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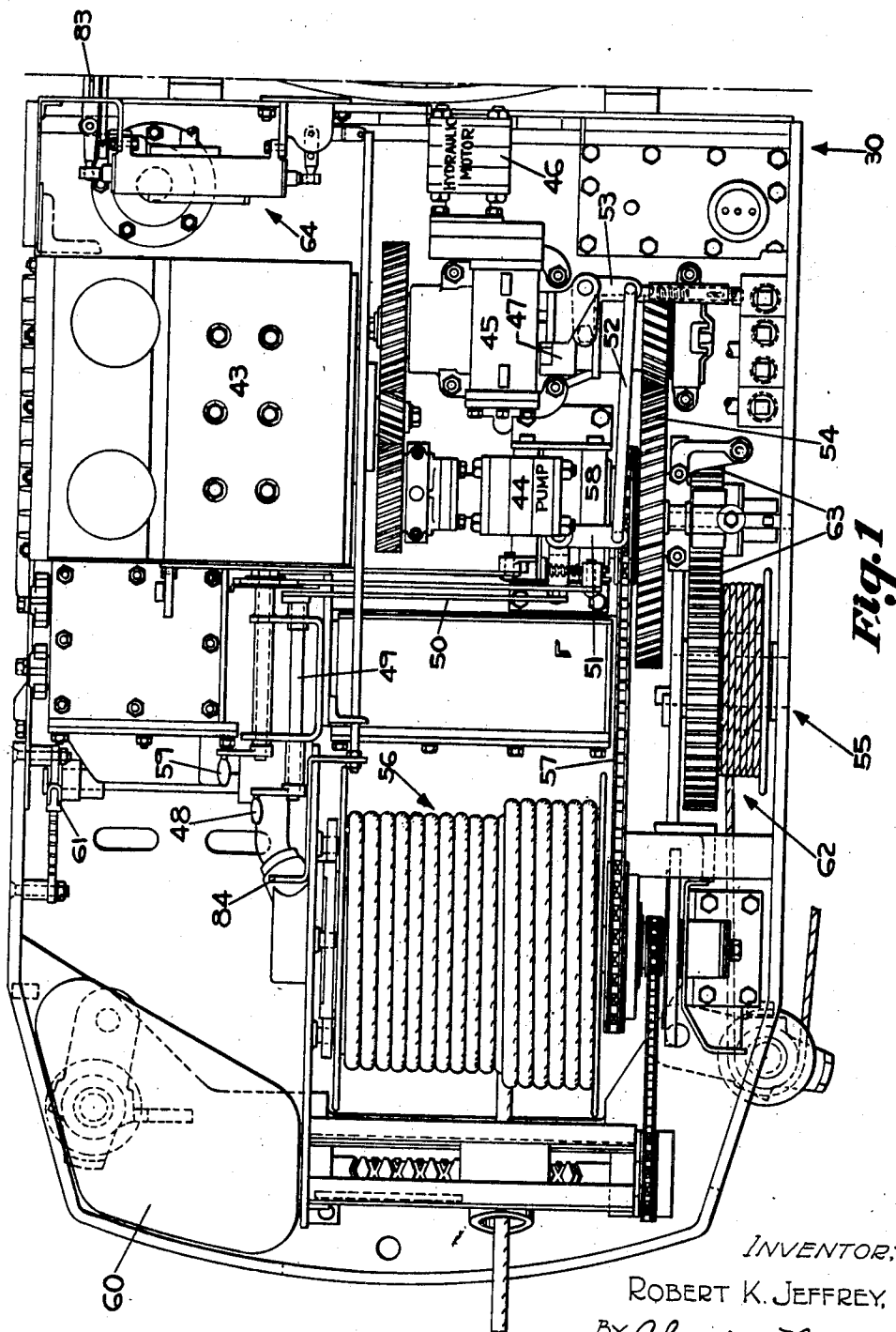
R. K. JEFFREY

2,334,009

MINING MACHINE

Filed May 23, 1941

5 Sheets-Sheet 1



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Nov. 9, 1943.

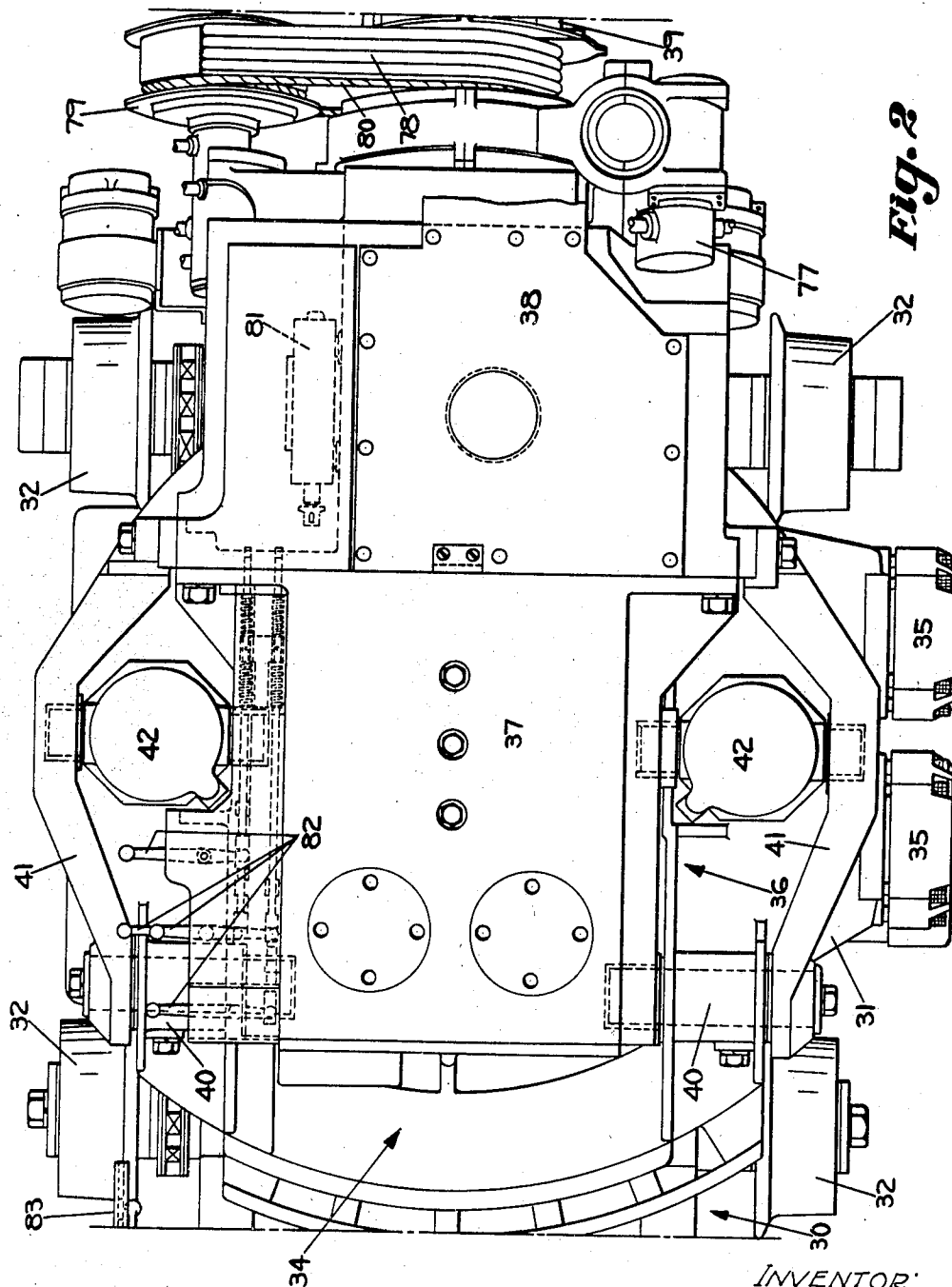
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5 Sheets-Sheet 2



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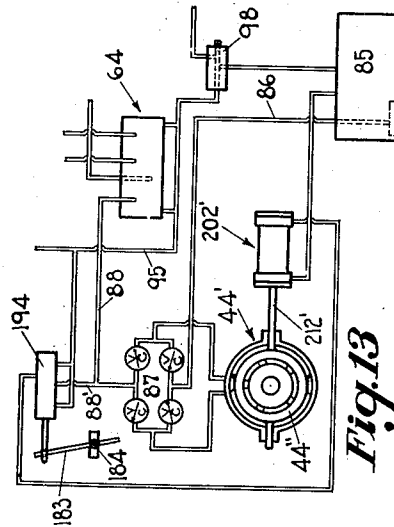
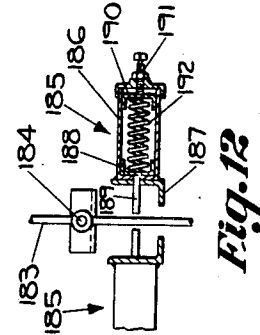
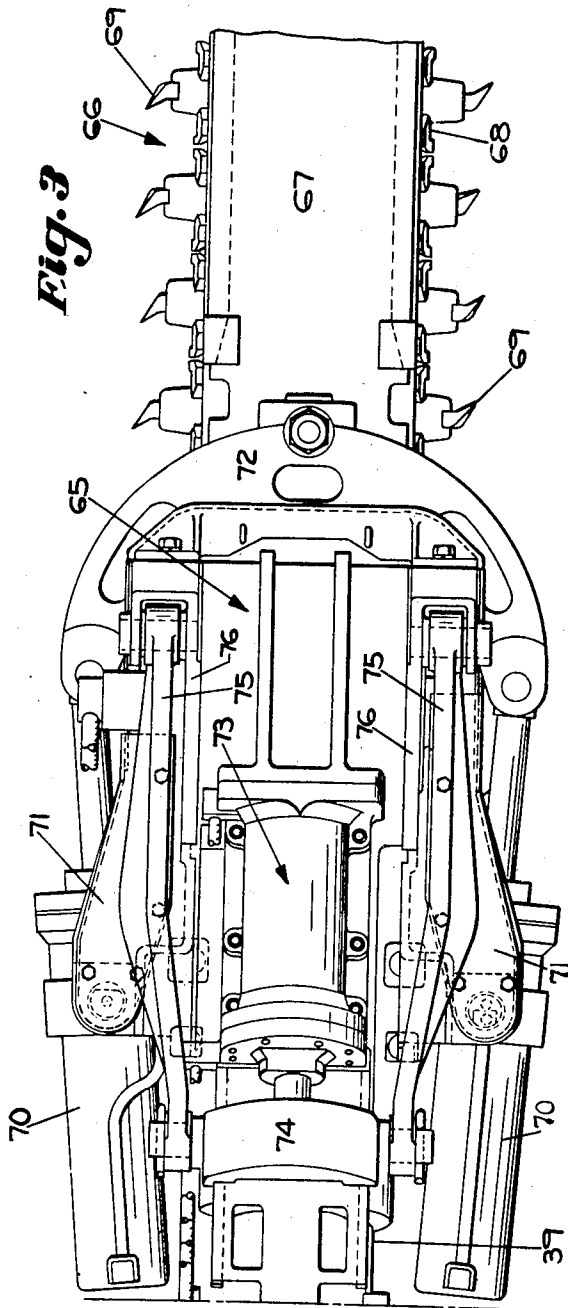
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MINING MACHINE

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5 Sheets-Sheet 3



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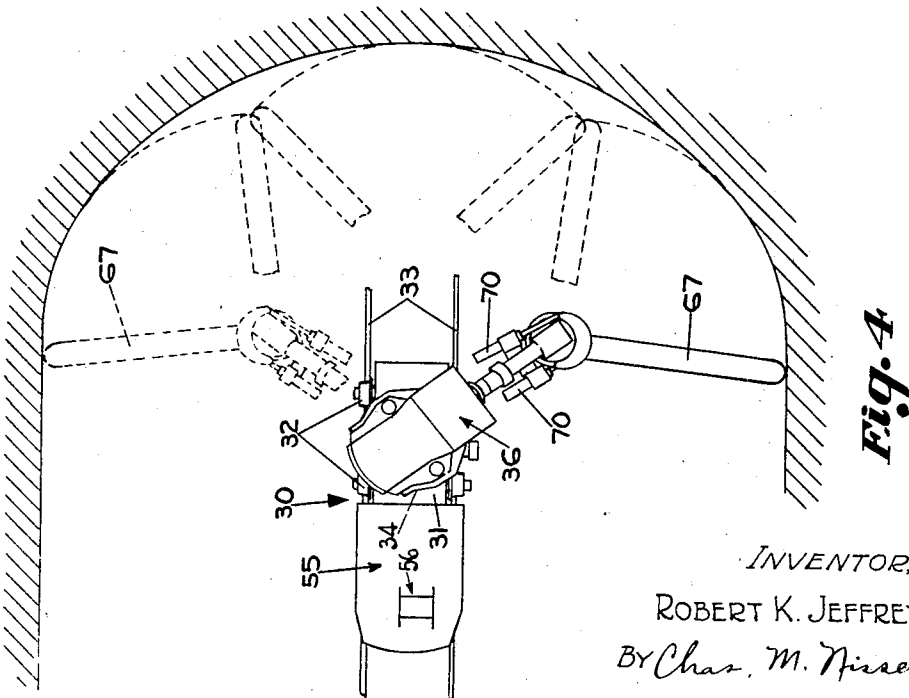
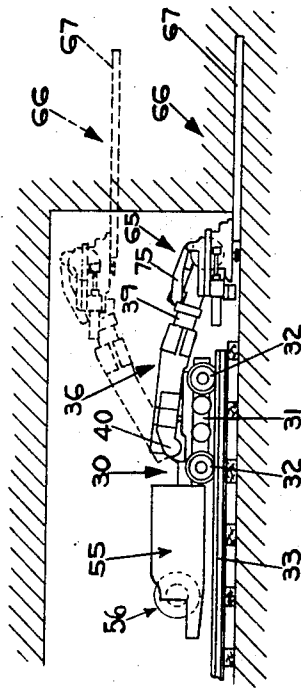
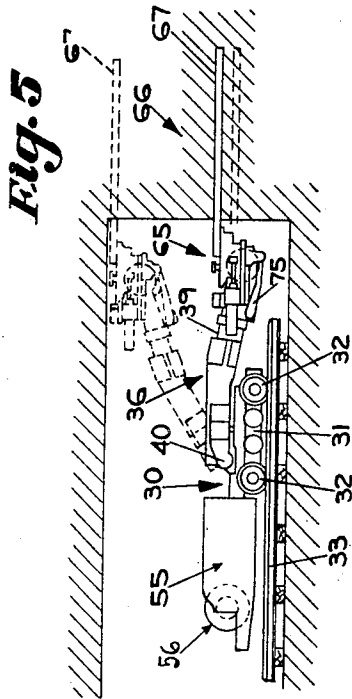
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MINING MACHINE

Filed May 23, 1941

5 Sheets-Sheet 4



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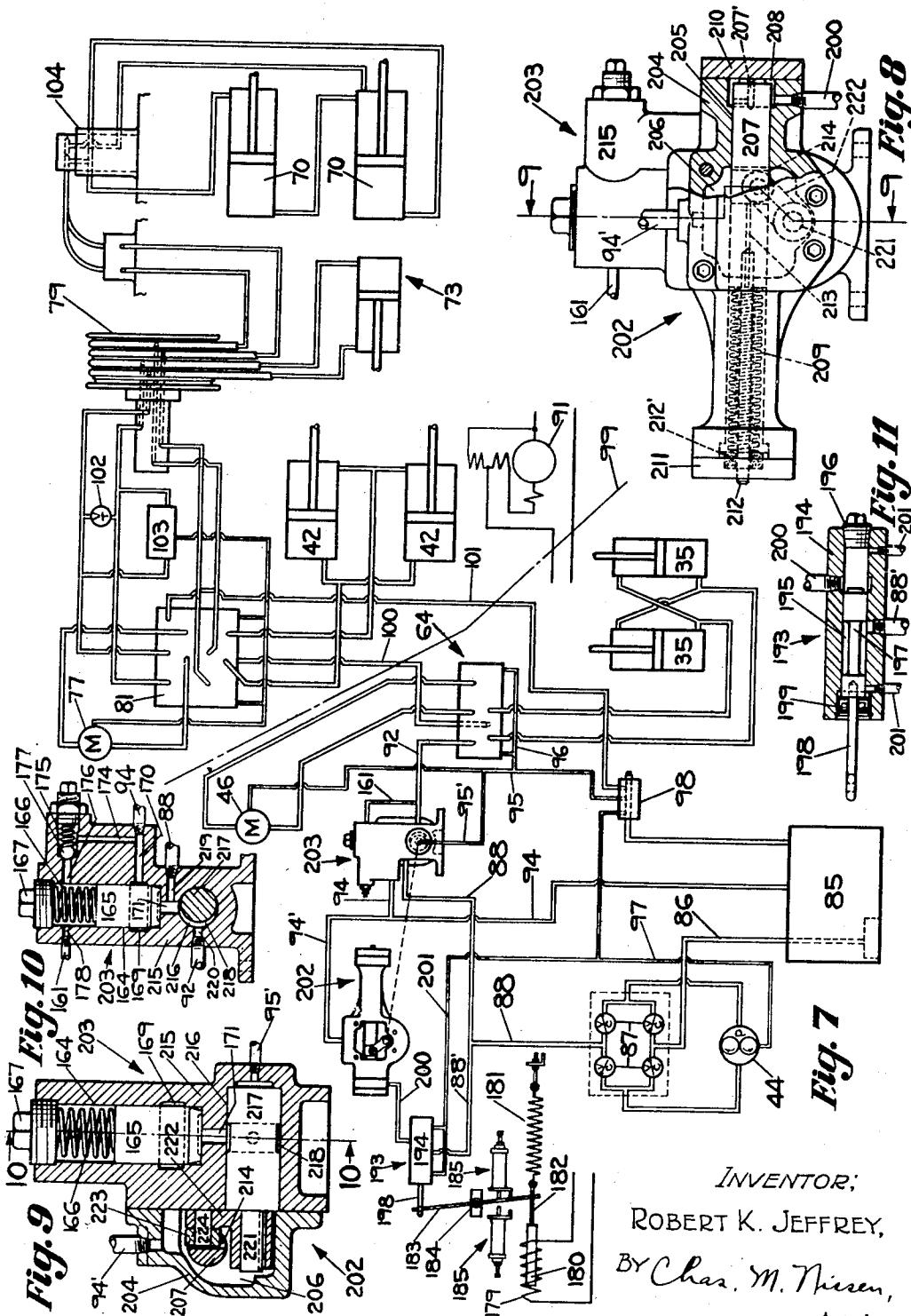
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MINING MACHINE

Filed May 23, 1941

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,334,009

MINING MACHINE

Robert K. Jeffrey, Columbus, Ohio, assignor to
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Application May 23, 1941, Serial No. 394,812

21 Claims. (Cl. 262—28)

This invention relates to a mining machine and particularly to an improved hydraulic control system for a mining machine.

An object of the invention is to provide a mining machine in which the feed rate of the kerf cutting mechanism is automatically adjusted to compensate for the load thereon thereby to prevent overloading of the driving motor for said kerf cutting mechanism.

Another object of the invention is to provide an improved hydraulic control system for a mining machine in which hydraulic means are provided to effect a feeding of the kerf cutting mechanism in which the rate of liquid supply to the hydraulic feeding mechanism is adjusted in accordance with the current flow in the driving motor of the kerf cutting mechanism to prevent overloading of said driving motor.

A further object of the invention is to provide an improved power operated hydraulic control valve.

Still another object of the invention is to provide a solenoid operated hydraulic control valve which is adapted to control the rate of fluid flow therethrough in accordance with the current flowing in an electrical circuit.

Another object of the invention is to provide a combined solenoid and mechanically operated hydraulic controlling valve adapted to vary progressively the rate of flow of hydraulic liquid therethrough.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Figs. 1, 2 and 3 placed end to end comprise a plan view of a mining machine incorporating the features of my invention;

Fig. 4 is a diagrammatic plan view of the mining machine illustrating various horizontal swinging cuts which can be made thereby;

Figs. 5 and 6 are diagrammatic elevational views of the mining machine showing several positions of adjustment of the cutter bar;

Fig. 7 is a piping diagram of the hydraulic control system of my invention;

Fig. 8 is a front elevational view of a power operated automatic volume control valve incorporated in the system of Fig. 7 with parts shown in section;

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 8 looking in the direction of the arrows;

Fig. 10 is a sectional elevational view taken on the line 10—10 of Fig. 9 looking in the direction of the arrows;

Fig. 11 is a sectional elevational view of a pilot control valve employed in the hydraulic system of Fig. 7;

Fig. 12 is an enlarged view partly in section showing the structure of an adjusting mechanism of the pilot valve of the control system of Fig. 7; and

Fig. 13 shows a modification of the system of my invention, being particularly a modification of the apparatus disclosed in Fig. 7.

This application is a continuation in part of my application, Serial No. 252,801, for a Mining machine, filed January 25, 1939.

The mining machine herein disclosed constitutes an improvement upon the mining machine disclosed in the application of Robert K. Jeffrey et al., Serial No. 206,448, filed May 6, 1938, now Patent No. 2,263,779, dated November 25, 1941, entitled Mining machine. It is to be understood that unless a contrary fact is indicated, the structure of the mining machine of the instant application follows the structure of the mining machine disclosed in complete detail in said above mentioned application of Robert K. Jeffrey et al.

It has been found in practice that there is a tendency for kerf cutting mechanism to overload the driving motor therefor under certain conditions, as the kerf cutting mechanism is fed into the coal while cutting a kerf either during a shearing, sumping or swinging operation.

The mining machine disclosed herein and constituting my invention operates automatically to control the feed rate of the kerf cutting mechanism to maintain the load on the driving motor substantially constant at its rated value, at which it has a maximum efficiency, which drives said kerf cutting mechanism, by controlling the volume of hydraulic fluid delivered to the feeding hydraulic motor or motors at a rate which is entirely independent of the pressure of the hydraulic fluid, being controlled only by the volume of flow thereof.

Referring particularly to Figs. 1, 2 and 3 which together comprise a plan view of the mining machine, and to Figs. 4, 5 and 6, which show the mining machine diagrammatically, it will be seen that said machine comprises a main frame 30 including a track mounted truck 31 provided with wheels 32 adapted to ride upon mine track rails 33.

Mounted upon the said truck 31 for adjustment about an upright axis is a turntable 34 adapted to be swung about said upright axis by a pair of oppositely acting hydraulic piston motors 35. Pivotaly mounted upon the turntable 34 for ad-

justment about a horizontal axis is a supplemental frame 36 formed by a housing 37 of an electrical driving motor 91 (see Fig. 7), contained therein, to which is rigidly attached a gear housing 38 provided with an integral and downwardly sloping neck to which is journaled gear housing 39; that is, the motor housing 37, gear housing 38 and neck carrying housing 39 are all rigidly attached together to form the supplemental frame 36. Said supplemental frame 36 is pivotally attached to the turntable 34 by journal bearings 40, 40 at the rear end of said supplemental frame 36 and turntable 34.

Also forming a part of said supplemental frame 36 is a pair of spaced arms or brackets 41 between each of which arms 41 and the motor housing 37 there is trunnioned the housing of a hydraulic piston motor 42, the piston rod of which is journaled to the turntable 34. The hydraulic piston motors 42 are adjustable to swing the supplemental frame 36 about the horizontal axis provided by the journal bearings 40, thereby to adjust the elevation of the forward end of said supplemental frame 36.

The rear end of the main frame 30 forms a supporting platform 55 upon which is mounted an electric motor 43 which serves a number of purposes. Said motor 43 drives a hydraulic pump 44 of the hydraulic control system and also drives the wheels 32 of the truck 31 to tram the mining machine along the mine rails through an appropriate gear train including clutch shifting mechanism 45 which is adapted also to effect a driving connection from the hydraulic motor 46 to said wheels 32 to effect low speed sumping of the entire mining machine while cutting a kerf. That is, the clutch shifting mechanism 45 includes a shiftable clutch member 47 which is operable from operating handle 48 through a gear train including pivoted shaft 49, rod 50, bell crank 51, rod 52 and bell crank shipper 53 to effect a driving connection to the wheels 32 by way of reduction gears 54 either from the electric motor 43 for high speed during tramping of the machine or from the hydraulic motor 46 for low speed during sumping thereof.

Also mounted upon the platform 55 is an electrical cable reel mechanism 56 which winds in and pays out the electric cable for supplying current to electric motor 43 and which is driven by the drive mechanism 57 including a control clutch 58 operable from appropriate operating mechanism including handle 59.

It is to be noted that the operating handles 48 and 59 are positioned at an operator's station at which there is an operator's seat 60 also adjacent to which is a brake handle 61 of a brake mechanism associated with the wheels 32 of truck 31. There is also mounted upon the platform 55 a steel draft cable mechanism 62 which may be operated from the electric motor 43 through an appropriate drive including gears 63 to aid in the sumping action of the mining machine particularly when operating under difficult conditions or to anchor the mining machine in the mine against retrograde movement.

Also mounted on an upright plate at the forward end of the platform 55 is a two-way control valve mechanism 64 having two valves therein one of which is controllable to swing the turntable about its upright axis by controlling the hydraulic flow of fluid to hydraulic motors 35, the other of which is operable to control the hydraulic motor 46 to effect the sumping of the entire mining machine along the track rails 33.

The outer end of the neck housing 39 terminates in and forms a turnover head 65. Mounted upon the turnover head 65 for swinging movement about an axis which is perpendicular to the plane thereof is a kerf cutting mechanism 66 comprising a flat elongated cutter bar 67 around which is adapted to move an endless cutter chain 68 carrying cutter bits 69. The cutter chain 68 is driven from a drive sprocket, in a manner well understood in this art, at the rear end thereof which drive sprocket is driven from the electric motor 91 (Fig. 7), contained within housing 37, through appropriate drive gearing which extends through the gear housing 38, neck housing 39 and turnover head 65. It may be stated that the sole function of the motor contained within housing 37 is to drive the cutter chain 68 of said kerf cutting mechanism 66.

To provide for controlled swinging movement of the kerf cutting mechanism 66 about its upright pivotal axis with respect to the turnover head 65, a pair of reversely operating hydraulic piston motors 70 is provided, the cylinders of which motors are pivotally attached to an operating bracket 72 which is rigidly attached to the cutter bar 67. It is thus manifest that by alternate reverse operation of the two motors 70 the cutter bar 67 may be swung in its own plane in reverse directions.

To provide for the swinging of the cutter bar 67 in a plane perpendicular to its own plane, particularly so that said cutter bar 67 may be horizontally positioned, for example in any of the positions illustrated in Figs. 5 and 6 of the drawings for different positions of adjustment of the supplemental frame 36, said cutter bar 67 is pivotally attached to the turnover head 65 on a transverse axis which is parallel to the plane of said cutter bar. To effect swinging movement of said cutter bar 67 transversely of its plane there is mounted on the turnover head 65 a hydraulic piston motor 73 the piston rod of which is attached to a sliding head 74 to which are connected operating arms 75 attached to opposite plates 76 which at their bottoms form a journal upon which the previously mentioned bracket 72 is journaled for swinging movement and which acts to support the kerf cutting mechanism 66 from the turnover head 65. It is evident that expansion and contraction of the hydraulic piston motor 73 will therefore produce a swinging movement of the cutter bar 67 in an arc perpendicular to its own plane. It is thus to be noted that the cutter mechanism 66 may be adjusted for swinging movement with respect to the turnover head 65 about axes that are disposed at a right angle with respect to each other.

To provide for the turning over of the head 65 so that the cutter bar 67 may be adjusted to a bottom cutting position, as illustrated for example in Fig. 6 of the drawings, or to a top cutting position, as illustrated for example in Fig. 5 of the drawings, or to vertical or intermediate positions on either side of the longitudinal axis of the neck housing 39, the said neck housing 39 is journaled on the aforementioned integral neck of the supplemental frame 36 and is provided with means for rotating it through almost, but not quite, 360 degrees, including a rotary type of hydraulic motor 77 (see Fig. 2), which is adapted to rotate the neck housing 39 through appropriate gear reduction mechanism preferably including worm gearing.

It may be stated that between the neck and its housing 39 there is a stop means which prevents

360 degrees of rotation but which permits the adjustment of the cutter bar 67 to any of the aforementioned positions.

To provide for the flow of hydraulic fluid to the hydraulic motors 70 and 73 which, of course, rotate with the turnover head mechanism 65 and thus rotate with respect to the supplemental frame 36, flexible hose hydraulic conduits 78 are provided which wind upon winding reel 79 which is driven to rotate with the neck housing 39 by a driving cable 80.

It may additionally be pointed out that mounted on one side of the gear housing 38 of the supplemental frame 36 is a four-way hydraulic control valve 81 including four slide pistons which slide pistons are individually controlled by four operating handles 82 (Fig. 2) positioned at an operator's station adjacent the rear end of the supplemental frame 36 and attached to the motor housing 37. There is one handle 82 for operating each of the pistons of the four-way valve 81.

It may be stated that one of said handles and one of said slide pistons is individual to the two motors 70, another individual to the motor 73, another individual to the motor 77 and another individual to the motors 42. In other words, motors 42, 77, 70 and 73 are individually controlled by the handles 82 which control individual pistons of the four-way valve 81.

It may also be mentioned that the previously mentioned two-way control valve 64 which is carried by the rear platform 55 has two slide valves one of which is individual to the hydraulic motor 46 to control the sumping of the entire mining machine and the other of which is individual to the hydraulic piston motors 35 for swinging the turntable 34, the latter of which is controllable from two positions, one of which is adjacent the control station where handles 82 are located, by virtue of handle 83, the other of which is controllable from the position near the operator's seat 60 by handle 84. This is desirable because during tramping of the mining machine through the mine it is sometimes necessary to swing the supplemental frame on the turntable 34, particularly while rounding curves in the mine. All of the hydraulic motors are controllable from the operator's station adjacent the handles 82, for this is the normal position of an operator while the machine is cutting a kerf in the mine.

As was previously pointed out, it is desirable to regulate automatically the feeding movement of the kerf cutting mechanism 66 and this is preferably done to maintain a substantially constant ampere load on the driving motor 91 (Fig. 7), contained within housing 37. In practice, the mechanism is preferably adjusted so that the cutter mechanism is driven at full speed until the current reaches approximately its full load rating, whereupon the feed rate of the kerf cutting mechanism is decreased until the motor 91 again draws its rated current, thereby preventing overloading thereof.

It is, of course, evident that with this automatic system the kerf cutting mechanism is operated at the maximum rate possible without undesirable overloading of its driving motor 91 which is the motor in housing 37, so that when easy cutting is encountered, the feed rate is increased and when hard cutting is encountered the feed rate is reduced. Furthermore, when the driving motor for the cutting mechanism is not operated at all, or is merely running light as when no cutting operation is being performed, the feed rate for adjusting the various hydraulic

piston motors is at a maximum thus providing for a high rate of adjustment to position the cutter mechanism for kerf cutting.

The apparatus which provides for this automatic control as above set forth, is disclosed in detail in Figs. 8 to 12 of the drawings, which will now be described in connection with Fig. 7 of the drawings which shows the hydraulic control system.

Referring first to Fig. 7 of the drawings, it is to be seen that the hydraulic control system comprises a tank or reservoir 85 for the hydraulic fluid or oil from which extends a feed pipe 86 leading to four reversely connected valves 87 interconnected to the hydraulic pump 44 from which valves 87 there extends a pressure pipe or conduit 88. The valves 87 are so connected that the pressure in the pipe 88 is always positive regardless of the direction of rotation of the reversible pump 44. In this connection it may be stated that driving electric motor 43 is of the reversible type so that the mining machine can be trammed in reverse directions and consequently the pump 44 is subjected to rotation in reverse directions, as shown in Fig. 1.

The pressure pipe 88 leads to and through a combined high pressure relief and automatic volume control valve mechanism 203, the detailed structure of which is disclosed in Figs. 8, 9 and 10 of the drawings, and hereinafter described in full detail.

As a general description, it may be stated that the automatic volume control valve mechanism 203 is operative to control the volume of fluid delivered to the operating hydraulic motors of the hydraulic system to maintain a substantially constant current flow in the electric motor contained in housing 37, which is illustrated at 91 in Fig. 7 of the drawings.

Leading from the automatic volume control valve 203 is pressure pipe or conduit 92 which delivers hydraulic fluid under pressure to the two-way control valve 64. The two-way control valve 64 is effective to control the selective feeding of hydraulic fluid in reverse directions to the hydraulic piston motors 35 and to the rotary hydraulic motor 46; there being, of course, an individual piston for the two motors 35 on the one hand and the motor 46 on the other.

It may be stated that, as above described in complete detail in the application of Robert K. Jeffrey et al., S. N. 206,448, now Patent No. 2,263,779, dated November 25, 1941, the two motors 35 and the single motor 46 are capable of operation at the same time or individually due to the particular construction of the control valve 64.

A return pipe 94 is provided to return hydraulic fluid from the pressure relief valve 203 to the reservoir 85 whenever said pressure relief valve 203 operates to relieve excessive pressure in the pressure pipe 88.

It may also be mentioned that leakage drain pipes 95, 96 and 97 are provided for the motor 46, two-way valve 64 and pump 44 to return any excess fluid, such as is received due to seepage past the bearings thereof, to the reservoir 85 by way of junction block 98.

That portion of the hydraulic control system above described which is to the lower left hand side of the line 99 in Fig. 7 of the drawings, is all mounted on the platform 55 and therefore is stationary with respect to the main frame of the mining machine. The portion of the system now to be described is mounted for adjustment

with respect to the main frame and is carried by the supplemental frame 35 or some structure which is attached to move therewith.

Extending to the four-way control valve 81 is a pair of flexible hydraulic fluid conduits or hoses 100 and 101, of which the former is a pressure hose leading from the valve 64 and the latter a return hose which leads to the junction block 98 and thence to the reservoir 85. It may be stated that pressure is delivered to the hose 100 from the pressure pipe 92 without regard to the position of any of the slide valves of the two-way valve 64. Said conduits or hoses 100 and 101 lead to and from the four-way control valve 81 which is provided with four individual slide valves as above set forth, one of which is operated to control the motor 77, another of which is operated to control the two motors 42 in parallel, still another of which is operated to control the motor 73 and the fourth of which is operated to control the reversely connected motors 70.

To provide for the floating of the cutter bar 67 on it pivot, when positioned in a vertical plane which is desirable for the cutting of vertical kerfs while the mining machine is sumping along a curved mine track, a by-pass valve 102 interconnects the conduits leading to the hydraulic piston motor 73 which in cooperation with an equalizing valve 103, also connected between said conduits, permits the floating of the piston in said motor 73 whenever valve 102 is open. As above described, the reel 79 provides for the rotation of the hydraulic piston motors 70 and 73 with the neck housing 39.

It is also evident, of course, that motors 70 must swing about the axis of the turnover head 65 which is parallel with the plane of the cutter bar 67. To provide for the continuation of the fluid conduit during this swinging motion a pivotally mounted packed bearing 104 is provided which forms continuing paths leading to the motors 70 for various positions of adjustment of the cutter mechanism 66 with respect to the head 65.

The armature circuit of the electric motor 91 has connected in series with it a solenoid 179 with which there is associated a plunger 180 which is connected to an adjustable helical spring 181 by a shaft 182. Shaft 182 is pivotally attached to an operating lever 183 pivoted at 184.

Associated with the lower portion of lever 183 is a pair of oppositely positioned cushioning spring abutments 185, the detail structure of which is illustrated in Fig. 12 of the drawings. Each of said spring abutments 185 comprises a casing 186 carrying a stop 187, and within which is mounted a slide piston 188 to which is attached an outwardly extending contact pin 189 adapted to contact the lever 183 after a predetermined pivotal movement thereof. Also, in the casing 186 is an adjustable cap 190 the position of which may be adjusted by adjusting screw 191.

Between the slide piston 188 and the cap 190 is a helical spring 192. It is manifest that by adjusting the cap 190 the tension on the spring 192 may be varied thus varying the amount of current that must flow in the solenoid 179 to adjust the position of the lever 183.

The lever 183 controls a pilot valve 193, the structure of which is disclosed in detail in Fig. 11 of the drawings. Said pilot valve 193 comprises a casing 194 provided with a central cylindrical bore 195 closed at one end by a plug 196 and having therein a slide piston 197 provided

with an operating rod 198 which is attached to said lever 183 and extends from the bore 195 through a sealing gland 199. The pressure pipe 88 has a branch 88' which leads to the central portion of the bore 195 thereby providing hydraulic fluid at this position. Leading from the bore 195 is a pipe or conduit 200. Forwardly and rearwardly of the piston 197 are drainage ports which lead to pipe or conduit 201 which, in turn, is connected to the junction block 98 and thence to sump 85.

It is manifest from reference to Fig. 11 of the drawings, that with the piston 197 in the position illustrated fluid pressure will not be supplied to the pipe 200 but said pipe 200 is free to drain fluid to conduit 201. However, when said piston is moved to the extreme right, as viewed in said Fig. 11, in response to a predetermined current flow in solenoid 179, conduits 88' and 200 will be in communication through bore 195 to supply hydraulic fluid under pressure to said conduit 200 which leads to a power operating mechanism 202 for volume control valve mechanism 203 which is rigidly attached to the combined high pressure relief and automatic volume control valve structure 203. When the current flow in solenoid 179 is below a predetermined value, piston 197 is moved by the spring 181 to the left, as illustrated in Figs. 7 and 11 of the drawings, to permit a flow of fluid from pipe 200 to drainage pipe 201, as aforesaid.

The power operating mechanism 202 comprises a main casting 204 provided with a central bore 205 which intermediate its ends communicates with a central chamber 206. Within the bore 205 and extending across the chamber 206 is an operating piston 207 the head end of which communicates with and extends into a chamber 208 which is an enlargement of the bore 205. The aforementioned pipe or conduit 200 communicates with the chamber 208. At the lefthand end of the bore 205, as viewed in Fig. 8 of the drawings, there is a helical spring 209 which abuts the piston 207 and urges it to the right, as viewed in Fig. 8, which, it may be stated, corresponds to the full open position of the automatic volume control valve 203.

The casting 204 is provided with opposite heads 210 and 211 to close the bore 205. The piston 207 is provided with an elongated piston position indicator 212 which is rigidly attached thereto and which slides through an aperture in the head 211 made fluid-tight by a packing gland 212'.

Piston 207 also has a by-pass passageway 207' which provides a movement limiting means to connect chambers 208 and 206 when piston 207 moves the desired maximum amount against spring 209.

To prevent a compression of air in the lefthand portion of the bore 205 as the piston 207 reciprocates, said piston 207 is provided with a groove 213 which extends from the lefthand end thereof to an upright notch 214 (see Fig. 9), formed in said piston 207 for a purpose to be described. Also connected to the chamber 206 is a drain pipe 94' which connects to the drain pipe 94 thereby draining any overflow from the chamber 206 to the sump 85.

Removably attached to the casting 204 of the power operating mechanism 202 is a casting 215 (see Figs. 9 and 10) of the combined high pressure relief and automatic volume control valve mechanism 203, which at its bottom is provided with a cylindrical bore 216 within

which is an eccentric control cylinder 217 provided with a tapering volume control groove 218. The bore 216 forms a chamber, orifice or passageway into which the hydraulic liquid is adapted to flow by way of inlet port 219 from pressure pipe or conduit 88 and from which said hydraulic liquid is adapted to flow to pressure pipe or conduit 92 by way of outlet port 220. The angular position of the cylinder 217 controls the effective size of the opening, chamber, orifice or passageway connecting ports 219 and 220.

To provide for the angular adjustment of said cylinder 217 it is provided at one end with an operating shaft 221 to which is keyed an operating arm 222 which is provided at its upper end with a roller 223 mounted upon a shaft 224. The roller 223 extends into the previously mentioned notch 214 of the piston 207. It is thus manifest that straight-line motion of the piston 207 is translated into this rotary motion of the cylinder 217 and the position of said cylinder 217 determines the effective size of the opening, chamber, orifice or passageway through which the hydraulic liquid flows from conduit 88 to conduit 92. A seepage pipe 95' is connected to drain pipe 95 to drain hydraulic liquid which seeps by the right hand end of cylinder 217 as viewed in Fig. 9 of the drawings.

It may be mentioned that in Fig. 7 of the drawings, the power operating mechanism 202 is shown separated from the high pressure relief and volume control valve 203 in the interest of clearness, but in practice they are preferably rigidly attached together as illustrated in Figs. 8, 9 and 10 of the drawings, with the shaft 221 rigidly connected to the cylinder 217.

The additional structure of the high pressure relief valve 203 includes a central cylindrical bore 164 in casting 215 within which is a control piston 165 moved downwardly by a relatively weak helical spring 166 which bears against a closure plug 167 for the bore 164.

At the bottom of the bore 164 and at a position generally surrounding the piston 165 when the latter is in its normal position, is a chamber 169 which is connected to return pipe 94 by a passageway 170. A bore 171 provides a communicating passageway between the bore 219 and the bottom of bore 164 thereby to subject the bottom of the piston 165 to the pressure in the bore 219 which, of course, is the same as the pressure in the pipe 88.

Interconnecting the bore 164, at a position above that assumed by the piston 165 during any operating condition, and the passageway 170 which leads to the drain pipe 94, is a passageway 174 leading to chamber 175 which in turn leads to passageway 176. An adjustable ball check valve 177 is provided in chamber 175 and will release upon a predetermined pressure in the bore 164 above the piston 165.

The pipe or conduit 161 communicates the pressure in the pressure pipe 92 to the bore 164. Consequently, the pressure on top of piston 165 is normally equal to that in pipe 92 and the pressure on its bottom is equal to that in pipe 88. The pressure drop in the fluid flowing through groove 218 for any given effective size opening is proportional to the volume of hydraulic liquid flowing therethrough. This pressure drop is not very great, but during normal operation is sufficient to overcome the weak spring 166, and may be of the order of twenty or twenty-five pounds per square inch, thereby lifting the piston 165 an amount to provide a

by-pass for the excessive hydraulic fluid not desired to operate one of the hydraulic motors 35, 42, 46, 70 or 77 leading to pipe 94 by way of chamber 169 and bore 171 to keep a substantially constant load on motor 91. The piston 165 acts under the influence of weak spring 166 to control the amount of fluid by-passed at such a value as to insure an adequate supply to the hydraulic motor being operated to keep motor 91 fully loaded, it being evident that in the absence of sufficient pressure drop across groove 218, piston 165 will be moved downwardly to reduce or shut off the by-pass.

To provide a safety valve against excessive pressure in the system, as when a hydraulic motor reaches the end of its stroke and hydraulic fluid continues to be fed to it, whenever the pressure in pipe 92 becomes excessive at any value which may be adjustably determined by the check valve 177, an example of which is 1200 pounds per square inch, the check valve 177 will operate to relieve this pressure and permit a flow of the hydraulic fluid to the return pipe 94. The flow of this high pressure fluid from the conduit 161 into the bore 164 is through a passageway 178 which is a very restricted area thereby causing an appreciable pressure drop whenever the fluid begins to flow through said passageway 178.

After the ball valve 177 has cracked and the high pressure fluid begins to flow to the return pipe 94 the pressure in the bore 164 above the piston 165 will fall below that on the bottom of said piston 165 due to said pressure drop through passageway 178 which will result in the fluid under pressure on the bottom of piston 165 moving it upwardly against the action of the weak spring 166, to provide a direct communication between the bore 171 and the passageway 170 by way of chamber 169. This, of course, will provide a direct communication between the conduits 88 and 94 thereby providing a direct return path for high pressure fluid in the line 88 to the return pipe 94. Whenever the pressure in the pressure pipe 92 is returned to normal, check valve 177 will close and the parts of the high pressure relief valve 203 will be returned to their normal positions as illustrated in Fig. 10 of the drawings.

In the operation of the mining machine incorporating the hydraulic control system above described, the reversible electric motor 43 may be connected by a direct mechanical drive to the wheels 32 of the mining machine for tramming in reverse directions. Furthermore, the motor 43 whenever in operation drives hydraulic pump 44 of the hydraulic control system to provide fluid for said control system in the pressure conduits 88, 92 and 100 at all times. The hydraulic fluid under pressure as delivered by said pump 44 is employed for sumping the kerf cutting mechanism 66 while performing a sumping cut by driving the rotary hydraulic motor 46 which may be connected to drive said wheels 32, as aforescribed. During any sumping operation the cutter chain 68 of the kerf cutting mechanism 66 is, of course, driven by the electric motor 91 which is within the housing 37. As previously mentioned, the electric motor 91 does not drive any other portion of the mining machine.

It is, of course, manifest that before any kerf cutting operation is to be performed, the cutter bar 67 must be adjusted to a desired position. This may be done with the motor 91 de-energized, or it may be done with said motor running

light, under which conditions the automatic volume control valve mechanism 203 in no wise restricts the volume of liquid delivered to any of the hydraulic motors. This preliminary adjusting of the cutter bar will probably call into play practically all of the hydraulic motors including motors 35 for swinging the turntable, motor 46 for moving the mining machine in its entirety forwardly or rearwardly at a slow speed, hydraulic piston motors 42 for adjusting the supplemental frame 36 about its horizontal axis with respect to the turntable 34, hydraulic piston motors 70 for swinging the cutter bar 67 with respect to the turnover head 65 in its own plane, hydraulic motor 73 for swinging said cutter bar transversely of or at right angles to its own plane, and rotary hydraulic motor 77 for turning over the head 65, neck housing 39 and all parts rigidly attached to them.

In the performance of the sumping operation as previously mentioned, it is, of course, evident that the cutter mechanism 66 is in operation and driven by the electric motor 91 in housing 37 to drive the continuous cutter chain 68. The sumping operation may be performed in a horizontal plane which plane may lie anywhere between the top or roof of the mine room, for example as illustrated in dotted lines in Fig. 5 of the drawings, and the bottom or floor of the mine room, for example as illustrated in the full line position at the bottom of Fig. 6 of the drawings. Furthermore, a horizontal sumping cut may be made at any intermediate position between the two extreme positions above mentioned.

In a wide entry such as one where the distance between the ribs is approximately equal to twice the distance from the turntable axis to the outer end of the cutter bar, a continuous horizontal arcuate cut may be made on the turntable axis, as illustrated by the semi-circle in full line in Fig. 4. In entries not so wide the successive arcuate horizontal connecting cuts illustrated by the dotted lines in Fig. 4 may be made, the turntable and supplemental frame 36 being held in adjusted position relative to the stationary truck 31 for each such successive arcuate cut. The feed of the kerf-cutter on the turntable axis is effected by means of the hydraulic motors 35, 35 and the horizontal kerf cut is on a relatively long radius. The feed of the kerf cutter on its own pivot is effected by means of the hydraulic motors 70, 70 and the horizontal kerf cut is on a shorter radius.

In narrow entries it is preferred first to make a sumping cut by traction feed along the mine track. That is, the whole machine is moved along the mine track at feeding speed to cause the kerf-cutter to cut a kerf rectilinearly parallel to the mine track in continuation of one of the ribs of the mine entry. This is followed by arcuate feeding horizontally either on the turntable axis or on the pivotal axis of the cutter bar while the truck is stationary on the mine track. Finally, a rectilinear withdrawal cut is made by traction feed to finish the horizontal kerf along the opposite rib of the mine entry. During the rectilinear sumping and withdrawal cuts parallel to the mine track, the cutter bar is held rigidly connected to the supplemental frame 36 and the latter is held rigidly connected to the truck 31. Horizontal kerfs may be cut between the ribs of the mine entries of various widths at any elevation between the floor and the roof.

Vertical or shear kerfs may be cut between the floor and roof of mine entries of various

widths anywhere between the ribs thereof. For such shearing cuts the cutter bar is adjusted to a vertical plane by means of the rotary hydraulic motor 77 and the shear kerf completed by rectilinear sumping and withdrawal cuts parallel to the mine track connected by arcuate cuts either on the pivotal axis of the cutter bar or on the axis of the trunnions 40, 40 (Figs. 2, 5, 6), the sumping and withdrawal cuts being effected by traction feed or by movement of the whole machine along the mine track at feeding speed and the upright arcuate cuts being made either by the motors 70, 70 or the motors 42, 42, while the truck is stationary on the mine track.

Also for adjustment purposes preparatory to kerf-cutting, the cutter bar may be swung about its pivotal connection to the turnover head 65 by hydraulic piston motors 78 or about the horizontal pivotal connection between the supplemental frame 36 and the turntable 34 provided by the journal bearings 40 under the influence of the hydraulic piston motors 42.

It is to be noted that said hydraulic piston motors 35, 42, 70 and 73 are all of the double acting type so that they may operate positively in reverse directions by reversing the direction of flow of the hydraulic fluid thereto.

It is to be particularly noted that when any of the hydraulic piston motors such as motors 35, 42, 70, 73 or 46 are in operation, and the electric driving motor 91 which drives the kerf cutting mechanism 66 is in operation, and a kerf is actually being cut thereby placing a load on said motor 91, the automatic control valve mechanism 203 is effective to maintain the feed rate of the cutter mechanism 66 at a value such as to maintain the current or, in other words, the load on the motor 91 within safe limits and at a substantially constant value.

In the system of Fig. 7 whenever the mining machine is performing any kerf cutting operation by the operation of any of the motors 35, 42, 46, 70 or 73, the current flow in the motor 91 flows through the solenoid 179 to energize it. As long as this current is below a predetermined value, as determined by the adjustment of the spring 181 and the spring abutments 185, which is preferably the rated load of said motor 91, pilot valve 193 is operated to the position illustrated in Fig. 11 and the volume control valve 203 is at full open position. This is generally only during adjustment or starting, for during normal operation the feed rate for full volume of hydraulic fluid would be at such a value as to overload motor 91 even for the very softest coal. Consequently, during normal operation as soon as the current flow to motor 91 reaches the predetermined value, preferably rated value, pilot valve 193 is operated to connect branch conduit 88' and conduit 200 thereby supplying hydraulic fluid to the chamber 208 of power operating mechanism 202. Piston 207 is then moved to the left, as viewed in Fig. 8 of the drawings, or to the right, as viewed in Fig. 7 of the drawings, to adjust the cylinder 217 thereby reducing the effective size of orifice or opening 218 which produces an increased pressure drop between pipes 88 and 92, which is also realized between the top and bottom of piston 165, thereby lifting it against spring 166 and by-passing a portion of the hydraulic liquid thereby reducing the volume of the hydraulic fluid supplied to the pressure conduit 92 and to whatever hydraulic motor is performing the feeding operation of the kerf cutting mechanism 66. This action will take

place until the feed rate of the kerf cutting mechanism 66 is reduced so that pilot valve 193 is returned automatically to its balanced position with pipe 200 sealed by the right hand boss of piston 197, in which the magnetic pull on plunger 180, due to the flow of a predetermined amount of current therethrough, equals the pull thereon due to spring 181, which will stop the movement of piston 207 of automatic power operating mechanism 202 which will be locked in this position of adjustment and hold the control cylinder 217 in this predetermined position.

It is, of course, evident that continued variations in the load on the motor 91 will cause continued operations of the solenoid 179 with resulting operation of the pilot valve 193 either to produce an additional decrease in the rate of fluid flow to the hydraulic feeding motor or to increase said feed rate, to maintain substantially constant the rate of current flow in the motor 91 and solenoid 179. In short, cylinder 217 is moved by power under the control of solenoid 179 to such a position that the load on motor 91 is limited as to a maximum value in that the feed rate of the kerf cutting mechanism 66 is adjusted by the current flow through said motor 91 to keep said motor 91 operating at substantially full load, and thus maximum efficiency, at all times.

To reiterate briefly, it is manifest that with the hydraulic control system of my invention the hydraulic motors for adjusting the cutter bar 67 to any position of adjustment preparatory to the cutting of a kerf are supplied with a maximum volume of hydraulic fluid, thus insuring their rapid movement to the desired positions of adjustment which, of course, are effected without any load on the kerf cutting mechanism or upon its driving motor 91, since these adjustments will be effected ordinarily with the driving motor 91 de-energized, or under any conditions, operating appreciably short of its rated load.

Once a kerf cutting operation is started and throughout the continuous operation of any kerf cutting operation involving the action of any of the hydraulic motors which are employed to adjust the cutter bar 67 during the cutting of a kerf, the energy supplied to the driving motor 91 of the kerf cutting mechanism 66 is employed, for example, by feeding the current through a solenoid, to control the feed rate of the kerf cutting mechanism to maintain the current flow in the driving motor 91 substantially constant.

As was previously mentioned, it is preferred that the fluid delivery to the feed motor, whichever one it may be, is preferably maintained at a value to maintain a predetermined load on the motor 91 which is preferably its rated load value, but to prevent hunting variations of a few percent above and below rated value are without effect and valve 193 is responsive only beyond this range. This is effected by adjusting cushion means 185. Therefore, the feed rate of the kerf cutting mechanism is automatically adjusted to prevent an overloading of the driving motor 91 for the kerf cutting mechanism and at the same time to operate it at its maximum efficiency.

It has been found in practice that a high pressure relief valve to by-pass fluid from the pump of a fluid pressure system for kerf cutting machines does not act properly to protect the cutter chain driving motor, and this is true even if this relief valve is controlled by the driving motor current because the feeding rate also then depends in part upon the total pressure in the system and not solely on the motor current.

The system of control shown in the accompanying drawings, depends only upon variation of the electric current passing through the cutter chain driving motor 91, and therefore this system of control provides smooth variations in feed rate and at the same time is entirely independent of the system pressure. Attempts to control the feed rate which involve the system pressure have been found to result in a series of starts and stops in the feed rate which is very unsatisfactory operation.

The fundamental difference between my system and the undesirable system above described is evident from the following fundamental consideration.

In the said undesirable system, the load on the electric driving motor for the kerf cutter becomes effective when it becomes excessive and then it operates to open the hydraulic feed line, like a high pressure relief valve, which practically stops the feeding of the mining mechanism entirely. This causes a reduced motor current and the hydraulic feed starts again quite suddenly and this usually causes a repetition of the above cycle.

In my system, the fundamental factor is that for every size of opening or orifice provided by groove 218 there is a predetermined rate of hydraulic fluid flow to the hydraulic feeding motor doing work. This predetermined rate is maintained entirely automatically because if it tends to increase there will be an increased pressure drop across orifice 218 which will lift piston 165 higher than its previous position to increase the amount of hydraulic fluid by-passed, while if it tends to decrease there will be a decreased pressure drop across orifice 218 which will move piston 165 lower than its previous position to decrease the amount of hydraulic fluid by-passed.

Of course, for each position of the cylinder 217 said opening or orifice provided by groove 218 has a predetermined size thus automatically demanding a different predetermined rate of fluid flow for each position thereof.

This predetermined fluid flow is fixed for each position of cylinder 217 but adjustable by adjusting the position of cylinder 217 and is entirely independent of the hydraulic pressure of the system or any variations thereof. In this respect it is fundamentally different from an ordinary by-pass valve for with such a valve the amount of hydraulic fluid by-passed is a function of both the size of the opening or orifice and the pressure of the system.

The control of the rate of hydraulic flow in my system is smooth and continuous for the current in the electric driving motor for the kerf cutter when effective merely adjusts the rate of hydraulic fluid flow to the hydraulic feeding motor by adjusting the position of cylinder 217, and as above stated the variable factor of the hydraulic pressure of the system is entirely eliminated.

My system of control also includes high pressure relief valve mechanism, as above described and is shown at 203 in Figs. 7, 8, 9 and 10, combined with the volume control mechanism which is adapted to protect the system against excessive pressures which would be encountered, for example, when a hydraulic motor reached the end of this movement and hydraulic fluid was still being fed to it.

As soon as the by-pass opens in response to excessive pressure the pressure in the motor line drops and the by-pass valve closes again followed by reapplication of the pressure in the motor line.

Such repeated opening and closing of the high

pressure relief valve causes the cutter bar to chatter and thereby signal the operator to stop the feeding of hydraulic fluid to the motor by adjusting the valve mechanism 64 or 81.

It will thus be seen that the efficiency of operation will be safely maintained at a maximum in that the electric motor 91 for driving the chain cutter will continuously and safely operate at its full load capacity or any other predetermined setting, so that when easy cutting is encountered, the rate of feed is automatically increased, and when the cutting is hard the rate of feed is automatically reduced. Moreover, when no cutting is taking place and the driving motor 91 is running free or is not operating, the rate of feed for adjustment of the kerf cutter relative to the supporting framework, is automatically raised to a maximum. That is, if the current to the motor 91 is low or is cut off during such adjustments of the kerf cutter, the spring 181 in Fig. 7 moves the valve 197 to the left, as viewed in Fig. 11, to permit the pipe 200 to be connected to the drainage pipe 201, whereupon the spring 209 (Fig. 8), is free to move the piston 207 to such position that the volume control valve cylinder 217 will be in its widest open position for maximum flow of the fluid pressure medium to the adjusting motors.

In Fig. 13 of the drawings I have shown a modification of the system of my invention and it is to be understood that except for changes indicated, this modified system follows the system above described and particularly the hydraulic system disclosed in Fig. 7 of the drawings. As a general statement it may be said that in the modified system of Fig. 13 I have eliminated the volume control valve mechanism 203 entirely. In place of the hydraulic power operated mechanism 202 I have substituted hydraulic power operated mechanism 202', the piston rod 212' of which is directly and positively connected to an adjustable ring 44' of a variable volume pump 44' which replaces the pump 44 of the system of Fig. 7. The pump 44' is of well known construction and may follow in general that illustrated in the patent to Floyd O. De Millar, No. 2,057,089, for a Hydraulic road grader, dated October 13, 1936, except that in the pump 44' the volume is controlled by positive adjustment of the controllable ring 44', while in the De Millar patent this ring is spring-biased to one position and is operated by a hydraulic plunger in the opposite direction.

Fundamentally the system of Fig. 13 operates the same as the system of Fig. 7. Specifically, they differ in this respect: In the system of Fig. 13 the pump 44' normally delivers hydraulic fluid under pressure at a rate in excess of that required to operate the feeding mechanism of the mining machine or any of the hydraulic jacks or motors which are controlled by hydraulic fluid. The amount of hydraulic fluid, however, actually delivered to any hydraulic motor or jack in the system of Fig. 7 is automatically controlled by the by-pass mechanism 203 and is maintained at any predetermined but variable value as determined by the current in the motor 91 as afore-described.

In the system of Fig. 13 all of the fluid output of the motor 44' is employed to do useful work and none of it is by-passed. For this reason the system of Fig. 13 is more efficient than that of Fig. 7. In the system of Fig. 13, instead of by-passing an amount of fluid from a pump

which generates an excess amount, the volumetric output of the pump 44' is controlled directly by controlling the eccentricity of the ring 44' in the manner well understood in the pump art and which is fully described in the above-mentioned patent to De Millar, No. 2,057,089.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. In apparatus of the class described, the combination with a frame, of cutting mechanism mounted thereon, mechanism comprising an electric motor for driving said cutting mechanism, fluid-pressure motor means for feeding said cutting mechanism, a volume control valve connected to said fluid-pressure motor means, a fluid-pressure motor for actuating said volume control valve, a pilot valve for controlling said fluid-pressure motor, and an electro-magnet in circuit with said electric motor and connected to said pilot valve to control the same in accordance with the current flow through said electric motor, the construction and arrangement being such that the said electric motor may be operated continuously at a predetermined full load capacity by reason of automatic regulation of the rate of feed of the cutting mechanism, such rate of feed being automatically increased when easy cutting is encountered in the mine vein and automatically decreased when the cutting is relatively hard, and when no cutting is taking place and the electric motor is not operating or running free the rate of feed for adjustment of the cutting mechanism is automatically increased to a maximum.

2. In apparatus of the class described, the combination with cutting mechanism, of an electric motor connected thereto to drive the same, hydraulic motor means for feeding said cutting mechanism, a volume control valve, a reciprocating hydraulic motor connected to said valve to actuate the same, a pilot valve for controlling said reciprocating hydraulic motor, a solenoid in circuit with said electric motor, a plunger in said solenoid, a spring connected to said plunger to retract the same when said solenoid is deenergized, a pivoted lever connecting said plunger and spring to said pilot valve, spring-pressed abutment mechanism associated with said lever and adapted to co-operate with said solenoid and spring to effect such operation of said pilot valve as to cause said reciprocating hydraulic motor to control said volume control valve to vary the rate of feed of the cutting mechanism in accordance with the load on the electric motor and thereby maintain such load at a predetermined value, and a hydraulic system of piping connections from the source of supply of pressure medium to secure such operation automatically.

3. In apparatus of the class described, the combination with cutting mechanism, of an electric motor connected thereto to drive the same, hydraulic motor means for feeding said cutting mechanism, a volume control valve, a reciprocating hydraulic motor comprising a spring-pressed plunger connected to said valve to control the same, a pilot valve connected to said reciprocating hydraulic motor, an electro-magnet

in circuit with said electric motor, means associated with said electro-magnet and said pilot valve to effect operation of the latter when current through said electric motor and said electro-magnet varies due to variations of load on said electric motor, and a hydraulic system for the said valves and said hydraulic motors to enable increase of current through said electro-magnet to operate the pilot valve to direct hydraulic pressure to said reciprocating motor to cause the latter to partially close said volume control valve to reduce the flow of pressure medium to said feeding hydraulic motor means and thereby reduce the rate of feed of the cutting mechanism to prevent loading said motor beyond a predetermined limit.

4. In apparatus of the class described, the combination with cutting mechanism, of an electric motor connected thereto to drive the same, hydraulic motor means for feeding said cutting mechanism, hydraulic means comprising a pilot valve for controlling the rate of feed effected by said hydraulic motor feeding means, a solenoid in circuit with said electric motor, a plunger in said solenoid, a spring acting on said plunger to retract the same when said solenoid is de-energized, a pivoted lever connecting said plunger and said pilot valve, limit stops on opposite sides of said lever set in accordance with the limits of said pilot valve, spring-pressed buffer devices on opposite sides of said lever in positions to be engaged by said lever before said limit stops are reached, means for adjusting the resistances offered by said buffer devices to movements of said lever by said spring and said solenoid acting on said plunger against the action of said spring, and a hydraulic system for said hydraulic motor and said hydraulic means to enable the latter to effect regulation of feed in accordance with variations of current flow through said solenoid due to variations of load on said electric motor and thereby maintain a substantially uniform load on the said electric motor.

5. In apparatus of the class described, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic means for feeding said cutting mechanism, a hydraulic system including mechanism for supplying hydraulic fluid to said hydraulic feeding means at a controllable rate including an adjustable member, mechanism operated as determined by the position of said adjustable member for continuously maintaining a substantially constant rate of hydraulic fluid flow to said hydraulic feeding means different for each of a plurality of operating positions of adjustment of said adjustable member, and means responsive to the load on said electric motor for adjusting said adjustable member to maintain said load within a predetermined range, said means being operable to increase the feed rate of said cutting mechanism when the load on said electric motor falls substantially below its rated value and to decrease said feed rate when said load goes substantially above said rated value.

6. In apparatus of the class described, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic means for feeding said cutting mechanism, a hydraulic system including mechanism for supplying hydraulic fluid to said hydraulic feeding means at a controllable rate including an adjustable member, mechanism operated as determined by the position of said adjustable member for continuously maintaining a substantially

constant rate of hydraulic fluid flow to said hydraulic feeding means different for each of a plurality of operating positions of adjustment of said adjustable member, said mechanism including a by-pass for part of said hydraulic fluid, and means responsive to the load on said electric motor for adjusting said adjustable member to maintain said load within a predetermined range, said means being operable to increase the feed rate of said cutting mechanism when the load on said electric motor falls substantially below its rated value and to decrease said feed rate when said load goes substantially above said rated value.

7. In apparatus of the class described, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic means for feeding said cutting mechanism, a hydraulic system including mechanism for supplying hydraulic fluid to said hydraulic feeding means at a controllable rate including a variable output pump having means for varying its volumetric output comprising an adjustable member, mechanism operated as determined by the position of said adjustable member for continuously maintaining a substantially constant rate of hydraulic fluid flow to said hydraulic feeding means different for each of a plurality of operating positions of adjustment of said adjustable member, and means responsive to the load on said electric motor for adjusting said adjustable member to maintain said load within a predetermined range, said means being operable to increase the feed rate of said cutting mechanism when the load on said electric motor falls substantially below its rated value and to decrease said feed rate when said load goes substantially above said rated value.

8. In a mining machine, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic mechanism for feeding said cutting mechanism, a hydraulic system for supplying fluid under pressure to said hydraulic mechanism, a variable output pump in said hydraulic system, adjustable means operable on said pump and constructed and arranged to have a plurality of positions in which the fluid delivery to said hydraulic mechanism is different for each position, and means responsive to the current flow in said electric motor for operating said adjustable means to adjust automatically the rate of feed of said cutting mechanism to prevent overloading of said electric motor, while maintaining it in operation substantially at its rated capacity, said means being operable to increase the feed rate of said cutting mechanism when the load on said electric motor falls substantially below its rated value and to decrease said feed rate when said load goes substantially above said rated value.

9. In a mining machine, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic mechanism for feeding said cutting mechanism, a hydraulic system for supplying fluid under pressure to said hydraulic mechanism, a pump in said hydraulic system, adjustable means constructed and arranged to have a plurality of positions in which the fluid delivery to said hydraulic mechanism is different for each position, and means responsive to the current flow in said electric motor for operating said adjustable means to adjust automatically the rate of feed of said cutting mechanism to prevent overloading of said electric

motor, while maintaining it in operation substantially at its rated capacity.

10. In a mining machine, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic mechanism for feeding said cutting mechanism, a volume control valve in the supply line connected to said hydraulic mechanism, means comprising an automatic valve for by-passing a portion of the hydraulic pressure medium before reaching said volume control valve, hydraulic mechanism for operating said volume control valve, and means operative in response to current flow in said electric motor for controlling said last-named hydraulic mechanism, the construction and arrangement being such that the feed rate of the hydraulic feeding mechanism is controlled by the current flow in said electric motor to prevent overloading the motor but effecting operation thereof at a predetermined maximum capacity.

11. In a mining machine, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic mechanism for feeding said cutting mechanism, a volume control valve in the supply line connected to said hydraulic feeding mechanism, means for effecting by-passing a portion of the hydraulic pressure medium from said volume control valve, a hydraulic motor for operating said volume control valve, a pilot valve for controlling said hydraulic motor, and means comprising an electro-magnet in circuit with said electric motor for operating said pilot valve, the construction and arrangement being such that the feed rate of the cutting mechanism is automatically regulated to keep the electric motor in operation at maximum capacity without overloading.

12. In a mining machine, the combination with cutting mechanism, of an electric motor for driving said cutting mechanism, hydraulic means for feeding said cutting mechanism, a constant volume hydraulic pump, a volume control valve in a supply line connecting said pump to said hydraulic feeding means, a variable by-pass for the hydraulic fluid from said volume control valve, hydraulic means for controlling said volume control valve, means dependent upon the setting of said volume control valve for automatically controlling said by-pass and thereby regulate the volume of liquid flowing to said hydraulic feeding means, and means responsive to current flow in said electric motor to effect automatic operation of said hydraulic means for controlling said volume control valve to vary the rate of feed of the cutting mechanism in accordance with the load on the electric motor, the rate of feed being slowed down when the load on the electric motor is increased above its rated value and the rate of feed being increased when the load on the electric motor is decreased below its rated value.

13. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon, means comprising an electric motor for driving said cutting mechanism, fluid-pressure motor means for feeding said cutting mechanism, a volume control valve connected to said fluid-pressure motor means, fluid-pressure motor means for operating said volume control valve, means for automatically by-passing variable portions of the fluid pressure medium from the volume control valve to effect variations in feeding rate of the cutting mechanism, and means comprising an electro-magnet in circuit with said electric motor and connected to said last-named fluid-pressure motor means to secure

operation of said volume control valve and said by-passing means to effect regulation of the volume of fluid pressure medium flowing to said fluid-pressure motor feeding means in accordance with the load on said electric motor.

14. In a mining machine, the combination with cutting mechanism, of hydraulic feeding means for said cutting mechanism, an electric motor connected to said cutting mechanism to drive the same, a hydraulic pump having a normal operating output of hydraulic fluid in excess of that usable by said hydraulic feeding means during normal operation of the machine, means comprising a volume control valve for conducting hydraulic fluid from said pump to said hydraulic feeding means, means comprising another valve for by-passing fluid from the pump before reaching said volume control valve, said by-pass valve acting automatically to by-pass a portion of the hydraulic fluid substantially continuously during normal operation of said hydraulic feeding means, and means operative in response to the current flow to said electric motor to actuate said volume control valve to effect said operation of said by-pass valve, the volume of fluid flowing to said hydraulic feeding means being thus regulated in accordance with the load on the motor, the feed of the cutting mechanism being slowed down when the load on the motor increases above its rated value and vice versa.

15. In a mining machine, the combination with cutting mechanism, of hydraulic means for feeding said cutting mechanism, an electric motor connected to said cutting mechanism to drive the same, means comprising a volume control valve and a supply conduit for directing hydraulic fluid under pressure to said hydraulic feeding means, a hydraulic pump having a normal operating output of hydraulic fluid in excess of that usable by said hydraulic feeding means during normal operation of the machine, said pump being connected to said supply conduit, pump by-pass means comprising a valve controlling a by-pass conduit leading from the supply conduit near the volume control valve to the return side of the pump, said pump by-pass means during normal operation of the machine serving to continuously by-pass a portion of the hydraulic fluid from the volume control valve to the return side of the pump, and means operative in response to current flow to said electric motor for setting said volume control valve to control the extent of movement of said by-pass valve and thereby regulate the volume of by-passed hydraulic fluid.

16. In apparatus of the class described, the combination with working mechanism, of an electric motor for driving said working mechanism, hydraulic feeding means for feeding said working mechanism to its work, a hydraulic pump having a normal operating output of hydraulic fluid in excess of that usable by said hydraulic feeding means during normal operation of the apparatus, a supply conduit between said pump and said hydraulic feeding means, a volume control valve having an adjustable size passageway in said supply conduit, means responsive to the current flow to said electric motor for adjusting said volume control valve to vary the effective size of said passageway, a pump by-pass for the excess hydraulic fluid from the supply conduit on the pump side of the volume control valve, and a valve for controlling said by-pass in accordance with the adjusted position of the volume control valve in the supply conduit.

17. In apparatus of the class described, the

combination with working mechanism, of an electric motor connected thereto to drive the same, hydraulic feeding means for feeding said working mechanism to its work, a hydraulic pump having a normal operating output of hydraulic fluid in excess of that usable by said hydraulic feeding means during normal operation of said apparatus, a supply conduit between said pump and said hydraulic feeding means, a volume control valve having an adjustable size passageway in said supply conduit, power-operated means for adjusting said volume control valve to vary the effective size of said passageway and hold said valve in adjusted position, means operative in response to current flow to said motor for adjusting said power-operated means whenever said current varies a predetermined amount from a desired value, a by-pass for the excess hydraulic fluid leading from said supply conduit, and a valve for controlling said by-pass in accordance with the adjustment of said size passageway in said supply conduit.

18. In apparatus of the class described, the combination with working mechanism, of an electric motor connected thereto to drive the same, hydraulic feeding means for feeding said working mechanism to the material to be worked upon, mechanism for supplying hydraulic fluid to said feeding means at a controllable rate, said mechanism comprising means including by-pass controlling means operating continuously to maintain said rate of hydraulic fluid flow at a predetermined value for each position of adjustment of an adjustable member thereof independently of the pressure of the hydraulic fluid, and means responsive to the current flow in said electric motor when it reaches a predetermined value for adjusting said adjustable member to adjust the value at which said rate of hydraulic fluid flow is predetermined to prevent overloading of said motor.

19. In apparatus of the class described, the combination with working mechanism, of an electric motor connected thereto to drive the same, hydraulic feeding means for feeding said working mechanism to the material to be worked upon, mechanism for supplying hydraulic fluid to said feeding means at a controllable rate, said mechanism comprising means operating contin-

uously to maintain said rate of hydraulic fluid flow at a predetermined value for each position of adjustment of an adjustable member thereof independently of the pressure of the hydraulic fluid, and means responsive to the current flow in said electric motor when it reaches the rated value of said motor for adjusting said adjustable member to adjust the value at which said rate of hydraulic fluid flow is predetermined to prevent overloading of said motor, and also responsive to a reduction in the current flow below the rated value of said motor for adjusting said adjustable member to prevent underloading of said motor.

20. In apparatus of the class described, the combination with cutting mechanism, of hydraulic motor means for feeding said cutting mechanism, an electric motor for driving said cutting mechanism, a pump having an output in excess of the normal fluid consumption of said hydraulic motor means, conduit means for delivering hydraulic fluid from said pump to said hydraulic motor means, a fluid by-pass control valve in said conduit means constructed normally to by-pass a portion of said hydraulic fluid during operation of said pump and hydraulic motor means, and mechanism operable by variations of the current flow to said motor to control said by-pass valve to increase the fluid by-passed whenever said electric motor is over-loaded and to decrease the fluid by-passed whenever said electric motor is operating below its rated load whereby said electric motor is automatically maintained in operation substantially at its full rated load.

21. In apparatus, of the class described, the combination with cutting mechanism, of hydraulic motor means for feeding said cutting mechanism, an electric motor for driving said cutting mechanism, a pump, conduit means for delivering hydraulic fluid from said pump to said hydraulic motor means, and mechanism operable by variations of the current flow to said motor to control the rate of flow of hydraulic fluid to said hydraulic motor means to decrease said fluid flow whenever said electric motor is over-loaded and to increase said fluid flow whenever said electric motor is operating below its rated load whereby said electric motor is automatically maintained in operation substantially at its full rated load.

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