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3,516,712

MINING MACHINE FOR MINING MATERIAL FROM THE ENTIRE FACE

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4 Sheets-Sheet 1

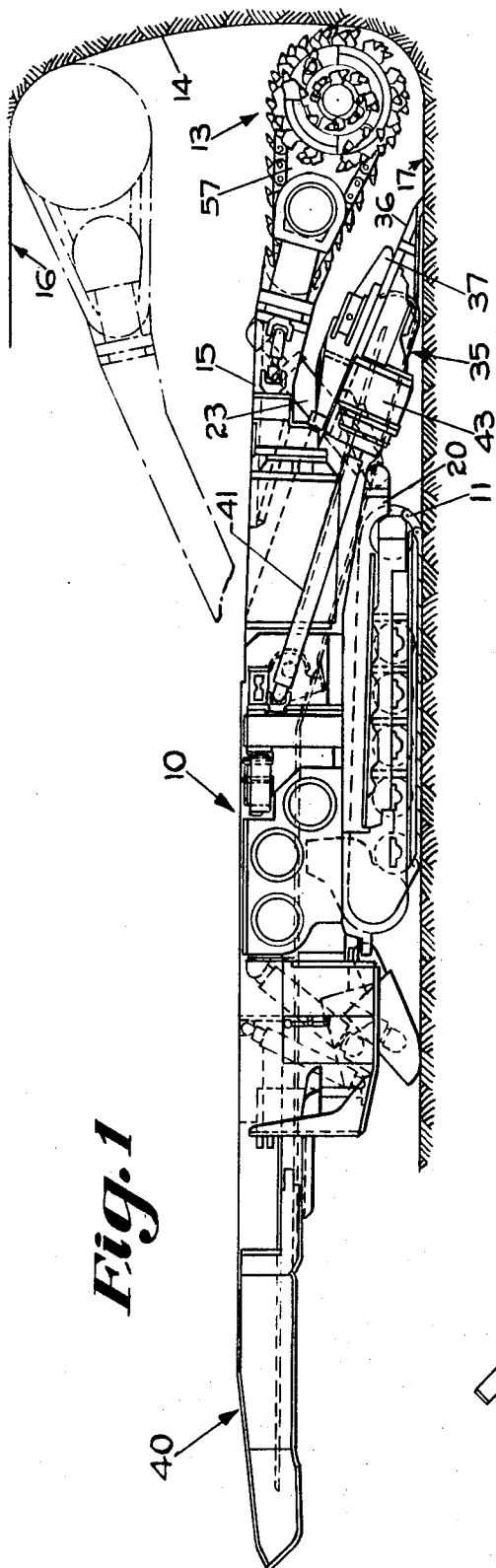


Fig. 1

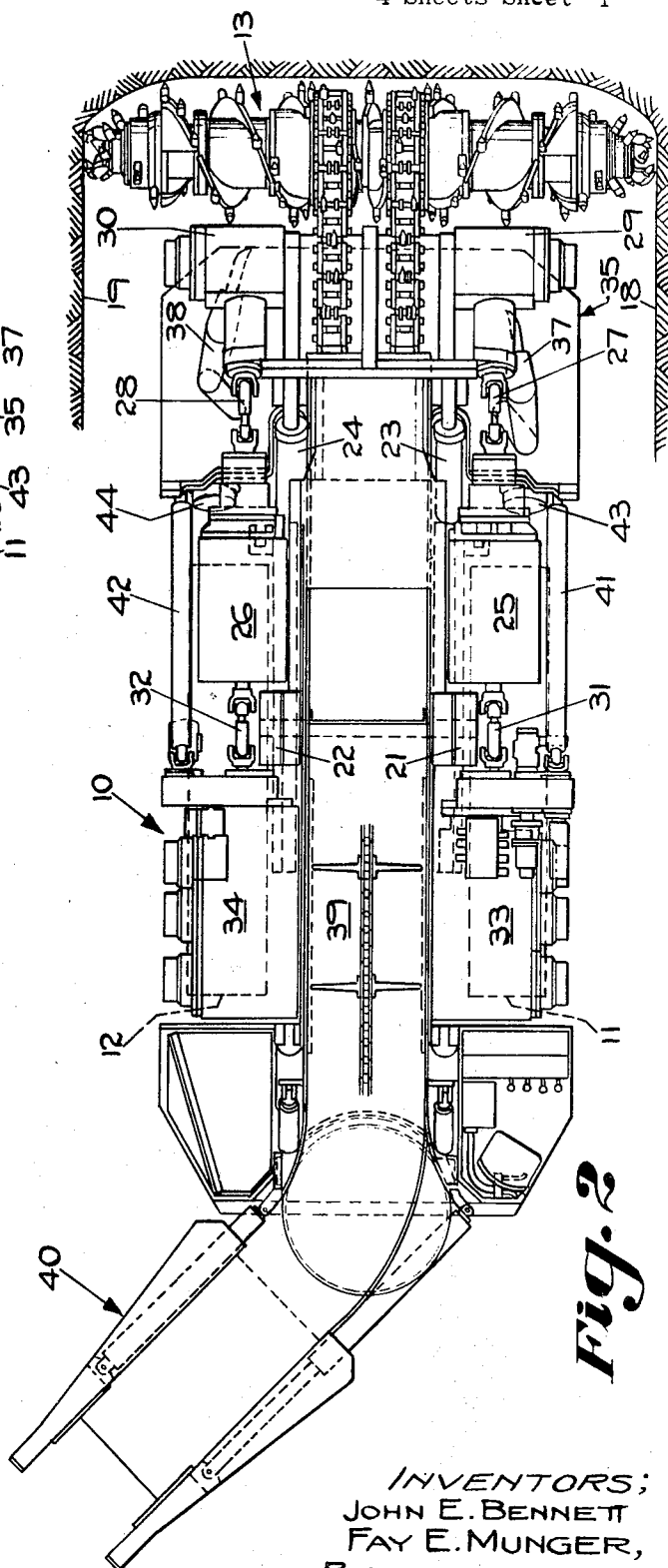


Fig. 2

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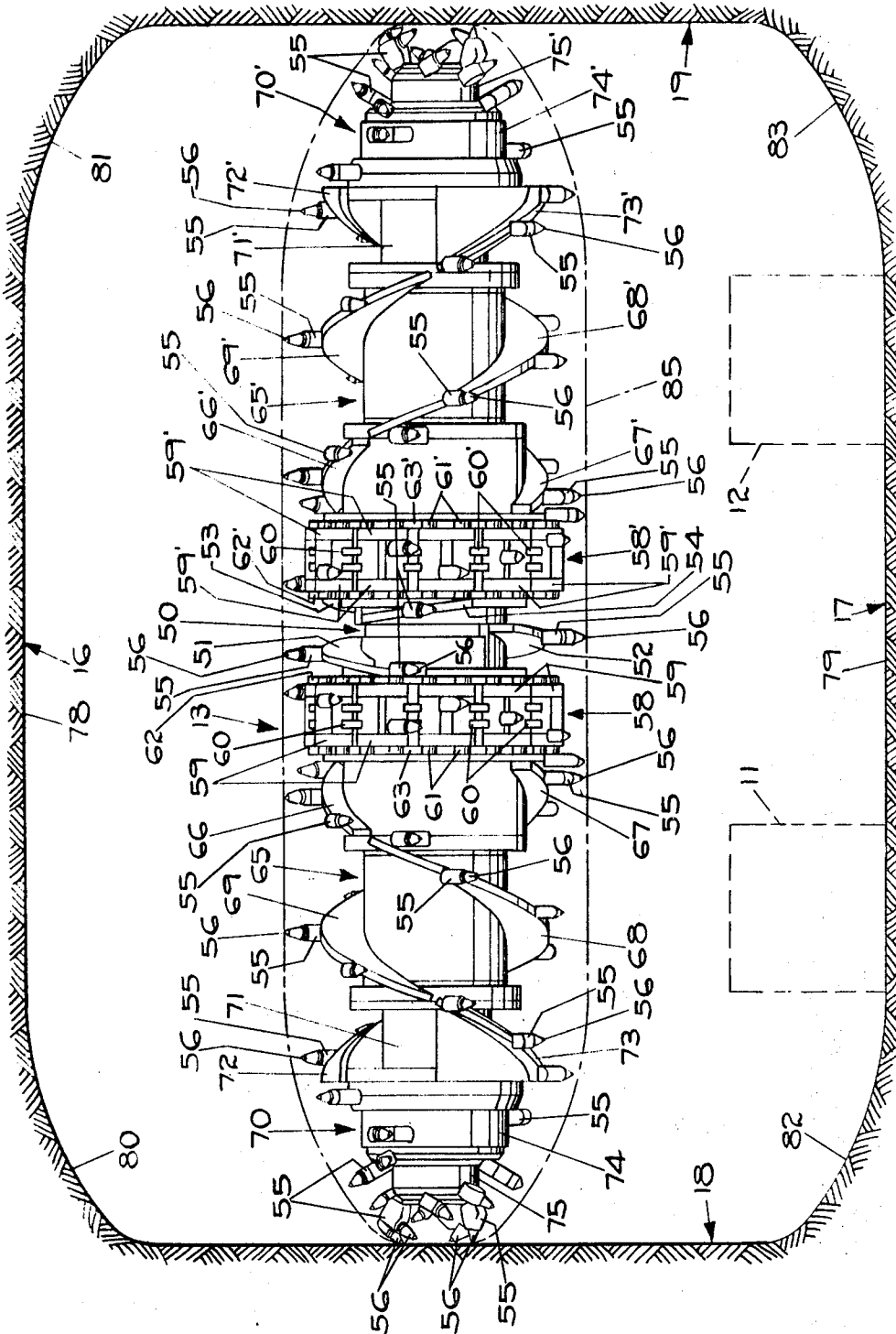


Fig. 3

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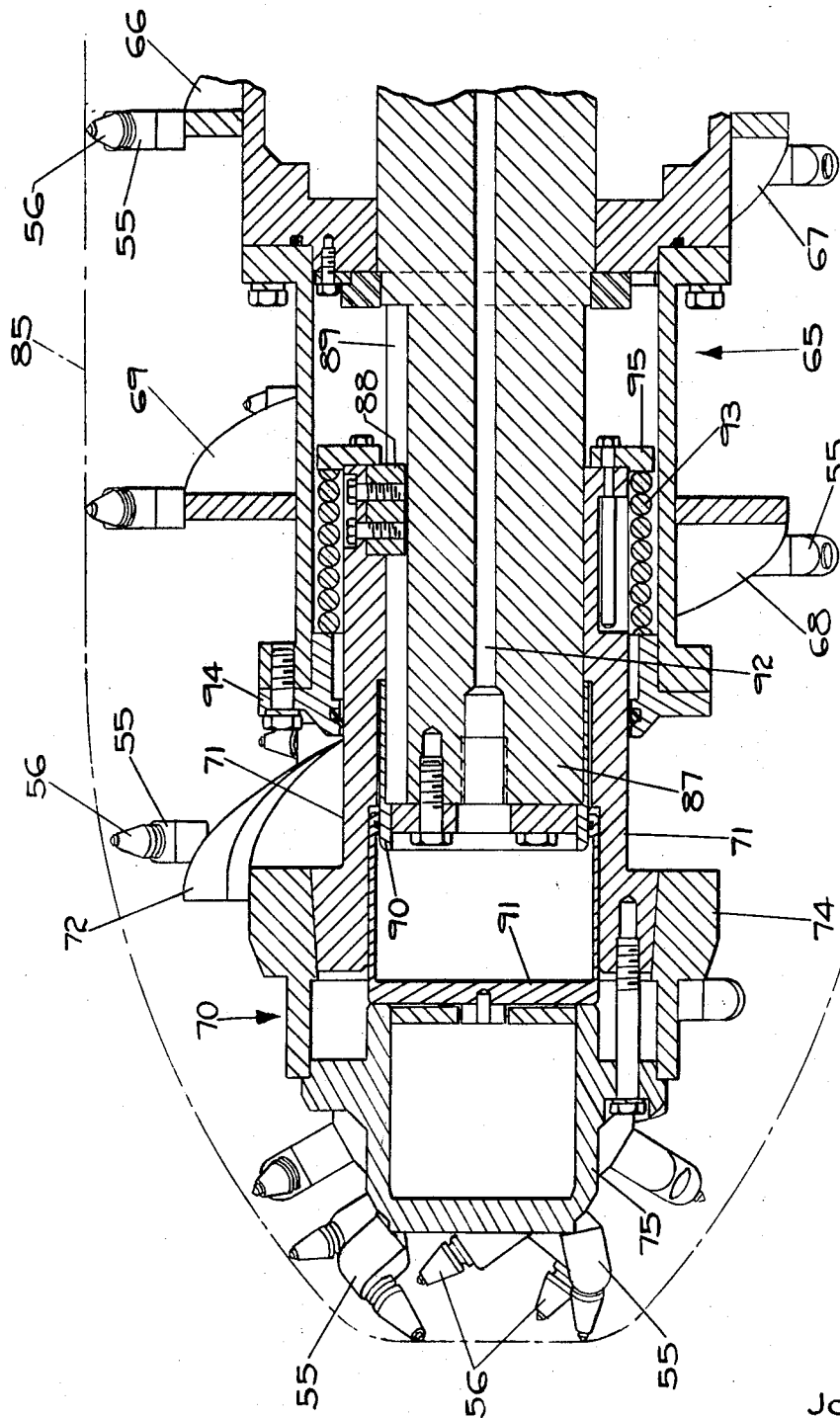
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MINING MACHINE FOR MINING MATERIAL FROM THE ENTIRE FACE

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11 Claims

ABSTRACT OF THE DISCLOSURE

A mining machine with a transverse rotary mining head to mine material from the entire area of the mine face by traversing the mining head through the mine face, and which produces a curved or arched form of the roof at each rib.

The instant invention relates to mining machines for mining material from the entire area of the mine face ahead of the mining machine.

In typical underground mining operations the material is mined from the mine face by a cutting and breaking action. The mining machine advances forwardly in the direction of the mine face to penetrate the face for the cutting and breaking action. It is a fundamental objective to mine the material at the highest rate, which is reflected in the rate of advance of the mining machine. The higher the rate that the material is removed from the mine face, the higher is the rate of advance of the mining machine.

The mining machine customarily has a mining head at its forward end, which is sumped into the mine face and mines the material by cutting and breaking. After the mining head is operated over the entire face area, the mining machine is advanced to again sump the mining head into the mine face and the operation is repeated. It is desired that the successive steps of advance be performed on a continuing basis, and the rate at which the material is mined from the mine face determines the rate at which the mining machine can be advanced for the successive steps of mining the material.

Another factor that affects the rate of advance of the mining machine is that of roof control. It is a serious problem in underground mining operations that as the mine face is advanced there is produced an exposed roof which was formerly supported by the material that has been mined from under the roof. This gives rise to the possibility of roof falls. Due to the nature of the geological strata, roof falls may involve tons of material, such as slate and rock, with the potential to cause personal injury and damage to the equipment. Therefore, great care is taken in underground mining operations to control the roof, with the purpose to avoid falls, and this is even subject to government regulations having the force of law.

In mining operations the roof may be controlled by the use of posts or props set between the floor and the roof as a substitute for the mined material, to provide vertical support. Another form of roof control is timbering in which timbers are set vertically, usually at the opposite ribs and another timber is laid across the tops of the upright timbers immediately below and bearing up against the roof. Wedges are driven in to force the cross timber against the roof in close contact to provide vertical support. Still another form of roof control is by roof bolting in which bolts with long shanks, of the order of three feet to four feet in length, are driven in above the roof and a plate is laid against the roof and held in place by a nut that is turned on the bolt. Roof bolting is advantageous because it permits

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greater flexibility in the placement of the roof supports than is the case with timbers, the roof bolts have considerably less bulk than the timbers, and therefore are easier to handle and do not occupy as much space as the timbers. The principle of roof bolting is to tie the strata immediately above the roof to more secure strata, thereby supporting the lower strata from higher firmer strata.

Any of the roof control systems are non-productive in nature, in that they do not directly produce mined material. The roof control procedures interrupt the actual mining operation, since the mining machine is stopped to permit roof supports to be installed. It is a limiting factor that the mining machine may not advance beyond a given distance under unsupported roof. Therefore, when the mining machine is advanced through this distance it must be stopped until roof supports are installed. Then the mining machine may resume its advance through the given distance, at which time there is another shut-down while the roof supports are placed. The distance that a mining machine may advance under an unsupported roof is usually relatively short, so that the production of the machine is materially affected by the necessary interruptions to install roof supports, and it is not possible to realize the full production capacity of the machine.

The mine face presents a face area which is bounded by the floor at the bottom, the roof at the top, and the ribs at the opposite sides, from which the material is mined. It is desired to remove the greatest volume of material from the mine face. Consonant with this objective the corners of the mine face would be cut square, to mine all the material between the boundaries of the floor, roof and opposite ribs. However, the square cut corners at the roof produce a poor condition from the standpoint of roof control. The roof control is improved in the case of boring machines which have large circular boring heads that advance into the mine face in the direction of the axes of the circular boring heads. The boring heads produce an arcuate configuration of the roof at each rib, which is a portion of the circle of the boring head. The physical effect of such arcuate configuration of the roof at each rib is similar to that in an arch in which the arch is self-supporting. However, the roof that is produced by the boring machines is not totally self-supporting, but there is a large measure of additional support for the roof stemming from the arched or curved configuration at the ribs. With this added measure of roof support it is possible to advance the mining machine through greater distances than would otherwise be the case before the machine is stopped for the installation of roof supports. This permits uninterrupted operation of the mining machine during longer periods of time, and materially improves the efficiency of the mining operation.

The boring type mining machine characteristically has a mining head which covers the entire face area. The mining head includes the circular boring heads and trimming cutting chains or trimming cutting bars which span the distance between the circular boring heads where the latter do not overlap. These trimming cutting chains or cutter bars provide a flat floor surface for the advance of the mining machine.

In another type of mining machine there is a rotary mining head which is considerably smaller than the area of the mine face from which the material is mined. The mode of operation is to sump the mining head into the material of the mine face, and then to traverse the mining head through the material to cut and break the material out of the mine face, and in this manner to cover the entire area of the mine face between the roof, floor and the opposite ribs. Such a mining machine is

illustrated in the patent to James Kilbourne, Pat. No. 3,305,273, Feb. 21, 1967, for Mining Apparatus Supporting and Driving Construction. The rotary mining head of the patent has a plurality of cutting bits disposed in a cylindrical form, which in the course of operating the mining machine produce square corners at the junctions of the roof with the opposite ribs. While this form of cutting head is effective to remove the greatest volume of material from the entire face area, it is not most satisfactory for roof control.

Accordingly, it is an object of this invention to provide a mining machine with a transverse rotary mining head, which produces a curved roof at each rib to improve the roof control.

It is another object of the invention to provide a mining machine with a transverse rotary mining head to mine material from the entire mine face by traversing the face and to form the roof with a curved or arched form at each rib.

It is a further object of the invention to provide an improved mining machine in which the mining head mines material from the entire mine face and produces a curved or arched form of the roof and floor at each rib with a substantially flat intermediate part of the roof and floor.

It is also an object of the invention to provide an improved transverse rotary mining head for traversing the mine face to mine material from the entire area of the mine face, in which each of the opposite ends of the mining head has a hemi-ovate form to form the roof with a curved or arched portion at each rib.

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

In the drawings:

FIG. 1 is a side elevation of a mining machine in accordance with the invention;

FIG. 2 is a plan view of the mining machine;

FIG. 3 is a front elevation view of the rotary mining head with an outline of the mine face area in which the material is mined;

FIG. 4 is an end elevation view of the rotary mining head; and

FIG. 5 is a section view of one end of the rotary mining head.

Referring to the drawings, there is illustrated in FIGS. 1 and 2 a mining machine 10 in accordance with the invention, supported on endless traction treads 11, 12 at opposite sides by which the machine is propelled. At the forward end of the mining machine 10 there is a rotary mining head 13, on a transverse axis, to be advanced or sumped into the mine face 14, and traversed through the material of the mine face, the mine material from the entire face area by a cutting and breaking action. The mining head 13 is supported on the forward end of a boom 15 by which it may be raised to the roof 16, sumped into the material of the mine face 14, and traversed through the material downwardly to the floor 16. The mining head 13 extends transversely between the opposite ribs 18, 19, and the latter define the side boundaries of the face area that is mined by the mining head 13. The mining head 13 is supported on the boom 15 at the forward end of the mining machine 10, for rotation of the mining head 13 about its transversely disposed axis.

The boom 15 is connected to the mining machine main frame 20 on transverse pivots 21, 22 on which the boom 15 is swung upwardly and downwardly by cylinders 23, 24, connected between the main frame 20 and the boom 15.

The mining machine 10 is powered by motors 25, 26 on opposite sides of the boom 15. Driving connections 27, 28 extend forwardly from motors 25, 26, respectively, to transmissions 29, 30, at opposite sides of the boom 15, from which the mining head 13 is driven. Pat. No.

3,305,273 illustrates in detail a form of the driving connections and transmissions by which the mining head 13 may be driven, in which the power of both motors 25, 26 is delivered to the entire mining head 13.

The motors 25, 26 also provide power for driving traction treads 11, 12. Drive connections 31, 32 extend rearwardly from motors 25, 26, respectively, to transmissions 33, 34 at opposite sides of the main frame 20 for delivering the drive to the traction treads 11, 12.

In the mining operation the material cut and broken out of the mine face 14 falls to the floor 17. There is a gathering head 35 at the front of the mining machine 10, below the boom 15. The gathering head 35 has an apron or deck 36 with its leading edge at the floor 17. Gathering arms 37, 38 at opposite sides of the gathering head 35 operate with an oscillating motion to reach down and to sweep the material into a conveyor 39 which extends longitudinally through the mining machine 10 from the gathering head 35 to the discharge boom 40 at the rear end of the mining machine 10. The conveyor 39 moves the mined material from the forward end of mining machine 10 to its rear end at which it is discharged to conveying apparatus for removing the mined material from the mining place. The gathering arms 37, 38 are powered by the motors 25, 26. Driving connections 41, 42 extend forwardly from transmissions 33, 34, respectively, to gathering head transmissions 43, 44, from which the gathering arms 37, 38 are driven.

In FIG. 3 there is a front elevation view of the rotary mining head 13. There is an intermediate section 50 of the mining head 13 with spiral flights 51, 52 at diametrically opposite positions, and additional spiral flights 53, 54. Several cutting bit holders 55, 55 are secured at spaced positions on the peripheries of the spiral flights 51, 52, 53, 54. A cutting bit 56 is releasably secured in each holder 55. The cutting bits 56 and their holders 55 are disposed at spaced positions in the circumferential direction and in the axial direction of the mining head 13, such that when the mining head 13 rotates, the cutting bits 56, 56 sequentially engage the material of the mine face at several positions across the mine face.

At the left side of the intermediate section 50 of the mining head 13, as viewed in FIG. 3, there is a cutting chain 58 extending around a gear case 57 at the forward end of the boom 15, that may be constructed in the manner of Pat. No. 3,305,273, and the gear case 57 forms a support for the mining head 13 on the boom 15 at the forward end of the mining machine. Such gear case supports 57 for the mining head 13 are each located at a position that is a substantial distance inward from the opposite ends or lateral extremities of the mining head 13 so that there is a free length of the mining head 13 that extends transversely outwardly in opposite directions from the gear case supports 57 along the transverse axis of the mining head 13. The path of cutting chain 58 is coincident with a major part of the circumference of the mining head 13, as best seen in FIG. 4. The chain 58 has a plurality of links 59, 59 with connecting links 60, 60, and articulated connections including pins 61, 61. The pins 61, 61 project from the opposite sides of the chain 58 to be engaged by a sprocket 62 on the intermediate mining head section 50 at one side of the chain 58, and another sprocket 63 at the other side of the cutting chain 58, which is secured to the outer mining head section 65. The sprockets 62, 63 rotate with the mining head 13 and by engagement with the outer ends of pins 61, 61 of the cutting chain 58 drive the latter concurrently with the rotation of the mining head 13, which may be generally in the same manner as in Pat. No. 3,305,273.

A plurality of cutting bit holders 55 are secured to the links 59, 60 of cutting chain 58 at spaced positions along and across the latter to provide a pattern of cutting bits 56, 56 in which they sequentially engage the material of the mine face 14 at spaced positions across the face,

as the cutting chain 58 is moved by rotation of the mining head 13.

The mining head 13 has an outer mining head section 65 at the left side, as viewed in FIG. 3, outboard of the cutting chain 58. Spiral flights 66, 67 are wound on one part of the mining head section 65 at diametrically opposite positions, and spiral flights 68, 69 are wound on another part of the mining head section 65 as continuations of the spiral flights 66, 67, respectively. A plurality of cutting bit holders 55 with their cutting bits 56, are secured to the outer mining head section 65 on the spiral flights 66, 67, 68, 69 at circumferentially and axially spaced positions to sequentially engage the material of the mine face 14 at spaced positions across the latter during rotation of the mining head 13.

Beyond the outer mining head section 65 there is an end mining head section 70 as an axial extension of section 65. End section 70 is connected to section 65 by a telescoping cylinder part 71 that may be extended and retracted relatively to section 65. The inner portion of the end section 70 in the area of telescoping cylinder part 71 has spiral flights 72, 73 wound at diametrically opposite positions as continuations of spiral flights 68, 69, respectively, when end section 70 is extended, as illustrated in FIG. 3. Several cutting bit holders 55 and their bits 56 are secured at spaced positions on spiral flights 72, 73, to sequentially engage the material of the mine face 14 at spaced positions across the latter. Beyond the spiral flights 72, 73, there is a collar 74 and an end cap 75 which are of successively lesser diameters towards the outer end of the end section 70. A plurality of cutting bit holders 55 and their bits 56 are secured to the collar 74 and to the end cap 75 at spaced positions in the circumferential and axial directions to sequentially engage the material of the mine face 14 at spaced positions across the latter. The disposition of the cutting bits 56 is best seen in FIGS. 3 and 4.

At the right side of the intermediate mining head section 50 there is another cutting chain 58' like the cutting chain 58, but oppositely disposed, and such cutting chain 58' and its parts are identified by the same reference numerals, with the addition of a prime ('). The right side of the mining head 13, as seen in FIG. 3, is the same as the left side, but the elements are oppositely disposed. The elements of the right side of the mining head 13 are identified by the same reference numerals as applied to the elements at the left side with the addition of a prime ('') to each reference numeral, and the description of the left side of the mining head 13 applies also to the right side of the mining head.

The cutting bits 56, 56 on the intermediate mining head section 50 and on the outer mining head sections 65, 65' are all at the same radius, and in rotating the mining head 13 these cutting bits 56, 56 move in the form of a cylinder. Likewise, the cutting bits 56, 56 on the cutting chains 58, 58' are disposed at the same radius so that they also move in the same cylindrical form in the portion of their paths which coincide with the mining head 13. These cutting bits 56, 56 moving in the cylindrical form, develop a flat intermediate surface 78 on the roof 16 and a flat intermediate surface 79 on the floor 17. Beyond the outer mining head sections 65, 65', the cutting bits 56, 56 which are on the end mining head sections 70, 70', are at positions of decreasing radial distances towards the outer end of the mining head 13. In the rotation of the mining head 13, the cutting bits 56, 56 on the end mining head sections 70, 70' move in a hemi-ovate form and produce curved or arched surfaces 80, 81 on the roof 16 downwardly to the rib 18 and to the rib 19, respectively. Similarly, the floor 17 is formed with a curved surface 82 up to the rib 18 and a curved surface 83 up to the rib 19. However, the flat intermediate surface 79 on the floor 17 is of sufficient width to accommodate the opposite traction treads 11, 12, as seen in FIG. 3, for move-

ment of the mining machine 10 on a flat part of the floor 17.

In FIG. 3 the total cutting profile of the mining head 13 is illustrated by the phantom perimetral line 85. The profile line 85 illustrates the equal radial distances of the cutting bits 56, 56 of the intermediate mining head section 50, of the outer mining head sections 65, 65', and of the cutting chains 58, 58', and the decreasing radial distances of the cutting bits 56, 56 on the end mining head sections 70, 70', which form the hemi-ovate end sections of the mining head 13. Such hemi-ovate end sections of the mining head 13 are formed along the free lengths of the mining head 13 extending from adjacent to the respective ribs 18, 19 transversely inwardly toward the supports 57 of the mining head 13 on the forward end of the boom 15. At each extreme end or lateral extremity of the mining head 13, the cutting bits 56, 56 are in a crown disposition, as best seen in FIGS. 3 and 4, and provide flattened ends of the opposite hemi-ovate sections of the mining head 13, to cut the ribs 18, 19.

Referring to FIG. 5, there is a shaft 87 extending axially through the mining head 13. The end mining head section 70 has its telescoping cylinder part 71 slidably mounted on the shaft 87 with a key 88 in a keyway 89. A slide collar 90 is secured to the outer end of the shaft 87, and a mating inner cylinder 91 is slidably engaged with the slide collar 90 in sealed engagement. A bore 92 extends through the shaft 87 to the inner cylinder 91. Hydraulic fluid is delivered through the bore 92 into the inner cylinder 91 to move the telescoping cylinder part 71 and the end mining head section 70 outwardly relatively to the shaft 87.

A coil spring 93 is disposed between the outer mining head section 65 and the telescoping cylinder part 71. A ring 94 is secured to the outer mining head section 65 abutting one end of spring 93, and a ring 95 is secured to the inner end of the telescoping cylinder part 71 abutting the other end of spring 93. In the extended position of the end mining head section 70, as seen in FIG. 5, the spring 93 is compressed between the rings 94, 95, and the end mining head section 70 is held in its extended position by hydraulic fluid trapped within the inner cylinder 91. The end mining head section 70 is retracted by release of the hydraulic fluid from the inner cylinder 91, and the force of the spring 93 between rings 94, 95 withdraws the telescoping cylinder part along the shaft 87 and within the outer mining head section 65. The telescoping ends of the mining head 13 establish the maximum width of cut between ribs 18, 19, since the crown ends of the mining head 13 abut ribs 18, 19. The opposite mining head end sections 70, 70' are retracted to provide clearance at the ribs 18, 19 for moving the mining machine 10 at other times than during the actual mining operation. During the mining operation the mining head 13 is driven, and when advanced into the mine face 14 it cuts its own clearance.

As illustrated herein, and particularly with reference to FIGS. 1 and 4, the mining head 13 is rotated in the clockwise direction so that the cutting bits 56, 56 engage the material in the mine face 14 in a descending direction. As viewed in FIG. 3, the cutting bits 56, 56 moved downwardly from top to bottom of the profile line 85. The removal of the material from the mine face 14 is a cutting and breaking action in which the cutting bits 56, 56 cut into the material, and concurrently, the cutting bits along with the several spiral flights break the material out of the mine face and it falls to the floor 17.

Initially, the boom 15 may be raised to place the cutting head 13 at the top of the mine face 14 adjacent the roof 16. The mining machine 10 is advanced on its traction treads 11, 12 to sump the rotating mining head 13 into the material of the mine face. Then the boom 15 is lowered, as the rotation of the mining head 13 is continued, to cut and break the material out of the mine

face 14 as the mining head 13 is traversed downwardly through the mine face to the floor 17. This procedure is then repeated for another cut by raising the mining head 13 to the roof 16 and sumping it into the mine face 14 for the next traverse through the material of the mine face 14.

In the mining operation the mining head 13 is effectively moved along the roof 16 so that the form of the roof 16 matches the form of the mining head 13 illustrated by the profile line 85 in FIG. 3. Thus, the roof 16 is exposed and formed with the curved or arched surfaces 80, 81 adjacent the ribs 18, 19, respectively. This improves the roof control by providing substantial intrinsic support for the exposed roof, and permits considerably greater advance of the mining machine 10 before it is necessary to stop and to interrupt the actual mining operation for the installation of roof supports. The mine floor 17 also is formed with curved or arched surfaces 82, 83 at the ribs 18, 19, respectively, and an intermediate flat surface 79 to accommodate the traction treads 11, 12 for movement of the mining machine 10.

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. A mining machine with a rotary mining head that is disposed at the forward end of the mining machine to cut and break material out of a mine face in a face area that is bounded by the floor at the bottom of the face, by the roof at the top of the face, and by the ribs at the opposite sides of the face, means to advance said mining head into the material of the mine face, a boom on the mining machine that extends forwardly, said boom including supporting means for said mining head on the boom at the forward end of said mining machine for the mining head to meet the mine face and to traverse said mining head through the material of the mine face in the face area between the floor and the roof, said mining head being disposed transversely across the forward end of said mining machine to rotate about one transverse axis, said supporting means for said mining head on said boom being located at a position that is a substantial distance inward from the opposite ends of the mining head so that there is a free length of the mining head that extends transversely outwardly in opposite directions from the mining head supporting means along said one axis, said mining head being at least as wide as the width of the remainder of said mining machine behind the mining head in order to cut the opposite ribs with sufficient distance between the ribs for movement of the mining machine between the ribs, each said free length of said mining head on opposite sides of said mining head supporting means having a substantially hemi-ovate form along the free length of the mining head extending from adjacent to the respective rib transversely inwardly toward said supporting means to produce an arched roof that arches downwardly to the rib at each side and to produce an arched floor that arches upwardly to the rib at each side.

2. A mining machine as recited in claim 1 in which said mining head includes means to extend and to retract a portion of said free length of the mining head including the hemi-ovate part of the mining head in the transverse direction in order to increase and to decrease the transverse width of the mining head between the opposite ribs.

3. A mining machine as recited in claim 1 in which said mining head has a substantially cylindrical form between the opposite hemi-ovate sections of the free lengths of the mining head in order to cut a substantially flat roof and floor between the opposite arched roof and floor portions, respectively.

4. A mining machine as recited in claim 1 in which said opposite hemi-ovate sections of the free lengths of said mining head are each terminated with a flat crown at the rib which cuts the material of the rib.

5. A mining machine as recited in claim 1, including spiral flights on the said mining head directed to feed mined material in toward the center of the mining machine, and cutting bits being mounted on said spiral flights to engage the material of the mine face.

6. A mining machine with a mining head that is disposed at the forward end of the mining machine to cut and break material out of a mine face in a face area that is bounded by the roof at the top of the face, by the floor at the bottom of the face, and by the ribs at the opposite sides of the face, said mining head being disposed transversely across the forward end of said mining machine and extending in a transverse direction, supporting means for said mining head that is disposed a substantial distance inward from the opposite ends of the mining head to provide a free length of the mining head at each side of said supporting means that extends along said transverse direction, means to advance said mining head into the material of the mine face, means to traverse said mining head through the material of the mine face in the face area between the floor and the roof, said mining head including opposite end sections of said free lengths of the mining head each of which has a substantially hemi-ovate configuration extending inwardly from said opposite ends of the mining head toward said supporting means to cut the roof and the opposite ribs and forming an arched roof that arches downwardly to the rib at each side.

7. A mining machine as recited in claim 6, including a forwardly extending boom for said supporting means, means in the mining machine to move said boom upwardly and downwardly, and said mining head is mounted on the forward end of said boom to be traversed through the material of the mine face by movement of said boom.

8. A mining machine as recited in claim 6, including a spiral flight wound around the mining head, cutting elements mounted on said spiral flight to sequentially enter the material of the mine face and the spiral flight moves the cut material inwardly towards the longitudinal centerline of the mining machine.

9. A mining machine as recited in claim 6, in which said opposite hemi-ovate end sections of the free lengths of said mining head are extensible and retractable to adjust the transverse width of the mining head between the opposite ribs.

10. A mining machine as recited in claim 6, in which said mining head includes a cylindrical mining head section intermediate said opposite hemi-ovate end sections of the free lengths of said mining head, and said opposite hemi-ovate end sections form transverse continuations of said cylindrical mining head section.

11. A mining machine as recited in claim 10, in which each of said opposite hemi-ovate end sections of the free lengths of said mining head has a substantially flat crown at the respective rib to cut the surface of the rib as the mining head is traversed through the material of the mine face.

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U.S. Cl. X.R.

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