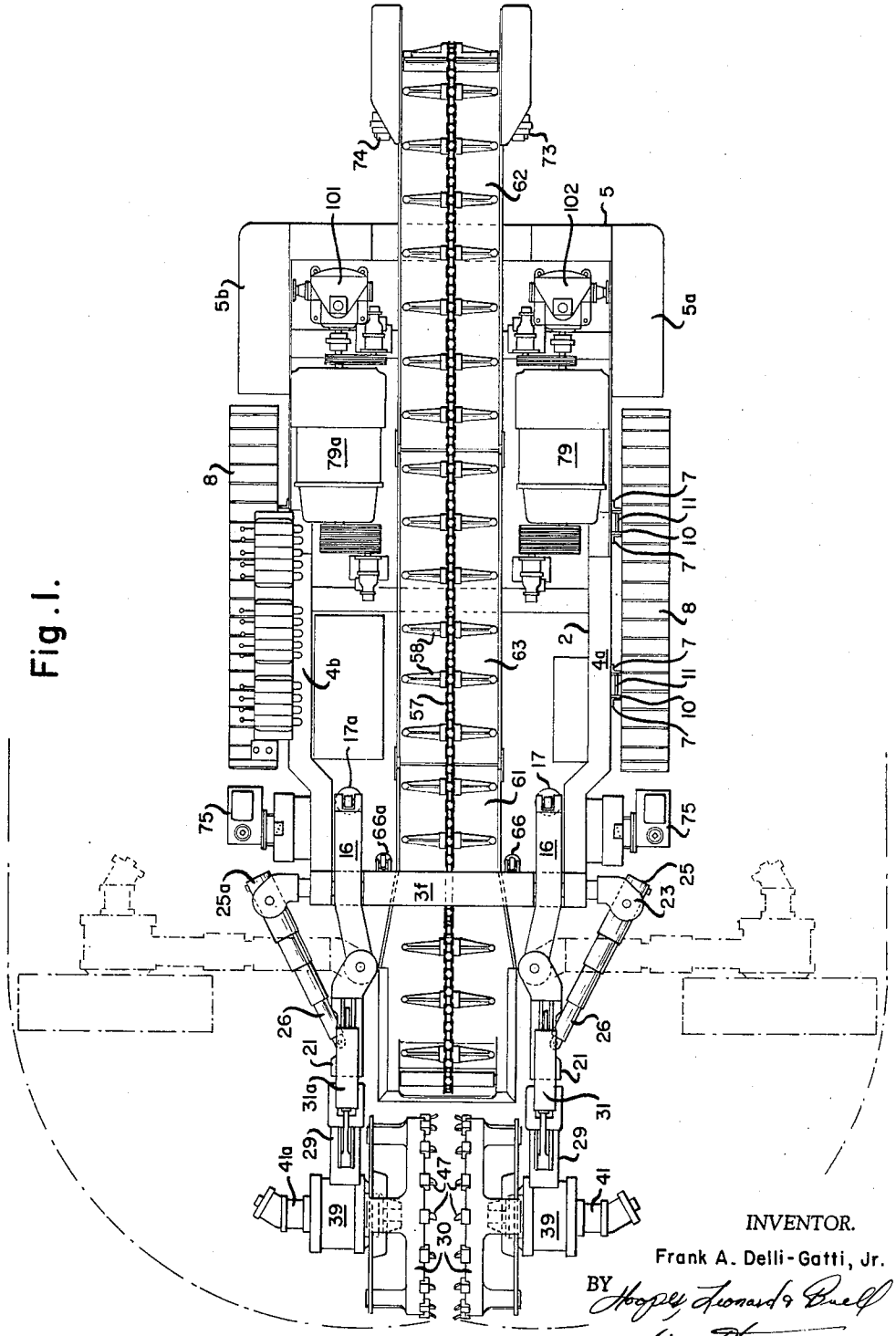
Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 1

Fig. 1.



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Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 2

Fig. 2.

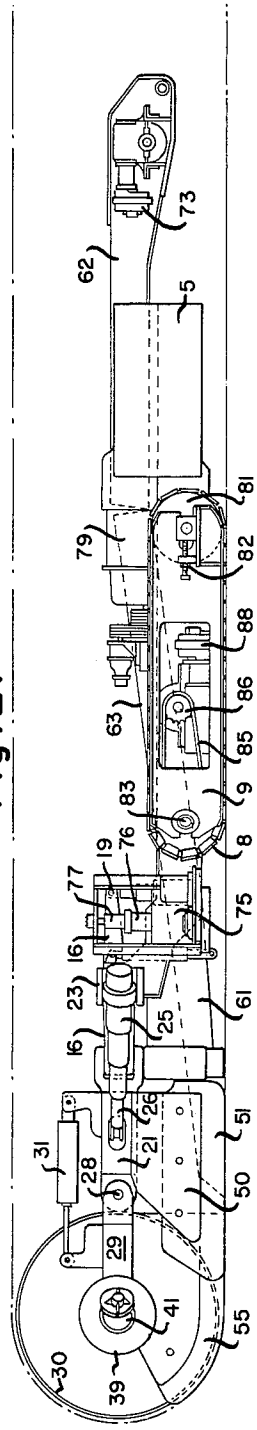


Fig. 14.

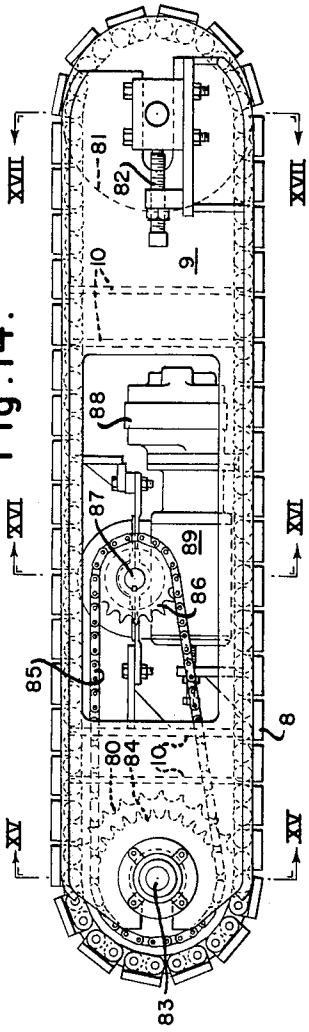


Fig. 17.

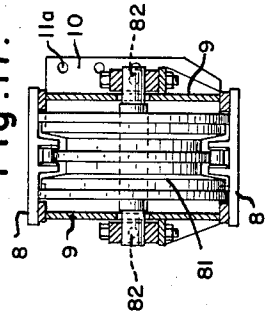


Fig. 16.

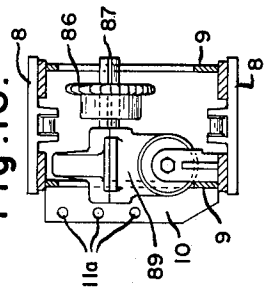
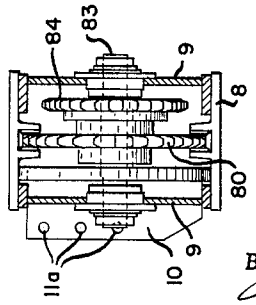


Fig. 15.



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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 3

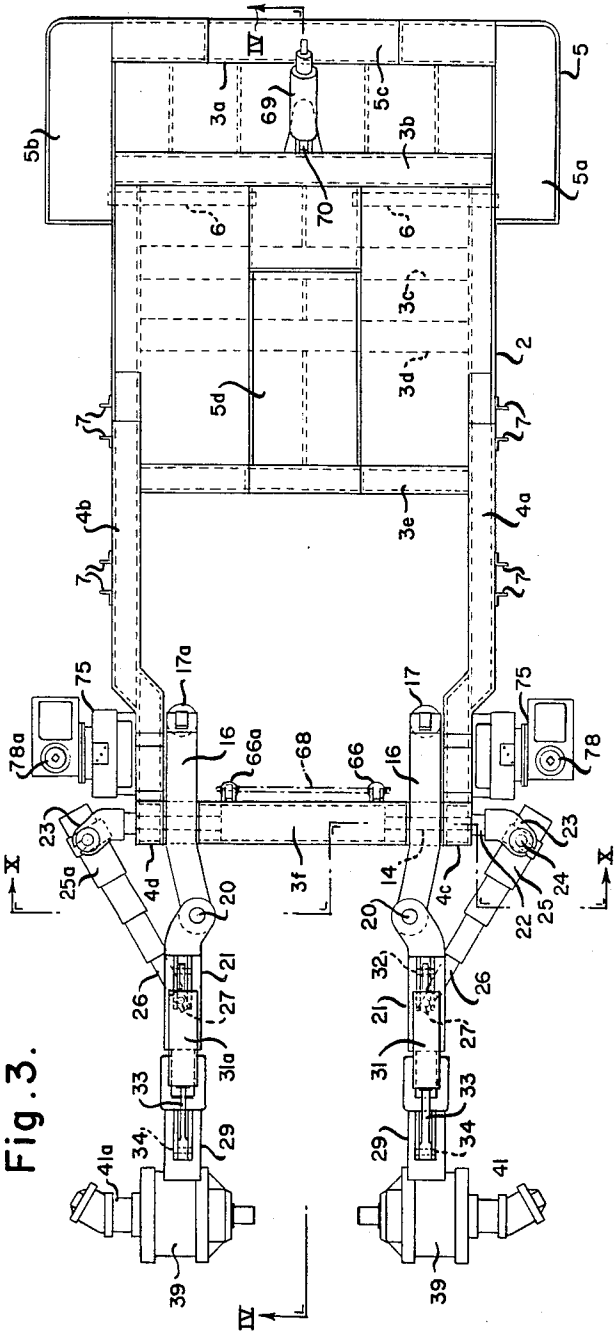

Fig. 3.

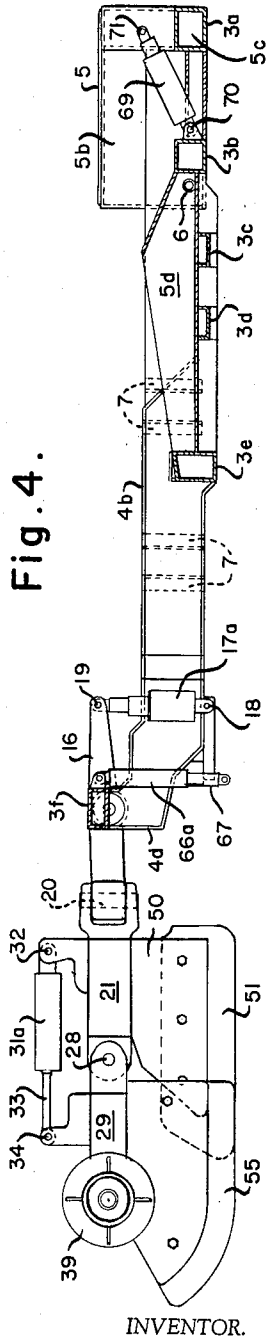

Fig. 4.

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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 4

Fig. 5.

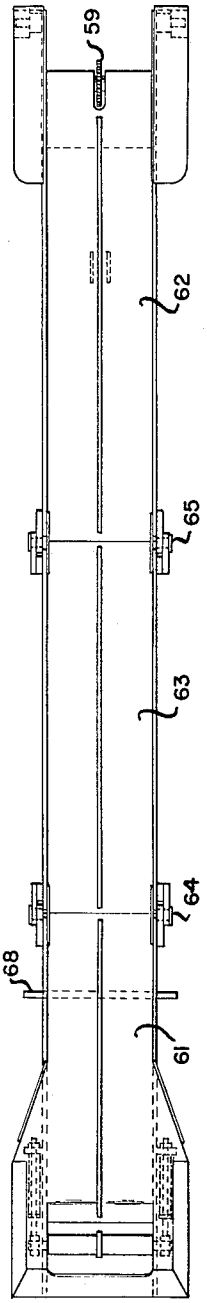


Fig. 6.

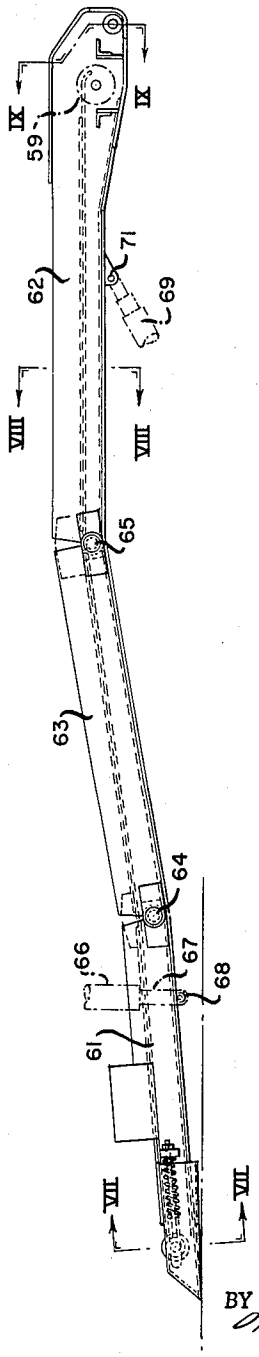


Fig. 9.

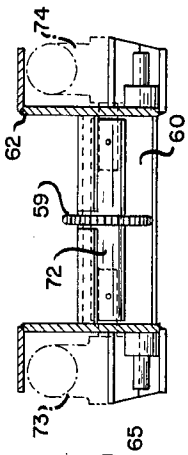


Fig. 8.

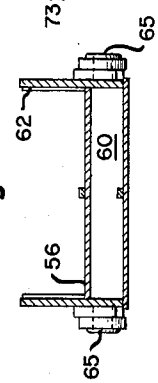
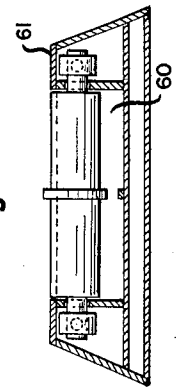


Fig. 7.



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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

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Fig. 10.

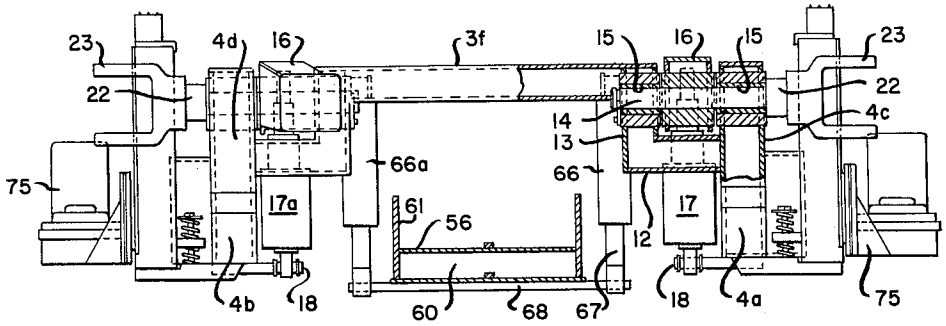
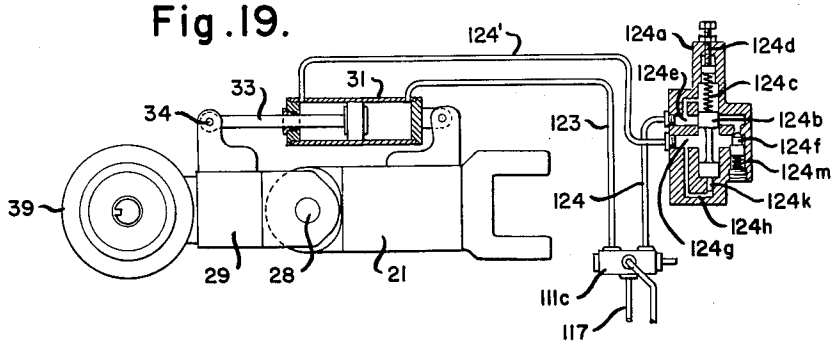


Fig. 19.



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Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 6

Fig. 11.

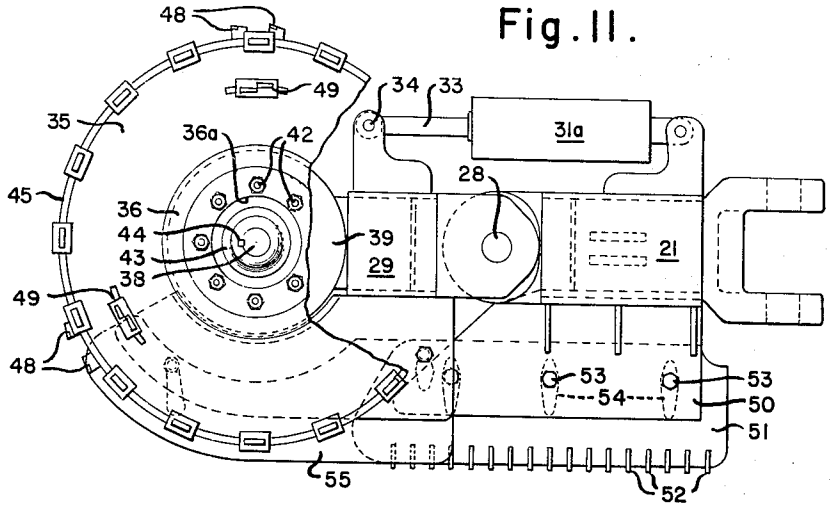


Fig. 12.

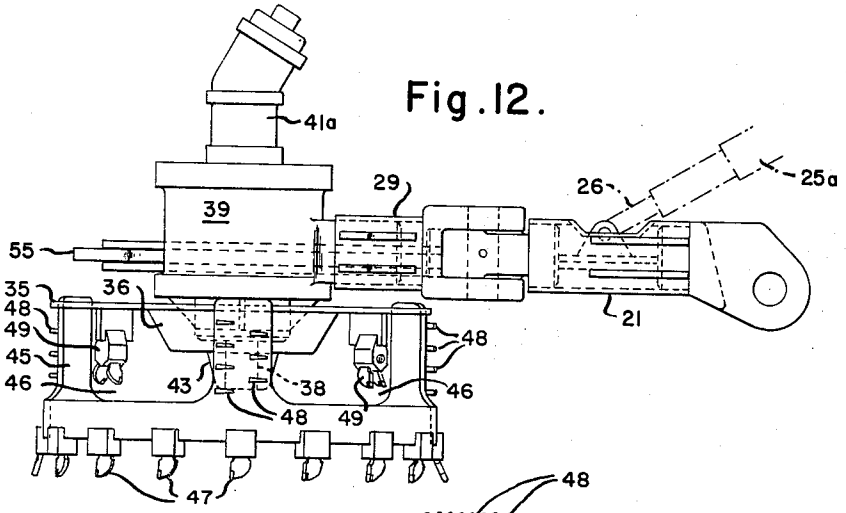
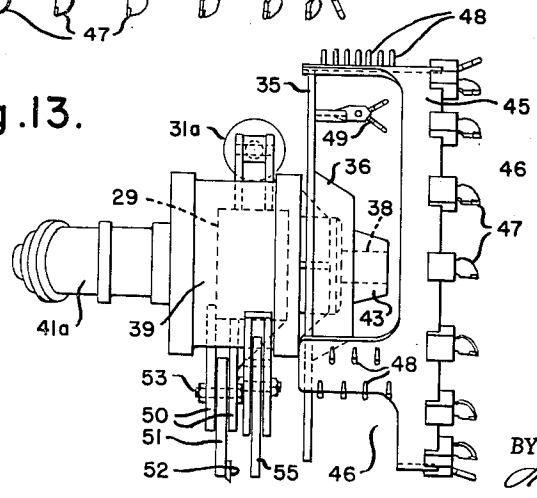


Fig. 13.



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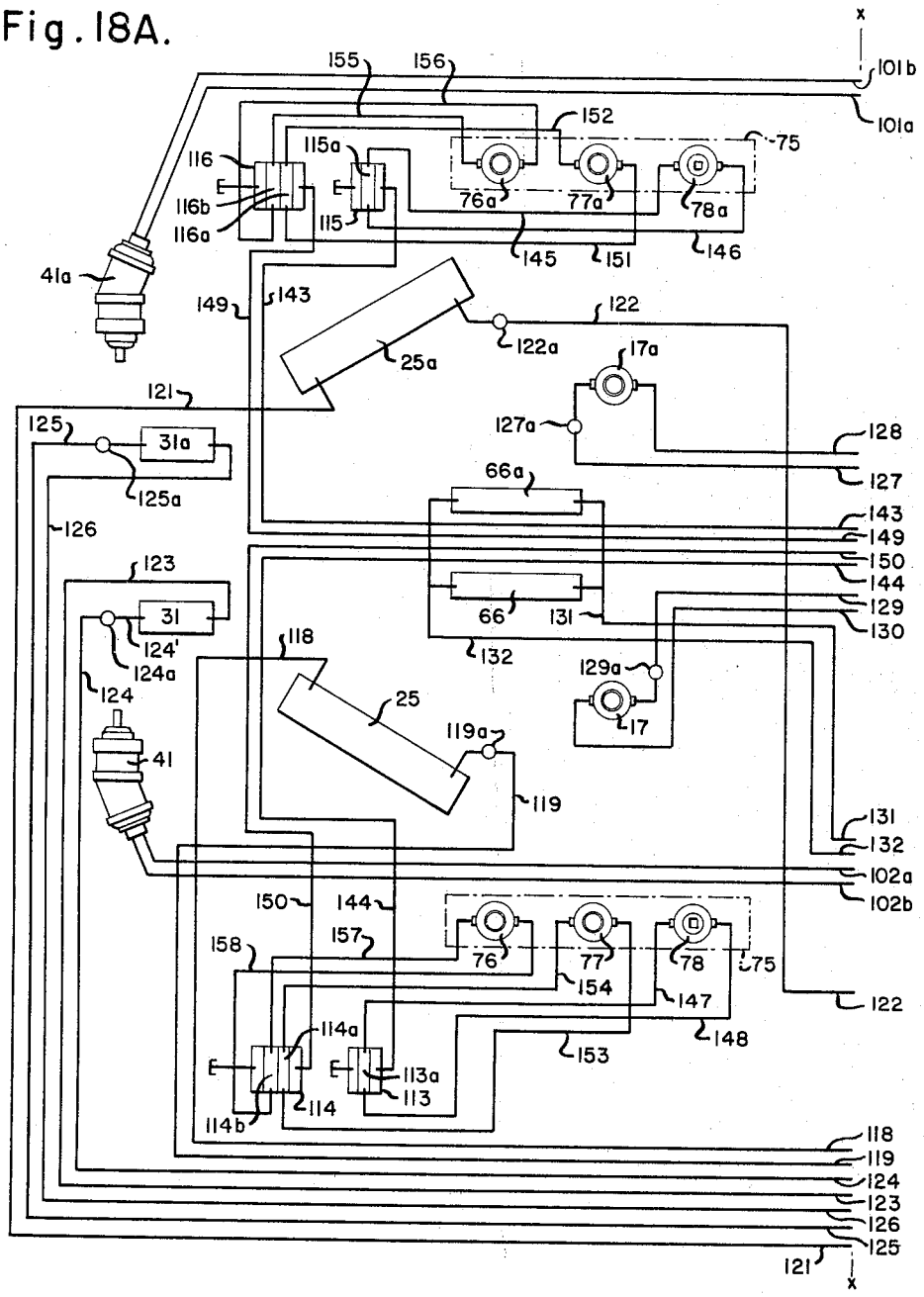
Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 7

Fig. 18A.



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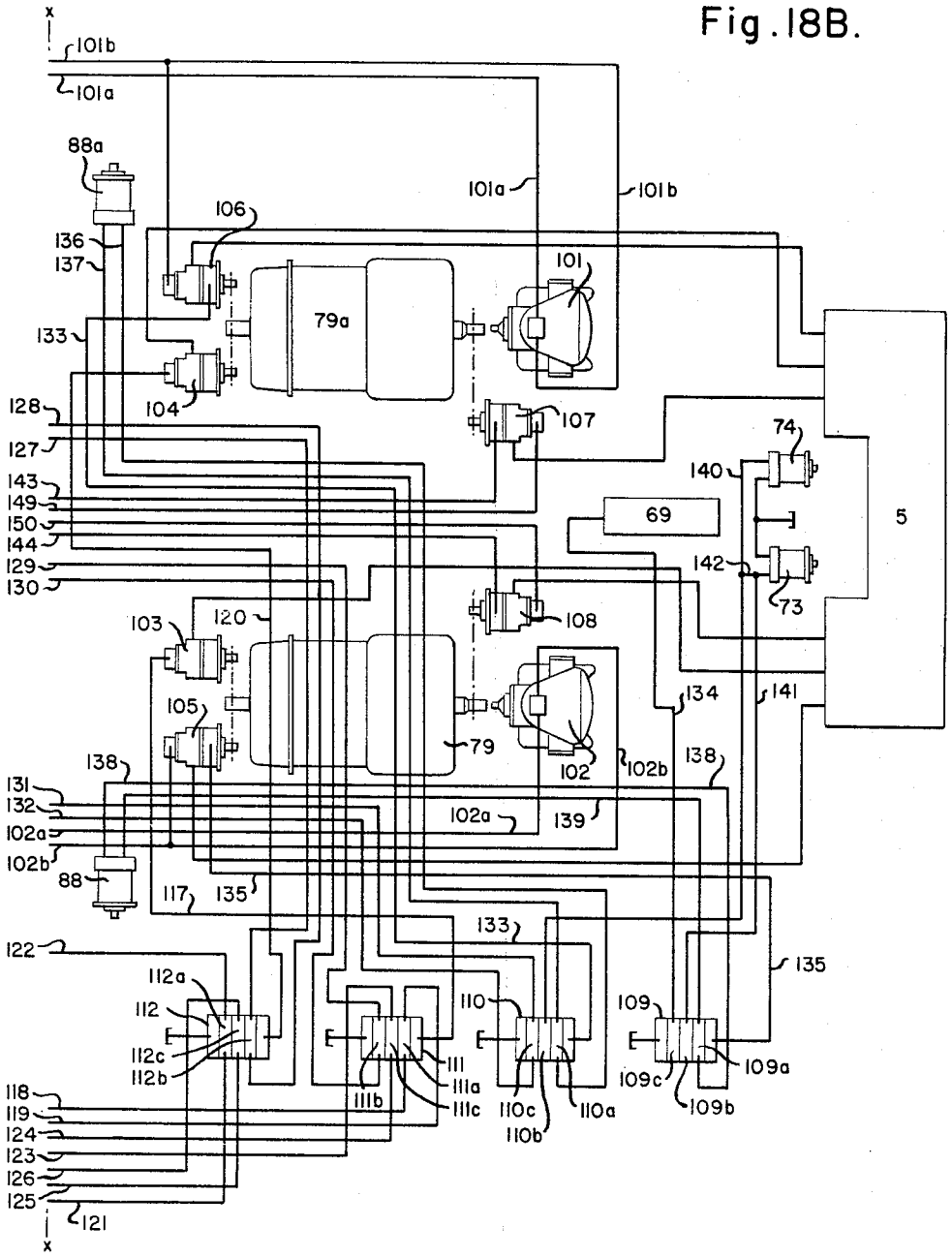
SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 8

Fig. 18B.



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Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

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Fig. 20.

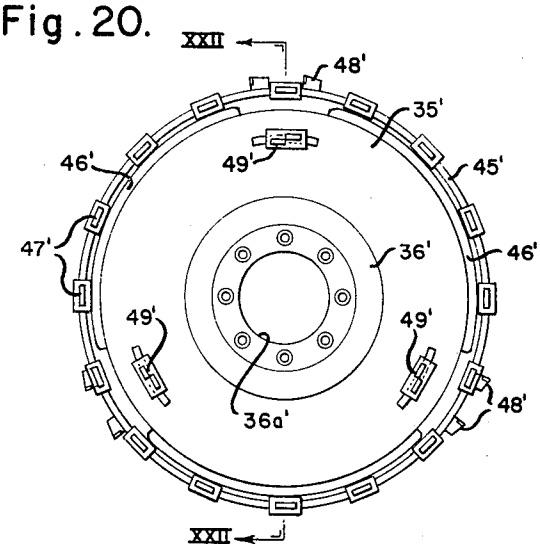
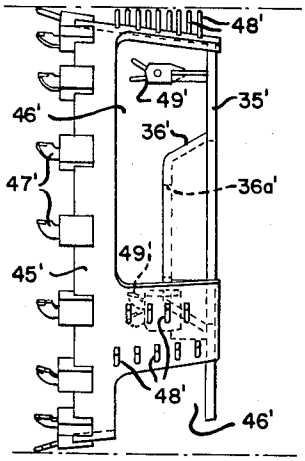


Fig. 21.



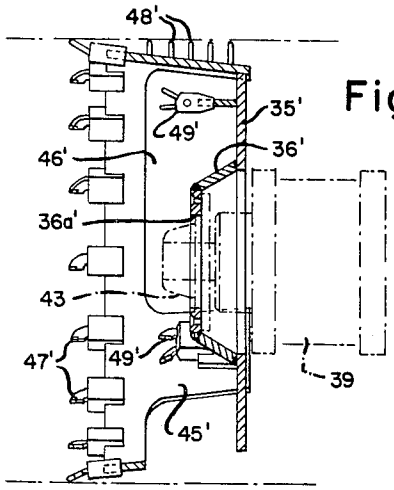


Fig. 22.

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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

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FIG. 23.

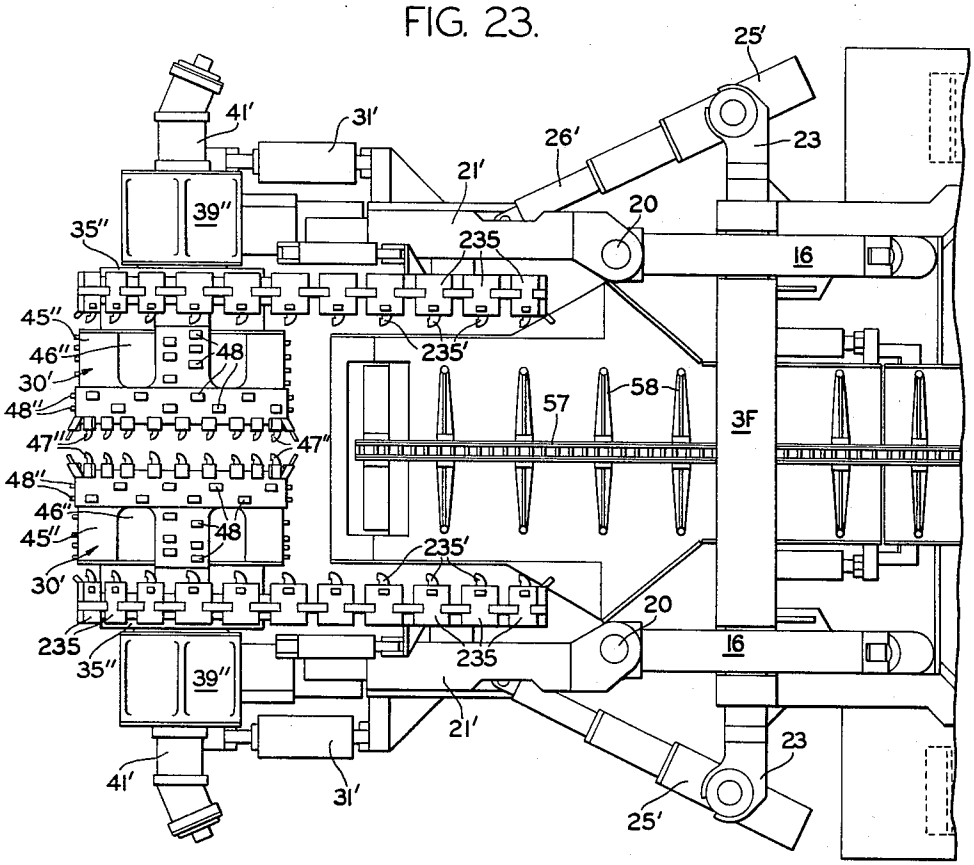
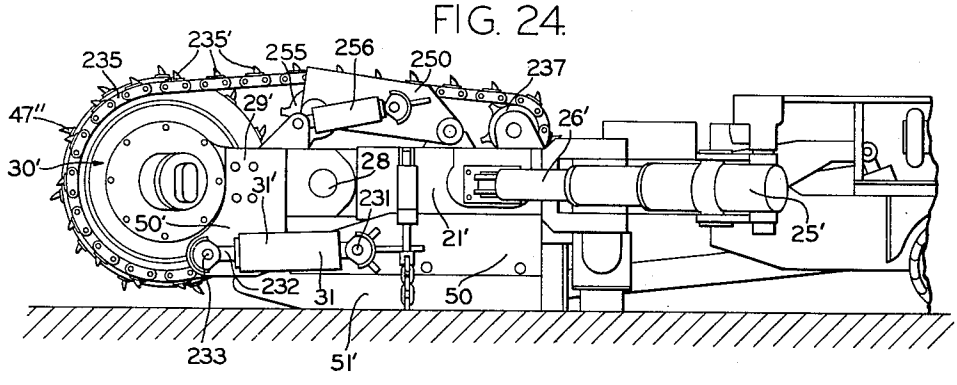


FIG. 24.



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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 11

FIG. 25.

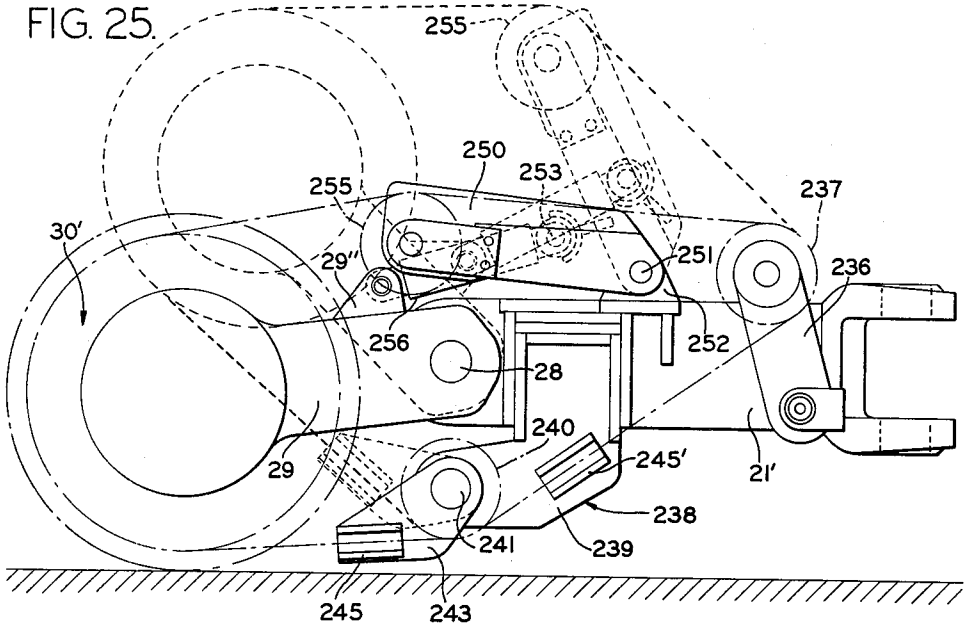


FIG. 26.

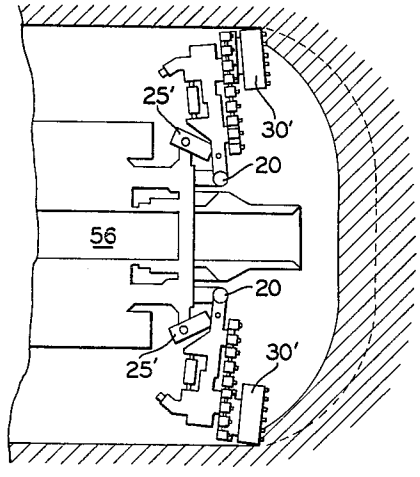
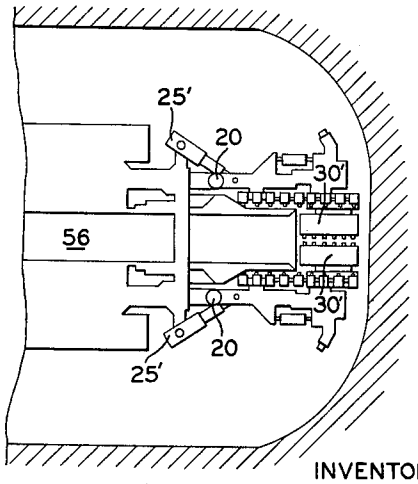


FIG. 27.



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Oct. 5, 1965 F. A. DELLI-GATTI, JR 3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Filed March 9, 1961 13 Sheets-Sheet 12

FIG. 28.

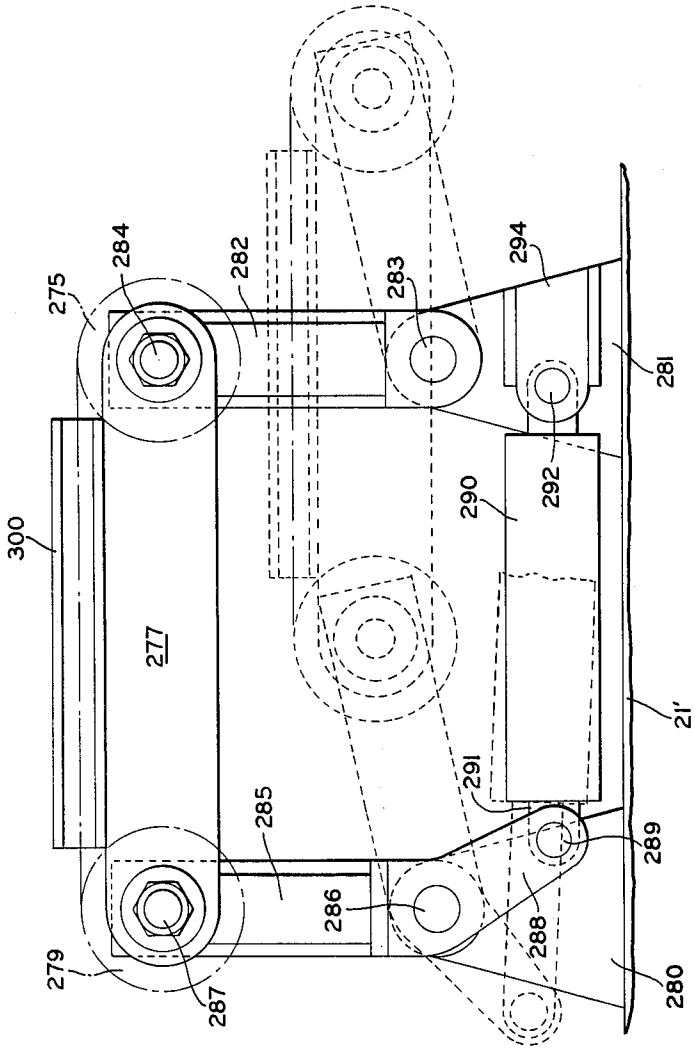
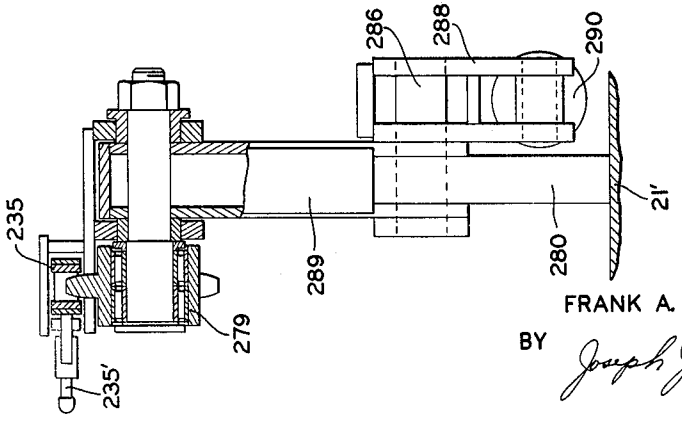


FIG. 29



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SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

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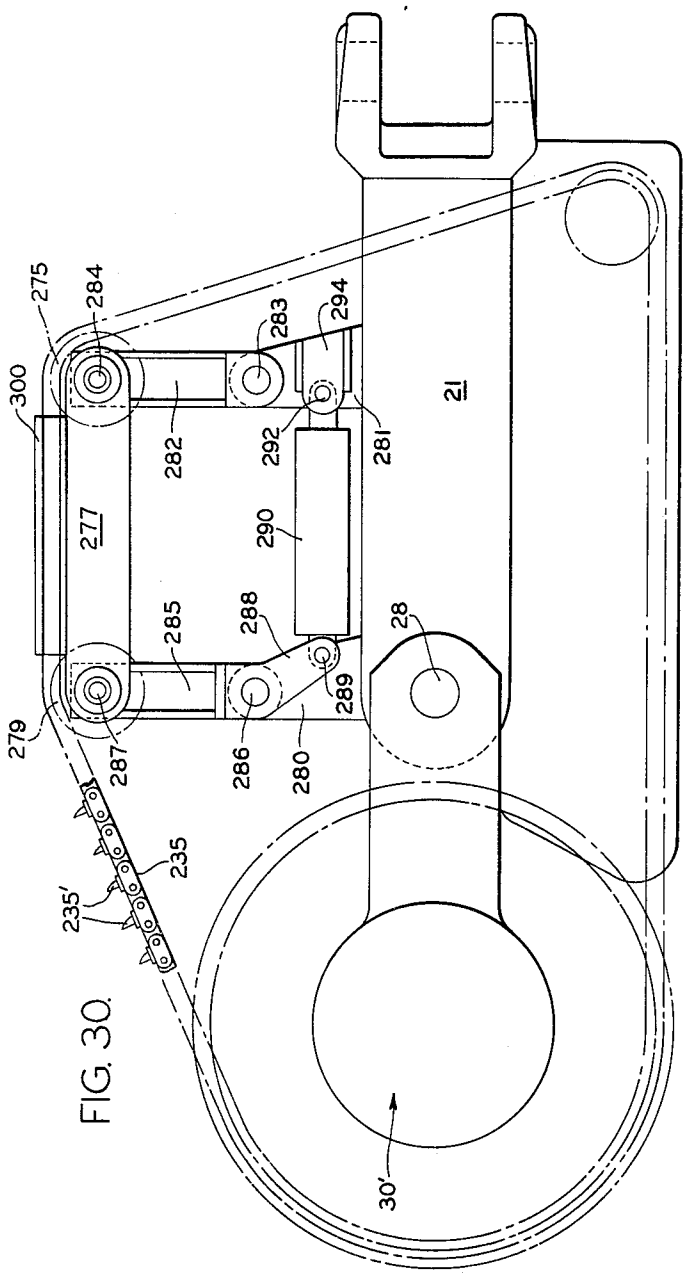

FIG. 30.

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United States Patent Office 3,210,123 Patented Oct. 5, 1965

3,210,123

SIDE SWINGING TYPE MINING MACHINE HAVING CUTTER DRUM AND CHAIN

Frank A. Delli-Gatti, Jr., Bridgeport, W. Va., assignor to Charles E. Compton

Filed Mar. 9, 1961, Ser. No. 94,644
11 Claims. (Cl. 299—64)

This application is a continuation-in-part of application Serial No. 795,440 filed February 25, 1959, now abandoned.

This invention relates to mining machines and particularly to machines for recovering mineral deposits such, for example, as coal. Although the mining machine may be adapted to other uses it is primarily adapted and intended for the mining of coal and for purposes of explanation and illustration will be described as embodied in a coal mining machine.

The present machine may be used either in surface mining or in deep mining. In either type of mining the coal must be removed from the vein and conveyed to a delivery point. This involves breaking the coal in the vein into pieces of such size that they can be practicably conveyed to the delivery point. The breaking up of the coal in the vein may, as known to those skilled in the art, be effected either by blasting or by mechanical means. If the coal is blasted it has to be undercut in advance of blasting and the coal after blasting lies in a heap on the mine floor whence it must be picked up and conveyed to the delivery point. This is not an efficient operation, particularly under present conditions of high cost of mining and low coal prices.

The mining machine herein disclosed comprises a supporting structure upon which preferably two arms pivotally mounted to turn substantially in the same generally horizontal plane together with means for turning the arms between positions in which they extend generally away from each other and positions in which they extend generally alongside each other, two rotary cutting heads, one carried by each arm for rotation about a generally horizontal axis, the heads substantially facing each other when the arms are in the second mentioned positions, and means for rotating the heads. The cutter head is a continuous circle of bits and cuts an uninterrupted arc wherein there is a smooth action with even load on all bits as compared to the standard boring machine which has segmented arms which cuts an interrupted arc having shock loading. As the arms move in generally circular paths generally toward each other the rotating heads bite into and break up the coal and at the same time move the coal from both sides to a central location where the coal may easily be conveyed rearwardly or away from the working face. A conveyor is provided for conveying material generally longitudinally of the supporting structure from one end portion thereof and the two arms are preferably pivotally mounted on the supporting structure adjacent that end portion of the supporting structure so that the arms are disposed generally at opposite sides of the center line of the conveyor to turn substantially in the same generally horizontal plane. In operation of the machine the arms are turned between positions in which they extend generally away from each other and in a direction transverse of the center line of the conveyor and positions in which they extend generally alongside each other and in a direction generally parallel to the center line of the conveyor. By providing the rotary cutting heads for horizontal sweeping action which heads have continuous cutter contact action throughout its cutting operation with the coal vibration as well as wobble is eliminated providing for a more efficient cut producing more marketable coal. In addition by providing a rotary cutting head of the type disclosed, shock is eliminated

providing for a continuous cutting action which removes the undesirable cyclic shock loads imparted to previously designed cutter heads. In addition thereto, the rotary cutter heads herein disclosed have cutters on their peripheral sides which permits the cutter head to side cut by a milling action which is laterally to the longitudinal direction of the mining machine thereby providing for greater versatilty and flexibilty. This feature is particularly advantageous in making a lateral connection to the adjacent parallel passageway. Through the use of the rotary cutting head in the horizontal sweeping action a larger percentage of marketable coal is obtained as the cutting action is one of undercutting. From the placement of the cutter arms of the mining machine a greater amount of room to either side of the mining machine is achieved which permits greater maneuverability for the mining machine as well as auxiliary equipment used closely therewith.

The conveyor for conveying material generally longitudinally of the mining machine preferably has sections at the respective ends thereof which are movable to a plurality of positions to enable the conveyor to receive and discharge material at various elevations and an intermediate section which is mounted in fixed position on the supporting structure.

The mining machine in the preferred form comprises a supporting structure, a conveyor extending longitudinally of the supporting structure, mining means at the forward end of the supporting structure for mining material and delivering the same onto the conveyor, the mining means including a mounting member pivotally mounted on the supporting structure and extending forwardly therefrom with a rotary cutter head thereon cooperative with a cutter chain which circulates relative to the mined material and which chain is driven by the cutter head, roof bolting means carried by the supporting structure at a location adjacent the rear end of the mounting member, an operator's control station disposed rearwardly of the roof bolting means and means extending from the mining means to the control station whereby an operator at the control station may control operation of the mining means. The machine provides a cutter chain which cooperates with the cutter head to increase the cutting capacity of the machine as well as removal of the marketable coal wherein the chain performs a conveying function as well as cutting function.

Accordingly, an object of this invention is to provide a new and improved coal mining machine of the combined cutting and loading type.

Another object of this invention is to provide a new and improved mining head for dislodging coal from a solid seam.

A further object of this invention is to provide a new cutter head having conveying means integrated therein which is mounted for horizontal pivotal swinging action.

A further object of this invention is to provide a new and improved cutter head having dual means coordinated to be swung in a horizontal pivotal movement from the respective lateral sides of a mining machine towards the forward longtiudinal center line of the machine.

A further object of this invention is to provide a mining machine having a new and novel cutter head that cuts a mine vein laterally of the longitudinally extending mining machine as well as forwardly thereof.

A further object of this invention is to provide a mining machine with a novel cutter head means which mines a longitudinally extending mineral vein that is substantially wider than the width of the mining machine in a continuous operation providing a maneuverable clearance space to either side of the mining machine.

A further object of this invention is to provide a new and improved mining machine having lateral spaced cutter

heads which are pivotally swingable horizontally toward the central longitudinal axis of the mining machine cooperative with auxiliary cutting means which moves the cuttings rearwardly to provide a mining machine with increased capacity.

A further object of this invention is to provide a new and improved mining machine with a pair of cooperative pivotally swingable non-vibratory cutter heads which are continuously in contact with the mineral vein without shock loading the cutter heads.

Other details, objects and advantages of the invention will become apparent as the following description of a present preferred embodiment thereof proceeds.

In the accompanying drawings there is shown a present preferred embodiment of the invention in which:

FIGURE 1 is a plan view of a mining machine;

FIGURE 2 is a side elevational view of the mining machine shown in FIGURE 1 to slightly reduced scale;

FIGURE 3 is a plan view of the main frame or supporting structure of the mining machine showing how the means for carrying the cutting heads are connected thereto; the cutting heads, conveyor, motors, pumps, endless traction elements and other elements are omitted for clarity of showing of the parts illustrated in this figure;

FIGURE 4 is a vertical cross-sectional view taken on the line IV—IV of FIGURE 3;

FIGURE 5 is a plan view of the conveyor;

FIGURE 6 is a side elevational view of the conveyor;

FIGURE 7 is a vertical transverse cross-sectional view to enlarged scale taken on line VII—VII of FIGURE 6;

FIGURE 8 is a vertical transverse cross-sectional view to enlarged scale taken on the line VIII—VIII of FIGURE 6;

FIGURE 9 is a vertical transverse cross-sectional view to enlarged scale taken on the line IX—IX of FIGURE 6;

FIGURE 10 is a vertical transverse cross-sectional view to enlarged scale taken on the line X—X of FIGURE 3 with parts omitted for clarity of showing of the parts illustrated in this figure;

FIGURE 11 is a side elevational view with a portion cut away of one of the rotary cutting heads and the means whereby it is mounted;

FIGURE 12 is a top plan view of the structure shown in FIGURE 11;

FIGURE 13 is an end elevational view of the structure shown in FIGURES 11 and 12;

FIGURE 14 is a side elevational view of one of the endless traction elements upon which the machine is mounted and the means for mounting and driving the same;

FIGURE 15 is a vertical transverse cross-sectional view taken on the line XV—XV of FIGURE 14;

FIGURE 16 is a vertical transverse cross-sectional view taken on the line XVI—XVI of FIGURE 14;

FIGURE 17 is a vertical transverse cross-sectional view taken on the line XVII—XVII of FIGURE 14;

FIGURES 18A and 18B together constitute a diagram showing one form of hydraulic circuitry for the mining machine;

FIGURE 19 is a diagram showing one form of hydraulic circuitry for controlling the piston in one of the head support tilting cylinders;

FIGURE 20 is a front elevational view of a tapered cutting head;

FIGURE 21 is a side elevational view of the tapered cutting head shown in FIGURE 20; and

FIGURE 22 is a vertical longitudinal cross-sectional view taken on the line XXIII—XXIII of FIGURE 20;

FIGURE 23 is a plan view of a modified design of the forward portion of the mining machine shown in FIGURES 1–22;

FIGURE 24 is a side elevational view of the forward portion of the mining machine shown in FIGURE 23;

FIGURE 25 is an enlarged side elevational view of the forward portion of the mining machine (FIG. 23) showing the cutter head in outline and the idler adjustable chain supporting structure;

FIGURE 26 is a schematic plan view of the forward portion of the mining machine showing the cutter heads in laterally extended position at the commencement of a cut;

FIGURE 27 is a schematic plan view of the forward portion of the mining machine showing the cutter heads in their forward advanced position at the completion of a cut;

FIGURE 28 is an elevational view of a modified form of an idler adjustable chain supporting structure shown in FIGURE 25 with parts omitted for clarity of showing of the parts illustrated in this figure;

FIGURE 29 is an end elevational view in partial cross section of the chain supporting structure shown in FIGURE 28 with parts omitted for clarity of showing of the parts illustrated in this figure.

FIGURE 30 is a side elevational view of the modified form of the idler adjustable cutter chain supporting structure shown in FIG. 28 in cooperative relationship with the rotary cutting head and cutter chain with certain parts omitted for clarity of showing the parts illustrated in this figure.

Referring now more particularly to the drawings, there is provided a welded steel frame or support structure designated generally by reference numeral **2**. The supporting structure is elongated generally in the right and left direction viewing FIGURES 3 and 4. It comprises cross members **3***a*, **3***b*, **3***c*, **3***d*, **3***e*, and **3***f* and longitudinal side members **4***a* and **4***b*. The cross member **3***f* is elevated relatively to the other cross members for a purpose to be described and the side members **4***a* and **4***b* have at their left hand ends viewing FIGURE 4 upwardly extending portions **4***c* and **4***d*, respectively, connected with the cross member **3***f* as will be described. The supporting structure is made up of steel plates and shapes welded together.

As an integral part of the supporting structure **2** there is a reservoir for hydraulic fluid, the reservoir being designated generally by reference numeral **5** and constituting side portions **5***a* and **5***b*, a rear portion **5***c* and a forwardly extending generally centrally located portion **5***d*. The portion **5***a* communicates directly with the portion **5***c* which in turn communicates directly with the portion **5***b*. The portions **5***a* and **5***b* are connected with the portion **5***d* by pipes **6**. In FIGURE 4 the portion **5***d* of the reservoir is shown as being open at a portion of its top, but when the base plate of the conveyor, presently to be described is applied and welded in place it closes the portion **5***d* of the reservoir. Consequently the reservoir for hydraulic fluid is completely closed and includes the portions **5***a*, **5***b*, **5***c*, **5***d* and **6**.

The side members **4***a* and **4***b* of the supporting structure have applied to their outer faces generally vertically extending angle members **7** for the purpose of supporting endless traction elements upon which the mining machine is carried and which move it from place to place. Each of the endless traction elements is designated by reference numeral **8** and is trained about a fabricated steel frame designated generally by reference numeral **9** and including vertical plates **10** which when the frame **9** is applied to the supporting structure of the machine lie inside and adjacent the outwardly projecting legs of the angle members **7** at that side of the machine. Bolts **11** pass through the outwardly projecting legs of the angle members **7** and through the plates **10** to fasten the frames **9** carrying the endless traction elements **8** to the supporting structure, it being understood that there is an endless traction element thus mounted to the supporting structure on each side thereof. Bolt holes **11***a* in the plates **10** and the outwardly projecting legs of the angle members **7** may be provided in equally spaced vertical arrangement as shown in FIGURE 16 so that the height above the bottoms of the endless traction elements **8** of the supporting structure **2** may be altered by matching up different bolt holes

in the plates and angle members and applying bolts **11** therethrough.

Each of the frame portions **4***c* (FIG. 10) and **4***d* of the supporting structure has extending inwardly therefrom a generally horizontal projection **12** has an upward extension **13**, and a trunnion member **14** is journaled in bearings **15** in each upward extension **13** and the cooperating frame portion **4***c* or **4***d* (see particularly FIGURE 10). Fastened to the trunnion member **14** at each side of the machine is a mounting member **16** in the form of a lever extending longitudinally of the machine. Each mounting member **16** is adapted to be turned about the generally horizontal axis of its trunnion **14** by a piston operating in a cylinder **17** (on the left hand side of the machine looking forward) or **17***a* (on the right hand side of the machine looking forward) pivoted to the supporting structure at **18** and whose piston rod is pivoted to the mounting member **16** at **19**.

Pivoted to each mounting member **16** by a generally vertical pivot pin **20** (FIGS. 3 and 4) is an arm **21** which projects generally horizontally to the left viewing FIGURES 3 and 4. Each trunnion member **14** has an outward extension **22** terminating in a yoke **23** in which is trunnioned by pivot means **24** a cylinder **25** (at the left hand side of the machine) or **25***a* (at the right hand side of the machine). Each of the cylinder **25** and **25***a* is of the telescoping type known to those skilled in the art and its piston terminates in a piston rod **26**. Each of the rods **26** is pivoted to the corresponding arm **21** by a pivot pin **27**. The pistons in the cylinders **25** and **25***a* may be and preferably are operated simultaneously to turn the arms **21** in the same generally horizontal plane between positions in which the arms **21** extend generally away from each other as shown in phantom lines in FIGURE **1** and positions in which such arms extend generally alongside each other as shown in solid lines in FIGURE 1 and in FIGURE 3. The fact that the cylinders **25** and **26***a* are carried by the yokes **23** which in turn are connected with the trunnion members **14** enables the pistons in the cylinders **25** and **25***a* to move the arms **21** back and forth regardless of the angular positions of the mounting members **16**.

Pivoted to each arm **21** by a generally horizontal pivot member **28** is a head support **29** in which is mounted for rotation about a generally horizontal axis a cutting head designated generally by reference numeral **30**. Each head support is adapted to be turned about the axis of its pivot member **28** by a piston operating in a cylinder **31** (at the left hand side of the machine) or **31***a* (at the right hand side of the machine) which is pivoted to the corresponding arm **21** at **32**, the piston rod **33** of the piston operating in each of the cylinders **31** and **31***a* being pivoted to the corresponding head support **29** at **34**.

Fluid pressure means are provided for maintaining the piston in each of the cylinders **31** and **31***a* against substantial movement in either direction in selected locations in the cylinder so that the angular relationship between the arm **21** and the head support **29** will remain constant for any desired setting. FIGURE 19 shows the hydraulic connections to the cylinder **31** and the means for maintaining the piston against substantial movement in either direction. Similar means are provided in connection with the cylinders **17**, **17***a*, **25** and **25***a* for maintaining the pistons in those cylinders against substantial movement in either direction in selected locations in the cylinder. Such means insure a smooth and uninterrupted operation of the machine and inhibit undesired movement of mounting members **16**, arms **21** and head supports **29** in either direction.

Each of the rotary cutting heads **30** comprises a generally circular base member **35** which as shown in the drawings is a steel plate having an offset mounting ring **36** at its center, the mounting ring having centrally thereof a circular opening **36***a*. Each mounting ring **36** is fitted over a hub **43** which in turn is mounted on a cutting head driving shaft **38** driven by a transmission **39** in a housing **40** carried by one of the head supports **29**, and each mounting ring **36** is fastened to the corresponding hub **43** by bolts **42** (FIG. 11). The respective transmissions are driven by hydraulic motors **41** (at the left hand side of the machine) and **41***a* (at the right hand side of the machine) respectively. Each hub **43** is keyed to the corresponding driving shaft **38** by a key **44**. When a head is to be replaced it is not necessary to remove the hub **43** but the nuts may be removed from the bolts **42** enabling removal of the head. Another head may be applied in its place and the bolts **42** and the nuts applied to them put in place to fasten the head to the hub **43**.

The rotary cutting head shown in FIGURES 11, 12 and 13 has annularly arranged projecting means in the form of a generally annular body **45** having therein openings **46** through which mined material is adapted to pass. Cutting means **47** are carried by the body **45** at the axial extremity thereof remote from the base member **35**, and additional cutting means **48** are carried by the body **45** intermediate its axial extremities and project outwardly. Further cutting or breaking means **49** are carried by the plate **35** and positioned generally within the space defined by the generally annular body **45**.

FIGURES 20, 21 and 22 show a tapered cutting head in which a generally annular body **45′** is connected at one axial extremity with a circular base member or plate **35′**, the body **45′** being of greater diameter at the axial extremity thereof remote from the plate **35′** than at the axial extremity thereof adjacent such plate. The tapered head carries cutting means **47′** analogous to the cutting means **47**, cutting means **48′** analogous to the cutting means **48** and cutting or breaking means **49′** analogous to the cutting or breaking means **49**. The cutting means **48′** relatively adjacent the axial extremity of the generally annular body **45′** adjacent the plate **35′** project outwardly farther than the cutting means **48′** relatively adjacent the axial extremity of the body **45′** remote from the base member **35′** so that the outer extremities of the cutting means **48′** considered collectively form substantially a cylinder.

Pushing means are floatingly mounted on the arms **21** and on the head supports **29** and are adapted to engage the ground and partake of limited up and down movement relatively to the members carrying them as they move over uneven ground.

Each arm **21** (FIGS. 11 and 13) has spaced apart downwardly projecting lower portions **50** between which is positioned the upper portion of a pusher **51** having teeth **52** extending downwardly from its lower portion. The pusher **51** is guided between the spaced apart portions **50** for generally up and down movement. Bolts **53** pass through the portions **50** and through vertically elongated slots **54** in the pusher **51**. The thickness of the pusher **51** is slightly less than the distance between the opposed faces of the downwardly projecting portions **50** so that the pusher can partake of limited up and down movement relatively to the portions **50** and to the arm **21** as it moves over uneven ground. A pusher **55** is similarly connected to each head support **29** and functions in the same way. The pushers **51** and **55** act cooperatively to push material ahead of them upon the inward sweeping movement of the head supports while the rotating heads remove the coal from the vein and break it and also assist in moving it inwardly or toward the center line of the mining machine. Although the teeth **52** are shown only on the bottoms of the pushers **51** similar teeth may be provided on the bottoms of the pushers **55**. The teeth aid in removing irregularities in the mine floor and contribute to the formation of a level surface for the advance of the mining machine.

There is provided a conveyor which is positioned substantially along the longitudinal center line of the mining machine. The conveyor has a pan **56** (FIG. 5) in which the coal is conveyed rearwardly or toward the right viewing FIGURE 1 by an endless chain **57** carrying pusher

flights 58. The chain is driven by a sprocket 59 so that its upper reach moves toward the right viewing FIGURE 1 and its lower reach moves toward the left. The lower reach of the chain moves in a space 60 below the pan 56. The conveyor has a plurality of tandem connection sections 61, 62, 63 pivotably connected at their respective adjacent ends. The conveyor has sections 61 and 62 at the respective ends thereof which are movable to a plurality of positions to enable the conveyor to receive and discharge material at various elevations. The central section 63 of the conveyor is mounted in fixed position in the machine. The bottom of the conveyor section 63 forms the cover for part of the portion 5*d* of the fluid reservoir. The section 61 is pivoted to the section 63 at 64 and the section 62 is pivoted to the section 63 at 65. The section 61 is swung upwardly and downwardly about its pivot 64 by pistons operating in cylinders 66 and 66*a* pivoted to the cross member 3*f* of the supporting structure, the piston rods 67 being connected with the conveyor section 61 by means of a cross bar 68. The conveyor section 62 is similarly swung up and down about the pivot 65 by a piston operating in a cylinder 69 pivoted to the supporting structure at 70, the piston rod being connected with the conveyor section 62 at 71.

The driving sprocket 59 for the endless conveyor element is fixed to a shaft 72 (FIG. 9) which is driven by a pair of hydraulic motors 73 and 74 connected with the ends of the shaft 72.

At the conclusion of a cycle of operation of the mining machine the heads are in the position shown in solid lines in FIGURE 1. To commence the next cycle the heads are swung outwardly by turning the arms 21 about the pivots 20. Normally the rotary cutting heads are continuously driven although if desired they may be stopped when the arms 21 are swung outwardly. When the arms 21 have reached their outward positions so that the heads have their cutters 47 facing toward the wall of coal to be mined the mining machine is moved forward or toward the wall of coal (the working face) upon the endless traction elements 8 a distance equal to a fraction of the diameter of the rotary cutting heads. The exact distance which the machine is moved forward at the beginning of the cycle depends on the type of coal being mined. Generally the forward advance will be through a distance of the order of one-third to one-half the diameter of the rotary cutting heads. The heads rotate in such a direction that when they are in the position shown in FIGURE 1 the upper portions of the heads move toward the working face and the lower portions of the heads move away from the working face. The heads are in the dotted line position of FIGURE 1 when the machine is moved forward at the beginning of the cycle. With the heads rotating the arms 21 are then swung from the dotted line position of FIGURE 1 to the full line position of FIGURE 1. The heads bite into the coal at the working face, breaking and removing the coal from the face and at the same time moving the coal toward the center line of the machine. Much of the coal which is removed from the face and broken by the head passes out of the heads through the openings 46 in the heads. The heads may also have openings at their rearward portions through the base member 35 or the base member 35 may be replaced by spokes with spaces between them as above indicated. The coal which drops down from the heads is pushed toward the center line of the machine by the pushers 51 and 55. The coal is taken by the conveyor and delivered rearwardly through the center of the machine and below the cross member 3*f* and is discharged at the rear end of the conveyor which may be elevated to a desired position to discharge coal into a desired receptacle such as a shuttle car or conveying means.

When the heads are partaking of an inward movement in the mining of coal it is desirable that the mounting members 16 be substantially horizontal so that the pivots 20 will be substantially vertical. Under those conditions the heads will swing in a substantially horizontal plane whereas if the mounting members 16 are tilted the heads will not swing in a horizontal plane and their operation will be less efficient. The elevation of the heads is adjusted by the pistons in the cylinders 31 and 31*a* without disturbing the generally horizontal movement of the heads during a mining operation. It may be desirable to make two passes for each position of the machine, one pass at the top of the seam and the other at the bottom of the seam, the elevation of the heads being determined by the pistons in the cylinders 31 and 32. In the second pass the pushers will clean up the shaft floor adjacent the working face.

The supporting structure carries roof bolting means 75 at a location adjacent the rear ends of the mounting members 16 and at the opposite sides of the supporting structure as shown in FIGURE 3. The operator's control station is disposed rearwardly of the roof bolting means at the right hand side of the machine looking forward as shown in FIGURE 1. Each of the roof bolting means 75 may have controls in its own immediate area as known to those skilled in the art. Each of the roof bolting units 75 comprise two hydraulic cylinders and a hyraulically driven chuck as known to those skilled in the art. The hydraulic cylinders of the roof bolting unit at the left-hand side of the machine are designated 76 and 77, respectively and the hydraulic cylinders of the roof bolting unit at the right hand side of the machine are designated 76*a* and 77*a*, respectively. The hydraulically driven chuck at the left hand side of the machine is driven by a hydraulic motor 78 (FIG. 3) and the hydraulically driven chuck at the right hand side of the machine is driven by a hydraulic motor 78*a*. The roof bolting units 75 may be purchased from a manufacturer of such units and no novelty is claimed for the units per se. However, their positioning as described and as shown in the drawings is novel and of great utility as they are disposed forwardly of the operator's station and close to the working face. This provides for the safety of the operator and greatly contributes to the efficiency of the mining operation.

Mounted atop the supporting structure are two motive units 79 and 79*a* (FIG. 1) which are shown as being electrical motors. The motors through connections which will be described below drive hydraulic pumps for supplying hydraulic fluid under pressure for the operation of the various components of the machine.

Each of the endless traction elements 8 is driven by a sprocket 80. Coacting with each sprocket 80 is an idler wheel 81 provided with a take-up adjustment 82 whereby the slack in the chain may be removed. Each sprocket 80 is fixed to a shaft 83 to which is also fixed a sprocket 84. Meshing with each sprocket 84 is a sprocket chain 85 for driving the corresponding endless traction element, the sprocket chain 85 being driven by a sprocket 86 fixed to a shaft 87 driven by a fluid motor 88 (at the left hand side of the machine) or 88*a* (at the right hand side of the machine) through a transmission 89. Each motor 88 or 88*a* and the associated transmission 89, drive chain 85 and related mechanism are all disposed substantially within the space surrounded by the corresponding endless traction element.

Referring now to FIGURES 18A and 18B each of the motors 79 and 79*a* drives four pumps. Motor 79 drives a single pump 103 and a double pump 105 from the left hand motor shaft extension viewing FIGURE 18B and a double pump 108 from the right hand shaft extension. Coupled in line with the right hand shaft extension is a variable delivery pump 102. Motor 79*a* drives a single pump 104 and a double pump 106 from the left hand motor shaft extension viewing FIGURE 18A and a double pump 107 from the right hand shaft extension. Coupled in line with the right hand shaft extension is a variable delivery pump 101.

The delivery pump 101 drives through hydraulic con-

duits or lines **101***a* and **101***b* the hydraulic motor **41***a* which furnishes the power to rotate the right hand cutting head. The variable delivery pump **102** drives through hydraulic conduits or lines **102***a* and **102***b* the hydraulic motor **41** which furnishes the power to rotate the left hand cutting head. The cutting heads may be driven at any desired speed as each of the variable delivery pumps **101** and **102** can deliver from 0 gallons per minute hydraulic fluid under pressure to the capacity of the pump.

The cylinders **25***a* and **25** receive their hydraulic power from the double pumps **104** and **103** respectively. They are controlled through valve blocks **112** and **111** respectively. Pump **103** delivers hydraulic fluid under pressure through line **117** to valve block **111**. Valve **111***a* of valve block **111** controls flow through lines **118** and **119** to the cylinder **25**. Pump **104** delivers hydraulic fluid under pressure through line **120** to valve block **112**. Valve **112***a* of valve block **112** controls flow through lines **121** and **122** to the cylinder **25***a*.

Cylinders **31** and **31***a* which control elevation of the cutting heads are connected to valve blocks **111** and **112** respectively. Pumps **103** and **104** supply hydraulic fluid under pressure to cylinders **31** and **31***a* respectively through valve **111***c* of valve block **111** and valve **112***c* of valve block **112**. Valve **111***c* delivers hydraulic fluid under pressure through lines **123** and **124** to cylinder **31** and valve **112***c* delivers hydraulic fluid under pressure through lines **125** and **126** to cylinder **31***a*. A counterbalance valve **124***a* for a purpose presently to be described is disposed in line **124**; the portion of line **124** between the valve **124***a* and the cylinder **31** is designated **124**. Five other counterbalance valves **119***a*, **122***a*, **125***a*, **127***a* and **129***a* are similarly disposed in the circuit in relation to cylinders **25**, **25***a*, **31***a*, **17***a* and **17**.

Cylinders **17***a* and **17** are connected to valve blocks **112** and **111** respectively. Pumps **103** and **104** also control the supply of hydraulic fluid under pressure for cylinders **17** and **17***a* through valve **112***b* of valve block **112** and valve **111***b* of valve block **111**, respectively. Valve **111***b* delivers hydraulic fluid under pressure through lines **129** and **130** to cylinders **17** and valve **112***b* delivers hydraulic fluid under pressure through lines **127** and **128** to cylinder **17***a*.

In one of the supply lines for each of cylinders **17**, **17***a*, **25**, **25***a*, **31** and **31***a* is disposed a counterbalance valve presently to be described.

The cylinders **66** and **66***a* work in unison to raise and lower the conveyor section **61**. They are controlled by valve **110***c* of valve block **110** through lines **131** and **132**. Hydraulic fluid under pressure for valve block **110** is furnished by pump **106** through line **133**.

Cylinders **17**, **17***a*, **25**, **25***a*, **31** and **31***a* are of the double acting type while cylinder **69** is of the single acting type. Pressure is needed only to raise and hold the conveyor section **62**, gravity being relied upon to lower that conveyor section. Cylinder **69** is supplied with hydraulic fluid under pressure through line **134** from valve **109***c* of valve block **109**. Valve block **109** receives its hydraulic fluid under pressure from pump **105** through line **135**.

The endless traction elements **8** are driven by the hydraulic motors **88** and **88***a*. Motor **88***a* drives the right-hand endless traction element and is controlled by valve **110***a* of valve block **110** through lines **136** and **137**, hydraulic fluid under pressure being supplied by pump **106** through valve block **110** as above stated. Motor **88** drives the left hand endless traction element and is controlled by valve **109***a* of valve block **109** through line **138** and **139**, hydraulic fluid under pressure being supplied by pump **105** through valve block **109** as above stated.

The hydraulic motors **73** and **74** are both coupled to the shaft **72** which carries the sprocket **59** and being so coupled those motors need to be synchronized. Motor **74** is controlled by valve **110***b* of the valve block **110** and motor through lines **140** and **141** respectively. Should the pressure of the hydraulic fluid fall below the requirements in either of valve blocks **109** and **110** a by-pass line **142** near the hydraulic motors **73** and **74** permits the pressure within the lines **140** and **141** to balance. Also, should either of the motors **73** and **74** tend to overrun the other due to an increase in pressure in its supply line the increased pressure will also be by-passed through line **142** to the other hydraulic supply line, again balancing the pressure. Should one of the pumps **105** and **106** fail the conveyor would continue to operate. Failure of the pump **106** would prevent operation of the right hand endless traction element driving motor **88***a* and the loss of one-half the normal supply of hydraulic fluid under pressure for conveyor motors **73** and **74** and would also prevent operation of the cylinders **66** and **66***a*. Failure of pump **105** would prevent operation of the left hand endless traction element driving motor **88** and the loss of one-half the normal supply of hydraulic fluid under pressure for conveyor motors **73** and **74** and would also prevent operation of the cylinder **69**. Such loss of operation of one or the other of the pumps **105** and **106**, however, would not prevent completion of an operative movement of the arms carrying the cutting heads and removal of the mined material.

Motors **78***a* and **78** receive their hydraulic power from double pumps **107** and **108** through lines **143** and **144** and valve blocks **115** and **113** respectively. Valves **115***a* and **113***a* of blocks **115** and **113**, respectively, furnish the hydraulic power to hydraulic motors **78***a* and **78** through lines **145**, **146**, **147** and **148**.

The hydraulic cylinders **77***a* and **77** which operate the mast used to stabilize the roof bolting units receive their hydraulic power from double pumps **107** and **108** through lines **149** and **150** and valve blocks **116** and **114** respectively. Valves **116***a* and **114***a* of blocks **116** and **114** furnish the hydraulic pressure to cylinders **77***a* and **77** through lines **151**, **152**, **153** and **154**, respectively. The hydraulic cylinders **76***a* and **76** which raise the hydraulic motors **78***a* and **78** enabling the drilling or bolting operation on the roof receive their hydraulic power from double pumps **107** and **108** through lines **149** and **150** and valve blocks **114** and **116**. Valves **116***b* and **114***b* of blocks **116** and **114** furnish the hydraulic power to cylinders **76***a* and **76** through lines **155**, **156**, **157** and **158**, respectively.

One of the supply lines for each of the cylinders **17**, **17***a*, **25**, **25***a*, **31** and **31***a* has therein a counterbalancing valve whose purpose is to maintain the piston in the cylinder against substantial movement in either direction in selected locations in the cylinder. By way of illustration the counterbalancing valve used in connection with the cylinder **31** will be described.

Referring to FIGURE 19, hydraulic fluid under pressure delivered through line **117** from pump **103** is controlled by valve **111***c*. When the cutting head is to be raised the valve **111***c* is operated to cause the fluid under pressure to pass to the counterbalance valve **124***a* through the line **124**; the fluid under pressure enters the valve **124***a* through port **124***e*. The valve **124***a* has a spool **124***b* which is spring biased to remain in the position shown in FIGURE 19, i.e., its lowermost position in the valve. Spring **124***c* is compressed by adjusting screw **124***d* and the spring pressure on the spool **124***b* is adjusted by turning the adjusting screw **124***d* in or out. The hydraulic fluid under pressure entering the port **124***e* of the valve **124***a* passes around the spool **124***b* and forces open a spring loaded check valve **124***f* and continues its flow through the valve **124***a*, passing out through port **124***g* and through line **124'** to the piston rod side of the piston within the cylinder **31**, forcing the piston toward the right viewing FIGURE 19 and expelling hydraulic fluid from the right hand end of the cylinder, causing the fluid to flow through the line **123** to the valve **111***c* whence it is delievered back to the reservoir **5**.

To lower the cutting head the valve **111***c* is operated to cause the hydraulic fluid under pressure entering the valve through the line **117** to flow through the line **123** and enter the cylinder **31** at the right hand end thereof, forcing the piston in the cylinder **31** to the left viewing FIGURE 19 and causing the hydraulic fluid at the left hand end of the cylinder to be expelled under pressure through line **124'** and into the valve **124***a* through port **124***g*. The hydraulic fluid being directed through passage **124***h* in the valve **124***a* is delivered to the bottom of the spool **124***b* to rise, opening the port **124***g* to port **124***e* and allowing the hydraulic fluid to continue on through line **124** to valve **111***c*, whence it flows back to reservoir **5**. In each of the above described operations raising and lowering the cutting head is accomplished by the action of the piston within the cylinder **31**, the hydraulic pressure being sufficiently high to override the pressure of the spring **124***c* above the spool **124***b* and also the spring **124***m* beneath the check valve **124***f*.

One of the positions of valve **111***c* is such that fluid under pressure entering through line **117** is allowed to pass freely through the valve while both the line **123** and the line **124** are closed. Such position of the valve may be termed the normal position. After the cutting head has been moved to a desired position by manipulation of the valve **111***c* as above described the valve is moved to normal position. Fluid under pressure is maintained in a now closed system having equal pressure on both sides of the piston in the cylinder **31**. The spool **124***b* and the check valve **124***f* prevent any displacement of the hydraulic fluid from the left hand side of the piston and the valve **111***c* prevents any movement of hydraulic fluid from the right hand side of the piston.

The spring **124***c* governs the pressure required to shift the piston to the left within the cylinder **31** and the spring **124***m* governs the pressure required to shift the piston to the right within the cylinder **31**.

A modification of the rotary cutting head is shown in FIGS. 23–27 inclusive, wherein a pair of spaced elongated horizontally extendings arms **21'** are suitably pivotably mounted at their rear end by vertically extending pivot pins **20** to the respective spaced pair of mounting members **16** in the same manner as arms **21** of the original embodiment are pivotably connected thereto and heretofore described in detail. The intermediate portion of each arm **21'** is suitably pivotably connected to piston rods **26'** of hydraulic jacks or telescopic cylinders **25'** of a type well known in the art. The hydraulic jacks **25'** may be and are preferably operated simultaneously to swing or pivot the arms **21'** in the same horizontal plane in the same manner as the arms **21** of the original embodiment shown in FIGURE 1. If desired, only one arm **21'** may be swung independently of the other arm. Cylinders **25'** as cylinders **25** and **25***a* are carried by the yokes **23** which in turn are connected with the trunnion members **14** (FIG. 10) which enables the pistons in the cylinders **25'** and **25** to move the arms **21'** as well as arms **21** back and forth regardless of the angular positions of the mounting members **16**.

Pivotably mounted on the forward end of each arm **21'** for movement in a vertical plane by a generally horizontal pivot member **28** is a head support **29'** in which is mounted for rotation a cutting head designated generally by reference numeral **30'**. Each head support **29'** is suitably adapted to be rotatably adjusted about the axis of pivot member **28** by a hydraulic cylinder **31'**, which cylinder **31'** is suitably pivotably connected by pivot member **231** (FIG. 24) to a downwardly projecting lower portion **50'** of each arm **21'** with the rod portion **232** of cylinder **31'** being suitably pivotably connected by pivot member **233** to the lower portion of head support **29'** of each cutting head **30'** (FIG. 24).

Fluid pressure means are provided for maintaining the pistons in the respective cylinders **31'** against movement and in rigid adjusted positions by similar means as cutting head **30** of the original embodiment of FIGS 1–19 in a manner similar to that shown in FIG. 19 previously described.

Each rotary cutting head **30'** is constructed in a manner similar to cutting head **30** previously described wherein a suitable circular support member **35''** (FIG. 23) is suitably rotatably mounted relative to head support **29'** to be described.

As shown in FIG. 25 the rear end portion of each arm **21'** has a support member **236** suitably rigidly mounted thereon in an upwardly extending position with an idler chain sprocket **237** suitably rotatably mounted at the uppermost end thereof for a purpose to be described. The intermediate portion of each arm **21'** has downwardly depending L-shaped member **238** suitably rigidly secured thereon with the vertically extending portion of the L-shaped member **238** being suitably secured thereto and with the forward horizontally extending portion **239** suitably rotatably supporting an idler sprocket **240** mounted therein at the outermost end thereof as on an axle **241**. Suitably rotatably mounted upon the axle **241** is a guide bracket **243** supporting a pair of forwardly extending chain guideways **245** for suitably guiding a cutter chain in a manner to be described. Suitably mounted on the lower portion of vertically extending portion of the L-shaped member **238** is a pair of chain guideways **245'** which extend in a longitudinal direction substantially in line with a line drawn tangent to the lower portions of chain sprockets **237** and **240**. The upper intermediate portion of each arm **21'** has an upwardly extending bracket **252** suitably rigidly secured thereto. Only the elements relative to the one arm will be explained however it will be understood that other arm (**21'**) is similarly constructed.

A longitudinally extending flat support member **250** has its rear end portion suitably pivotally mounted by a horizontally extending pivot pin **251** to the upwardly extending bracket **252** for pivotal movement relative thereto as well as relative to arm **21'**. The forward end portion of flat support member **250** suitably rotatably support an idler chain sprocket **255** for a purpose to be described. An elongated link connecting member **256** has one end (upwardly extending as shown in FIG. 25) suitably pivotably connected to the intermediate portion of flat support member **250** and the other end (downwardly extending as shown in FIG. 25) suitably pivotally connected to a bracket **29''** which bracket **29''** is suitably connected to the upper intermediate portion of head support **29'**. As cutter head **30'** is adjusted in an upwardly clockwise direction (FIGS. 24 and 25) by hydraulic jack **31'** about pivot pin **28**, link connecting member **256** exerts a rotative force on flat support member **250** causing support member **250** to rotate clockwise about pivot pin **251** thereby swinging idler sprocket **255** upwardly into the position indicated by phantom lines in FIG. 25. Similarly, chain guide member **245** is pivoted about pivot pin **241** in a clockwise direction by a cutter chain to be described.

Rotary cutting head **30'** (FIG. 24) is similar in construction to the rotary cutting head shown in FIGS. 11, 12 and 13 of the original embodiment wherein a circular support member **35''** (FIG. 23) is suitably mounted over a suitable hub for rotation relative to a mounting head support **29'** with the support member **35''** mounted on a driving shaft which is suitably driven by transmission means **39''** in a manner well understood in the art. Each respective transmission means **39''** is driven by a hydraulic motor **41'** in the same manner as described in the original embodiment for rotatably driving cutter head **30'**. It is to be understood that other power means including electric motors may be used.

Suitably mounted on support members **35''** and concentrically therewith is an annularly arranged body member **45''** having openings **45''** therein through which mined material is adapted to pass as disclosed in the orig-

inal embodiment and as is well understood in the art. Cutting means 47'' are carried by the body member 45'' at the axial extremity thereof remote from the support member 35'' and additional cutting means 48'' are carried by the body 45'' intermediate its axial extremities which cutting means 48'' project radially outwardly therefrom. The circumferential periphery of support member 35'' lying closely adjacent transmission means 39'' has a plurality of sprocket teeth suitably rigidly secured thereto, which sprocket teeth are coplanar with idler chain sprocket 255, idler chain sprocket 237 and idler chain sprocket 240. A closed loop cutter chain 235 is suitably mounted upon the respective idler chain sprockets 255, 237, 240 and the sprocket teeth of the support member 35'' for continuous circulating motion as is well understood in the art. Cutter chain 235 has cutter bits 235' suitably mounted in sockets along the cutter chain, which cutter bits 235' extend in the same general direction as the cutter bits 47'' mounted on the extremity of the rotary cutting head 30'. The forward portion of cutter bits 47'' extend forwardly and radially outwardly beyond the outer limits of cutter bits 235' of the cuttter chain 235 such that the outermost limits of travel of the cutter bits 235' by the cutter chain 235 do not travel the full extent to which cutter bits 47'' travel on the rotary cutting head 30' thereby maintaining a clearance space therebetween. Thus the primary cutting is done by the cutter bits 47' on cutter head 30'. The cutting done by the cutter chain 235 in addition to the trimming action (best seen in FIG. 25) is that between the rotary cutting head 30' and idler sprocket 255 as well as that between the lower portion of rotary cutting head 30' and idler sprocket 240. In addition to this cutting action cutter chain 235 performs a conveying action which will be more fully described hereinafter. Pushing means 51' are mounted on the lower projecting portions 50' of each arm 21' and are floatingly mounted in the same manner in which pushers 51 are mounted on the arms 21 of the head support 29 wherein the pushing means 51' are adapted to engage the ground and partake of limited up and down movement relatively to the members carrying them as they move over uneven ground.

The operation of the modified embodiment shown in FIGS. 23–27 inclusive is very similar in manner to the operation of the original embodiment wherein the commencement of a cycle is shown in FIG. 26 wherein the cutting heads 30' are located in an outwardly extended position so that when the arms 21' have reached their laterally extended position, the heads of the cutters 47'' face toward the wall of the coal to be mined. The mining machine is then moved forward or towards the wall of the coal of the working face upon the endless traction elements 8 a distance equal to a fraction of the diameter of the rotary cutting heads. With the cutting head 30' rotating the arms 21' are then swung from the position shown in FIG. 26 to the positions shown in FIG. 27 wherein the heads 30' bite into the coal at the working face, break and remove the coal from the face as they are swung inwardly toward the longitudinal central axis of the machine. While cutter chain 235 is circulated by the rotation of cutting head 30', it performs a cutting action on the mine face between the rotating cutting head 30' and the idler sprocket 255 as well as between head 30' and idler sprocket 240 while its lower portion conveys the cut coal rearwardly towards the central conveyor 57 for movements rearwardly of the machine onto shuttle cars or other mineral moving equipment. In addition to the conveying action by the cutter chain 235 the pusher 51' simultaneously moves over the uneven ground and pushes coal inwardly toward the head supports to aid in the removal of coal while the rotating heads remove the coal from the seams. The conveying action of the chains materially increases the capacity of the machine since there is no tendency of loose coal to pile up towards the forward center of the mining machine. A side cutting action which is principally a milling action is particularly important in making a break through to an adjoining parallel passageway wherein the lateral radially extending cutter bits 48'' on the body member 45'' of rotary cutting head 30' are positioned closely adjacent the lateral walls of a mine passageway so that as the mining machine is pivoted about the longitudinal central axes by advancing the thread on one side of the mining machine while applying the brakes on the other side, the cutter bits 48'' of the cutting head 30' mill a recess and a laterally extending clearance space so that after a sufficient lateral clearance has been cut away the mining machine may be propelled into a suitable position to attack the lateral entranceway into a full passageway to connect an adjacent parallel passageway.

A modification of the chain guide means as shown in the embodiment of FIGS. 23–27 inclusive is shown in FIG. 28 which is principally a parallelogram type linkage mechanism wherein a pair of spaced upwardly extending brackets 280 and 281 respectively are suitably secured to the upper portion of arms 21' respectively. An elongated upwardly extending arm link member 282 has its lower end portions suitably secured to the upper portion of bracket 281 by a horizontally extending pivot pin 283 and its upper portion suitably supporting by a pivot pin 284 a sprocket wheel 275 for rotation thereon. An elongated crank member 285 has its intermediate portion suitably secured by a horizontally extending pivot pin 286 to the upper portion of upwardly extending bracket 280. Crank member 285 extends and is parallel to link member 282 with the upper portion of link member 285 suitably supporting for rotation a sprocket wheel 279 by a horizontally extending pivot pin 287 connection therewith. A horizontally extending link member 277 suitably joins the upper end portions of crank member 285 and link member 282 through the respective pivot pins 284 and 287 to thereby require simultaneous movement of one crank member upon movement of the other link member or vice versa. Suitably secured to the upper portion of link member 277 is a guide member 300 having guideways thereon substantially parallel to the longitudinal extending axes of link member 277 for guiding a cutter chain in a manner to be described. The lower portion of link member 285 has its lower extremity suitably pivotally secured to rod 291 of a hydraulic jack 290 by a horizontally extending pivot pin 289. Hydraulic jack 290 has its cylindrical portion suitably secured by horizontally extending pivot pin 292 to a bracket 294 which is suitably mounted closely adjacent the intermediate portion of bracket member 281. As shown in FIG. 28 hydraulic cylinder 290 is shown in the retracted position wherein the vertically extending crank and link members 285 and 282 are respectively parallel with each other and normal to the horizontally extending link member 277 which extend therebetween. Upon extension of jack member 290 the lower portion of crank member 285 is swung in a clockwise direction about pivot pin 286 thereby swinging the upper portion of crank member 285 similarly in a clockwise direction and moving idler sprocket 279 clockwise. Similarly link member 282 is likewise moved clockwise through the link member 277, which suitably connects the two members 282 and 285. In this motion sprocket wheels 275 and 279 move the same amount and in the same direction maintaining their parallel relationship so that as the cutter chain 235 previously described, is guided by the respective idler sprockets 275 and 279 in a true horizontal manner therebetween at all times, regardless of the position in which rotating cutting member 30' is moved so that as the roof of the mine is cut by the rotary cutting head 30' and the cutter chain 235, the roof is left in substantially a horizontal extending plane.

FIG. 30 discloses the relationship of the rotary cutting head 30' previously described in cooperation with the cutter chain 235 and the chain guide means shown in FIG. 28 and described hereinabove. In this embodiment

the rotary cutting head 30' performs its cutting action as described above however the cutter chain 235 performs a greater cutting action since its upward reaches extend a considerable distance above the rotary cutting head 30'. The rotary cutting head 30' operates substantially at floor level while the cutter chain 235 performs a cutting operation above the level of the cutting head 30' so that a one pass operation is effected which provides a mine passageway of greater height in less time than ordinarily required. In addition, the height of the cutting performed by the cutter chain 235 and the rotary cutting head 30' can be adjusted through the use of hydraulic jacks such as jacks 290 to vary the effective cutting height in accordance with the seam to be mined. If desired a hydraulic take-up device may be mounted on the arm 21' in cooperative relationship with the cutter chain 235 to maintain the cutter chain 235 in taut condition.

While I have shown and described certain present preferred embodiments of the invention it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

What I claim is:

1. A cutting head comprising an elongated arm support having a forward end; a cutter drum mounted on said forward end of said arm support for rotation relative thereto about a generally horizontal axis substantially normal to the longitudinal axis of said arm support; said cutter drum having a forward portion; cutter elements mounted substantially in a continuous line peripherally around said forward portion of said drum; sprocket teeth mounted circumferentially around said drum spaced rearwardly from said forward portion; means carried by said arm support for rotating said cutter drum; chain guide means mounted on said arm support for rotation relative thereto about a generally horizontal axis; a cutter chain carried by said chain guide means and said sprocket teeth for movement through an endless orbital path in a substantially vertical plane.

2. A cutting head comprising an elongated arm support having a forward end; a cutter drum mounted on said forward end of said arm support for rotation relative thereto about a generally horizontal axis substantially normal to the longitudinal axis of said arm support; said cutter drum having a forward portion; cutter elements mounted substantially in a continuous line peripherally around said forward portion of said drum; sprocket teeth mounted circumferentially around said drum spaced rearwardly from said forward portion; means carried by said arm support for rotating said cutter drum; chain guide means including idler sprockets mounted on said arm support for rotation relative thereto about a generally horizontal axis; a cutter chain carried by said idler sprockets and said sprocket teeth for movement through an endless orbital path in a substantially vertical plane; and said chain guide means including a parallelogram linkage means for maintaining the upper reaches of said cutter chain in substantially a horizontal line.

3. A cutting head comprising an elongated arm support having a forward end; a cutter drum mounted on said forward end of said arm support for rotation relative thereto about a generally horizontal axis substantially normal to the longitudinal axis of said arm support; said cutter drum having a forward and rearward portion; cutter elements mounted substantially in a continuous line peripherally around said forward portion of said drum; sprocket teeth mounted circumferentially around the rearward portion of said drum; means carried by said arm support for rotating said cutter drum; chain guide means including idler sprockets mounted on said arm support for rotation relative thereto about a generally horizontal axis; a cutter chain carried by said idler sprockets and said sprocket teeth for movement through an endless orbital path in a substantially vertical plane; and said cutter drum having a plurality of openings circumferentially around the drum intermediate said forward and rearward portions.

4. A mining apparatus comprising: a mobile frame; an arm having one end mounted to said frame for swinging movement about a generally vertical axis; means for swinging said arm about said generally vertical axis; a cutter chain carried at least in part by said arm for circulatory motion relative thereto; a cutter drum mounted on the other end of said arm for rotation relative thereto about a generally horizontal axis; means carried by said arm for rotating said drum about said generally horizontal axis; cutting elements mounted circumferentially on a forward portion of said cutter drum; and means mounted on said drum rearwardly of said forward portion and engageable with said cutter chain for driving said cutter chain.

5. A mining apparatus comprising: a mobile frame having a forward portion; an arm mounted at one end thereof to the forward portion of said frame for pivotal movement about a generally vertical axis; a cutter drum mounted on the other end of said arm for rotation about a generally horizontal axis relative to said arm; cutter chain means carried at least in part by said arm for movement relative thereto in an endless orbital path; means carried by said arm for rotating said drum about said generally horizontal axis; cutting elements mounted circumferentially on a forward portion of said cutter drum; and means mounted on said drum rearwardly of said forward portion and engaging said chain means for circulating the latter in said orbital path.

6. A mining apparatus comprising: a mobile frame having a forward portion; an arm mounted at one end thereof to the forward portion of said frame for pivotal movement about a generally vertical axis; means for pivoting said arm about said generally vertical axis; a cutter drum mounted on the other end of said arm for rotation about a generally horizontal axis relative to said arm; cutter chain means carried at least in part by said arm for movement relative thereto through an endless orbital path in a substantially vertical plane; means carried by said arm for rotating said drum about said generally horizontal axis; cutting elements mounted circumferentially on a forward portion of said cutter drum; and means mounted on said drum rearwardly of said forward portion and engaging said chain means for circulating the latter through said orbital path.

7. A mining apparatus comprising: a mobile frame having a forward portion; a conveyor carried by said frame and extending longitudinally thereof; an arm mounted at one end thereof to the forward portion of said frame for pivotal movement about a generally vertical axis; means for pivoting said arm about said generally vertical axis; a cutter drum mounted on the other end of said arm for rotation about a generally horizontal axis relative to said arm; cutter chain means carried at least in part by said arm for movement relative thereto through an endless orbital path in a substantially vertical plane; means carried by said arm for rotating said drum about said generally horizontal axis; cutting elements mounted circumferentially on a forward portion of said cutter drum; means mounted on said drum rearwardly of said forward portion and engaging said cutter chain means for circulating the latter through said orbital path; and means on said arm for guiding a portion of the orbital path of said cutter chain means upwardly and in a direction toward the conveyor.

8. A mining apparatus comprising: a mobile frame having a forward portion; a conveyor carried by said frame and extending longitudinally thereof; an arm mounted at one end thereof to the forward portion of said frame for pivotal movement about a generally vertical axis; means for pivoting said arm about said generally vertical axis; a cutter drum mounted on the other end of said arm for rotation about a generally horizontal axis relative to said arm; cutter chain means carried at least

in part by said arm for movement relative thereto through an endless orbital path in a substantially vertical plane; means carried by said arm for rotating said drum about said generally horizontal axis; cutting elements mounted circumferentially on a forward portion of said cutter drum; sprocket teeth mounted on said drum rearwardly of said forward portion and cooperatively engageable with said cutter chain means; and means on said arm for guiding a portion of the orbital path of said cutter chain means upwardly and in a direction toward the conveyor.

9. In a mining machine: a mobile frame having a forward portion; conveying means mounted on said support frame for moving mined material longitudinally along said frame; a pair of laterally spaced arm members disposed on opposite sides of said conveying means and mounted at their one ends on said forward portion of said frame for swinging movement about generally vertical axes, respectively; means for swinging said arm members about said vertical axes, respectively; drum cutters mounted on the outer ends of said arm members, respectively, for rotation thereon about generally horizontal axes; means carried by said arms for rotating said drum cutters, respectively; cutter chain means carried at least in part by said arm members for movement relative thereto through endless orbital paths, respectively; and means mounted on said drum cutters cooperatively engageable with said cutter chain means, respectively, for driving the latter in said orbital paths, respectively.

10. In a mining machine: a mobile frame having a forward portion; conveying means mounted on said support frame for moving mined material longitudinally along said frame; a pair of laterally spaced arm members disposed on opposite sides of said conveying means and mounted at their one ends on said forward portion of said frame for swinging movement about generally vertical axes, respectively; means for swinging said arm members about said vertical axes, respectively; cutter drums mounted on the other ends of said arm members, respectively, for rotation thereon about generally horizontal axes; cutter elements mounted circumferentially on forward portions of said drum, respectively; means mounted on said arms for rotating said cutter drums, respectively; cutter chains carried at least in part by said arm members for movement relative thereto through endless orbital paths, respectively; and means mounted on said cutter drums rearwardly of said forward portions cooperatively engageable with said cutter chains, respectively, for driving the latter in said orbital paths, respectively.

11. In a mining machine: a mobile frame having a forward portion; conveying means mounted on said support frame for moving mined material longitudinally along said frame; a pair of laterally spaced arm members disposed on opposite sides of said conveying means and mounted at their one ends on said forward portion of said frame for swinging movement about generally vertical axes, respectively; means for swinging said arm members about said vertical axes, respectively; cutter drums mounted on the other ends of said arm members, respectively, for rotation thereon about generally horizontal axes; cutter elements mounted circumferentially on forward portions of said drums, respectively; means mounted on said arms for rotating said cutter drums, respectively; cutter chains carried at least in part by said arm members for movement relative thereto through endless orbital paths in substantially vertical planes, respectively; means mounted on said cutter drums rearwardly of said forward portions cooperatively engageable with said cutter chains, respectively, for driving the latter in said orbital paths, respectively; and means mounted on each of said arms for guiding a portion of the orbital path of the cutter chain associated therewith upwardly and in a direction toward the conveying means.

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