

Oct. 5, 1965

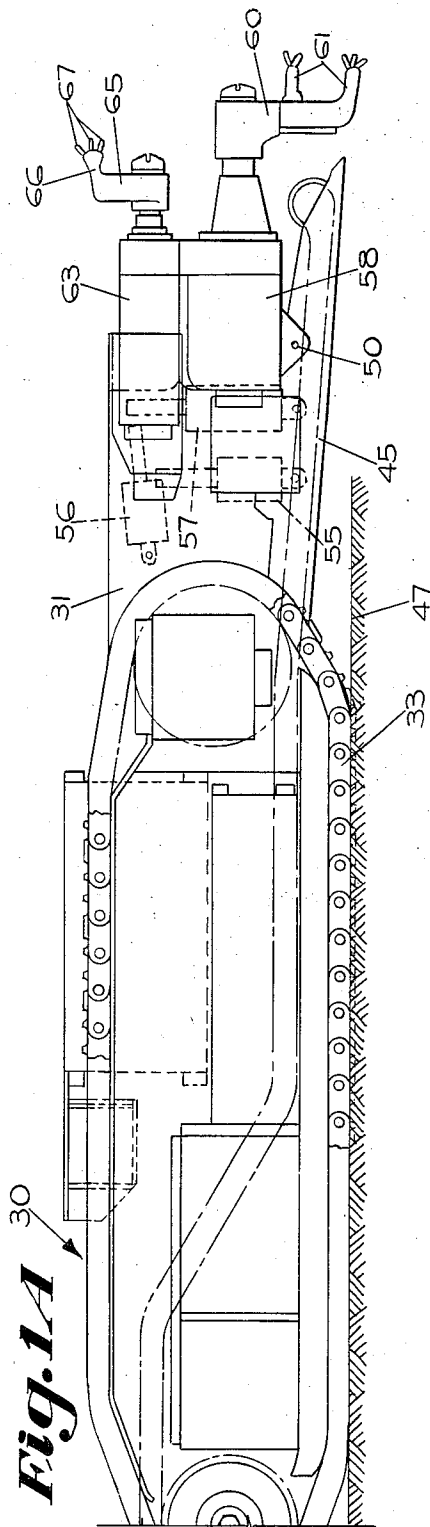
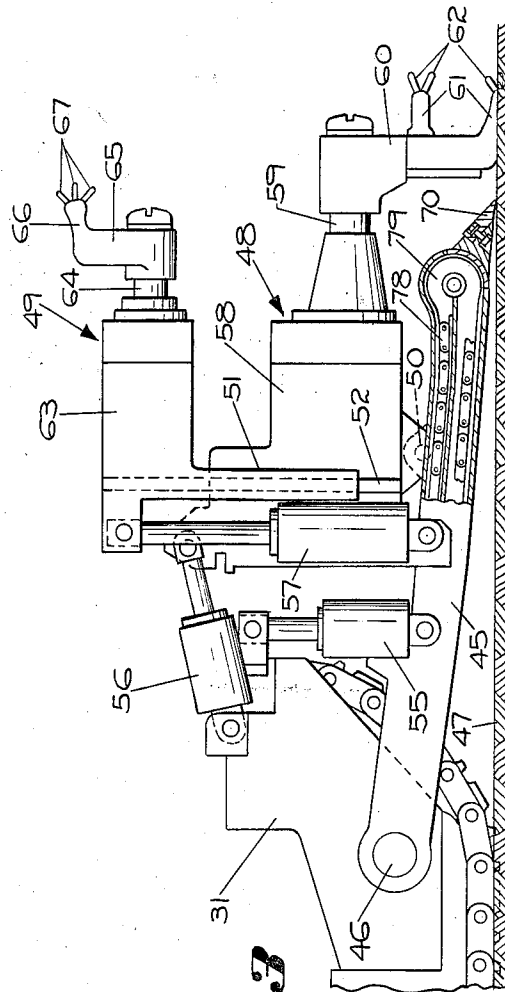
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 1



INVENTOR;  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young ATT'Y.

Oct. 5, 1965

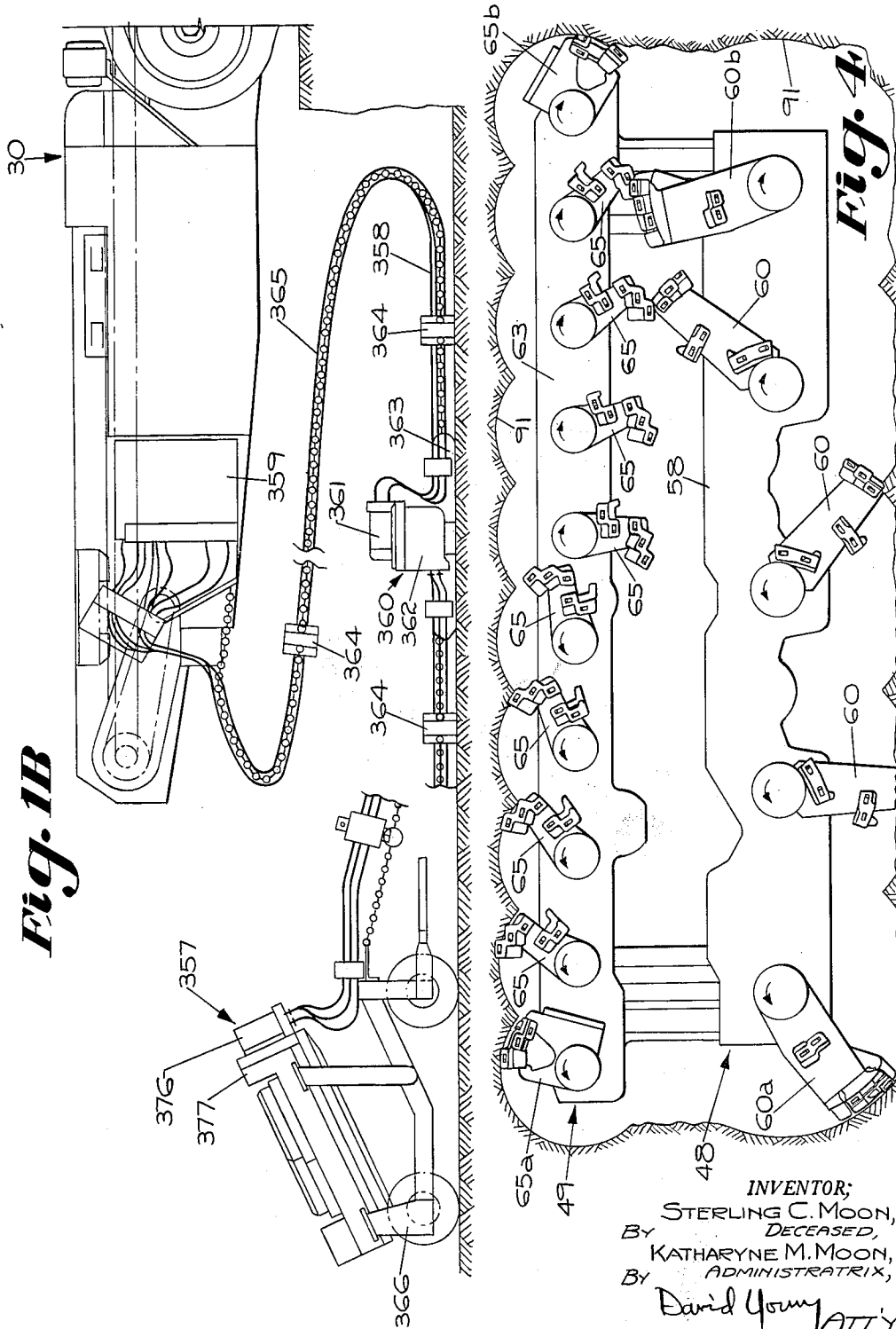
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 2



Oct. 5, 1965

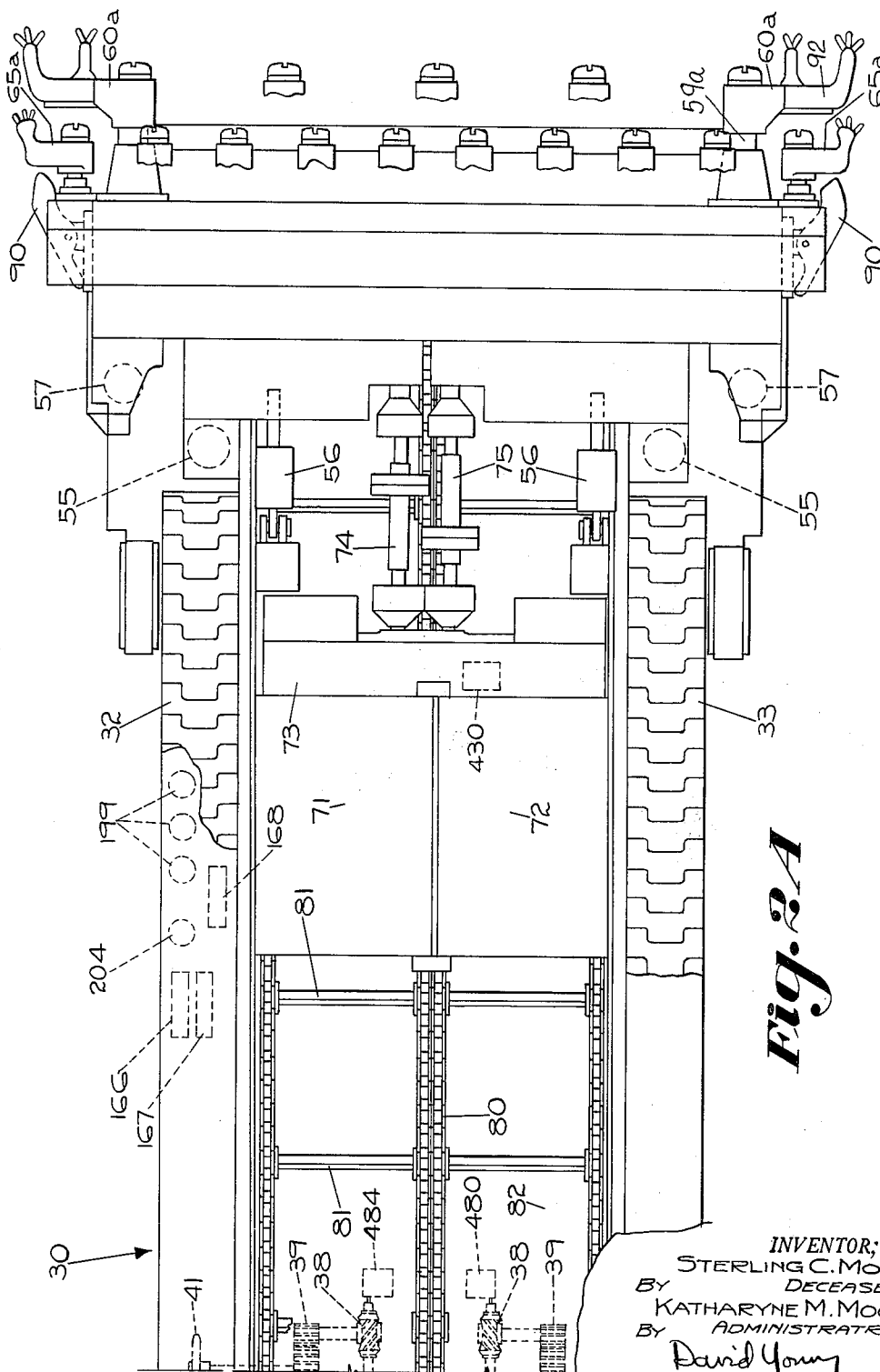
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 3



INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 4

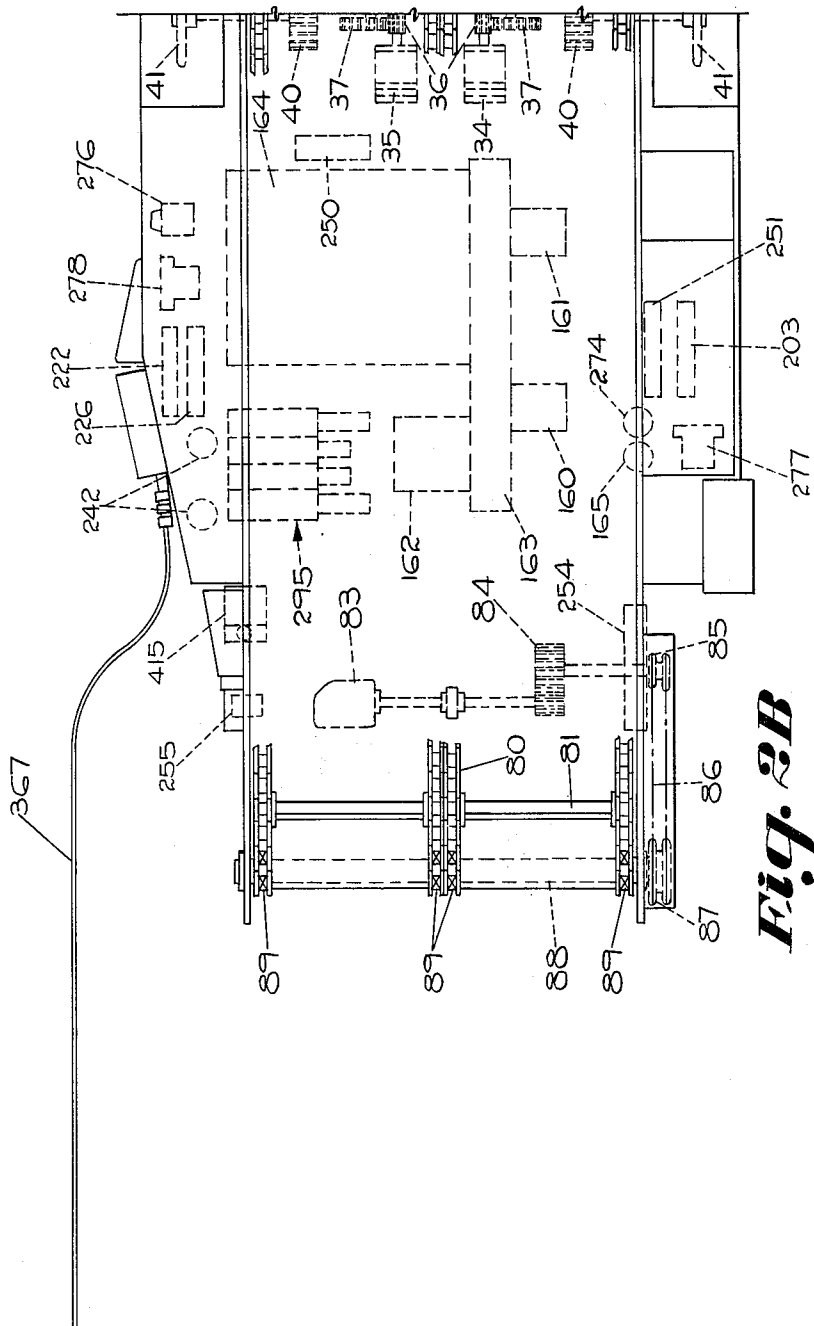


**Fig. 2B**

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
David Young ATT'Y.

Oct. 5, 1965

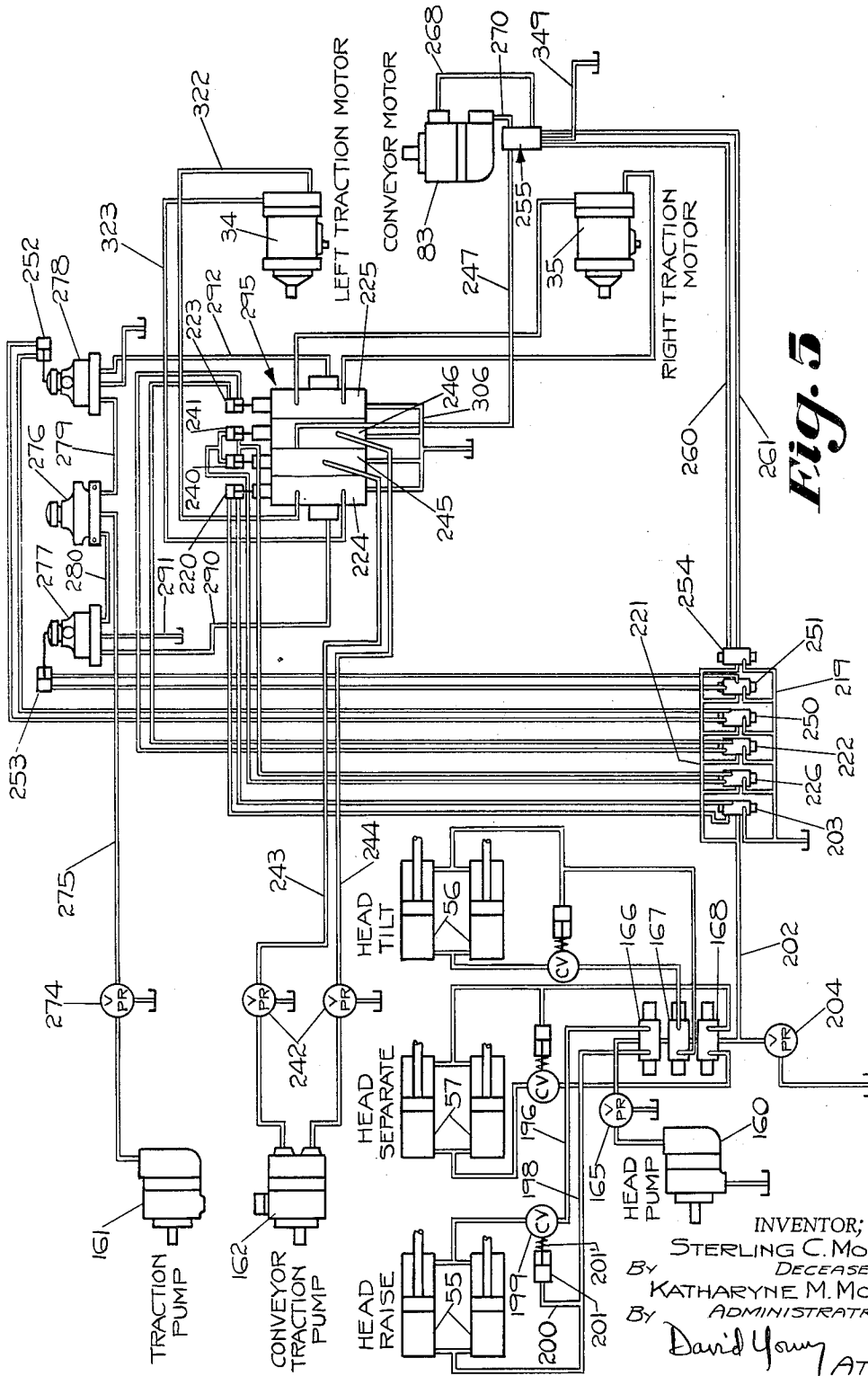
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 5



INVENTOR;  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 6

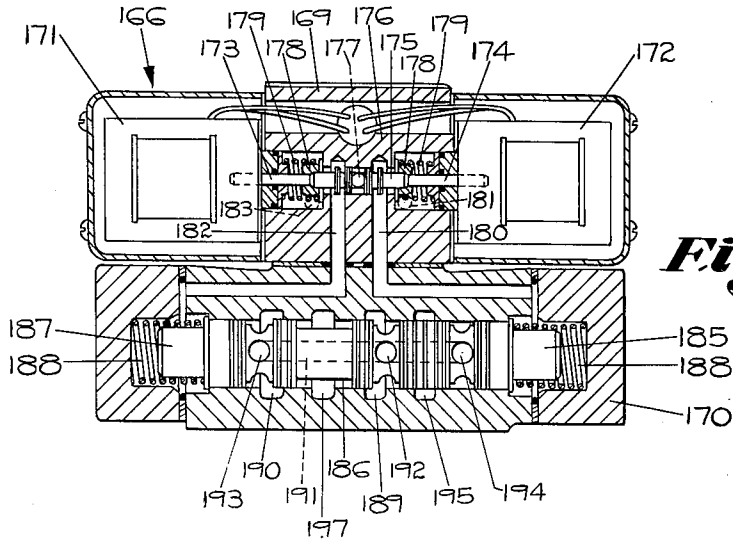


*Fig. 6*

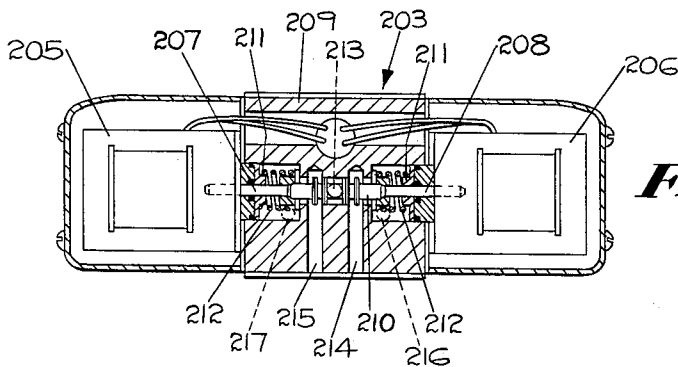


*Fig. 7*

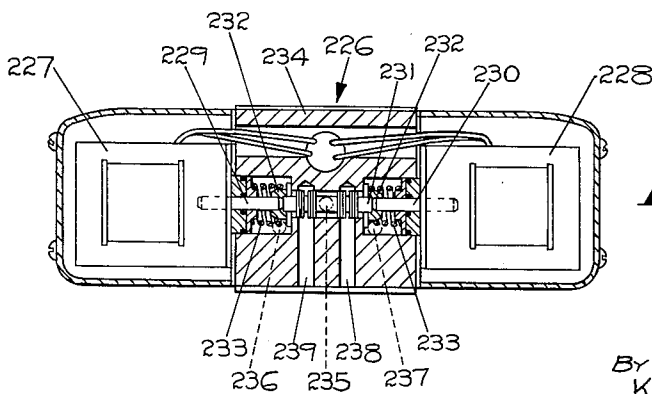


*Fig. 8*

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 7

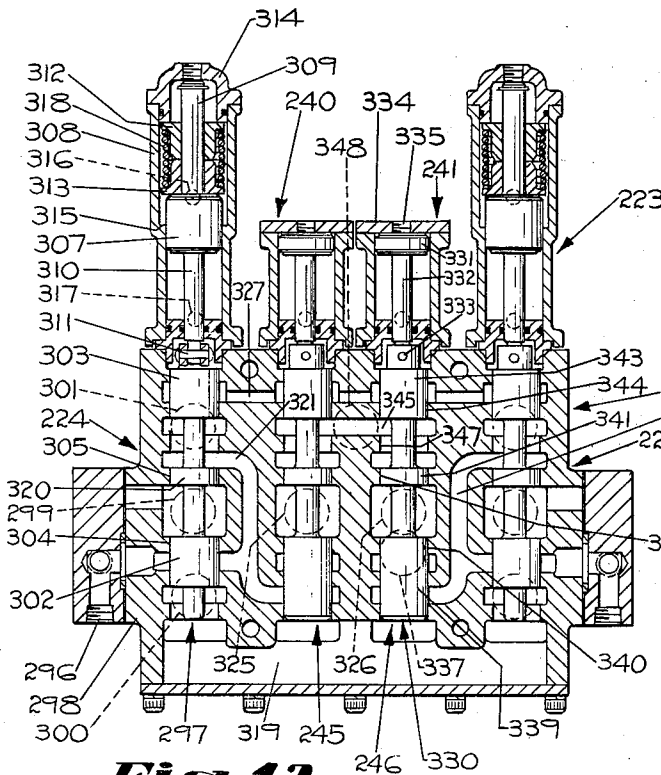


**Fig. 13**

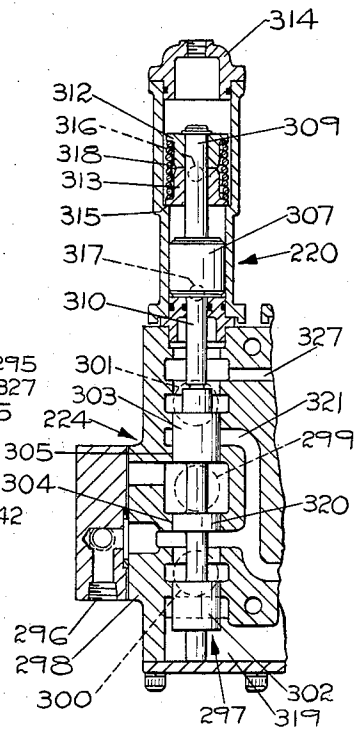


**Fig. 14**

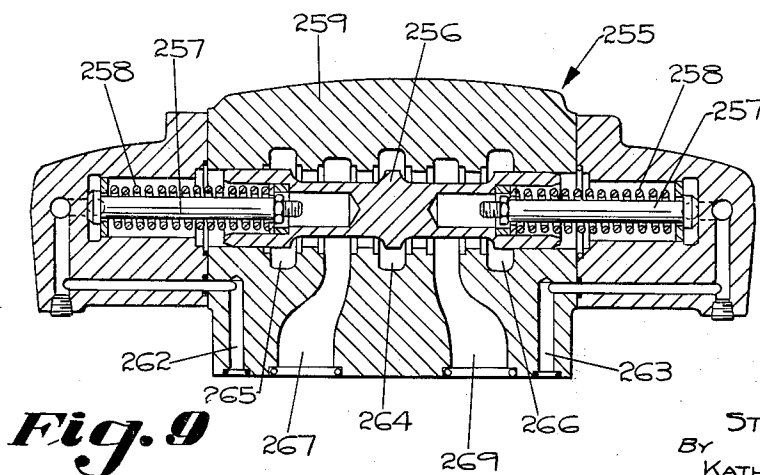


**Fig. 9**

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
BY David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 8

**Fig. 11**

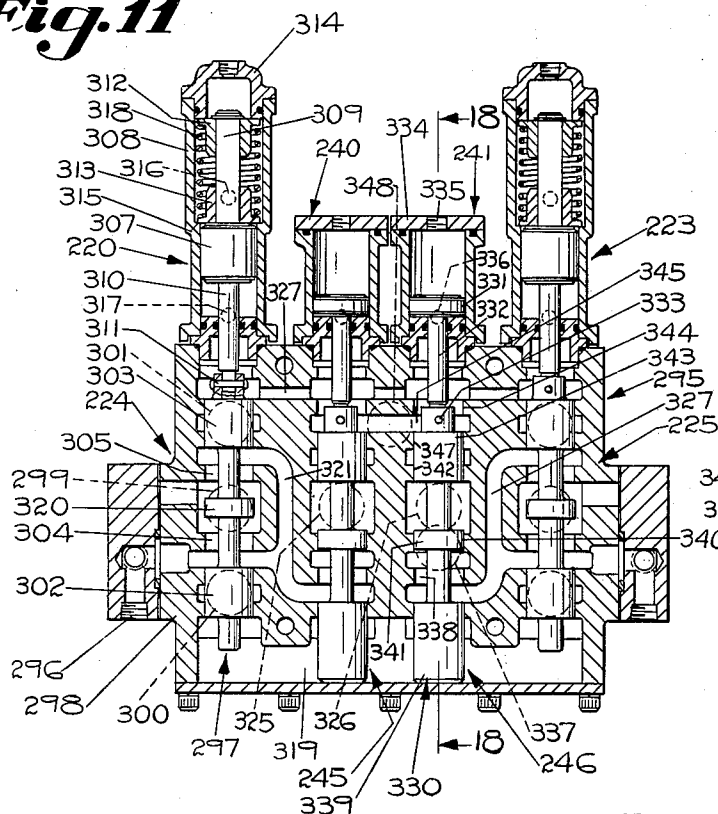


**Fig. 12**

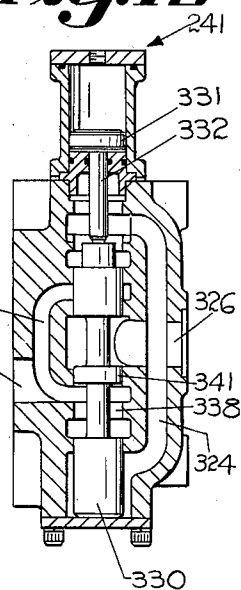
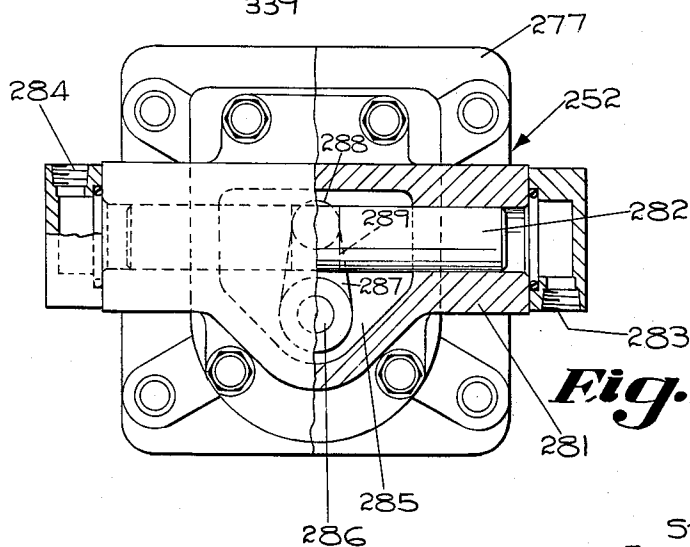


**Fig. 10**

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 9

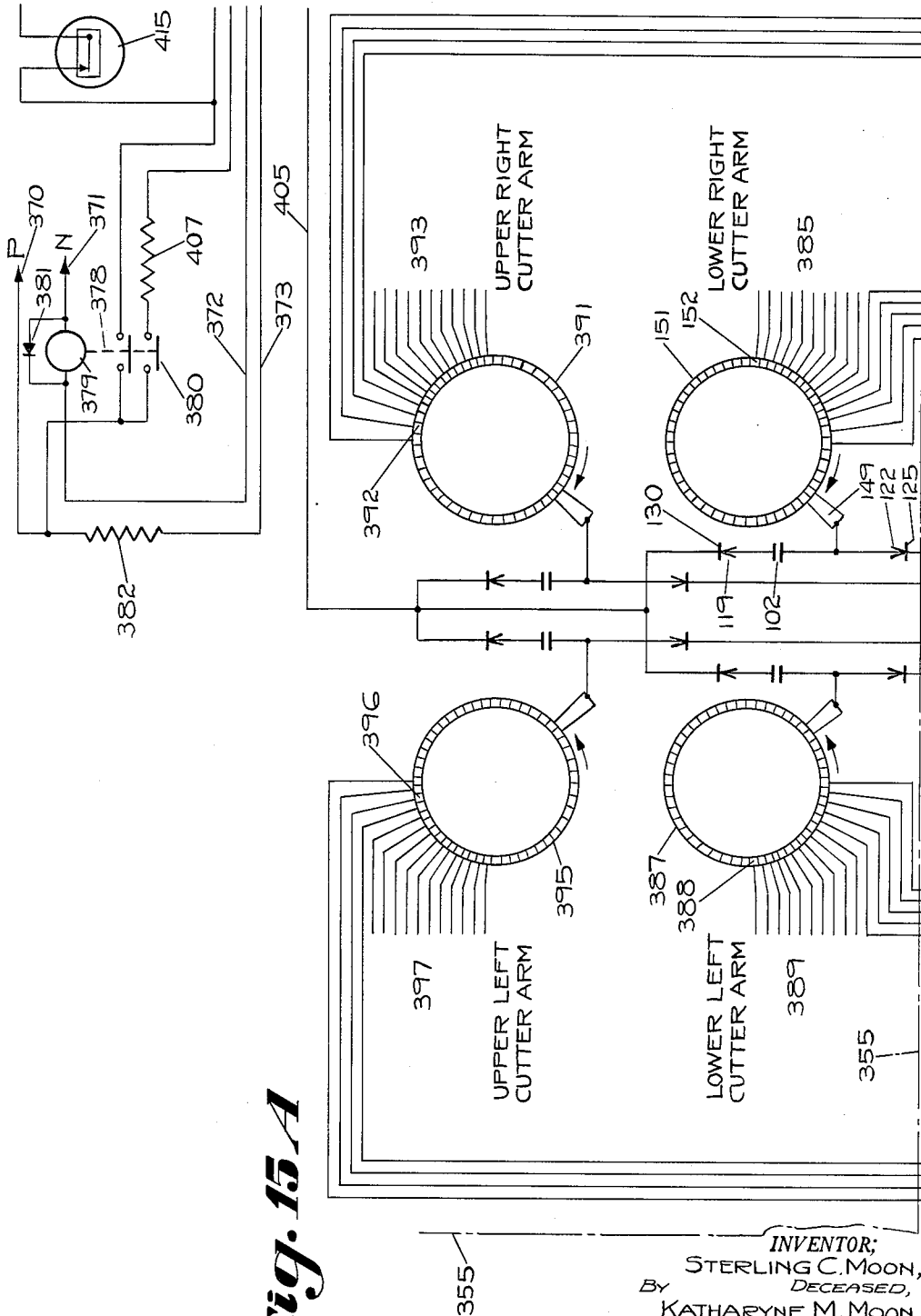


Fig. 15A

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young ATT'Y.

Oct. 5, 1965

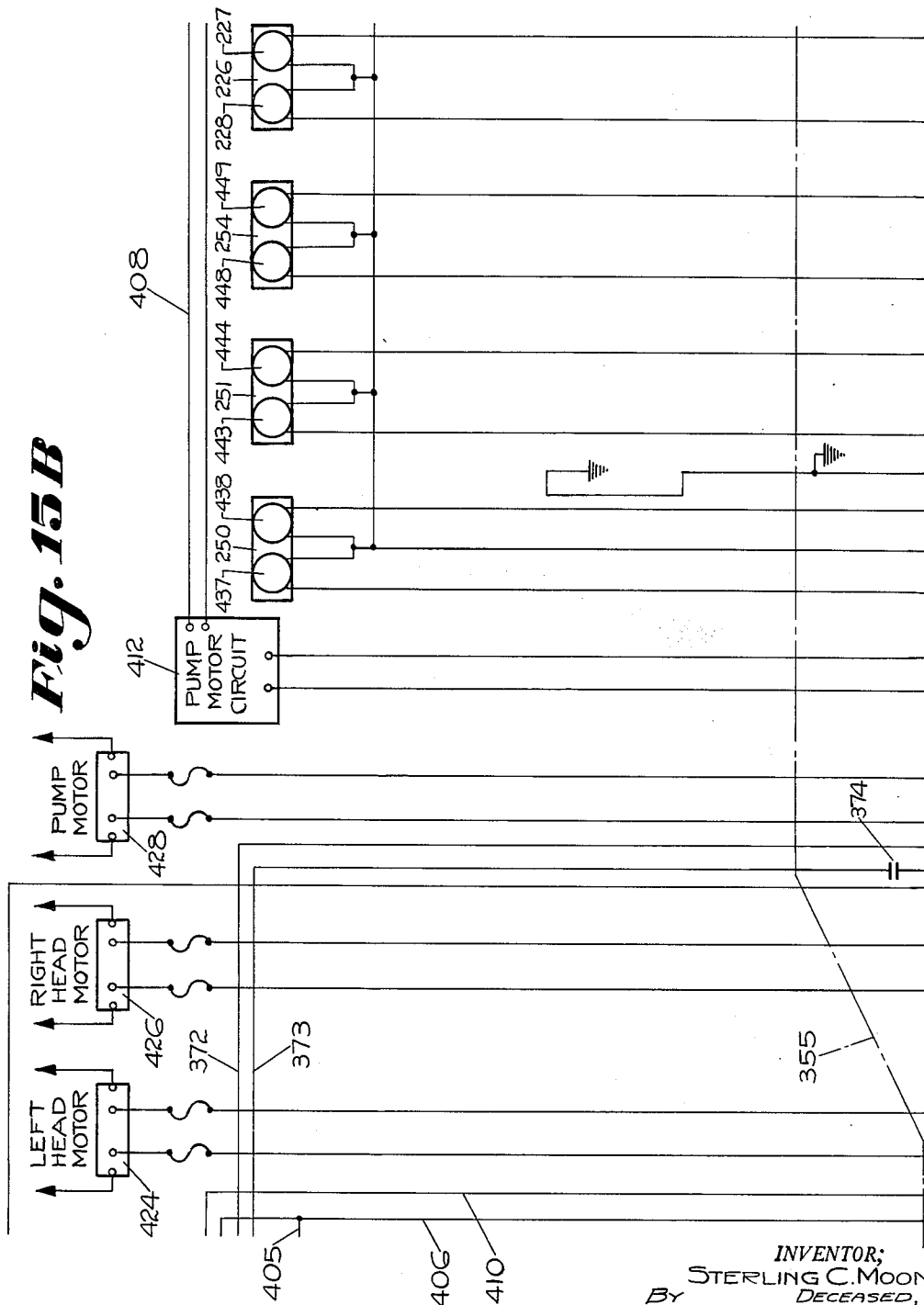
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 10



INVENTOR;  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

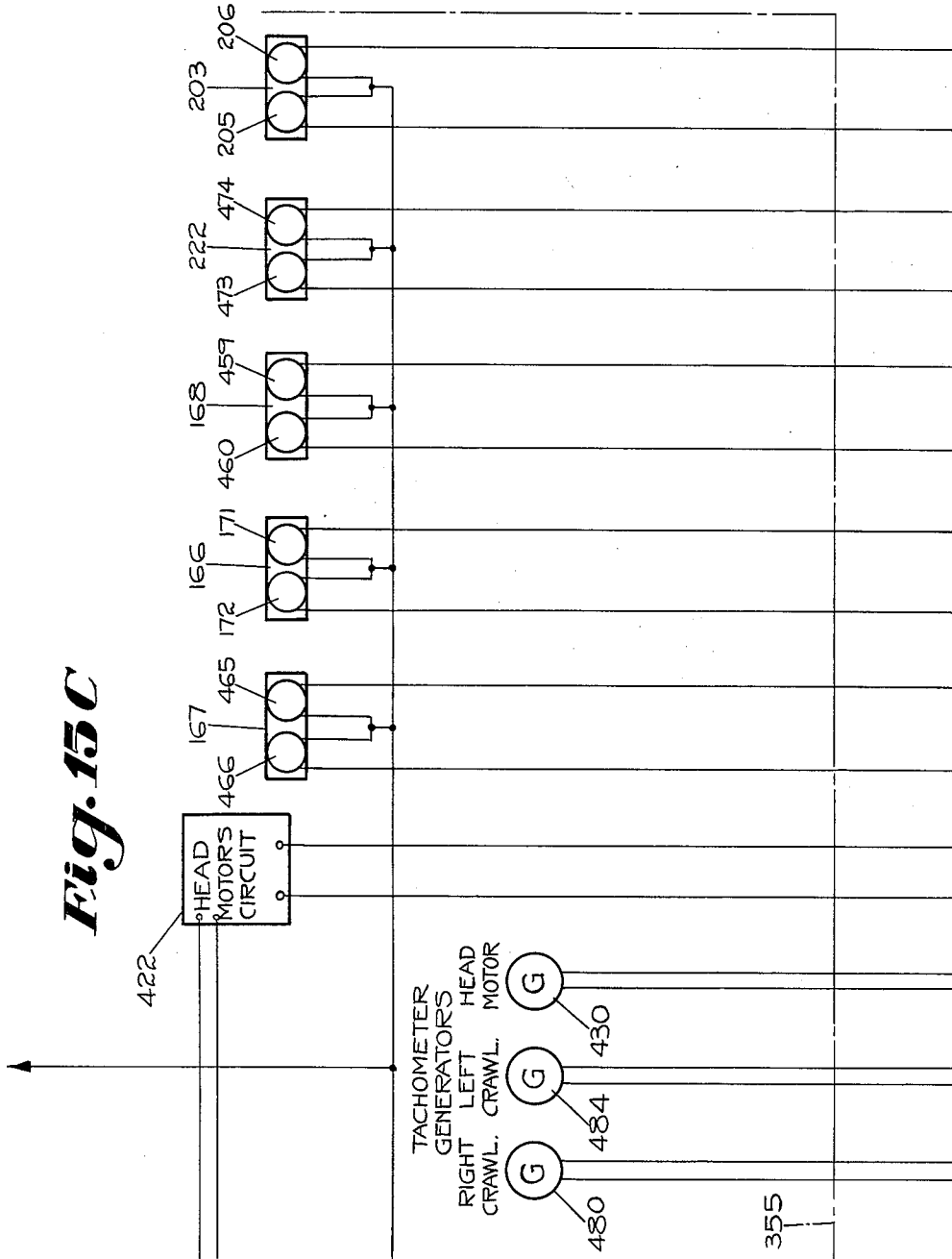
3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 11

*Fig. 15C*



INVENTOR;  
STERLING C. MOON,  
DECEASED,  
BY KATHARYNE M. MOON,  
ADMINISTRATRIX,  
BY *David Young* ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 12

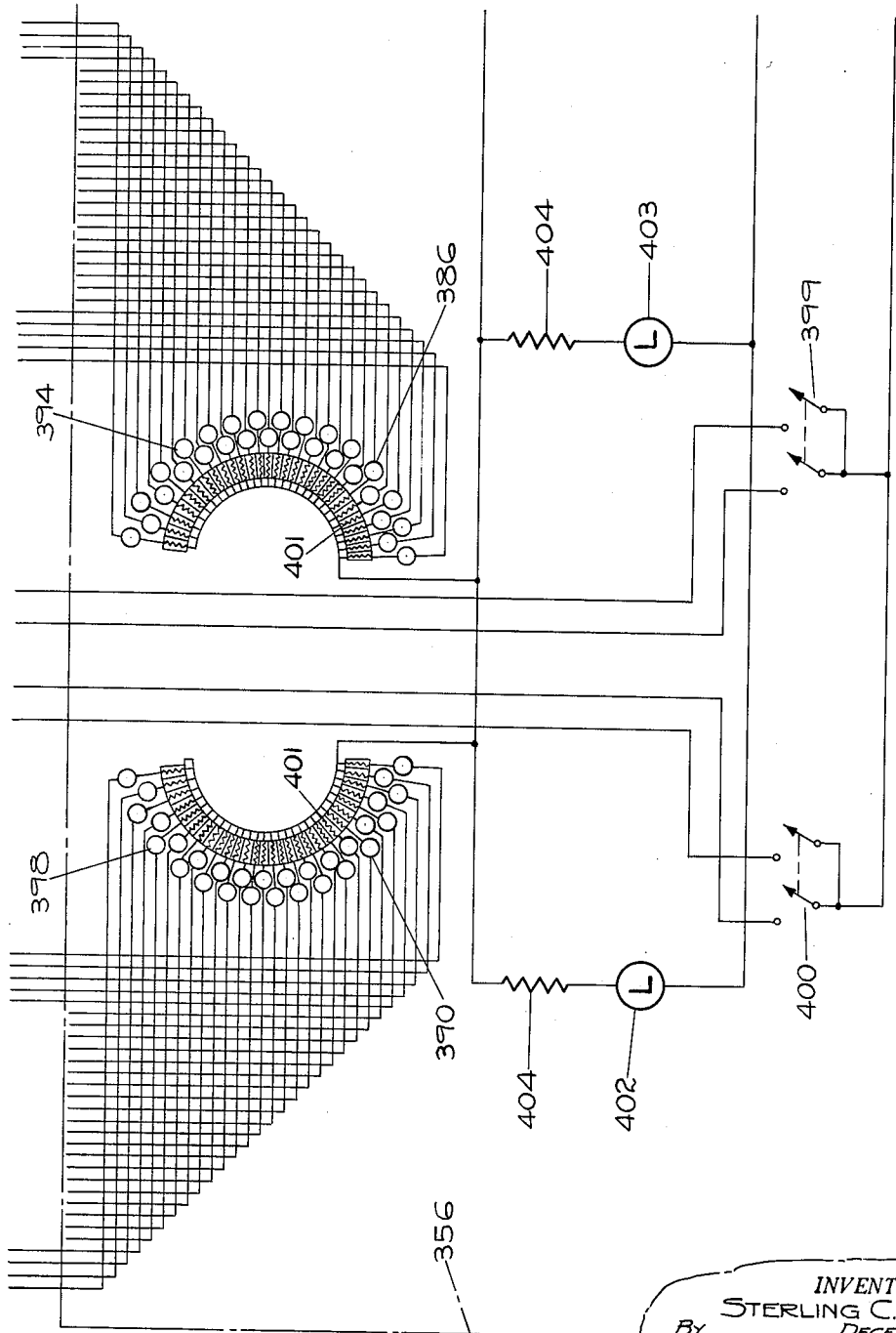


Fig. 15D

INVENTOR:  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young ATT'Y.

Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 13

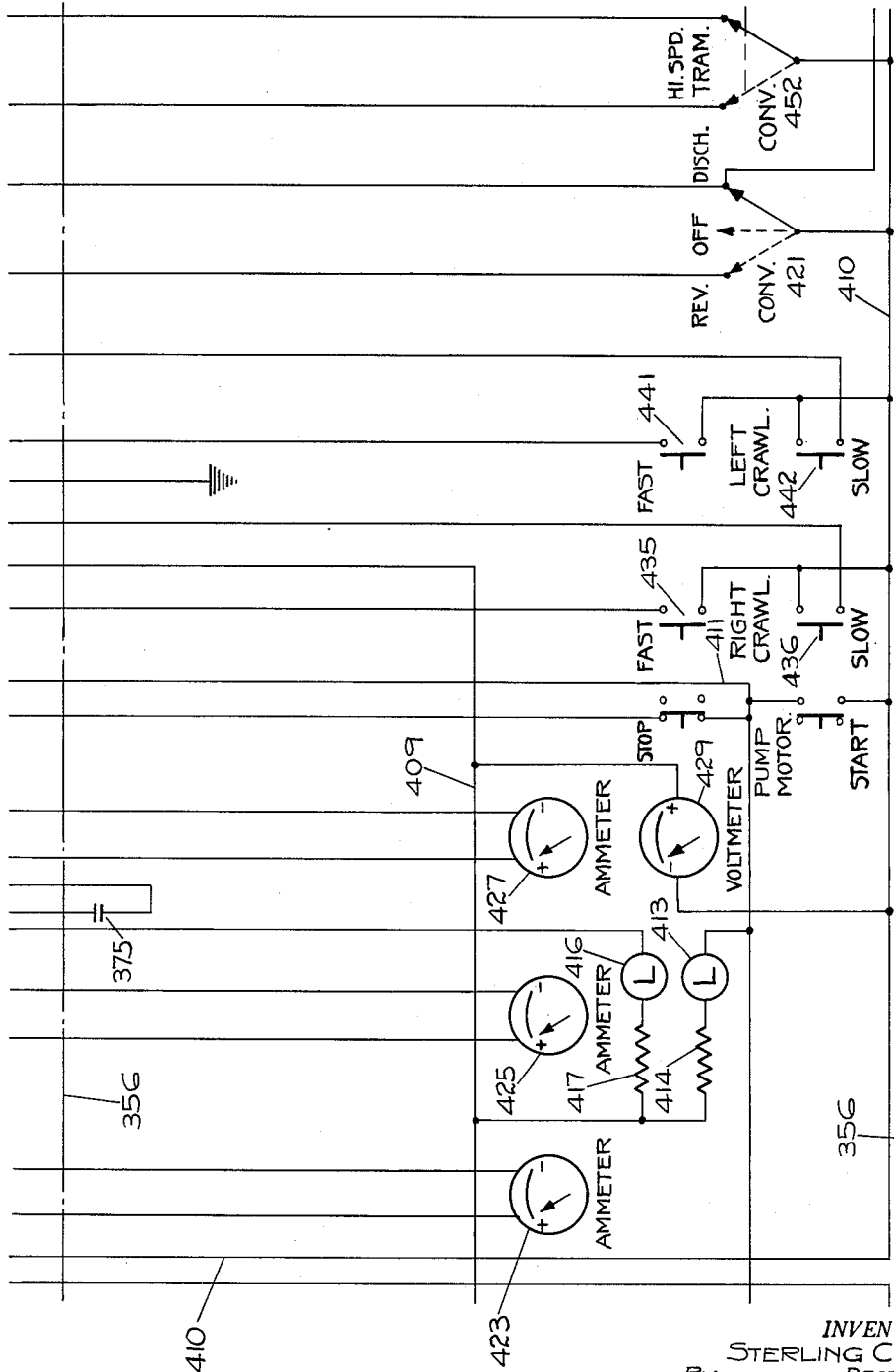


Fig. 15E

INVENTOR:  
STERLING C. MOON,  
DECEASED  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young  
ATTY.

Oct. 5, 1965

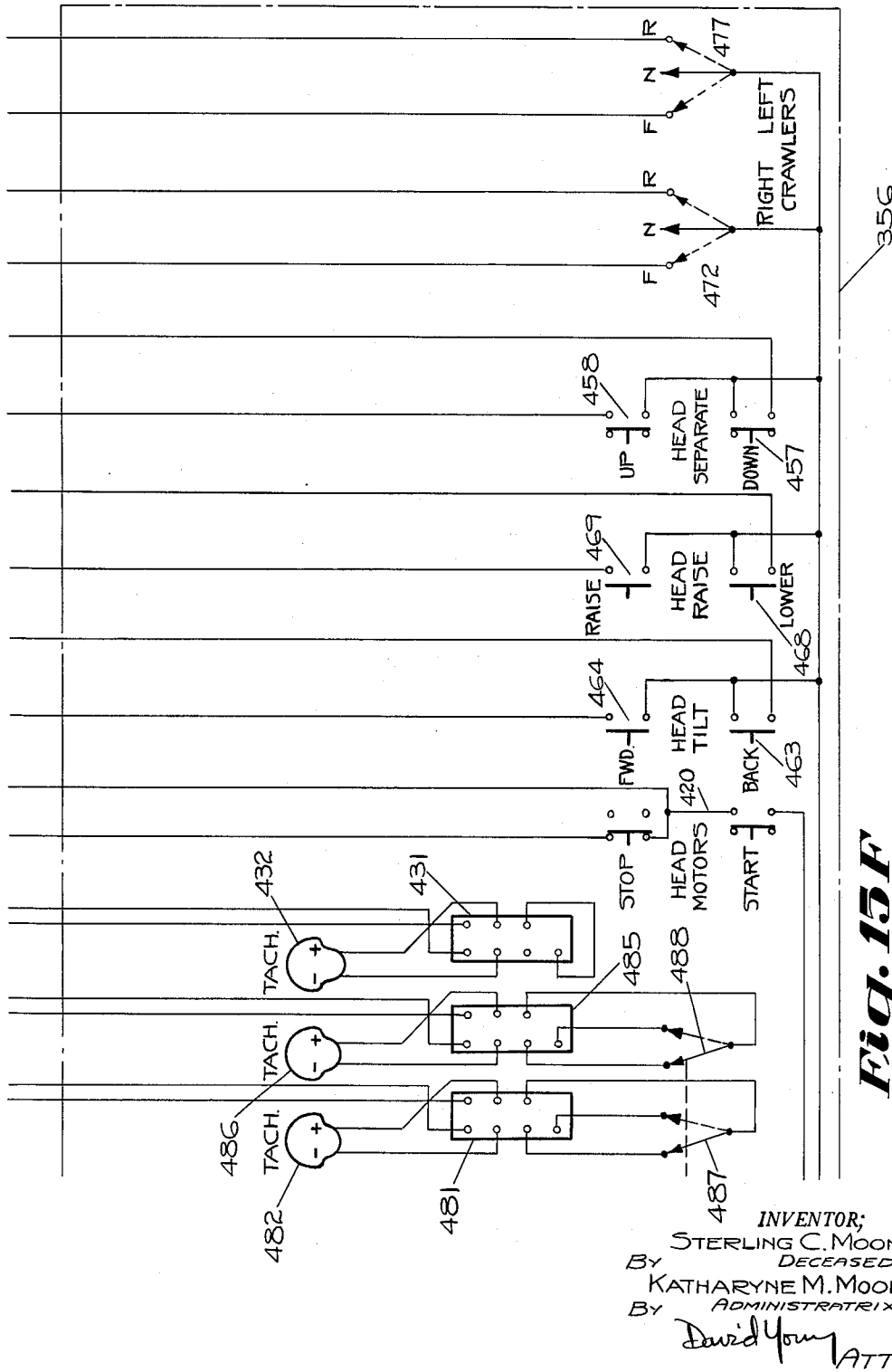
S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 14



Oct. 5, 1965

S. C. MOON

3,210,122

CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Sept. 4, 1959

15 Sheets-Sheet 15

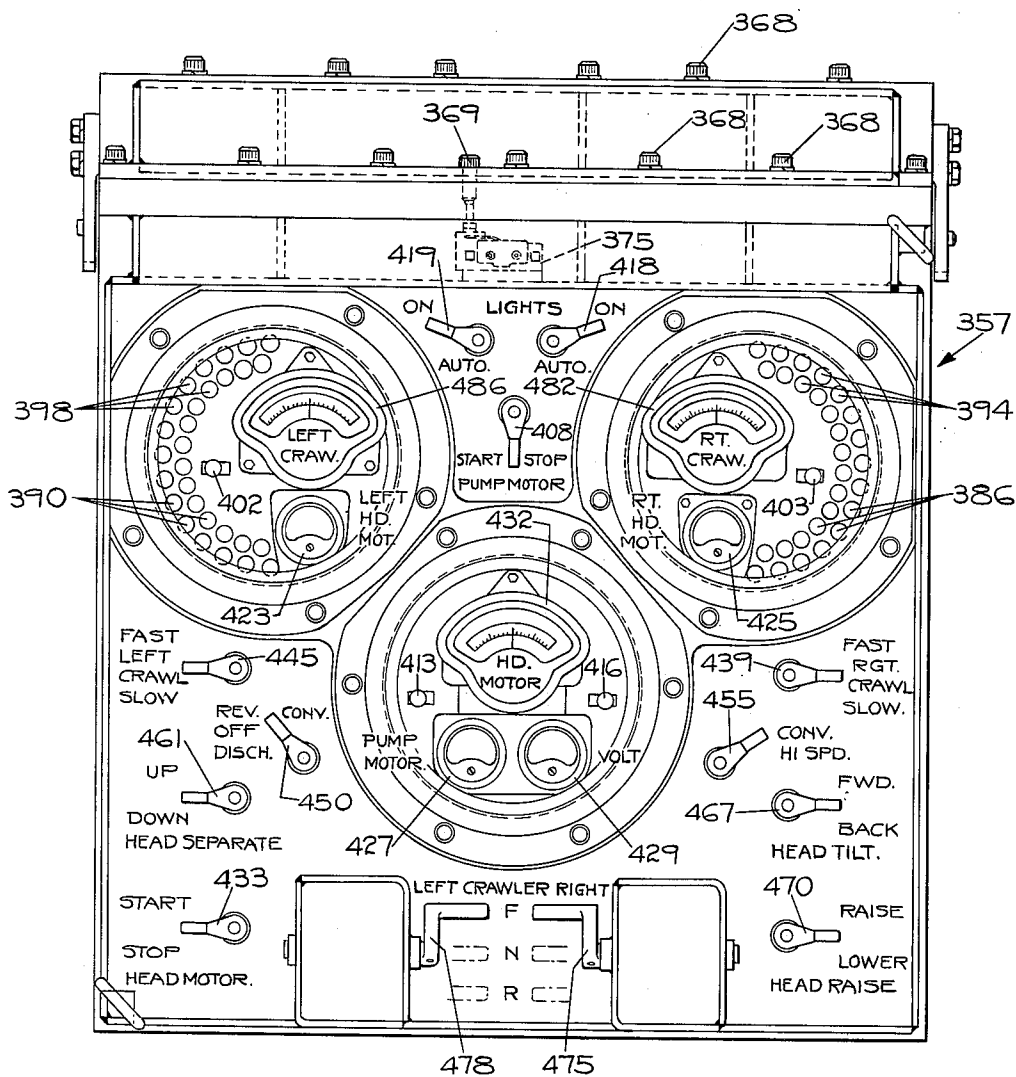


**Fig. 16**

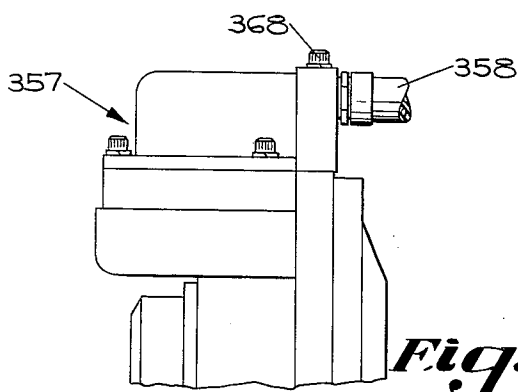


**Fig. 17**

INVENTOR;  
STERLING C. MOON,  
DECEASED,  
By KATHARYNE M. MOON,  
ADMINISTRATRIX,  
By David Young ATT'Y.

1

3,210,122

## CONTINUOUS MINING MACHINE AND CONTROL SYSTEM THEREFOR

Sterling C. Moon, deceased, late of Dublin, Ohio, by  
Katharyne M. Moon, administratrix, Dublin, Ohio,  
assignor, by mesne assignments, to Jeffrey Galion  
Manufacturing Company, a corporation of Ohio  
Filed Sept. 4, 1959, Ser. No. 838,110  
12 Claims. (Cl. 299—30)

The instant invention relates to continuous mining machines for the mining of coal, which are adapted to be continuously advanced into the mine face to remove the coal therefrom, and which include conveying means to carry the mined material away from the mine face and to discharge the same at the rear of the machine, to permit the continuous advance of the mining machine into the face. More particularly the instant invention relates to a continuous mining machine in which there is provided a system for sensing the advance of the mining machine into the selected material in the mine face, which is the coal, and the mining machine includes a control system for operating the mining machine from a position that is remotely located with respect to the mine face and the mining machine, the remote control system including the sensing system, and the mining machine being operated from the remote location in accordance with the signals which indicate the course of advance of the mining machine into the selected material.

It is a prime object of this invention to provide a continuous mining machine provided with a control system for the operation of the mining machine from a position that is spaced with respect to the mine face and the mining machine.

It is still another object of the instant invention to provide a continuous mining machine which includes hydraulic mechanisms for operating the machine, and hydraulic controls for said hydraulic mechanisms in which there is provided means for operating said hydraulic controls from a position remotely located with respect to the mining machine.

It is a further object of the instant invention to provide a continuous mining machine including a hydraulic system for operation of the mining machine, and an electrical control system for operation of the hydraulic system, in which the electrical system includes controls which may be located at a position remotely disposed with respect to the mining machine.

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. 1A and 1B together are a side elevational view of a continuous mining machine embodying the instant invention;

FIGS. 2A and 2B together are a plan view of the continuous mining machine of FIGS. 1A and 1B;

FIG. 3 is an elevational view of the continuous mining machine showing the mining heads and the hydraulic mechanisms for adjusting the same;

FIG. 4 is a front elevational view of the mining heads of the mining machine showing the disposition of the mining devices;

FIG. 5 is a diagrammatic illustration of the hydraulic system for the mining machine of this invention;

FIGS. 6, 7 and 8 are sectional views of control valves of the hydraulic system of FIG. 5;

FIG. 9 is a sectional view of a conveyor reversing valve for the hydraulic system of FIG. 5;

FIG. 10 is a partial sectional view of a volume control valve for the hydraulic system of FIG. 5;

2

FIG. 11 is a sectional view of a four-unit valve for the hydraulic system of FIG. 5;

FIG. 12 is a sectional view of the four-unit valve taken on the line 12—12 in FIG. 11;

FIGS. 13 and 14 are sectional views of the four-unit valve showing different positions thereof;

FIGS. 15A to 15F together form a diagrammatic illustration of the electrical system for the continuous mining machine of this invention;

FIG. 16 is a plan view of the face of the control box embodying the electrical controls for the continuous mining machine of this invention; and

FIG. 17 is a side elevational view of the top of the control box shown in FIG. 15.

The instant invention relates to continuous mining machines, particularly such as are adapted to be used in the mining of coal in underground operations, or in other mining operations in which the mining machine is adapted to be advanced into the ground. Customarily the controls for such machines are placed at an operator's station at the side of the machine, and the operator of the machine accompanies it as it advances into the mine face, it being understood that it is a characteristic mode of operation of such a continuous mining machine that it forms a room or tunnel in the mine as it advances into the mine face, which room or tunnel is generally of greater dimension than the overall transverse dimensions of the machine, thereby providing room for the operator, and also providing room for backing the machine out of the room or tunnel and permitting it to be maneuvered into position to advance into another mine face.

It is recognized that there are certain dangers inherent in coal mining operations. It is accordingly customary to follow prescribed procedures for insuring the safety of those engaged in the coal mining operation. The inherent dangers connected with the mining of the coal are further reduced by the provision of apparatus for removing the coal from the mine face without requiring the proximate presence of a machine operator at the machine. In accordance with the instant invention there is provided a continuous mining machine which is adapted for coal mining operations, and which includes a sensing system for sensing the material in the mine face and providing signals indicating the course of advance of the mining machine relative to the location of the coal in the mine face, so that the course of advance of the mining machine may be guided accordingly, to keep the mining machine in the coal seam. The continuous mining machine of this invention further includes a control system in which the sensing devices provide signals at a position remotely located with respect to the mining machine that indicate the advance of the mining machine, and controls at that remote position by which the mining machine may be operated.

Referring to the drawings, FIGS. 1—4, there is illustrated therein a continuous mining machine 30 embodying the instant invention, and comprising a main frame 31 supported on a pair of endless crawler traction treads 32, 33 disposed at opposite sides of the main frame 31. The continuous mining machine 30 is propelled in forward or reverse directions by the crawler traction treads 32, 33, and may be steered by operating the crawler traction treads 32, 33 at different speeds. The crawler traction treads 32, 33 are operated by individual hydraulic motors 34, 35, respectively, which are supported in the main frame 31. An identical mechanical drive extends between each of the hydraulic motors 34, 35 and the respective crawler traction treads 32, 33 for driving the latter. The drives to the crawler traction treads 32, 33 each comprises a pinion 36 driven by a hydraulic motor 34, 35 and driving a gear 37 which, in turn, drives a worm and worm wheel 38, the latter driving a pinion 39 which drives gear 40 that is

3

co-axially mounted on a shaft with a drive sprocket 41 that is engaged with a crawler traction tread 32, 33 to drive the latter. The operation of each of the hydraulic motors 34, 35 may be reversed for driving the crawler traction treads 32, 33 in reverse, as when backing the continuous mining machine 30 away from a mine face. Also, the rate of delivery of hydraulic fluid to each of the motors 34, 35 may be independently varied to drive the crawler traction treads 32, 33 at different speeds for steering the continuous mining machine 30.

At the forward end of the continuous mining machine 30 there is a forwardly extending support 45 that is pivotally mounted on the main frame 31 on laterally extending pins 46. The support 45 extends forwardly from the main frame 31 along the floor 47 of the mine, with the support 45 being inclined downwardly in a forward direction, as best seen in FIG. 3.

The support 45 carries a lower mining head 48 and an upper mining head 49, which are disposed in substantial vertical alignment one above the other. The lower mining head 48 is pivotally connected to the support 45 by laterally extending pins 50. The upper mining head 49 is supported on the lower head 48 and includes depending guides 51 at the opposite sides thereof, which are engaged with tracks 52 on the lower mining head 48 for guiding the movement of the upper mining head 49 upwardly and downwardly relatively to the lower mining head 48.

A double acting hydraulic cylinder and piston mechanism 55 is connected between the main frame 31 and the support 45 and is operative to raise and lower the support 45 by swinging the same upwardly and downwardly on the pivot pins 46. A double acting cylinder and piston mechanism 56 is connected between the main frame 31 and the lower mining head 48, and by operation of the cylinder and piston mechanism 56 the lower mining head 48, as well as the upper mining head 49 which is supported on the lower mining head 48, are tilted forwardly and rearwardly on the axis of the pivot pins 50. A third cylinder and piston mechanism 57 is connected between the lower mining head 48 and the upper mining head 49, for raising and lowering the latter relatively to the lower mining head 48.

The lower mining head 48 comprises a gear box 58 that extends laterally across the forward end of the continuous mining machine 30. A plurality of transversely aligned shafts 59 extend forwardly from the gear box 58, there being five shafts 59 in the disclosed embodiment of the invention. A radially extending cutter arm 60 is secured to each shaft 59. Each cutter arm 60 comprises integral bit holders 61, each of which is adapted to receive a plurality of forwardly extending bits 62. Within the gear box 58 there is enclosed a train of gears for rotating all the shafts 59 simultaneously, and in timed relation to each other. As seen in FIG. 4, the cutter arms 60 have different circumferential positions. The two cutter arms 60 at the left side and the cutter arm 60 at the center of the mining head 48, as seen in FIG. 4, are rotated in a counterclockwise direction, while the two cutter arms 60 at the right side of the mining head 48 are rotated in a clockwise direction. The cutter arms 60 are each rotated at the same speed, and are disposed in different selected circumferential positions so that there is no interference of the cutter arms 60 with each other during the simultaneous rotation thereof.

The upper mining head 49 includes a gear box 63, which also encloses a gear train for rotating a plurality of transversely aligned shafts 64 that project forwardly from the front of the gear box 63. In the illustrated embodiment of the invention the upper mining head 49 is provided with ten shafts 64, each of which has secured thereto a radially extending cutter arm 65. Each cutter arm 65 includes integral bit holders 66 for the reception of forwardly extending mining bits 67. The five cutter arms 65 at the left side of the upper mining head 49, as viewed in FIG. 4, are rotated in a counterclockwise direction, and

4

the five cutter arms 65 at the right side of the upper mining head 49 are rotated in a clockwise direction. All of the cutter arms 65 are rotated simultaneously at the same speed by the gears within the gear box 63, and are placed in different circumferential positions on the respective shafts 64, to avoid any interference between the cutter arms 65 during the simultaneous rotations thereof.

As illustrated in FIG. 4, the upper mining head 49 is separated or raised with respect to the lower mining head 48, for mining a maximum height of material from the mine face. The cutter arms 60, 65 on the respective mining heads 48, 49 each operate in circular paths which are overlapping. The cutter arms 60, 65 are advanced into the mine face by the operation of the crawler traction treads 32, 33 advancing the whole mining machine 30 forwardly. As the mining bits 62, 67 are brought into the mine face, these bits operate to cut and break the material out of the mine face. The circular paths of the cutter arms 60, 65 cumulatively define a mine face area from which material is removed in the mining operation. As seen in FIGS. 2 and 4, the laterally outermost cutter arms 60a, 60b, 65a, 65b at each side of the mining machine 30, extend laterally beyond the maximum lateral dimension of the mining machine 30, whereby there is produced as result of the mining operation a room or tunnel which is wider than the mining machine 30. Each of the cutter arms 60, 65 is an eccentric element extending to only one side of its shaft 59, 64, respectively, whereby upon rotation of the cutter arms 60, 65, the laterally outermost cutter arms 60a, 60b, 65a, 65b may be withdrawn from the sides of the tunnel or mine room, and disposed in positions lying within the transverse dimensions of the mining machine 30. The cutter arms 60a, 60b, 65a, 65b thus being moved to positions out of contact with the side walls of the mine room or tunnel, it is possible to freely maneuver the mining machine 30.

The forward end of the support 45 includes a transversely extending blade 70 which is adapted to be disposed on the floor 47 of the mine behind the lower cutter arms 60. Since the cutter arms 60 operate in circular paths, they form cusps of material in the mine floor 47, and the blade 70 operating behind the cutter arm 60 removes these cusps from the floor 47, leaving the latter relatively smooth and level for the advance of the crawler traction treads 32, 33 thereafter.

The forward end of the main frame 41 supports a pair of electric motors 71, 72 for driving the lower mining head 48 and the upper mining head 49, respectively. The drive from the motors 71, 72 is delivered to a gear case 73 which combines the power of the motors 71, 72. A universal jointed drive shaft 74 extends from the gear case 73 to the lower mining head 48, and a second universal jointed drive shaft 75 extends from the gear case 73 to the upper mining head 49. The drive shafts 74, 75 each include telescoping sections to permit adjustment of the mining heads 48, 49 as previously described.

The support 45 also carries one end of an endless chain conveyor 78, which is guided around an idler sprocket assembly 79 at the forward end of the support 46. The conveyor 78 extends rearwardly from the forward end of the support 45, through the main frame 31 of the mining machine 30, as best seen in FIG. 1, and terminates at the rear end of the mining machine 30, at which point the conveyor 78 discharges the mined material. The conveyor 78 comprises two individual chain conveyors arranged side by side and each including oppositely disposed endless drive chains 80, to the links of which there are secured a plurality of transversely extending flights 81, which are adapted to sweep the mined material over the bed 82 of the conveyor 78. The endless chain conveyor 78 is driven by a hydraulic motor 83 driving gears 84 which, in turn, drive a dual sprocket 85 that is connected by a chain drive 86 to dual sprockets 87, which are coaxially mounted on the driven shaft 88 with chain

driving sprockets 89 that are engaged with the chains 80 for driving the latter.

The rotation of the cutter arms 65 of the upper mining head 49 is in such directions as to sweep the mined material towards the center of the mining machine 30. Similarly, the direction of rotation of the two outer cutter arms 60 at each end of the lower mining head 48 is in such directions as to sweep the mined material in towards the center of the mining machine 30. As the cutter arms 60, 65 are advanced into the mine face, the blade 70 works along the mine floor to remove the cusps left between the cutter arms 60, and also works its way into the material mined by the cutter arms 60, 65 to guide this material upwardly onto the support 45 to be received by the conveyor 78 and to be carried rearwardly thereby to the rear end of the mining machine 30 for discharge of the mined material therefrom. Since the mined material is carried away from the area of the mine face as it is mined, the advance of the cutter arm 60, 65 is not impeded and the mining operation may be carried on continuously. At each side of the lower mining head 48 there is provided a pivoted gathering guide 90, which also works to crowd the mined material in towards the center of the mining machine 30, to be received by the conveyor 78 for carrying this material away from the mine face.

It is a characteristic of coal that it is found in the ground in seams which lie in relatively level planes. The coal may vary in thickness within a given seam, and the seam may rise and descend within the ground. Therefore it is customary for the operator of a continuous mining machine to view the face of the mine in which the mining machine is working to thereby visually determine whether the mining machine is following the coal seam. The mining heads 48, 49 are adjustable in a vertical direction relatively to each other for the purpose of adjusting to varying heights of coal in the coal seam. Thus where the coal seam is found to increase or decrease in height, the upper mining head 49 is elevated or lowered by means of the heads separating cylinder and piston mechanism 57, so that the vertical reach of the cutter arms 60, 65 is substantially equal to the height of the coal seam in which the machine is working. When the coal seam is found to drift upwardly or downwardly, the mining heads 48, 49 can be tilted either forwardly to operate the mining machine in a descending path, or the mining heads 48, 49 can be tilted backwardly to follow the coal seam in an ascending path, the tilting of the mining heads 48, 49 being accomplished by use of the tilting cylinder and piston mechanism 56. As a further adjustment in following the ascending or descending path of the coal seam, the support 45 and the mining heads 48, 49 carried thereby, can be raised by means of the raise cylinder and piston mechanism 55.

Above and below the coal seam there is generally found material which is relatively harder than the coal, such as rock or shale. Ideally, it is desired that the cutter arms 60, 65 do not enter the relatively harder material which is found above and below the coal seam, for the reason that this material is waste as far as the coal mining operation is concerned, and any such material removed from the mine face with the coal must later be separated from the coal product. Also the operation of the cutter arms 60, 65 in material that is relatively harder than coal produces excessive wear on the mining bits 62, 67, thereby severely reducing the life thereof, and making necessary more frequent replacement of the bits, which of course interrupts the mining operation and is therefore undesirable.

With the continuous mining machine 30 embodying the instant invention it is intended to make unnecessary visual observation of the mine face, and for this purpose the cutter arms 60, 65 include sensing means for the purpose of sensing the course of advance of the mining machine, and more particularly the advance of the mining bits 62, 67 of the cutter arms 60, 65, respectively, into material that is relatively harder than the coal. The sensing means is included in a signaling system so constructed that it

provides signals at a location remote from the mining face indicating the advance of the mining machine into material that is relatively harder than the coal. These signals are provided continuously during the operation of the cutter arms 60, 65 at a remotely located station at which all the controls for the mining machine 30 are located, as will be described in greater detail hereinafter, thereby making it unnecessary for the machine operator to take a position immediately adjacent the mining machine when the signals provided by the signaling system indicate that the mining machine is advancing into material relatively harder than coal, the mining heads 48, 49 are adjusted as previously described to move the mining bits 62, 67 back into the coal seam, such adjustment being made in accordance with the signals of the signaling system. Similarly, the limits of the coal seam may be located by adjustment of the mining heads 48, 49. During such exploratory adjustment the signaling system will indicate the entry of the mining bits 62, 67 into material other than coal, whereupon the mining heads 48, 49 may be adjusted back to just clear the material other than coal, and the mining operation will proceed with only the removal of coal from the mine face.

As seen in FIG. 4, the cutter arms 60, 65 remove material from a determinate area 91 of the mine face, which is defined by the cumulative rotary sweep of the several cutter arms 60, 65 in the lower and upper rows of cutter arms respectively. The limits of the determinate area 91 of the mine face from which the material is removed are defined by the two outermost lower cutter arms 60a, 60b of the lower mining head 48, and by the two outermost cutter arms 65a, 65b of the upper mining head 49. Considering that the coal is found in laterally extending seams which are of a fairly regular nature, it is sufficient in sensing the location of the coal seam to perform this sensing function at the limits of the determinate mine face area 91 from which the coal is removed by the cutter arms 60, 65. Accordingly, the sensing devices are incorporated in each of the cutter arms 60a, 60b, 65a, 65b. Since it is merely necessary to sense the material of the mine face at the limits of the determinate area 91 of the mine face from which the coal is removed, the sensing devices in the cutter arms 60a, 60b, 65a, 65b each operates in a quadrant which is coextensive with a corner of the determinate mine face area 91 defined by the cumulative sweep of all the cutter arms 60, 65.

In the operation of the continuous mining machine 30 embodying the sensing devices in the several cutter arms, if the cutter arm 65a senses material other than coal in the mine roof, the upper cutter head 49 can be lowered relatively to the lower cutting head 48 to thereby get below the relatively harder material, so that the mining machine in its continued operation will be operating solely in coal. Upon continued operation of the mining machine it may be found that the disposition of the relatively harder material in the roof of the mine indicates that the coal seam is drifting downwardly, which will call for a forward tilting of the mining heads 48, 49 to operate the mining machine in a descending path. Depending on the location of the coal seam as determined by the several sensing devices, it may be found that a further adjustment is needed to lower the support 45 and the blade 70 to follow the downward drift of the coal seam for the purpose of removing the maximum height of coal from the mine face.

During operation of the mining machine 30, where the sensing devices in either the cutter arms 60a, 60b or the cutter arms 65a, 65b do not provide any signals indicating the presence of material harder than the coal below or above the coal seam, the mining heads 48, 49 and the blade 70 may be adjusted upwardly and downwardly until there are produced signals indicating the location of the relatively harder material, following which the mining heads 48, 49 and the blade 70 may be further adjusted to clear the relatively harder material, and to remove the maximum height of coal from the mine face.

7

Since the signaling system continuously provides signals to the operator at the control station for the mining machine, it is a relatively simple matter for him to make adjustments of the mining mechanisms of the machine as described hereinabove, directed to the purpose of removing the maximum amount of coal from the mine face.

The continuous mining machine 30 is operated and controlled by various hydraulic mechanisms diagrammatically illustrated in FIG. 5, which shows the hydraulic circuits for the machine. The hydraulic system includes a hydraulic head pump 160 which supplies the hydraulic fluid under pressure for operating the cylinder and piston mechanism 55 for raising the mining heads 48, 49, the cylinder and piston mechanism 56 for tilting the mining heads 48, 49, and the cylinder and piston mechanism 57 for separating the mining heads 48, 49 by elevation of the mining head 49 relatively to the mining head 48. The hydraulic pump 160 also supplies hydraulic fluid under pressure for operating various controls in the hydraulic system illustrated in FIG. 5, as will be described in greater detail hereinafter. Another hydraulic pump 161 supplies hydraulic fluid under pressure for operating the hydraulic traction motors 34, 35 which drive the crawler traction treads 32, 33, respectively. A third hydraulic pump 162 supplies hydraulic fluid under pressure for driving the hydraulic motor 83 which operates the conveyor 78. By the use of certain controls in the hydraulic system the hydraulic fluid supplied under pressure by the hydraulic pump 162 can be combined with the hydraulic fluid supplied to the hydraulic traction motors 34, 35 for driving the latter at high speed when the mining machine is being trammed other than in a mining operation. When the hydraulic pump 162 is so used it does not supply any hydraulic fluid to the hydraulic conveyor motor 83. As seen in FIG. 2B, each of the hydraulic pumps 160, 161, 162 is mechanically connected to a gear housing 163, which encloses a train of gears for transmitting driving power to the several hydraulic pumps from an electrical motor 164, which drives the gear train in the gear housing 163 and supplies power thereto.

The hydraulic pump 160 supplies hydraulic fluid under pressure through a pressure relief valve 165 to a bank of three solenoid controlled, pilot operated control valves 166, 167, 168. The control valve 166 is connected to the cylinder and piston mechanism 55 for raising the mining heads 48, 49, the control valve 167 is connected to the cylinder and piston mechanism 56 for tilting the mining heads 48, 49, and the control valve 168 is connected to the cylinder and piston mechanism 57 for separating the mining heads 48, 49.

The solenoid controlled, pilot operated control valves 166, 167, 168 are identical, and control valve 166 is illustrated in detail in FIG. 6, by way of example. The control valve 166 comprises a solenoid controlled pilot valve 169 mounted on top of the main control valve 170. The pilot valve 169 comprises solenoids 171, 172 disposed in the opposite ends of the valve 169. The solenoids 171, 172 include armatures 173, 174, respectively, which extend from the solenoids 171, 172 towards the valve spool 175 that is centrally disposed in the valve body 176. The armatures 173, 174 abut the opposite ends of the valve spool 175, and reciprocate the latter, upon energization of one or the other of the solenoids 171, 172, by reciprocation of the corresponding one of the armatures 173, 174. The valve body 176 includes a pressure port 177, which is centrally located in the valve body, and is closed by the valve spool 175 when neither of the solenoids 171, 172 is energized, and the valve spool 175 is in its centered position. Each of the opposite ends of the valve spool 175 has secured thereto a spring guide 178 for a compression spring 179. The compression springs 179 act through the spring guides 178 to maintain the valve spool 175 in its centered position when the solenoids 171, 172 are not energized.

Upon energization of the solenoid 171 the valve spool

8

175 is reciprocated to the right, as viewed in FIG. 6, whereby the pressure port 177 is connected to the flow port 180. The valve spool 175 also closes the tank port 181 with respect to the flow port 180. In this position of the valve spool 175 the pressure port 177 is closed with respect to the flow port 182, and the latter is connected to the tank port 183. Thus, with the solenoid 171 energized, the flow of hydraulic fluid is from the pressure port 177 through the flow port 180 into the main control valve 170, in which the fluid thus applied acts on the piston end 185 of the valve spool 186, thereby reciprocating the latter to the left, as viewed in FIG. 6. The piston end 187 of the valve spool 186 forces the hydraulic fluid out through the flow port 182 and through the pilot valve 169 to the tank port 183.

When the solenoid 172 is energized, the valve spool 175 is reciprocated to the left, as viewed in FIG. 6, thereby connecting the pressure port 177 to the flow port 182 for supplying hydraulic fluid under pressure to the piston end 187 of the valve spool 186 to reciprocate the latter to the right, as viewed in FIG. 6. The piston end 185 of the valve spool 186 forces the hydraulic fluid out of the main control valve 170 through the flow port 180 and out the tank port 181.

The piston ends 185, 187 of the valve spool 186 each acts as a spring guide for a compression spring 188, which maintain the valve spool 186 in a centered position within the main control valve 170 when there is no hydraulic fluid acting on either of the pistons 185, 187. The main control valve 170 includes a pressure port 189 through which hydraulic fluid under pressure is admitted to the main control valve 170, and a tank port 190 through which hydraulic fluid is exhausted from the control valve 170. The valve spool 186 includes an axially extending central bore 191, and a plurality of radial ports 192 communicating with the bore 191. The radial ports 192 are located in the region of the pressure port 189. In the region of the tank port 190 the valve spool is similarly formed with a plurality of radial ports 193 that communicate with the axial bore 191. With the valve spool in its centered position, as illustrated in FIG. 6, the hydraulic fluid flows from the pressure port 189, through the radial ports 192, into the axial bore 191, and out through the radial ports 193 and the tank port 190, for exhausting of the hydraulic fluid from the main control valve 170.

Upon energization of the solenoid 171 the operation of the pilot valve 169 is as previously described to reciprocate the valve spool 186 to the left, whereby the radial ports 193 are sealed from the tank port 190. The radial ports 192 maintain communication with the pressure port 189, and the hydraulic fluid flows through the axial bore 191 to the radial ports 194, which are in communication with the flow port 195 that is connected by a hydraulic line 196 to one end of the cylinder and piston mechanisms 55 to supply hydraulic fluid under pressure to the latter for operation thereof.

When the solenoid 172 is energized the operation of the pilot valve 169 is as above described to reciprocate the valve spool 186 to the right, as seen in FIG. 6, whereby the tank port 190 is sealed from the pressure port 189, and the latter is directly connected to the flow port 197 for the flow of hydraulic fluid from the pressure port 189 around the valve spool 186 to the flow port 197. Hydraulic fluid under pressure is supplied from the flow port 197 to the cylinder and piston mechanisms 55 through a hydraulic line 198, for operating the cylinder and piston mechanisms 55 by reciprocation thereof.

Each of the cylinder and piston mechanisms 55 is double acting, and when hydraulic fluid is delivered to the cylinder and piston mechanisms 55 through the hydraulic line 196, hydraulic fluid is exhausted from the opposite end of the cylinder and piston mechanisms 55 through the hydraulic line 198. The exhausted hydraulic fluid is returned to the control valve 170 through flow port 197 which is in direct communication with the tank

port 190, and the exhausted hydraulic fluid flows from the flow port 197 around the valve spool 186 and out through the tank port 190.

When hydraulic fluid under pressure is delivered through hydraulic line 198 to one end of the cylinder and piston mechanisms 55, hydraulic fluid exhausts from the other end of the cylinder and piston mechanisms 55 through hydraulic line 196 and enters the control valve 170 through flow port 195. The flow port 195 is in communication with the tank port 190 through radial ports 192, axial bore 191 and radial ports 193, whereby the exhausted hydraulic fluid flows from the flow port 195 to the tank port 190 and is exhausted from the control valve 170.

The hydraulic line 196 includes a check valve 199 which permits the free flow of hydraulic fluid through the line 196 to the cylinder and piston mechanisms 55, but normally prevents return flow of hydraulic fluid through the line 196, so that the cylinder and piston mechanisms 55 will maintain their adjusted positions. The line 198 is open so that hydraulic fluid can be freely exhausted from the cylinder and piston mechanisms 55 through this line. When hydraulic fluid is delivered under pressure to the cylinder and piston mechanisms 55 through the line 198, this hydraulic fluid under pressure is also communicated through the pilot line 200 to a pilot 201 which operates to open the check valve 199, to permit the exhaust of hydraulic fluid from the cylinder and piston mechanisms 55 through the hydraulic line 196. The pilot 201 includes a return spring 201' for restoring pilot 201 and closing check valve 199.

The solenoid controlled, pilot operated control valves 166, 167, 168 are connected in series, the tank port of the valve 166 being connected to the pressure port of the valve 167, and the latter is similarly connected to the valve 168. Since the pressure port 189 in the control valve 170 of the solenoid controlled, pilot operated control valve 166 is connected to the tank port 190 when neither solenoid 171, 172 is energized, there is a free flow of fluid through the valve 166 to the valve 167, and the same is true as to the flow of hydraulic fluid through the valves 167, 168 when either of the solenoids of these valves is energized. Thus it is seen that any one of the solenoid controlled, pilot operated control valves 166, 167, 168 may be individually operated to adjust the cylinder and piston mechanisms 55, 56, 57, respectively. The hydraulic circuit connecting the control valves 167, 168 to the cylinder and piston mechanisms 56, 57, respectively, is the same as that connecting the control valve 166 to the cylinder and piston mechanisms 55, and operate in the same manner.

The tank port of the solenoid controlled, pilot operated control valve 168 is connected to a hydraulic line 202 which delivers hydraulic fluid under pressure to a solenoid controlled pilot valve 203. The pressure of the hydraulic fluid in the hydraulic line 202 is less than the pressure of the hydraulic fluid delivered to the control valves 166, 167, 168, and is maintained at the lower value by the pressure relief valve 204.

The solenoid controlled pilot valve 203 is illustrated in detail in FIG. 7, and comprises solenoids 205, 206 disposed at the opposite ends of the valve 203. The solenoids 205, 206 have armatures 207, 208, respectively, which extend towards each other into the valve body 209, and abut the opposite ends of the valve spool 210. Each end of the valve spool 210 includes a spring guide 211 for a compression spring 212 that centers the valve spool 210 in the valve body 209 when either solenoid 205, 206 is energized. The valve body 209 includes a pressure port 213 which is closed by the valve spool 210 when the latter is centered in the valve body 209. Upon energization of the solenoid 205, the valve spool 210 is reciprocated to the right by the armature 207, as viewed in FIG. 7, thereby connecting the pressure port 213 to the flow port 214, whereby the hydraulic fluid will flow

from the pressure port 213 to the flow port 214. Upon energization of the solenoid 206, the valve spool 210 is reciprocated to the left, as viewed in FIG. 7, by the armature 208, thereby connecting the pressure port 213 to the flow port 215, and flow of the hydraulic fluid will be from the pressure port 213 to the flow port 215. The valve body 209 also includes tank ports 216, 217, and when the pressure port 213 is connected to the flow port 214, the flow port 215 is connected to the tank port 217, and the tank port 216 is closed by the valve spool 210. Similarly, when the pressure port 213 is connected to the flow port 215, the flow port 214 is connected to the tank port 216, and the tank port 217 is closed by the valve spool 210.

The solenoid controlled pilot valve 203 controls and operates a double acting pilot 220 by the selective delivery of hydraulic fluid to the latter from either of flow ports 214, 215. When hydraulic fluid under pressure is delivered from one of flow ports 214, 215 to the double acting pilot 220, the other of said flow ports 214, 215 receives the hydraulic fluid which is exhausted from the pilot 220, and this exhausted hydraulic fluid leaves the valve body 209 through a corresponding one of tank ports 216, 217.

A manifold hydraulic line 221 delivers hydraulic fluid under pressure to solenoid controlled pilot valve 222 which is identical to the solenoid controlled pilot valve 203. A manifold tank line 219 connects pilot valves 203, 222 to the tank. The pilot valve 222 operates a double acting pilot 223 in the same manner as the pilot valve 203 operates the pilot 220. The pilot 220 is connected to a reversing valve 224 and the pilot 223 is connected to a similar reversing valve 225. The reversing valves 224, 225 are oppositely disposed, but are otherwise identical and control the direction of operation of the hydraulic traction motors 34, 35, respectively, as will be described in greater detail hereafter.

The manifold hydraulic line 221 also delivers hydraulic fluid under pressure to the solenoid controlled pilot valve 226, which is illustrated in detailed in FIG. 14. The control valve 226 includes two solenoids 227, 228, which are disposed in the opposite ends of the valve 226. The solenoids 227, 228 include armatures 229, 230, respectively, which extend inwardly towards each other and abut the opposite ends of the valve spool 231. Each end of the valve spool 231 includes a spring guide 232 for a compression spring 233, which operate to maintain the valve spool 231 centered within the valve body 234. A pressure port 235 is centrally disposed in the valve body 234, and is sealed by the valve spool 231 when it is in its centered position. The valve body 234 also includes tank ports 236, 237 disposed at the opposite sides of the valve body 234, and the tank ports 236, 237 are closed by the valve spool 231 when the latter is in its centered position. Upon energization of the solenoid 227, the valve spool 231 is reciprocated to the right, as viewed in FIG. 8, by the armature 229, thereby connecting the pressure port 235 to the flow port 238 for flow of hydraulic fluid from the pressure port 235 to the flow port 238. The tank port 237 is sealed and the flow port 239 is connected to the tank port 236, and any hydraulic fluid exhausting into the flow port 239 is exhausted from the valve body 234 through the tank port 236. Upon energization of the solenoid 228 the valve spool 231 is reciprocated to the left, as viewed in FIG. 8, by the armature 230, whereby the pressure port 235 is connected to the flow port 239, and the tank port 236 is sealed. The flow port 238 is connected to the tank port 237 for the exhaust of hydraulic fluid through the flow port 238 and out the tank port 237.

The solenoid controlled pilot valve 226 operates a pair of double acting pilots 240, 241 which have common connections to the pilot valve 226. The pilot 240 is mechanically connected to a flow control valve 245, and the pilot 241 is similarly mechanically connected to a flow control

valve 246. The flow control valves 245, 246 are operative to deliver hydraulic fluid under pressure to the conveyor hydraulic motor 83 through a common hydraulic line 247, or alternatively, the flow control valves 245, 246 operate to deliver the hydraulic fluid under pressure to the reversing valves 224, 225, respectively, for combining the hydraulic fluid which is normally delivered to the hydraulic conveyor motor 83 with the hydraulic fluid delivered to the traction motors 34, 35 for operating the latter at a high speed, as when the mining machine 30 is trammed during times other than when it is in mining operation.

The hydraulic manifold line 221 also delivers hydraulic fluid under pressure to each of a pair of solenoid controlled pilot valves 250, 251, which are identical to the solenoid controlled pilot valve 226. The pilot valve 250 supplies hydraulic fluid under pressure to a double acting pilot 252, and the pilot valve 251 supplies hydraulic fluid under pressure to a double acting pilot 253. The pilot 252 operates a volume control valve 278, and the pilot 253 operates a volume control valve 277, which govern the volume of hydraulic fluid delivered to the reversing valves 225, 224, respectively, as will be described in greater detail hereinafter.

The hydraulic manifold line 221 also delivers hydraulic fluid under pressure to a solenoid controlled pilot valve 254 which is identical to the solenoid controlled pilot valve 203. The pilot valve 254 delivers hydraulic fluid under pressure to a conveyor reversing valve 255 which is operated by the hydraulic fluid. The conveyor reversing valve 255 is illustrated in detail in FIG. 9, and comprises a spool 256 having a spring guide 257 at each end thereof for compression springs 258 that maintain the spool 256 normally centered in the valve body 259. Hydraulic lines 260, 261 connect the pivot valve 254 to the ports 262, 263 in the valve body 259. The hydraulic fluid under pressure supplied by the pilot valve 254 to the conveyor reversing valve 255 enters the latter through one or the other of ports 262, 263, and the pressure of this hydraulic fluid is applied to one end or the other end of the valve spool 256 for reciprocating the latter in the valve body 259.

The valve body 259 includes a pressure port 264 to which the hydraulic line 247 is connected for delivering the hydraulic fluid to the reversing valve 255 from the flow control valves 245, 246. With the valve spool 256 in its centered position the pressure port 264 is connected to each of the tank ports 265, 266, and the hydraulic fluid merely flows through the conveyor reversing valve 255 without being delivered to the conveyor hydraulic motor 83, thereby rendering the latter inoperative. When hydraulic fluid under pressure is delivered from the pilot valve 254 through the port 262, the valve spool 256 is reciprocated to the right, as viewed in FIG. 9, and hydraulic fluid is exhausted through port 263 to the pilot valve 254. The pressure port 264 is sealed from both tank ports 265, 266, and the flow port 269, and is connected to the flow port 267, for delivering the hydraulic fluid through the flow port 267 and the hydraulic line 268 to the hydraulic conveyor motor 83 for operating the latter in one direction. When the hydraulic fluid under pressure is delivered from the pilot valve 254 through the port 263, the valve spool 256 is reciprocated to the left, as viewed in FIG. 9 and hydraulic fluid is exhausted through port 262 to the pilot valve 254. The pressure port 264 is sealed from both tank ports 265, 266, and the flow port 267 and is connected to the flow port 269 to deliver hydraulic fluid through hydraulic line 270 to the hydraulic conveyor motor 83 for operating the latter in the reverse direction.

The hydraulic pump 161 delivers hydraulic fluid under pressure for operating the hydraulic traction motors 34, 35 that drive the traction treads 32, 33, respectively, in advancing the mining machine during the mining operation. The hydraulic line 275 connects the hydraulic

pump 161 through a pressure relief valve 274 to a flow divider valve 276 which divides the flow of hydraulic fluid evenly, and supplies the divided hydraulic fluid to the volume control valves 277, 278 through the hydraulic line 279, 280, respectively. The volume control valves 277, 278 are operative to control the volume of hydraulic fluid delivered to the hydraulic traction motors 34, 35, respectively, thereby controlling the speed of the hydraulic motors 34, 35. Referring to FIG. 10, the volume control valve 277 is illustrated in greater detail. The volume control valve 277 is a conventional hydraulic device comprising a rotary element by which the volume of hydraulic fluid flowing out of the valve 277 is controlled. The volume control valve 277, as utilized in the present hydraulic system, further includes the pilot 252 by which the volume control valve 277 is operated. The pilot 252 includes a body 281 in which there is reciprocally mounted a double acting piston 282. The opposite ends of the body 281 include ports 283, 284 through which hydraulic fluid under pressure is supplied from the pilot valve 251. By supplying hydraulic fluid under pressure through port 283 the piston 282 is reciprocated to the left, as viewed in FIG. 10, by the action of the hydraulic fluid on the adjacent end of the piston 282, and the opposite end of the piston 282 forces hydraulic fluid out of the pilot body 281 through the port 284, this hydraulic fluid being returned to the tank through the pilot valve 251 and the manifold tank line 219, as previously described. When hydraulic fluid under pressure is supplied through the port 284, the operation of the piston 282 is in reverse, and the piston 282 is reciprocated to the right, as viewed in FIG. 10.

The piston 282 extends through an enclosed chamber 285 in which there is disposed a shaft 286 by which the volume control valve 277 is operated. A crank 287 is secured to the operating shaft 286, and the other end of the crank 287 includes a pin 288 which is seated in a laterally extending notch 289 formed in the piston 282. Reciprocation of the piston 282 oscillates the crank 287 to rotate the shaft 286, thereby operating the volume control valve for regulating the volume of hydraulic fluid delivered through the latter. The volume control valve 277 may also be considered to be a variable flow divider valve, in that its operation is to take the supply flow of hydraulic fluid and to divide it between the tank and the traction motor 34. Thus in one extreme position of the piston 282 the volume control valve 277 delivers all of the incoming hydraulic fluid through hydraulic line 290 to the hydraulic traction motor 34, and in the other extreme position of the piston 282 all of the hydraulic fluid is delivered to the tank through the hydraulic line 291. In the former condition the hydraulic traction motor 35 is operated at maximum speed, while in the latter condition the hydraulic traction motor is rendered inoperative. Between the two extreme positions of the piston 282 the volume control valve 277 has an infinite number of adjustments to vary the volume of hydraulic fluid delivered to the hydraulic traction motor 34.

The volume control valve 278 is similar to the volume control valve 277, and is similarly connected in the hydraulic circuit to operate in the same manner with respect to the delivery of hydraulic fluid for operation of the hydraulic traction motor 35. The solenoids of the pilot valves 250, 251 are intermittently energized by a momentary switch to inch the pistons 282 of the volume control valves 277, 278 back or forth. In the normal operation of the mining machine 30 it is desired to advance forwardly in a straight line which calls for operating the crawler traction treads 32, 33 at equal speeds. For this purpose the volume control valves 277, 278 are set to deliver the same volume of hydraulic fluid to each of the hydraulic traction motors 34, 35. However, should it be desired to steer the mining machine 30 during the mining operation, or at any other time, such steering is accomplished by varying the volume of hydraulic fluid delivered

to the respective hydraulic traction motors 34, 35, this being accomplished by corresponding operation of the pilots 252, 253 for the volume control valves 278, 277, respectively.

The hydraulic fluid from the volume control valve 277 is delivered through hydraulic line 290 to the reversing valve 224, and the hydraulic fluid is delivered from the volume control valve 278 through the hydraulic line 292 to the reversing valve 225. The reversing valves 224, 225 are integral parts of a four unit valve 295 which is illustrated in detail in FIGS. 17 to 20. The reversing valves 224, 225 are similar, except that they are oppositely disposed in the four unit valve 295, as seen in FIG. 11. The four unit valve 295 also includes the pilots 220, 223 for operation of the reversing valves 224, 225, respectively, the pilots 220, 223 also being integral parts of the four unit valve 295.

Considering the reversing valve 224 in greater detail, the hydraulic line 290 delivers hydraulic fluid from the volume control valve 277 to the pressure port 296. As seen in FIG. 11 the valve spool 297 of the reversing valve 224 is in its neutral position in which it is centrally disposed with respect to the valve body 298. The valve body 298 includes a tank port 299 in the rear face of the valve body 298. In the front face of the valve body 298 there are formed flow ports 300, 301. The flow ports 300, 301 each function as either a supply or return port in accordance with the position of the valve spool 297 as will appear in greater detail hereinafter. In the neutral position of the valve spool 297 the flow ports 300, 301 are blocked by the spool pistons 302, 303, respectively, and the port 296 is directly connected to the tank port 299 through the internal ports 304, 305 in the valve body 298. Thus in the neutral position of the valve spool 297 the flow of hydraulic fluid is from the pressure port 296 to the tank, through the tank port 299 which connects to the manifold tank line 306.

The pilot 220 includes a piston 307 reciprocally mounted in the pilot body 308. The piston 307 includes an upwardly extending stem 309 and a depending stem 310. The depending stem 310 is connected by a pin 311 to the top of the valve spool 297 for transmission of the motion of piston 307 to the valve spool 297. A spring guide 312 is mounted on the top of the stem 309 and another spring guide 313 is mounted on the bottom of the stem 309. The upper spring guide 312 is seated against the cover 314 for the pilot body 308, and is movable downwardly with the piston 307, but its uppermost position is limited by the cover 314. The lower spring guide 313 is seated on the top of the piston 307, and is movable upwardly with the piston 307, but is limited in its downward position to that position shown in FIG. 11 by the annular rib 315.

The pilot body 308 includes flow ports 316, 317 by which hydraulic fluid under pressure is delivered to one side or the other of the piston 307 from the pilot valve 203. The delivery of hydraulic fluid under pressure through port 316 causes a downward reciprocation of the piston 307, as seen in FIG. 14, thereby exhausting hydraulic fluid through the port 317 and through the pilot valve 203, the latter returning the exhausted hydraulic fluid to the tank through the manifold tank line 219. Downward reciprocation of the piston 307 also reciprocates the valve spool 297 downwardly. Delivery of hydraulic fluid under pressure to the pilot 220 through port 317 reciprocates the piston 307 upwardly, as seen in FIG. 13, exhausting hydraulic fluid through the port 316 to the pilot valve 203 and thence to the tank through manifold tank line 219, and results in an upward reciprocation of the valve spool 297. The spring 318 which is seated on the spring guides 312, 313 is double acting, whereby reciprocation of the piston 307 in either direction is in opposition to the force of the spring 318, and compresses the latter. Since the pilot valve 203 has its pressure port 213 blocked and its flow ports 214, 215 open

to the tank ports 216, 217, respectively, when the solenoids 205, 206 are not energized, the spring 318 in the pilot 220 operates to maintain the piston 307 in a centered position when the solenoids 205, 206 of the pilot valve 203 are not energized.

Upward reciprocation of the valve spool 297 sets the reversing valve 224 for forward operation of the traction motor 34, as seen in FIG. 13. The spool piston 302 moves upwardly into the internal port 304 closing this port and at the same time opening the flow port 300 to the bottom tank canal 319 of the four unit valve 295. The spool piston 320 is moved upwardly into the internal port 305 sealing this port from the tank port 299. The spool piston 303 moves upwardly to open the flow port 301. With the valve spool 297 so adjusted, the flow of hydraulic fluid from the port 296 is through the canal 321 to the flow port 301, which supplies the hydraulic fluid under pressure to the traction motor 34 through hydraulic line 322 for operating the hydraulic traction motor 34 in the forward direction. The hydraulic fluid which is exhausted from the hydraulic traction motor 34 is returned to the reversing valve 224 through hydraulic line 323 which connects the flow port 300. The exhausted hydraulic fluid flows from the flow port 300 into the bottom tank canal 319 of the four unit valve 295. The four unit valve 295 includes a canal 324 disposed in alignment with each of the flow control valves 245, 246, and the canals 324 are each connected at all times to the bottom tank canal 319 of the four unit valve 295 to receive the flow of hydraulic fluid which is exhausted from the hydraulic traction motors 34, 35. The canals 324 are individually connected to the tank ports 325, 326 which connect the manifold tank line 306.

For reverse operation of the hydraulic traction motor 34, the valve spool 297 is reciprocated downwardly in the valve body 298, whereby the spool piston 320 closes the internal port 304, and the spool piston 302 moves below the flow port 300 connecting the latter to the pressure port 296. Hydraulic fluid under pressure is then supplied from the flow port 300 through hydraulic line 323 to the hydraulic traction motor 34 for driving it in reverse direction. The spool piston 303 opens the flow port 301 and closes an internal port 305 thereby connecting the flow port 301 to the canal 327 which connects to the canal 324. The hydraulic fluid which exhausts from the hydraulic traction motor 34 is returned through the hydraulic line 322 to the flow port 301, and flows through the canal 327 to the canal 324 which delivers the hydraulic fluid to the port 325 from which it is exhausted to the tank through the manifold tank line 306. The reversing valve 225 operates in the same manner as the reversing valve 224 with the return hydraulic fluid from the hydraulic traction motor 35 exhausting through the tank port 326.

The four unit valve 295 also includes the flow control valves 245, 246 and the respective pilots 240, 241 therefore, these all being integral elements of the four unit valve 295. The conveyor-traction pump 162 delivers hydraulic fluid under pressure through pressure relief valves 242 and hydraulic lines 243, 244 to the flow control valves 245, 246, respectively. The flow control valves 245, 246 are each two position valves, and in one position thereof the hydraulic fluid under pressure is delivered to the hydraulic conveyor motor 83, and in the other position thereof the hydraulic fluid under pressure is delivered to the reversing valves 224, 225, respectively, to be combined with the hydraulic fluid under pressure from the pump 161 delivered by the reversing valves 224, 225 to the hydraulic traction motors 34, 35, respectively. By this system there is provided an increased volume of hydraulic fluid for operating the hydraulic traction motors 34, 35 at a high speed for propelling the mining machine 30 at high speed, such high speed propulsion being utilized at times when the mining machine 30 is not performing any mining operation, but is merely trammed from one location to another.

15

As seen in FIG. 11, the flow control valve 246 includes a valve spool 330 which is adapted to be reciprocated between a lower position, as shown in FIG. 11, and an upper position, as shown in FIG. 13. The pilot 241 includes a piston 331 with a depending rod 332, which is secured to the top of the valve spool 330 by a pin 333, whereby the reciprocation of the piston 331 is transmitted to the valve spool 330 for reciprocating the latter. The pilot body 334 includes flow ports 335, 336 which are connected to the solenoid controlled pilot valve 226. The delivery of hydraulic fluid under pressure from the pilot valve 226 through the port 335 reciprocates the piston 331 downwardly to the position seen in FIG. 11, with the hydraulic fluid exhausting from the underside of the piston 331 through the port 336, back to the pilot valve 226 and thence to the tank. The supply of hydraulic fluid under pressure through the port 336, reciprocates the piston 331 upwardly, as seen in FIG. 13, exhausting the hydraulic fluid through the port 335, the exhausted hydraulic fluid returning to the tank through the pilot valve 226. The pilot valve 226 operates to control the delivery of hydraulic fluid to the pilot 241 in the manner previously described.

As seen in FIG. 11, the flow control valve 246 is set for operating the hydraulic traction motor 35 at high speed, in which the flow of hydraulic fluid through the valve 246 is combined with the flow of hydraulic fluid through the reversing valve 225. The flow control valve 246 includes a pressure port 337 in the front face of the four unit valve 295, which connects through the internal port 338 to the canal 327, whereby the hydraulic fluid supplied through the port 337 combines with the hydraulic fluid delivered to the reversing valve 225. By upward reciprocation of the valve spool 330, as seen in FIG. 13, the internal port 338 is sealed by the spool piston 339, and the internal port 340 is also sealed by the spool piston 339. The spool piston 341 seals the internal port 342, and the spool piston 343 seals the internal port 344, taking a position above the canal 345. The pressure port 337 is then connected through the canal 346 to the internal port 347, which connects the transverse canal 345. The flow control valves 245, 246 have a common flow port 348 to which the transverse canal 345 is connected. Hydraulic line 247 connects from the common flow port 348 to the conveyor reversing valve 255, which controls the direction of delivery of the hydraulic fluid to the conveyor motor 83. The conveyor reversing valve 255 either by-passes the hydraulic fluid to the tank through hydraulic line 349, or will direct the flow of hydraulic fluid to the conveyor motor 83 through one of hydraulic lines 268, 270 for operating the conveyor motor in either a forward or reverse direction, as previously described.

Combined with the hydraulic system for operating the mining machine 30, there is provided an electrical system which includes controls for the mining machine, electrical controls for the various hydraulic control devices, and the signaling system by which signals are provided indicating the advance of the mining machine with respect to the coal seam. The electrical system is digrammatically illustrated in FIG. 15A to 15F. In the electrical circuit diagram, that part of the circuit which is included within the dot-dash line 355 represents electrical equipment on the mining machine 30. That portion of the electrical circuit diagram included within the dot-dash line 356 represents electrical equipment which is included within a control box 357, seen in FIG. 1B. That portion of the electrical circuit diagram between the dot-dash lines 355, 356 represents an electrical cable 358 which extends between the control box 357 and a junction box 359 at the rear end of the mining machine 30.

In accordance with this invention the electrical controls for operating the mining machine 30 are included in the control box 357, which is supported on a wheeled truck 366 to permit the same to be readily moved to follow the mining machine 30. The electrical cable 358 is

16

connected at one end to the control box 357, and at its other end to the junction box 359 on the mining machine 30, whereby the current is conducted between the control box 357 and the mining machine 30 for operating the various electrical devices on the mining machine 30. The electrical cable 358 may be made in one continuous length, or it may be made of several shorter lengths to facilitate storage of the cable 358. Where the electrical cable 358 comprises several shorter lengths, the several lengths of cable are connected to each other between the mining machine 30 and the control box 357 by a connector box 360 having a plug portion 361 and a socket portion 362, by which the separate lengths of cable 358 are electrically connected to each other. The connector box 360 is mounted on a skid base 363 to facilitate moving the same along the mine floor. A plurality of cable clamps 364 are secured to the cable 358 at equally spaced positions along the length thereof, and lengths of chain 365 are secured to the cable clamps 364, and between the latter and the mining machine 30, the connector box 360, and the wheeled truck 366. By means of the chain 365 the cable 358 and the connector box 360 may be readily pulled along the mine floor without the transmission of any force to the cable 358, thereby avoiding any damage to the latter.

The mining machine 30 includes a positive terminal 370 and a negative terminal 371 for connecting a trailing power cable 367 to the mining machine 30, which supplies direct current power to the machine from a remotely located power source. The positive and negative lines 372, 373 include switches 374, 375, and a resistance 382 to limit the current in lines 372, 373. The switch 374 is located in the connector box 360 and is adapted to be opened prior to separation of the plug portion 361 from the socket 362 of the connector box 360. The control box 357 similarly includes a plug portion 376 and a socket portion 377, which are adapted to be joined for connecting the conductor cable 358 to the various electrical devices in the control box 357. The switch 375 is located in the control box 357, as seen in FIG. 16, and is adapted to be opened prior to separation of the plug portion 376 from the socket portion 377 in the control box 357. The plug portion 376 is secured to the socket portion 377 by a plurality of bolts 368. There is also included a bolt 369 which is so placed that it will close the switch 375 when it is threaded into the plug portion 376 and the socket portion 377 of the control box 357. When connecting the plug portion 376 to the socket portion 377 all the bolts 368 are first secured, and the bolt 369 is secured last, whereby it is insured that all the electrical connections are firmly made before there is energization of any of the circuits. When the plug portion 376 is separated from the socket portion 377, the bolt 369 is first removed to open the switch 375, and then the bolts 368 are removed. The plug portion 361 and the socket portion 362 of the connector box 360 are similarly constructed and include the switch 374 which is similar to the switch 375, and is opened prior to separation of the plug portion 361 from the socket portion 362. Opening of either of the switches 374, 375 de-energizes the electrical circuits in the mining machine 30 as well as those extending to the control box 357, and operates as a safety feature for this equipment. When the cable 358 is connected through the connector box 360, or is connected to the control box 377, the switches 374, 375 respectively are closed after all of the other electrical connections are made, thereby avoiding the possibility of any incendiary spark.

The terminal circuit includes a relay 378 having a coil 379, which is placed in the negative line 372. The relay further includes dual contactors 380 which are adapted to close the several circuits connected to the positive line 373. When the power line 367 is connected to the terminals 370, 371, and the switches 374, 375 are closed, the coil 379 is energized to operate the contactors 380 to close their circuits. When either of the switches

374, 375 is opened, or the power is disconnected from the terminals 370, 371, the relay coil 379 is de-energized, which induces a reverse voltage in the coil 379, which normally produces an incendiary spark at the point where the circuit is opened. In order to avoid the production of this incendiary spark, which is a dangerous condition in a mine, a rectifier 381 is connected across the coil 379, thereby rendering the circuits safe. Of course, when the circuit including the coil 379 is opened, the latter is de-energized, opening the dual contactor 380 and thereby de-energizing the other circuits as well. Should the positive lead of the power cable 367 be mistakenly connected to the negative terminal 371, the rectifier 381 shunts the current around the coil 379, and the latter will not be energized, and none of the electrical circuits can be operated until such time as the power cable 367 is properly connected to the terminals 370, 371 in accordance with the polarity thereof.

The commutator 151 is concentrically disposed with respect to the axis of the shaft 59a, and corresponds in position to the circular path of the lower right cutter arm 60a. The segments 152 of the commutator 151 which lie in the quadrant corresponding to the quadrant of operation of the cutter arm 60a defining the lower right limit of the determinate area 91 of the mine face from which coal is removed by the mining machine, are connected by lines 385 to a bank of lights 386, which are disposed in a quadrant corresponding to the quadrant in which the commutator segments 152 are disposed.

The lower left cutter arm 60b includes a sensing device and signaling system identical to that of the cutter arm 60a, having a commutator 387. The commutator segments 388 corresponding to the quadrant of operation of the cutter arm 60b defining the lower left limit of the determinate mine face area 91 from which coal is removed, are connected by lines 389 to a bank of lights 390, disposed in a quadrant corresponding to the quadrant of commutator segments 387. The upper cutter arms 65a, 65b each includes a sensing device and signaling system like that of the cutter arm 60a, with the signaling systems being set to sense the material of the mine face in quadrants at the upper outer limits of the determinate mine face area 91 from which the coal is removed. The right upper cutter arm 65a has a signaling system including the commutator 391 having a quadrant of commutator segments 392 connected by lines 393 to a bank of lights 394 corresponding in position to the commutator segments 392. The signaling system of the upper left cutter arm 65b includes a commutator 395 having a quadrant of commutator segments 396, connected by lines 397 to a bank of lights 398 corresponding in position to the commutator segments 396. The lights 386, 394 are disposed in staggered positions in the arc of a half circle, with the lower half of the lights 386, including the odd light, being connected to the commutator 151, and the upper half of the light being connected to the commutator segments 392. The lights 390, 398 are similarly but oppositely disposed in the arc of a half circle, and are connected to the commutator segments 388, 396, respectively.

The brush 149 in the signaling system for the lower right cutter arm 60a is mechanically connected to the shaft 59a, and is rotated thereby around the stationary commutator 151. The switch 102 is disposed in the cutter arm 60a and is adapted to be closed by the yielding action of the bit holder 92 when it encounters material in the mine face that is relatively harder than coal. The circuit is energized through the contact spring 119 and the contact 130, through the switch 102 to the brush 149, and through that commutator segment 152 with which the brush 149 is in contact. By energization of the circuit current is thereby supplied to a light 386, which corresponds in position to the position of the cutter arm 60a at which it encountered the relatively harder material in the mine face, which caused the closing of the switch

102. It is thus seen that the lights 386 are energized when the cutter arm 60a encounters relatively harder material than coal in the mine face, and provides a signal showing the presence of such material, and also showing the position of the cutter arm 60a at which it encountered the relatively harder material. As previously described the operation of the signaling system is in the quadrant of operation of the cutter arm 60a defining the lower right limit of the determining mine face area 91 from which coal is removed.

An alternate circuit is provided for shortening out the switch 102. This circuit includes the switch 399, which closes the circuit through the brush 122 and the ring contact 125, and thence through the brush 149 and that commutator segment 152 with which the brush 149 is in contact, to illuminate one of the lights 386. This operation, of course, is not dependent on the sensing of material that is relatively harder than coal, since the switch 102 is by-passed. This circuit may be used to test the operation of the signaling system, or it may be used to check the position of the cutter arm 60a after it has stopped rotating. A like alternate circuit is provided for each at the other cutter arms 60b, 65a, 65b. The cutter arms 60a, 60b, 65a, 65b, during the cutting operation, operate in paths that extend beyond the lateral dimension of the mining machine 30. The cutter arms 60a, 60b, 65a, 65b may be rotated to positions in which they are all located within the lateral dimensions of the mining machine 30, which will take them out of contact with the side walls of the tunnel or room being bored by the mining machine 30, and will facilitate maneuvering of the mining machine 30 since the cutter arms will not abut the mine walls. In moving the cutter arms 60a, 60b, 65a, 65b to their retracted positions, the movement thereof can be checked by use of the alternate circuit by closing switches 399, 400. Switch 399 will operate the signaling system with respect to cutter arms 60a, 65a and switch 400 will operate the signaling system with respect to cutter arms 60b, 65b. The movement of the several cutter arms will be indicated by the successive illumination of the lights 386, 390, 394, 398, and when none of the lights is illuminated by rotation of the several cutter arms, it is known that the cutter arms 60a, 60b, 65a, 65b are all disposed within the lateral dimension of the mining machine 30, and out of contact with the mine walls.

Only the signaling circuit for the lower right cutter arm 60a has been described in detail for the reason that the signaling circuit for each of the other cutter arms 60b, 65a, 65b is identical to that described with respect to the cutter arm 60a, as seen in FIG. 15. The lights 386, 394, 390, 398 are oppositely disposed on the face of the control box 357, as seen in FIG. 15. At the top of the face of the control box 357 there are provided dual switch actuators 418, 419 for the switches 399, 400, respectively, by which the alternate light circuits are closed. Each switch actuator 418, 419 has an "on" position for operating the alternate light circuits, and an automatic position in which the light circuits are operated through the switches 102 in the cutter arms for sensing the mine face. The light circuits further include a resistance 401 connected in series with each one of the lights 386, 390, 394, 398 for reducing the voltage to the lights commensurate with the size thereof. In the circuits described thus far there is further provided dial lights 402, 403, which are located on the face of the control box 357 to illuminate the same. Each light 402, 403 has a resistance 404 to limit the voltage supplied to the respective lights 402, 403. The signaling circuits including the switches 102 are supplied with current from the line 405, which is a positive line, and the alternate light circuits are supplied with current from a positive line 406. The current in the lines 405, 406 is limited by a resistance 407 connected in series with each of the lines 405, 406.

A positive line 410 supplies current from the dual contactor 380 to the other electrical control circuits. A

start-stop motor switch 411 is connected to the positive line 410 and to the control circuit 412 for the pump motor 164. The motor switch 411 is provided with switch actuator 418 on the face of the control box 357, for operation of the switch 411. A dial light 413 is connected to the positive line 410 through the start-stop switch 411, for illuminating a portion of the face of the control box 357. A resistance 414 is connected in series with the light 413 to limit the voltage to the light 413.

A normally closed centrifugal switch 415 is connected to the positive line 410 and to a red light 416, having a resistance 417 connected in series therewith to limit the voltage to the light 416. The centrifugal switch 415 is mechanically connected to the conveyor 78, and is driven thereby when the conveyor 78 is driven. Operation of the conveyor 78 driving the centrifugal switch 415 causes the latter to open, whereby the light 416 is not illuminated. When the conveyor 78 is stopped, or if the conveyor 78 should be stopped by jamming, the centrifugal switch 415 closes and the light 416 will then be illuminated, providing a signal on the face of the control box 357 to the machine operator indicating stoppage of the conveyor 78.

A head motors start-stop switch 420 is connected to the positive line 410 through the switch 421, the latter controlling the operation of the conveyor 78. The start-stop switch 420 is connected to a motor control circuit 422 for starting and stopping operation of the head motors 71, 72 that drive the cutter arms 60, 65. By connection of the head motors switch 420 through the conveyor switch 421, the head motors 71, 72 cannot be operated unless the conveyor 78 is operating to discharge from the mining machine 30 the material mined by the cutter arms 60, 65. Electrical connections 408 connect the pump motor circuit 412 to the head motors circuit 422, so that the head motors 71, 72 cannot be started unless the pump motor 164 is first started. When the pump motor 164 is stopped, the head motors 71, 72 are also stopped, and the operation of the other devices of the machine are also stopped as will appear in greater detail hereinafter.

An ammeter 423 is connected to the left head motor 71 across a shunt 424, and a second ammeter 425 is connected to the right head motor 72 across a shunt 426. The ammeters 423, 425 are placed at opposite sides of the face of the control box 357, corresponding to the disposition of the head motors 71, 72, and show the current being supplied to the head motors 71, 72, thereby providing a measure of the load on the head motors 71, 72, and indicating to the machine operator any overloads on either or both motors.

An ammeter 427 is connected to the pump motor 164 across a shunt 428, and is centrally disposed on the face of the control box 357 to indicate the current drawn by the pump motor 164, which is a measure of the load on the pump motor 164. A voltmeter 429 is connected across the positive line 410 and the negative line 409 to show the supply voltage to the equipment. The voltmeter 429 is placed on the face of the control box 357 adjacent the pump motor ammeter 427.

A tachometer generator 430 is connected to the gear case 73 of the head motors 71, 72 to be driven thereby, and is electrically connected to a resistance box 431, through which current is supplied to a tachometer 432 for indicating the speed of the drive of the head motors 71, 72, which is related to the speed of the cutter arms 60, 65 and serves to provide an indication of whether the cutter arms 60, 65 are operating properly. The tachometer 432 is centrally disposed on the face of the control box 357 above the pump motor ammeter 427 and the voltmeter 429.

Switches 435, 436 are each connected to the positive line 410, and are alternately operated to energize the solenoids 437, 438, respectively, of the pilot control valve 250 for the right traction motor 35. The pilot control valve 250 controls the operation of the volume control valve 278 to govern the supply volume of hydraulic fluid

to the right traction motor 35, thereby controlling the speed thereof. The switches 435, 436 are alternately operated by a switch actuator 439 on the face of the control box 357.

Switches 441, 442 are each connected to the positive line 410 and are adapted to be alternately closed to energize solenoids 443, 444, respectively, of the pilot control valve 251, which controls the operation of the volume control valve 277 to govern the supply volume of hydraulic fluid to the left traction motor 34, thereby controlling the speed thereof. The switches 441, 442 are adapted to be alternately closed by a switch actuator 445 on the face of the control box 357.

A three position conveyor switch 421 is connected to the positive line 410 for alternate energization of one or the other of the solenoids 448, 449 of the pilot control valve 254, which controls the direction of operation of the conveyor 78. When the switch 421 is operated to energize the solenoid 448 the conveyor 78 is operated in the reverse direction. The conveyor 78 is operated in reverse when it becomes jammed with material, and by such reverse operation the jammed material is released and the conveyor 78 may then be restored to operation for discharging material from the end of the mining machine 30. The switch 421 is operated to energize the solenoid 449 for operating the conveyor 78 for discharge of material from the mining machine 30. The switch 421 has an intermediate "off" position in which neither solenoid 448, 449 is energized, the conveyor 78 being rendered inoperative by setting the switch 421 in this position. A switch actuator 450 is provided on the face of the control box 357 for setting the switch 421 to any one of its three positions. The start-stop switch 420 for the head motors 71, 72 is connected to the positive line 410 through the switch 421. The start-stop switch 420 is operative to start the head motors 71, 72 only when the conveyor switch 421 is in the conveyor discharge position for energization of the solenoid 449. This is a safety feature which prevents operation of the head motors 71, 72 while the conveyor 78 is either inoperative, or is operated in reverse direction, since the head motors 71, 72 must not be driven unless the conveyor 78 is operative to collect the mined material from the mine face and to discharge the same from the rear of the mining machine 30.

The conveyor-high speed tram switch 452 is connected to the positive line 410, and has two positions for energizing one or the other of solenoids 227, 228 of the pilot control valve 226, which controls the operation of the pilots 240, 241. Energization of the solenoid 227 operates the pilots 240, 241 to set the flow control valves 245, 246 for operation of the hydraulic conveyor motor 83, as previously described. Operation of the switch 452 to energize the solenoid 228 operates the pilots 240, 241 to set the flow control valves 245, 246 for operation of the hydraulic traction motors 34, 35 at high speed. The switch 452 is provided with a switch actuator 455 on the face of the control box 357, having two positions corresponding to the positions of the switch 452.

Head separate switches 457, 458 are each connected to the positive line 410 and are alternately operated. Upon closing of the switch 457 the solenoid 459 is energized, and the alternate closing of switch 458 energizes solenoid 460, the solenoids 459, 460 being included in the pilot operated control valve 168, which controls the operation of the cylinder and piston mechanisms 57 for separating the mining heads 48, 49 and for bringing them back together. A switch actuator 461 is provided on the face of the control box 357 for alternately closing one or the other of switches 457, 458. The switch actuator 461 is normally maintained in a neutral position in which neither switch 457, 458 is closed.

Head tilt switches 463, 464 are each connected to the positive line 410, and are alternately operated for energization of the solenoids 465, 466, respectively. The sole-

noids 465, 466 are included in the pilot operated control valve 167 which controls the operation of the hydraulic cylinder and piston mechanisms 56 for tilting the mining heads 48, 49. A switch actuator 467 is provided on the face of the control box 357 for alternately closing one or the other of the switches 463, 464. The switch actuator 467 is normally maintained in a neutral position in which neither switch 463, 464 is closed.

Head raise switches 468, 469 are connected to the positive line 410 and are alternately closed to alternately energize the solenoids 171, 172, respectively, of the pilot operated control valve 166, which controls the operation of the cylinder and piston mechanisms 55 for raising and lowering the mining heads 48, 49 and the support 45 therefor. A switch actuator 470 is provided on the face of the control box 357 for alternately closing one or the other of the switches 468, 469. The switch actuator 470 is normally maintained in a neutral position in which neither switch 468, 469 is closed.

Right crawler switch 472 is connected to the positive line 410 and is operative to energize one or the other of solenoids 473, 474 of pilot control valve 222. The pilot control valve 222 operates the pilot 223 for the reversing valve 225 that controls the delivery of hydraulic fluid to the right traction motor 35. When the switch 472 is operated to its forward position the solenoid 473 is energized, setting the reversing valve 225 for delivery of hydraulic fluid to the right traction motor 35 for operation of the latter in a forward direction to propel the mining machine 30 forwardly. Operation of the switch 472 to its reverse position energizes the solenoid 474, which sets the reversing valve 225 for delivery of hydraulic fluid to the right traction motor 35 to operate the latter in the reverse direction, as when backing the mining machine 30 away from the mine face. The switch 472 has a neutral position in which neither solenoid 473, 474 is energized, and the reversing valve 225 is set in a neutral position in which no hydraulic fluid is delivered to the right traction motor 35 to render the latter inoperative, whereby the mining machine 30 remains stationary. The switch 472 is provided with a switch actuator 475 having forward, neutral, and reverse positions corresponding to the positions of the switch 472 for operating the latter.

The left crawler switch 477 is connected to the positive line 410 and is adapted to energize one or the other of the solenoids 205, 206 of the pilot control valve 203 for operating the pilot 220 of the reversing valve 224 for setting the latter to deliver hydraulic fluid to the left traction motor 34, to drive the latter in either a forward or reverse direction, or alternately to render the left traction motor 34 inoperative by not delivering any hydraulic fluid thereto. The operation of the left crawler switch 477 is the same in all respects as the right crawler switch 472. A switch actuator 478 for the switch 477 is provided on the face of the control box 357. Each of the switch actuators 475, 478 is formed as a crank extending in opposite directions towards each other with the positions thereof corresponding to the crawler traction treads 33, 32 controlled thereby. The switch actuators 475, 478 are so disposed that they may be operated together with one hand for simultaneous operation of the left and right traction motors 34, 35 and the corresponding crawler traction treads 32, 33.

A tachometer generator 480 is connected to the drive from the right traction motor 35 for operation thereby. The tachometer generator 480 is connected to a resistance box 481 to which there is also connected to tachometer 482. The current delivered by the tachometer generator 480 to the tachometer 482 provides an indication on the tachometer 482 of the speed of the right crawler traction tread 33. A second tachometer generator 484 is connected to the drive from the left traction motor 34 for operation thereby. The tachometer generator 484 is electrically connected to a resistance box 485 to which there is also connected a tachometer 486. The current supplied

by the tachometer generator 484 to the tachometer 486 provides an indication on the tachometer 486 of the speed of the left crawler traction tread 32.

The tachometers 482, 486 are placed on the face of the control box 357 at the right and left sides thereof, respectively, corresponding to the respective crawler traction treads 33, 32. The resistance boxes 481, 485 are connected through switches 487, 488 to set the range of the tachometers 482, 486, respectively, for low speed operation of the crawler traction treads 32, 33, as when advancing the mining machine 30 into the mine face during the mining operation. The switches 487, 488 are ganged to the conveyor-high speed switch 452, and when the latter is set for high speed operation of the crawler traction treads 32, 33 the switches 487, 488 are correspondingly set to connect the resistance boxes 481, 485 for high range operation of the tachometers 482, 486, respectively. The tachometers 482, 486 show the speed of advance of the mining machine 30 and provide an indication to the operator at the remote control station as to whether the mining operation is progressing at a satisfactory rate. The tachometers 482, 486 also indicate the speed of the crawler traction treads 32, 33 relatively to each other, that is to say whether one of the crawler traction treads 32, 33 is operating faster than the other, whereby suitable adjustment can be made to equalize the speed of the crawler traction treads 32, 33 by operation of switch actuators 439, 445. Also adjustment can be made of the speed of the crawler traction treads 32, 33 to operate them at unequal speeds, as when steering.

Referring to FIG. 16, there is illustrated the control box 357 at which the machine operator takes his station for operating the mining machine 30. The operation of the mining machine 30 is started by moving the pump motor switch actuator 408 to the start position which sets the pump motor 164 in operation to drive the hydraulic pumps 160, 161, 162 for supplying hydraulic fluid to the hydraulic system of the machine. The pump motor switch actuator 408, after being moved to the start position, automatically returns to its neutral position, and may thereafter be used to stop the operation of the pump motor, which will also automatically stop operation of the head motors 71, 72, by virtue of the connections 408 between the pump motor circuit 412 and the head motor circuit 422. By stopping operation of the pump motor 164, the operation of the various hydraulic devices is also stopped since the supply of hydraulic fluid under pressure is cut off thereby.

Following the starting of the pump motor 164, the head motors start-stop switch actuator 433 is moved to start position for energizing the head motor circuit 422 for operation of the head motors 71, 72. The switch actuator 433 automatically returns to its neutral position and may thereafter be used to stop the operation of the head motors 71, 72. The head motors start-stop switch 420 is connected through the conveyor switch 421 to the positive line 410 of the control circuit. Therefore, before the head motors 71, 72 can be started, the conveyor switch actuator 450 must be in discharge position, which sets the conveyor 78 for discharging the mined material from the mining machine 30. Setting the conveyor switch actuator 450 to the discharge position connects the head motor start-stop switch 420 to the positive line 410. Movement of the conveyor switch 450 to either the neutral position, in which the conveyor 78 is rendered inoperative, or to the reverse position, in which the conveyor 78 is operated in reverse direction, also serves to disconnect the head motor start-stop switch 420 from the positive line 410 whereby the head motors 71, 72 are rendered inoperative. Thus, the mining machine 30 cannot be operated to remove material from the mine face unless the conveyor switch actuator 450 is first moved to its discharge position for operation of the conveyor 78 to remove the mined material from the mine face and to discharge the same at the rear of the mining machine 30. As another step

in starting the head motors 71, 72, the switch actuator 455 is set to conveyor position prior to starting head motors 71, 72, for delivery of hydraulic fluid under pressure to the conveyor hydraulic motor 83 for operation of the latter.

After starting the pump motor 164, setting the controls for the conveyor 78, and starting the head motors 71, 72, the switch actuators 475, 478 are moved from the neutral position to the forward position, whereby the mining machine 30 is advanced into the mine face by the crawler traction treads 32, 33. During the mining operation the tachometer 432 shows the speed of operation of the head motors 71, 72, and the ammeters 423, 425 show the load on the head motors 71, 72, by which it can be determined by the operator if the mining mechanisms are functioning properly. The pump motor ammeter 427 shows the load on the pump motor 164, by which it can be determined if the pump motor is operating properly, and the voltmeter 429 shows the voltage delivered to the mining machine 30.

The tachometers 482, 486 show the speed of the right and left crawler traction treads 33, 32, respectively, by which it can be determined if the latter are being driven at equal speeds for advancing the mining machine 30 in a straight line. Should it be found that the crawler traction treads 32, 33 are operating at unequal speeds the right and left crawler switch actuators 439, 445 can be operated individually to equalize the speed of the crawler traction treads 32, 33. Either of the switch actuators 439, 445 may be operated to increase or decrease the speed of the respective crawler traction treads 33, 32. Operation of both switch actuators 439, 445 at the same time and in the same direction, may be utilized to increase or decrease the rate of advance of the mining machine 30, as may be required by the condition of the mine face.

During the mining operation the switch actuators 418, 419 are maintained in the automatic position, which opens the switches 399, 400, thereby rendering the signaling system operative to illuminate the lights 386, 390, 394, 398 in accordance with the location of material harder than the coal as found by the sensing devices of the cutter arms 60a, 60b, 65a, 65b, each of which includes a sensing device. The lights 386, 390, 394, 398 are distributed in correspondence with the limits of the determinate mine face area 91 from which the coal is removed by the cutter arms 60, 65, so that by observation of the lights, the disposition of the relatively harder material in the mine face is readily apparent. Upon encountering the relatively harder material in the mine face, the mining heads 48, 49 are adjusted by use of the switch actuators 461, 467, 470. The switch actuator 461 is provided for separating the mining heads 48, 49 by raising the mining head 49 relatively to the mining head 48 and, likewise can be utilized to bring the mining heads 48, 49 together by lowering the mining head 49 relatively to the mining head 48. Thus the vertical disposition of the mining heads 48, 49 can be adjusted in accordance with the height of the mine seam in which the mining machine 30 is operating to remove a maximum height of coal from the mine face. The vertical adjustment of the mining heads 48, 49 is made in accordance with the signals provided by the lights 386, 390, 394, 398, which indicate the disposition of material relatively harder than the coal in the mine face. The switch actuator 461 is normally maintained in a neutral position, and after movement thereof to either the up or down position it automatically returns to the neutral position upon release thereof.

The head tilting switch actuator 467 is used to tilt the mining heads 48, 49 forward or back to follow a descending or ascending seam of coal. Operation of the switch actuator 467 is also in accordance with the signals provided by the lights 386, 390, 394, 398, which show the disposition of the material in the mine face that is relatively harder than coal. The disposition of this relatively harder material will indicate to the operator whether the coal

seam is following a descending or ascending path in the mine, and the adjustments of the mining heads 48, 49 are made accordingly. The head raise switch actuator 470 is utilized to raise and lower the mining heads 48, 49 and the support 45 therefor, along with the tilting of the mining heads 48, 49 to follow the ascending or descending path of the coal seam. Each of the switch actuators 467, 470 is normally maintained in a neutral position, and following operation of either of the switch actuators 467, 470, it will return automatically to the neutral position upon release thereof. The switch actuators 461, 467, 470 for adjusting the mining heads 48, 49 control the operation of the valves 166, 167, 168, and since the latter are connected in series, as previously described, the switch actuators 461, 467, 470 are operated individually.

The operation of the mining machine 30 may be stopped by moving the pump motor actuator 408 to stop position. This stops the operation of the head motors 71, 72 as well as the pumps 160, 161, 162, thereby rendering all the mechanisms of the mining machine 30 inoperative. Another procedure for stopping the operation of the mining machine 30, which is followed when it is desired to tram the machine away from the mine face following a mining operation, is to move the lights switch actuators 418, 419 to the on position, which renders the signal lights 386, 390, 394, 398 operative to show the positions of the cutter arms 60a, 60b, 65a, 65b in the quadrants of operation thereof lying in the perimeter of the determinate mine face area 91 from which coal is removed during the mining operation. The head motors 71, 72 are then operated by means of the head motor switch actuator 433 to bring the aforesaid cutter arms out of contact with the side walls of the mine, the movement of the cutter arms to the withdrawn positions being indicated by the signal lights 386, 390, 394, 398. When the cutter arms 60a, 60b, 65a, 65b are withdrawn from the side walls of the mine, the head motors 71, 72 are stopped by operation of the switch actuator 433, and thereafter the pump motor 164 is stopped by operation of the switch actuator 408.

Following stoppage of the mining machine 30 the switch actuator 455 is operated to the high speed position for tramping at high speed. The conveyor switch actuator 450 is set to off position, although it will be understood that with the switch actuator 455 set to high speed position there will be no hydraulic fluid supplied to the conveyor hydraulic motor 83. The pump motor switch actuator 408 is then operated to start the pump motor 164, and the switch actuators 475, 478 for the crawler traction treads 32, 33 are operated to either the forward or reverse positions, depending upon the direction in which it is desired to tram the mining machine 30. As previously described, during tramping at high speed the hydraulic fluid which is normally delivered to the conveyor hydraulic motor 83 for operation thereof is delivered to the traction motors 34, 35 and combined with the hydraulic fluid delivered from the traction pump 161 for operating the traction motors 34, 35 at high speed. During tramping the tachometers 482, 486 will indicate the speed of the crawler traction treads 33, 32, respectively, and the switch actuators 439, 445 may be operated to increase or decrease the tramping speed, or may be operated to steer the mining machine 30 by operation of the crawler traction treads 32, 33 at different speeds, as previously described. In the course of tramping the mining machine 30, or before such tramping is started the switch actuators 461, 467, 470 may be operated, as previously described, for adjusting the position of the mining heads 48, 49 as may be found necessary.

By the instant invention there is provided a mining machine which can be operated from a station remotely located with respect to the mine face. The mining machine includes a control system connected to the various mechanisms of the mining machine for controlling said mechanisms and the mining machine as a whole from the

remotely located control station. The control system includes means providing signals at the control station indicating the disposition in the mine face of material which is different from the selected material of the mine face that it is desired to remove by the mining operation. The disposition of the different material is indicated at the control station with respect to the mining mechanisms of the mining machine, whereby said mining mechanisms can be adjusted with respect to the mine face for operation thereof to remove only the selected material from the mine face. While the invention has been described herein as applied to a mining machine that is remotely controlled and operated, it will be apparent that various elements of the invention are adaptable to use with mining machines that are not remotely operated and controlled.

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 applicant therefore wishes not to be restricted to the precise construction herein disclosed.

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

1. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating said mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means.

2. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating said mining heads, a first hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual control means for each of said hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each control means including solenoid means for operation of the control means, traction means for propelling the mining machine and advancing the mining means into the mine face, conveying means for carrying mined material away from the mine face and discharging said mined material at the rear of the mining machine, a hydraulic motor for driving said

traction means, a second hydraulic pump for delivering hydraulic fluid under pressure to the traction hydraulic motor for operating the latter to drive the traction means at low speed, a hydraulic fluid volume control valve for control of the volume of hydraulic fluid delivered to the traction hydraulic motor to vary the speed of the latter, hydraulic pilot means for operating the volume control valve, a pilot valve for controlling the delivery of hydraulic fluid to the pilot means for operating the latter, solenoid means for operating the pilot valve, a forward and reverse valve for controlling the direction of flow of hydraulic fluid to the traction motor to reverse the direction of operation thereof, hydraulic pilot means for operating the forward and reverse valve, a pilot valve for controlling the delivery of hydraulic fluid to the pilot means to operate the latter, solenoid means for operating the pilot valve, a hydraulic motor for operating the conveying means, a third hydraulic pump for delivering hydraulic fluid under pressure to the conveying means hydraulic motor for operating the latter to drive the conveying means, a control valve for directing the flow of hydraulic fluid from the third hydraulic pump to the conveying means hydraulic motor, hydraulic pilot means for operating the control valve to divert the flow of hydraulic fluid from the conveying means hydraulic motor to the forward and reverse valve for delivery of hydraulic fluid from both the second hydraulic pump and the third hydraulic pump to the traction motor to drive the latter at high speed, a pilot valve for controlling the delivery of hydraulic fluid to the pilot means to operate the latter, solenoid means for operating the pilot valve, said first hydraulic pump supplying hydraulic fluid under pressure to each of the hydraulic pilot means through the respective pilot valves therefor.

3. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining heads and mining means into the mine face, a hydraulic motor for driving said traction means, a hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive the traction means, a hydraulic fluid volume control valve for control of the volume of hydraulic fluid delivered to the hydraulic motor to vary the speed thereof, a hydraulic pilot for operating said volume control valve to vary the volume of hydraulic

fluid delivered to the hydraulic motor, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for said pilot valve, and means connecting said third hydraulic control means to the last said pilot valve for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said pilot valve for operation of said hydraulic pilot.

4. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining heads and mining means into the mine face, a hydraulic motor for driving said traction means, a hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive traction means, a forward and reverse valve for controlling the direction of flow of hydraulic fluid to the hydraulic motor to reverse the direction of operation thereof, a hydraulic pilot for operating said forward and reverse valve, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for said pilot valve, and means connecting said third hydraulic control means to the last said pilot valve for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said pilot valve for operation of said hydraulic pilot.

5. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means,

pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining heads and mining means into the mine face, conveying means for carrying mined material away from the mine face and discharging said mined material at the rear of the mining machine, a hydraulic motor for operating the conveying means, a hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive the conveying means, a control valve for directing the flow of hydraulic fluid from the hydraulic pump to the hydraulic motor, a hydraulic pilot for operating said control valve, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for said pilot valve, and means connecting said third hydraulic control means to the last said pilot valve for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said pilot valve for operation of said hydraulic pilot.

6. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining means into the mine face, a hydraulic motor for driving said traction means, conveying means for carrying mined material away from the mine face and discharging said mined material at the rear of the mining machine, hydraulic motor for operating the conveying means, a hydraulic pump for delivering hydraulic fluid under pressure to said hydraulic motors, a control valve for alternately directing the flow of hydraulic fluid from the last said hydraulic pump to the conveying means hydraulic motor or to the traction means hydraulic motor, a hydraulic pilot for operating said control valve, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under

pressure to said pilot, solenoid operating means for said pilot valve, and means connecting said third hydraulic control means to the last said pilot valve for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said pilot valve for operation of said hydraulic pilot.

7. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining heads and mining means into the mine face, conveying means for carrying mined material away from the mine face and discharging said mined material at the rear of the mining machine, a hydraulic motor for driving said traction means, a second hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive the traction means at low speed, a forward and reverse valve for controlling the direction of flow of hydraulic fluid to the traction motor to reverse the direction of operation thereof, a hydraulic pilot for operating said forward and reverse valve, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for said pilot valve, a hydraulic motor for operating the conveying means, a third hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive the conveying means, a control valve for directing the flow of hydraulic fluid from the third hydraulic pump to the conveying means hydraulic motor, a hydraulic pilot for operating said control valve to divert the flow of hydraulic fluid from the conveying means hydraulic motor to the forward and reverse valve for delivery of hydraulic fluid from both the second hydraulic pump and the third hydraulic pump to the traction hydraulic motor to drive the latter at high speed, a pilot valve for operating the last said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for the last said pilot valve, and means connecting said third hydraulic control means to the last said two pilot valves for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said two pilot valves for operation of said hydraulic pilots.

8. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one

above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising, a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to a second of said hydraulic control means and from the second of said hydraulic control means to a third of said hydraulic control means, traction means for propelling the mining machine and advancing the mining heads and mining means into the mine face, conveying means for carrying mined material away from the mine face and discharging said mined material at the rear of the mining machine, a hydraulic motor for operating the conveying means, a hydraulic pump for delivering hydraulic fluid under pressure to the hydraulic motor for operating the latter to drive the conveying means, a control valve for directing the flow of hydraulic fluid from the hydraulic pump to the hydraulic motor, a hydraulic pilot for operating said control valve, a pilot valve for operating said pilot by controlling the delivery of hydraulic fluid under pressure to said pilot, solenoid operating means for said pilot valve, a reversing valve for controlling the direction of flow of hydraulic fluid to the hydraulic motor for reversing the direction of operation of the conveying means, a hydraulic pilot for operating said reversing valve, a pilot valve for operating the last said pilot by controlling the delivery of hydraulic fluid under pressure to the last said pilot, solenoid operating means for the last said pilot valve, and means connecting said third hydraulic control means to the last said two pilot valves for delivery of hydraulic fluid under pressure from the first said hydraulic pump to the last said two pilot valves for operation of the last said two hydraulic pilots.

9. In a mining machine adapted to remove material from a mine face, a mining head disposed at the front of the mining machine and adapted to be advanced into the mine face, said mining head including mining means for removing material from the mine face, means for advancing said mining head into the mine face, hydraulic power means for raising the mining head, hydraulic power means for tilting the mining head, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hy-

draulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve, respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to the other of said hydraulic control means.

10. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for raising the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve, respectively, said individual hydraulic control means being connected in series for delivery hydraulic fluid under pressure from one of said hydraulic control means to the other of said hydraulic control means.

11. In a mining machine adapted to remove material from a mine face, a first mining head and a second mining head disposed at the front of the mining machine one above the other and adapted to be advanced into the mine face, each mining head including mining means for removing material from the mine face, means for advancing said mining heads into the mine face, hydraulic power means for tilting the mining heads, hydraulic power means for separating the mining heads, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said

hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve, respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to the other of said hydraulic control means.

12. In a mining machine adapted to remove material from a mine face, a mining head at the front of the mining machine and adapted to be advanced into the mine face, said mining head including mining means for removing material from the mine face, means for advancing said mining head into the mine face, first hydraulic power means for adjusting the mining head, second hydraulic power means for adjusting the mining head, a hydraulic pump for supplying hydraulic fluid under pressure to each of said hydraulic power means for operating the latter, individual hydraulic control means for each of said hydraulic power means interposed between the hydraulic pump and each hydraulic power means to control the delivery of hydraulic fluid to the respective hydraulic power means, each hydraulic control means comprising a hydraulic valve for controlling the flow of hydraulic fluid to the respective hydraulic power means, pilot valve means connected to the hydraulic valve for operating said hydraulic valve, solenoid means for operating said pilot valve, means connecting the hydraulic pump to the hydraulic valve and to the pilot valve to supply hydraulic fluid under pressure to the hydraulic valve and to the pilot valve for operation of the hydraulic power means and the hydraulic valve, respectively, said individual hydraulic control means being connected in series for delivery of hydraulic fluid under pressure from one of said hydraulic control means to the other of said hydraulic control means.

#### References Cited by the Examiner

##### UNITED STATES PATENTS

|           |       |                 |           |
|-----------|-------|-----------------|-----------|
| 2,615,302 | 10/52 | Camerota        | 60—52     |
| 2,699,328 | 1/55  | Alsbaugh et al. |           |
| 2,745,648 | 5/56  | Robbins.        |           |
| 2,745,015 | 7/56  | Lee             | 214—83.36 |
| 2,771,958 | 11/56 | Ball            | 180—6.48  |
| 2,826,402 | 3/58  | Alsbaugh et al. |           |
| 2,866,626 | 12/58 | Moon.           |           |
| 2,877,999 | 3/59  | Snyder et al.   |           |

BENJAMIN HERSH, *Primary Examiner.*

WILLIAM J. KANOF, PHILIP ARNOLD, CHARLES E. O'CONNELL, *Examiners.*