Feb. 15, 1966 L. D. HAGENBOOK 3,235,311

VIBRATORY CUTTER MEANS FOR MINING MACHINES

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Fig. 1

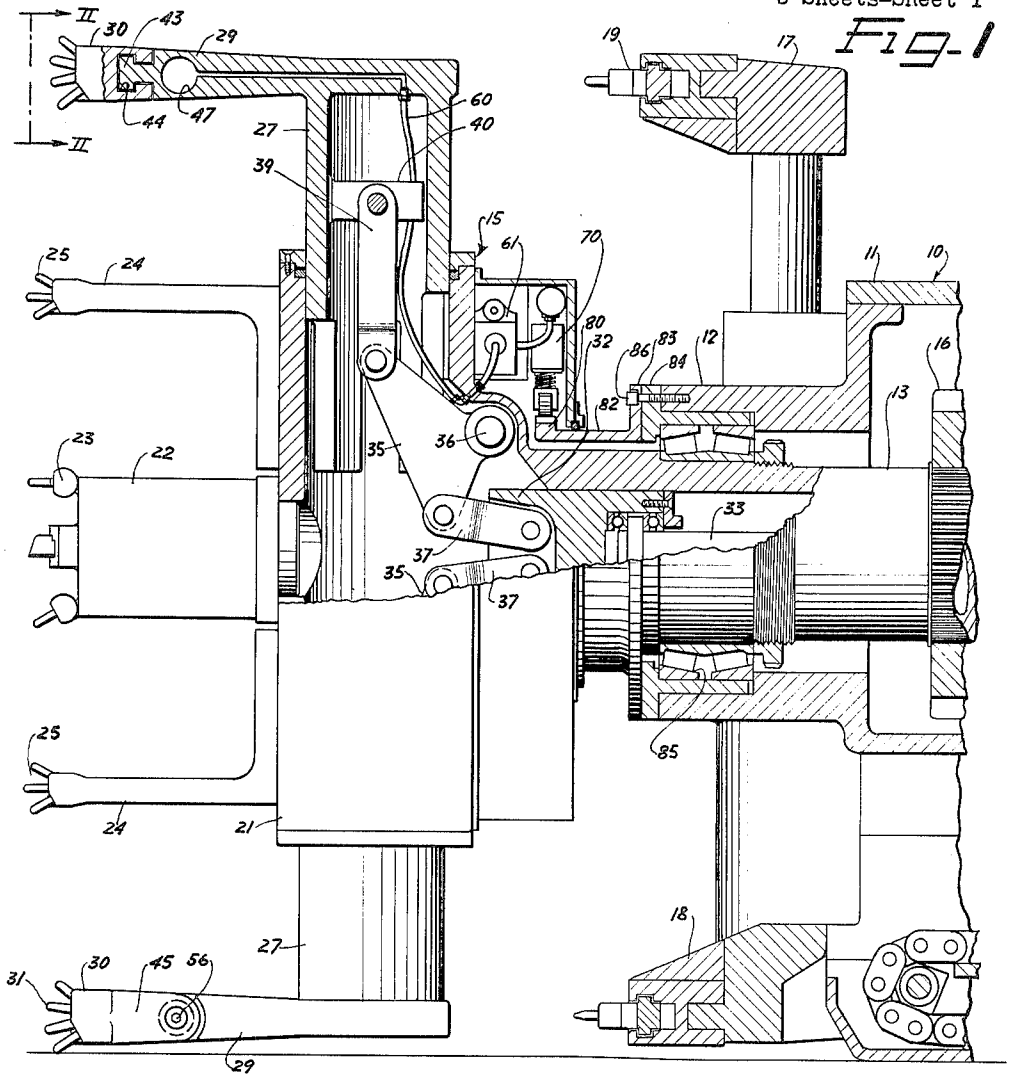
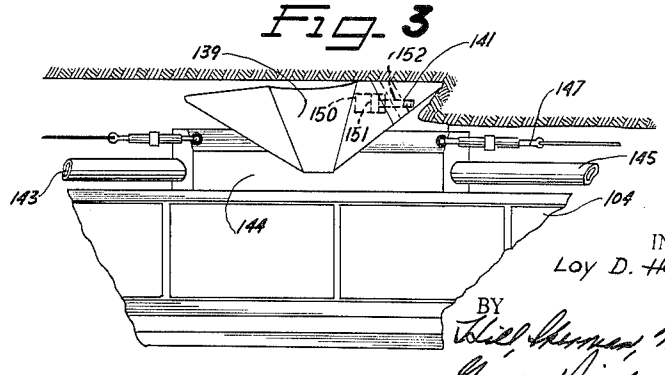


Fig. 3



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Fig. 4

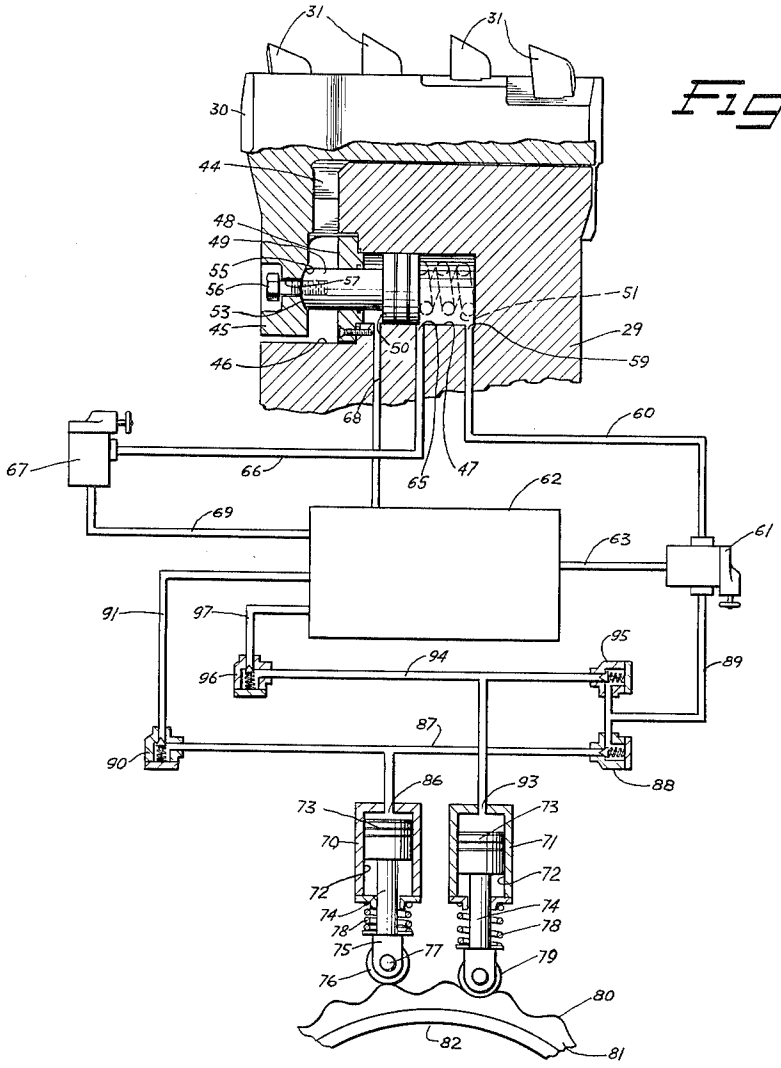
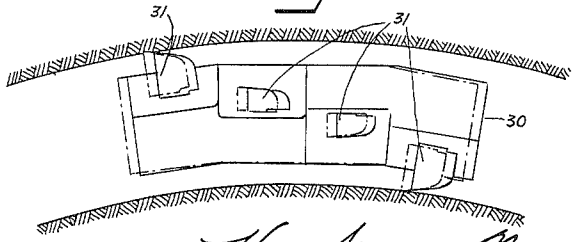


Fig. 2



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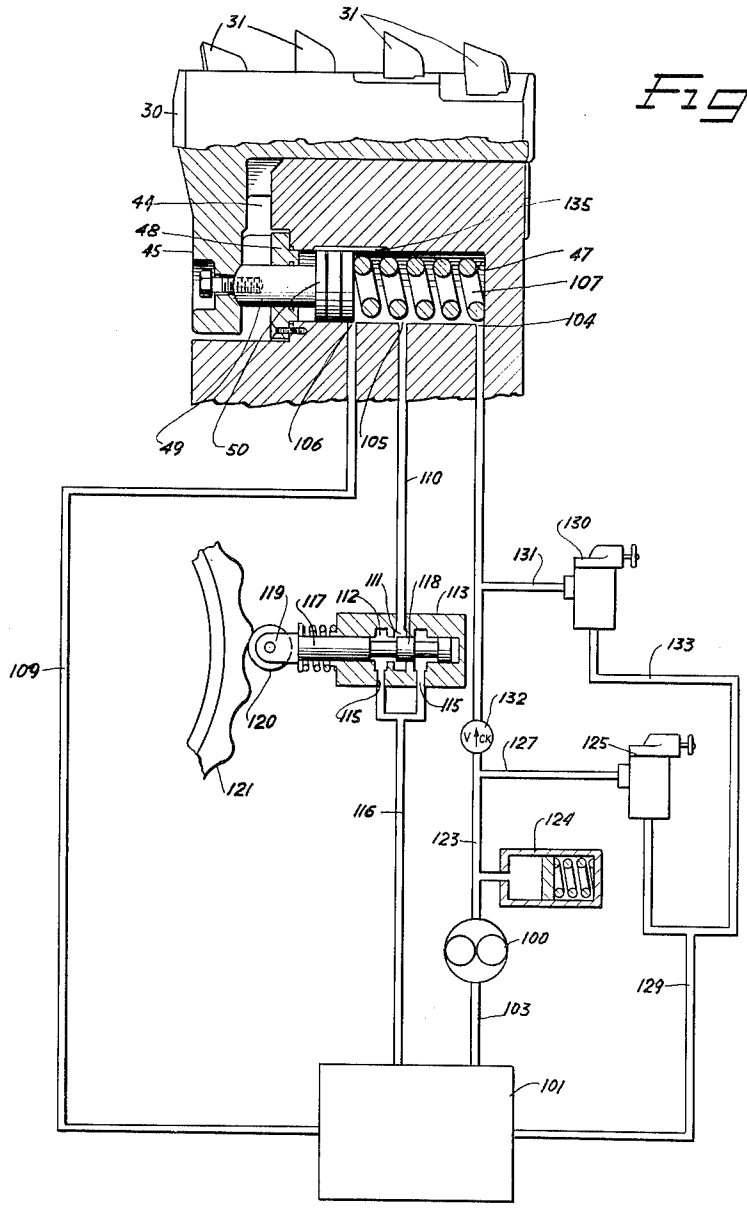
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VIBRATORY CUTTER MEANS FOR MINING MACHINES

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Fig. 5



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3,235,311

VIBRATORY CUTTER MEANS FOR MINING MACHINES

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6 Claims. (Cl. 299—1)

This invention relates to improvements in mining machines.

A principal object of the present invention is to improve upon the cutting ability of the cutter bits of mining machines by pulsating or vibrating the cutter bits as the bits become loaded while traveling in their cutting paths.

Another object of the invention is to reduce the power requirements for driving the cutters of mining machines and the like by providing an improved mounting for the cutter bits of the mining machine, pulsating or vibrating the bits when loaded during the operation of mining.

Still another object of the invention is to increase the efficiency of cutting of mining machines by mounting the cutter bits in their cutter supports for movement along the cutter supports and by providing a pulsating means for reciprocably moving the bits along their cutter supports in a pulsating or vibratory manner upon the encountering of predetermined loads on the bits.

A still further object of the invention is to improve upon continuous mining machines of the rotary boring type by mounting the cutter bits in their cutter supports for reciprocal movement along the supports, and by providing fluid pressure means operated by rotary movement of the cutter supports for reciprocably moving the bits in a pulsating or vibratory manner, as the cutter bits become loaded.

These and other objects of the invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings wherein:

FIGURE 1 is a partial fragmentary longitudinal sectional view taken through the cutting end of a continuous mining machine constructed in accordance with the principles of the present invention;

FIGURE 2 is a diagrammatic end view of a cutter block and cutter bits of a continuous mining machine, showing the bits cutting an annular kerf in the working face of a mine;

FIGURE 3 is a diagrammatic view showing the principles of the present invention applied to a plow type of cutter;

FIGURE 4 is a diagrammatic view showing the mounting of the cutter bits on their cutter support and showing one form of fluid pressure system for vibratorily moving the cutter bits; and

FIGURE 5 is a view somewhat similar to FIGURE 4 and showing a modified form of fluid pressure system for imparting vibratory motion to the cutter bits.

In FIGURE 1 of the drawings, I have shown the cutting end portion of a continuous mining machine 10 of the boring type having a cutter frame 11, mounted on and projecting forwardly from the main frame (not shown) of the machine, for vertical adjustment with respect thereto in a conventional manner. The cutter frame 11 has spaced hollow bosses 12 extending forwardly therefrom, only one hollow boss being shown herein in order to simplify the illustration of the invention. The boss 12, as shown in FIGURE 1, forms a bearing support for a shaft 13 for a boring head 15. The shaft 13 is shown as being a hollow shaft and as extending within the cutter frame 11 and having a spur gear 16 splined thereto for

driving said shaft and the boring head 15, in a conventional manner.

The cutter frame 11 also forms a support for an upper cutter or trimmer bar 17 and a lower cutter or trimmer bar 18. The trimmer bars 17 and 18 have a cutter chain 19 guided for movement therealong for cutting along the roof to cut out the depending cusps left between the boring heads 15 and cutting along the mine floor to cut out the upwardly extending cusps left between said boring heads.

The boring head 15 is shown in FIGURE 1 as being a conventional form of telescopic boring head having a hollow diametral boring arm 21 formed integrally with the shaft 13. The boring arm 21 has a central pilot cutter support 22 extending forwardly therefrom, having cutter bit carrying cutter blocks 23 projecting forwardly therefrom for cutting a pilot kerf in the mine face. The boring arm 21 also forms a support for outwardly spaced cutter supports 24, 24 having cutter bits 25, 25 projecting forwardly therefrom, and pitched at various angles with respect to said cutter supports to cut clearance therefor.

Hollow telescopic arms 27 are shown as being mounted in opposite ends of the boring arm 21 for telescopic movement with respect thereto. Each boring arm 27 has a cutter support 29 projecting forwardly therefrom and slidably carrying a cutter block 30, as will hereinafter be more clearly described as this specification proceeds. The cutter blocks 30 have a plurality of cutter bits 31 projecting from the face thereof and pitched at varying angles with respect to said block to cut clearance for said cutter blocks and for the cutter supports 29.

The telescopic arms 27 are adjustably moved together and held in fixed relation with respect to each other by a slide 32 slidably carried within the hollow interior portion of the hollow shaft 13. The slide 32 may be moved along the shaft 13 and held in fixed relation with respect thereto by a hydraulic cylinder and piston including a piston rod 33 extending from a cylinder (not shown) and having connection with said slide for moving said slide along the hollow interior portion of the shaft 13 and for holding said slide in fixed relation with respect to said shaft.

The slide 32 is connected with the telescopic arms 27 by bell cranks 35. The bell cranks and connections therefrom to the cutter supports are the same for each cutter support so one connection only need herein be shown and described. The bell crank 35 is pivotally connected within a backwardly recessed portion of the diametral arm 21 by a transverse pivot pin 36. The slide 32 is connected with lever arm of the bell crank 35 by a link 37. The other lever arm of the bell crank 35 is connected with the telescopic arm 27 by a link 39 pivotally connected between spaced connector bars 40, extending across the hollow interior portion of the telescopic arm 27.

The cutter supports 29 generally conform in end view to the annular kerf cut by the cutterbits 31 and each has a T-shaped tongue 43 extending therealong, slidably interengaged with a corresponding groove 44 extending along the cutter block 30 and opening to the ends thereof. Each cutter block 30, as shown in FIGURE 4 has a leg 45 extending inwardly from the advance face thereof along a notch 46 formed in the advance end of the cutter support 29. A cylinder 47 is shown in FIGURE 4 as formed integrally with the cutter support 29 and as opening into the advance face of the notch 46. The open end of the cylinder 47 is closed by an end cap 48 having a piston rod 49 slidably extending therethrough. A piston 50 is mounted within the cylinder 47 for movement therealong. The piston 50 may be biased in outwardly extending relation with respect to the cylinder 47 by pressure in the cylinder 47, equal to the normal cutting force on the cutter bits 31,

or by a compression spring 51, herein shown in dotted, since the compression spring is only shown as an alternate biasing means for the piston 50.

The outer end of the piston rod 49 is rounded as indicated by reference character 53 and engages a corresponding rounded or generally spherical socket 55 formed in the inner face of the leg 45. A machine screw 56 extending loosely through a larger diameter drilled hole 57, drilled through the leg 45, is provided to retain the leg 45 to the piston rod 49 and to accommodate limited freedom of movement of said leg in the cutter block 30 with respect to the piston rod 49, to prevent binding of the piston rod and piston, where the block 30 may become misaligned with respect to the cutter support 29 during cutting.

A pressure port 59 opens into the head end of the cylinder 47 and is connected with a fluid pressure line 60 leading from a relief valve 61 connected with a tank 62, to return fluid thereto upon excessive pressures in the cylinder 47, through a return line 63. A return port 65 leads from the cylinder 47 intermediate the ends thereof and has connection with a return line 66 connected with a relief valve 67. The relief valve 67 is loaded to the normal cutting forces on the bits 31 to bias the cutter block 30 in the forwardly extended position shown in FIGURE 4. A return line 69 connects said relief valve to the tank 62. A third port 68 leads from the cylinder 47 and is connected directly to the tank 62. This port is at the opposite side of the piston 50 from the port 65 and is closed as the piston reaches the end of the pressure stroke, to accommodate fluid in the piston rod end of said cylinder to cushion said piston.

The means for suppiying fluid under pressure to the pressure line 60 is shown in FIGURE 4 as comprising two alternately operable fluid pressure pumps 70 and 71. The pumps 70 and 71 are suitably mounted on the boring arm 21 for rotation therewith (FIGURE 1), and are each cylinder and piston types of pumps of a similar construction. Each pump includes a cylinder 72 having a piston 73 therein having a piston rod 74 extensible therefrom. A yoke 75 as mounted on the lower end of the piston rod 74 and has a follower roller 76 mounted thereon between the furcations thereof on a pivot pin 77. A spring 78 is provided to move the piston 73 on its suction stroke.

The pump 71 is exactly like the pump 70 and has a follower roller 79 on the lower or outer end of its piston rod. The follower rollers 76 and 79 alternately engage the peaks and valleys of an undulating cam face 80. The cam face 80 is formed along a radial flange 81 extending radially outwardly of the outer end of a sleeve 82 encircling the shaft 13 and spaced outwardly therefrom (FIGURE 1). The sleeve 82 has an inner radial flange 83 abutting the outer face of a bearing retainer 84, for bearings 85 for the shaft 13, and secured to the end of the hollow boss 12 as by machine screws 86.

The pump 70 has a port 86 in its head and connected with a line 87. The line 87 is connected at one end with a check valve 88 opening upon pressure in said line to accommodate the flow of fluid through a pressure line 89 connected with the relief valve 61. The line 87 has connection at its opposite end with a check valve 90 set to be closed by pressure in the line 87, and to open upon suction in said line. A suction line 91 connects the tank 62 with the check valve 90.

In a like manner the pump 71 has a port 93 in its head end connected with a line 94, shown as having a check valve 95 opening upon pressure in the line 84 at one end and as having a check valve 96 opening upon the suction stroke of the pump 71 at its opposite end, and connected with the tank 62 through a suction line 97. The check valve 95 is connected with the pressure line 89.

As has previously been mentioned the pressure relief valve 67 may be set to a value substantially equal to the normal cutting forces on the bits 31 to hold the piston in the position shown in FIGURE 4. The relief valve 61 is loaded to a higher pressure than the relief valve 67 to accommodate the supply of fluid under pressure to the cylinder 47 at a higher pressure than the forces of the resistance to normal cutting, to provide the pressure to force the piston 50 and cutter block 30 forwardly along the cuttter support 29, which may be to a position where said piston closes the groove 70.

During rotation of the boring head 15, the pumps 70 and 71 will be alternately driven on their pressure strokes as the followers 76 and 79 ride along the high portions of the cam 80 and will be returned by the return springs 78 to effect the suction strokes of said pumps. During each pressure stroke of each pump, assuming the forces of cutting are greater than normal and the port 65 is closed, fluid under pressure will be supplied to the piston 50 at a higher pressure than the force of resistance of the cutter bits 31 to normal cuttting determined by the setting of the relief valve 61. This will force the piston 50 and cutter block 30 in a forward direction along the cutter support 29. As the pressure is released as the respective follower moves down along the low part of the cam, the cutting forces on the cutter bits 31 will move the block 30 backwardly along the cutter support 29 and force fluid to return to tank 62 through the low pressure relief valve 67.

The two pumps 70 and 71 will thus intermittently force the piston 50 outwardly along its cylinder, while the cutting forces on the bits 31, 31 will return said piston. The cutter bits 31 are thereby pulsated in a vibratory manner as abnormal cuttting forces are encountered, to thereby increase the penetrability of the cutter bits and greatly facilitate the cutting action thereof, and reduce the power requirements for driving the boring arms and for feeding the boring arms axially into the working face of the mine.

In the form of the invention illustrated in FIGURE 5, a motor driven pump 100 connected with a tank 101 through a suction line 103, affords the source of hydraulic fluid under pressure to pulsate the cutter bits 31 as the cutting forces on the cutter bits increase above normal cutting forces.

The vibrating or pulsating cylinder and piston shown in FIGURE 5 is similar to that shown in FIGURE 4, except the cylinder is longer, to accommodate three ports 104, 105 and 106 along the length thereof. The connection from the piston rod to the cutter block 30 is also the same as in the form of the invention illustrated in FIGURE 4, so the same part numbers will be applied to the cutter block, cylinder and piston and connection from the piston to the cutter block, as were applied to the form of the invention illustrated in FIGURE 4.

In this form of the invention, the piston 50 is positively biased outwardly along the cylinder 47 by a compression spring 107, which may be loaded to substantially the normal forces of cutting on the cutter bits 31, 31.

The port 106 is a return port and is connected with a return line 109 leading to the tank 101. The port 105 is a pulsating port and has a low pressure line 110 connected thereto and leading to a port 111 communicating with a valve chamber 112 in a valve block 113. Two spaced pulsating ports 115, 115 spaced on opposite sides of the port 111 lead from the valve chamber 112 and are connected with a return line 116 leading to the tank 101.

A valve spool 117 is slidable within the valve chamber 112 and has a central land 118 movable to close the port 111 and intermittently block the port 111, and stop the flow of fluid to the tank 101, and in effect create a water hammer acting on the piston 50. The land 118 also opens the port 111 to either of the ports 115, to alternately release pressure from the cylinder 47. The valve spool 117 has a yoke 119 on its outer end having a follower roller 120 mounted between the furcations thereof and engaging an undulating cam face 121 like the cam

face 80, and held from rotation during rotation of the valve block 113 with the boring head 21.

The pump 100 is connected with a pressure line 123 having an accumulator 124 connected therein. The pressure line 123 is directly connected with the port 104 at the head end of the cylinder 47 and has a check valve 132 therein. A relief valve 125 is connected with the pressure line 123 through a pressure line 127 leading from the pressure line 123 upstream of the check valve 123. The relief valve 125 is connected to tank 101 through a return line 129. A pressure relief valve 130 is connected with the pressure line 123, downstream of the check valve 132 and the high pressure relief valve 125, through a pressure line 131. The relief valve 130 is connected to the tank through a return line 133 connected with the return line 129.

The relief valve 125 is set high enough to accommodate the building up in pressure in the accumulator 124 and is provided to relieve excessive pressures from the pump 100.

The relief valve 130 connected in the pressure line 123 is set to relieve pressure from the cylinder 47 upon excessive pressure therein and is therefore set at a higher pressure than the relief valve 125.

In the form of the invention just described, the reactions to normal cutting are generally balanced by the spring 107, and the return line 106 is normally open when said piston is in a balanced condition. A groove 135 leading along a wall of the cylinder 47 accommodates the leakage of fluid to the piston rod end of the cylinder and thereby provides fluid to cushion the piston 50 at the ends of its pressure strokes.

During the cutting operation, the pump 100 will supply fluid under pressure to the cylinder 47 through the pressure line 123. When cutting conditions are normal, fluid will pass to tank through the return line 106. As the resistance to cutting increases sufficiently to move the piston to close the port 106, pressure will be supplied to the piston 50 at a pressure determined by setting of the relief valve 130. The land 118 blocking the port 111 will suddenly stop the flow of fluid under pressure, and the pressure of the fluid plus the inertia of the suddenly stopped fluid will provide an impact force on the piston 50 to move the cutter block 30 and cutter bits 31 in the direction of travel thereof and thereby momentarily increase the velocity of the cutter bits. As, however, said land opens said port to either of the ports 115, the forces of cutting will move the cutter block and piston 50 backwardly until pressure is again built up in the cylinder 47 by closing of the port 111. In this form of the invention a water-hammer-like pulsating force is applied to the piston 50 and cutter bits 31 to intermittently move said bits in the direction of travel thereof from the solid line positions shown in FIGURE 2 to the broken line positions shown in this figure as long as the cutting loads remain greater than the loading of the spring 107.

In FIGURE 3 I have diagrammatically shown the principles of my invention applied to a plow type of cutter 139 movable along the mine face along a back-up rail 140. The cutter 139 is shown as having a cutter tip 141 slidably guided in the cutter for oscillatible movement with respect thereto. A pressure line 143 leads to one end of a support block 144 for the cutter 139, while a return line 145 leads from the opposite end of said support block. The pressure line 143 and the return line 145 may supply hammer-like pulsating pressures to a cylinder 150 and piston 151 therein. The piston 151 is shown in FIGURE 3 as having a piston rod 152 extending therefrom and connected with the cutter tip 141, to vibrate said tip as the cutter 139 is drawn along the mine face by a flexible cable 147.

This illustrative modification of the invention has been included merely to show the adaptation of the principles of the present invention to various types of cutters or tools and particularly to cutters for cuttings or forcing coal directly from a mine face. Fluid pressure systems like the ones described herein may be provided to vibratorily move the cutting tip 141.

While I have herein shown and described one form in which may invention may be embodied, it may readily be understood that various variations and modifications in the invention may be attained without departing from the spirit and scope of the novel concepts thereof.

I claim as my invention:

1. In a mining machine, a frame,
a cutter support movable relative to said frame,
a cutter,
a slidable guiding connection between said cutter and said cutter support accommodating movement of said cutter along said cutter support in forward and return directions,
a hydraulic cylinder and piston connected between said cutter support and cutter and balanced in accordance with the forces of normal cutting on said cutter to retain said cutter in forwardly extended relation with respect to said cutter support,
and means for supplying a moving column of liquid under pressure through said cylinder and along the pressure side of said piston, greater than the forces of normal cutting, comprising a power driven pump having liquid connection with the opposite end of said cylinder from said cutter support and cutter,
a return liquid connection leading from said cylinder and accommodating the flow of a moving column of liquid through said cylinder,
and a valve in said return liquid connection and reciprocably driven to intermittently block the moving column of liquid flowing through said cylinder,
and to thereby create water-hammer-like pulsating forces on said piston and cutter.

2. In a mining machine,
a movable cutter support,
a cutter slidably mounted on said cutter support for movement in forward and return directions,
a hydraulic cylinder having a piston therein connected between said cutter and cutter support,
a pump,
a pressure line leading from said pump to the opposite end of said cylinder from said cutter,
a return line leading from said cylinder and spaced from said piston when in its extended position,
a relief line leading from said cylinder between said pressure line and said return line,
said pressure line, said return line and said relief line accommodating a movable column of liquid to flow through said cylinder along the pressure side of said piston,
a valve in said relief line,
said piston blocking the flow of liquid through said return line when the cutting forces on said cutter are greater than normal,
and means for reciprocably moving said valve to block said relief line and block the moving column of liquid flowing through said cylinder and thereby create water hammer-like forces on said piston effected by the pressure of liquid on said piston and the inertia of the suddenly stopped flow of liquid,
to intermittently move said cutter with respect to said cutter support in the direction of travel of said cutter with a hammer-like action.

3. A mining machine in accordance with claim 2 wherein a spring loaded to at least the normal forces of cutting biases said cutter in extended relation with respect to said cutter support and accommodates retractible movement of said piston to cover said return line when said cutter encounters cutting forces greater than normal.

4. In a mining machine, a frame,
a boring head rotatably mounted on said frame and having at least one cutter support,

a cutter slidably mounted on said cutter support for movement in forward and return directions,

a hydraulic cylinder having a piston therein connected between said cutter and cutter support and normally biasing said cutter in extended relation with respect to said cutter support,

a pump,

a pressure line leading from said pump to the opposite end of said cylinder from said cutter,

a return port leading from said cylinder and spaced along said cylinder from said piston when said cutter is in extended relation with respect to said cutter support,

a relief line leading from said cylinder between said return port and said pressure line, said pump supplying a movable column of liquid through said cylinder and out said return and relief lines when the cutting conditions are normal,

a valve in said relief line mounted on said boring head,

and a cam and follower connection between said frame and valve for intermittently moving said valve to block said relief line to create a water hammer effect on said piston upon the blocking of said return port by said piston upon retractible movement of said cutter effected by overload cutting conditions.

5. A mining machine in accordance with claim 4 wherein a spring within said cylinder normally loaded to at least the normal forces of cutting biases said piston and cutter in extended relation with respect to said cylinder and permits said piston to retractibly move to close said return port and thereby effect an intermittent hammering action on said piston and cutter upon blocking of said relief line by said valve.

6. In a rotary boring head,

a generally radially extending arm,

a frame,

means for supporting said boring arm on said frame for rotation with respect thereto,

other means for rotatably driving said boring arm,

a cutter support extending forwardly of said boring arm,

a cutter extending in advance of said cutter support,

a cutter block carrying said cutter,

a slidable guiding connection between said cutter block and said cutter support, guiding said cutter block for reciprocable movement along said cutter support toward and from the direction of rotation of said cutter,

a cylinder and piston connected between said cutter support and said cutter block and balancing the forces of cutting on said cutter,

cam means on said frame,

a pump having fluid connection with said cylinder for supplying a moving column of liquid under pressure along the pressure side of said piston at pressures greater than the forces of cutting,

and a valve intermittently actuated by said cam means for intermittently blocking the release of liquid from said cylinder,

and thereby creating water hammer-like forces on said piston effected by the pressure of liquid on said piston and the inertia of the suddenly stopped flow of liquid and intermittently moving said cutter with respect to said cutter support in the direction of travel of said cutter and cutter support.

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