41 and 42 passed through the heat exchanger 44 which has input and output ports 45 and 46 for the introduction and evacuation of cooling fluid. The control lines 41 and 42 are further directed along alternately disposed relief valves 47 and proceed to a spring-centered, four-way valve 48. The control line 41, if the mode of operation will so allow, passes through the four way valve 48 to a terminus 49 between the oscillation cylinders 16. From the terminus 49 the control line is directed by means of connecting lines 50 and 51 to each oscillation cylinder. Similarly, control line 42 is carried to a terminus 52 where it is directed to both oscillation cylinders 16 by means of connecting lines 53 and 54. Lines 55 shown connected between the terminuses 49 and 52 and the oscillation cylinders 16 are evacuation lines. Each is passed through a check valve 56 to insure against the introduction of pressure from control lines 41 and 42. A manual pilot-valve 57 is provided in the system for manual start-up and halt of the oscillation system. The manual pilot valve 57 receives a pilot pressure, via pilot pressure line 58, which it either will or will not communicate to four-way valve 48. Manual pilot valve 57 is a two position valve. It directs pilot pressure to one end of a spool of the four-way valve 48 to start the oscillation of the cutter arms 4, or it directs the hydraulic fluid from port X of four-way valve 48 to reservoir 28 to stop oscillation. When pressure is applied to port X of four-way valve 48 the spool thereof will shift, and when pressure is removed the spool will center itself. Line 74 to port Y directs leakage back to reservoir tank 28 from the opposite end of the spool in valve 48. Manual pilot valve 57 provides for a remote control of four-way valve 48, and valve 48 directs the large volume of hydraulic fluid to the cylinders 16 or provides a closed loop, P to T, when the dual pump 32 is idling, without restrictions to its flow, and locks cylinders 16 in position.

In FIGURE 6 is shown an electric motor 62 which drives a constant volume pump 63 direct coupled. Vane pump 65 and a water pump 75 is driven by a chain drive 64 from means, such as a sprocket mounted on the motor coupling and driven in common with the constant volume pump 63. The outlet of the vane pump is passed through a filter 67 and connects with supercharging line 39. A vane section line 68 proceeds from the check valve 69 through another check valve 70 to reservoir 28. Element 76 is an oil bucket or drum, and has coupled thereto a two-way manual valve 77. The vane pump 65 can pump hydraulic fluid to the system from reservoir tank 28, and when manual valve 77 is shifted, the reservoir tank 28 can be filled from the oil drum 76 by vane pump 65. Oil passes through filter 67 and check valves 69 and 70 to tank 28. Water is directed from the water pump 75 to heat exchanger 44 and on to water sprays located at various points of the cutter boom frame 8 (such sprays not being shown).

The operation of the oscillation system is best understood by reference to FIGURES 3 through 7 in conjunction with the following discussion.

The hydraulic arrangement for the oscillation is a "closed system" consisting of two hydraulic cylinders 16, two relief valves 47, a pilot control valve 25, a dual pump 32 having a constant volume section 34 and a variable volume piston pump section 32 with a bias cylinder 30 and a control cylinder 31 disposed across the latter section, a four-way valve 48, heat exchanger 44, and manual pilot valve 57.

A 50 HP, at 1200 r.p.m., electric motor 35 drives the two pumps 32 and 37 through a gear train 36. Variable volume piston pump 37, a servo-controlled pump is of a type, such as Vickers Model No. M–PVB29–RSG–10–D–10–048, which supplies 29.3 g.p.m. of hydraulic fluid at 1800 r.p.m. This is used to power the tram motors and all hydraulic cylinders of the miner, excepting the oscillation cylinders 16.

Pump 32 is of a type such as Vickers Model No. M–PVB29–RDE–10–WA–10–098 which is a dual pump. It comprises a variable volume section 33 which supplies 29.3 g.p.m. at 1800 r.p.m., to operate the hydraulic cylinders 16, and a fixed vane section 34 which produces 4.75 g.p.m., at 1800 r.p.m. to operate the bias cylinder 30 and control cylinder 31 which two cylinders control the variable volume section 33. Two check valves 40 permit "make-up" or supercharging fluid to be applied to the closed circuit by way of supercharging line 39. Relief valves 59 and 60 provide 350 p.s.i. from the fixed vane section 34 to an internal control circuit of the variable volume section 33. This internal control circuit supplies hydraulic power to the two opposed cylinders, the bias cylinder 30, having a 1$\frac{1}{16}$" diameter, and a control cylinder 31, having a 1½" diameter. The two cylinders are fastened to a camming yoke in the variable volume section 33 so as to change the position of the camming yoke. With the camming yoke of variable volume section 33 in one position, high-volume hydraulic fluid pressure is directed toward cylinders 16 through oscillation control line 41; with the camming yoke in the alternate position, oscillation control line 42 communicates the pressurized fluid. The control cylinder 31, having more area than the bias cylinder 30, easily overcomes the bias cylinder and moves the camming yoke of the variable volume pump 33 "over-center." This causes the oscillation cylinders 16 to decelerate, stop and accelerate in the opposite direction. Flow is directed to the control cylinder 31 by control cylinder hydraulic line 29 through four-way pilot valve 25 which is actuated by cam 23 by the position of the oscillation cylinders 16. At a precise instant, the cam 23 shifts the pilot valve 25 and reverses the system without having to bottom the pistons in the oscillation cylinders 16. When the pilot valve **25** is actuated by the cam **23** again, the control cylinder hydraulic line **26** is directed to reservoir tank **28** through drain line **27** while the bias cylinder **30**, having constant pressure, overcomes the control cylinder **31** and moves the camming yoke "over-center," again reversing the flow to the oscillation cylinders **16**, thus imparting an oscillation motion to the cutter arms **3**. The Vickers pump (of Vickers Incorporated, Division of Sperry Rand Corporation, Troy, Mich. 48084) used in the preferred embodiment of the invention is a packaged assembly. The whole unit contains the two pump sections **33** and **34**, the two cylinders **30** and **31**, the two relief valves **59** and **60**, and the check valves **40**. Other embodiments, which employ the same kinds of components in an arrangement as disclosed, can be constructed without departing from the spirit of my invention.

The two main lines, oscillation control lines **41** and **42**, proceeding from the variable volume pump **33** incorporate a common heat exchanger **44** for cooling the oil and oppositely disposed relief valves **47** are set to relieve at 3000 p.s.i. In the event that the cutter arms **3** are stalled, fluid will relieve to the suction side of the pump through one or the other of valves **47**.

A spring centered, pilot operated four-way valve **48** is actuated by manual pilot valve **57** to start or stop the cutter arms oscillation. When the manual pilot valve **57** is pushed in (contrary to the position shown in FIGURE 5), the four-way valve **48** is in a neutral position. The cutter arms **3** will not oscillate and the pilot pressure line **58** is diverted to port **2** of pilot valve **57** which is blocked preventing loss of control pressure. Pilot port X of four-way valve **48** is vented to tank **28**, allowing the spring centered 4-way valve **48** to center its spool, and forming a closed loop for the variable volume section **32**. At the same time, fluid is locked in the oscillation cylinders **16**, thereby preventing the cutter arms from moving from side to side if they are bumped. When pilot valve **57** is pulled out (the position as shown in FIG. 5), the spool of the four-way valve **48** is shifted, and pressure is diverted to one side of oscillation cylinders **16**. This begins the stroking action of the cylinders.

The vane section **34** of the dual pump **32** provides pilot pressure to actuate the four-way valve **48** and also a servo-control of the variable volume pump **37** which meters fluid to tram motors as well as all other hydraulic cylinders on the miner. A 5 p.s.i. check valve **61** prevents siphoning of the pilot pressure line **58** between the two pumps **37** and **32**.

As shown in FIG. 6, a 50 HP 1200 r.p.m. electric motor **62** drives a 43 g.p.m. volume piston pump **63** and, through a chain drive **64**, a 12 g.p.m. vane pump **65** and a water pump **75**. The outlet **66** of the constant volume pump **63** is directed (by valving not shown) to conveyor drive circuits or to the variable volume pump **37** to increase the tramming speed of the miner. It also provides, as a safety, an alternate means of tramming the miner in the event that the variable volume pump **37** is disabled.

The 12 g.p.m. vane pump **65**, as noted earlier, resupplies the reservoir tank **28**. It is used to pump 10 micron filtered hydraulic fluid through a filter **67** into the reservoir tank **28**. It supplies the fluid to the suction line **78** of the vane section **34** of the dual pump **32** by way of line **68** and supercharges the oscillation circuit, through line **39**, at 50 p.s.i. thereby replacing any fluid lost through leakage. The 50 p.s.i. supercharge pressure is maintained by a check valve **69**. The outlet side of this check valve is connected to a 5 p.s.i. check valve **70** before returning to the reservoir tank **28**.

Returning to FIGURE 3, an electric motor **71** is shown fixed within a section of a cutter arm **3**. The motor **71** is coupled to the cutter discs **4** by means of a gear train and shaft coupling **72**. It is this provisioning of the motor **71** that facilitates a reduction in the height dimension of the miner. Further, this arrangement obviates any necessity for the complex and mechanically limited universal

coupling of rotation motors practiced in the prior art. Thus, this miner construction taught by my disclosure achieves a low profile and can realize a vertical displacement of the cutting arms unlimited by rotation motor coupling.

FIGURE 7, in the diagrams presented thereon, will serve to elucidate the inventive novelty of the hydraulically-controlled oscillation of the cutting arms. The heavy line in angular-serpentine disposition represents the amplitude of pressure to which the control cylinder **31** is exposed. As the illustration depicts, the control cylinder has pressure addressed thereto, by way of hydraulic line **29** (FIG. 4), which constantly cycles. The pressure diminishes, from a maximum, to zero, maintains zero pressure, and then increases to maximum again. The bias cylinder **30** is effectively displaced or released, as a consequence of the action of the control cylinder **31**, as depicted by the light, linear dashed line. The bias cylinder **30**, constantly under pressure by way of hydraulic line **26** (FIG. 4) becomes more and more effective on the camming yoke within the variable volume section **33** as the control cylinder **31** pressure diminishes. When the control cylinder pressure is at zero, the bias cylinder **30** maintains effectiveness over the the camming yoke. Subsequently, the control cylinder **31** resumes control over the camming yoke, and overcomes the bias cylinder pressure. At time **T1**, the bias cylinder **30** has control over the camming means, and by time **T3** it has been overcome by the superior force of the control cylinder **31**. Between times **T2** and **T5** the cutting arms **3** are moved in a given direction, for instance, towards the centerline of the miner. From time **T5** to what would be time **T8**, the cutting arms **3** proceed to move in the opposite direction; i.e., away from the centerline of the miner. The fluid pressure, directed to cylinders **16** to cause movement of the cutting arms **3** to a given disposition, at time **T1** proceeds to diminish. The disposition of the camming yoke, at time **T1**, will be as shown. At time **T2**, the two pressures as registered by cylinders **30** and **31** are in balance and so therefore is the camming yoke, and the cutting arms **3** have fully diminished movement. Between times **T2** and **T3** the pressures, operative in opposite directions, cooperate to commence movement of the arms **3** to the alternate disposition. Between times **T3** and **T4** the now full and opposite pressures continue the movement of the arms **3** to the alternate position. The movement is now at a given momentum, whereas from times **T1** to **T3** it was gradually increasing. Between times **T4** and **T5** pressures again proceed to diminish, and movement of the arms **3** also diminishes, halting at time **T5**.

Clearly then my disclosure teaches the use of a variable volume pump to achieve a progressive and gradual increase and diminution of hydraulic fluid addressed to the cutter arms oscillation cylinders. Further, my disclosure teaches how to control and redirect the massive flows of hydraulic fluid without necessitating abrupt decelerations in said flows.

While I have described my invention in connection with specific apparatus, it is to be clearly understood that this is only by way of example and not as a limitation to the scope of my invention or set forth in the objects thereof and in the accompanying claims.

I claim:

1. A mining machine, comprising:

a chassis;

a plurality of arms coupled to said chassis and extending forwardly thereof;

cutting elements rotatably mounted in the forward ends of said arms;

first means carried by said chassis for raising and lowering said arms;

means providing a variable-volume, pressurized hydraulic fluid for powering the mining machine;

hydraulic-actuated means, coupling said fluid providing means with said arms, to cause oscillation of said arms in sidewise directions; and second means carried by said arms for rotating said cutting elements; wherein said variable-volume, hydraulic fluid providing means includes a hydraulic pump having a plurality of output means, and each output means of said plurality discharges increasing and diminishing flows of hydraulic fluid to said hydraulic-actuated means which cause said arms to oscillate across an arc, in increasing and diminishing rates of movement.

2. A mining machine, according to claim 1, wherein: said second means comprise drive means mounted wholly within said arms.

3. A mining machine, according to claim 1, wherein: said pump further has camming means displaceable between first and second dispositions to provide said flows of said hydraulic fluid in a given direction, and in a direction contrary to said given direction, by way of said output means, to said hydraulic-actuated means;

biasing means tangential with said camming means to urge said camming means to assume said first disposition, and counterbiasing means tangential with said camming means operable to overcome said biasing means so as to cause said camming means to assume said second disposition; and

wherein said hydraulic-actuated means includes means connected to, and operative of, said counterbiasing means.

4. A mining machine, according to claim 1, wherein: said hydraulic-actuated means comprises means which causes displacement of said arms, in the oscillation thereof, in a movement cycle comprising a first movement of gradually decreasing momentum, a second movement of increasing momentum, and a third movement of a given momentum.

5. A mining machine, according to claim 4, wherein: said displacement causing means includes means effective, in said first movement, to displace said arms in a given direction, and effective, in said second and third movements, to displace said arms in an opposite direction.

6. A mining machine, according to claim 1, wherein: said hydraulic-actuated means comprises means which causes displacement of said arms, in the oscillation thereof, in a movement cycle comprising a first movement of gradually increasing momentum, a second movement of a given momentum, and a third movement of diminishing momentum.

7. A mining machine, according to claim 6, wherein: said displacement causing means includes means effective, in said first, second, and third movements, to displace said arms in a given direction.

8. A mining machine, according to claim 1, wherein: said hydraulic actuated means include control means for selectively commencing and ceasing oscillation of said arms.

9. A mining machine, according to claim 8, wherein: said control means include means for restraining said arms against said movement.

10. A mining machine, according to claim 1, further comprising:

trunnion means mounted through said chassis;

crank means journaled on said trunnion means;

reciprocating means intercoupling said crank means and said chassis; and

linkage means intercoupling the arms of said plurality with said crank means.

11. A mining machine, according to claim 10, wherein: said crank means comprises first and second cranks, at least one of said cranks being disposed on one side of said chassis;

said first and second cranks being unitized to rotate in common about said trunnion; and

wherein said reciprocating means is coupled to said first crank, and said linkage means is coupled to said second crank.

12. A mining machine, according to claim 10, wherein:

said reciprocating means comprise a plurality of hydraulic cylinders, said cylinders having reciprocable pistons carried therein, and hydraulic fluid ports formed therein for the communication of said hydraulic fluid therewith for causing reciprocation of said pistons;

wherein said hydraulic-actuated means further comprise means for communicating said hydraulic fluid with said ports, and means for controlling the fluid communication therewith;

said controlling means having a first constantly-biased mode of operation and a second variably-powered mode of operation, and including pilot means operable for changing the operation thereof between said first and second modes; and

wherein said crank means include means operative of said pilot means to change said controlling means from said first to said second mode of operation.

13. A mining machine, according to claim 12, wherein:

said fluid providing means provides hydraulic fluid having a given direction and provides hydraulic fluid having a direction contrary to said given direction;

said hydraulic-actuated means couples said fluid providing means with said communicating means via a plurality of coupling channels; and

said fluid providing means and said communicating means cooperate to communicate said hydraulic fluid having said given direction with said cylinders, by way of one channel of said plurality, and said hydraulic fluid having said contrary direction with said cylinders, by way of another channel of said plurality.

14. A mining machine, comprising:

a chassis;

a plurality of arms coupled to said chassis and extending forwardly thereof;

cutting elements rotatably mounted in the forward ends of said arms;

means carried by said chassis for raising and lowering said arms;

means carried by said arms for rotating said cutting elements;

means providing a supply of hydraulic fluid;

means hydraulically-actuated, and coupled to said arms, for causing oscillation of said arms in sidewise directions;

means for communicating said supply with said oscillation causing means to actuate same; and

means operatively interposed between said communicating means and said oscillation-causing means for controlling the supply communication;

said control means comprising means for progressively increasing said communicating fluid to a given, pressured volume, means for progressively decreasing said communicating fluid from said given, pressured volume, and means for reversing communication direction of said fluid, automatically in synchronism with said oscillation.

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