Feb. 2, 1960 W. E. MARSHALL ET AL 2,923,536

IMPACT TYPE CUTTING DEVICE FOR EXCAVATING MACHINERY

Filed Aug. 25, 1958 4 Sheets-Sheet 1

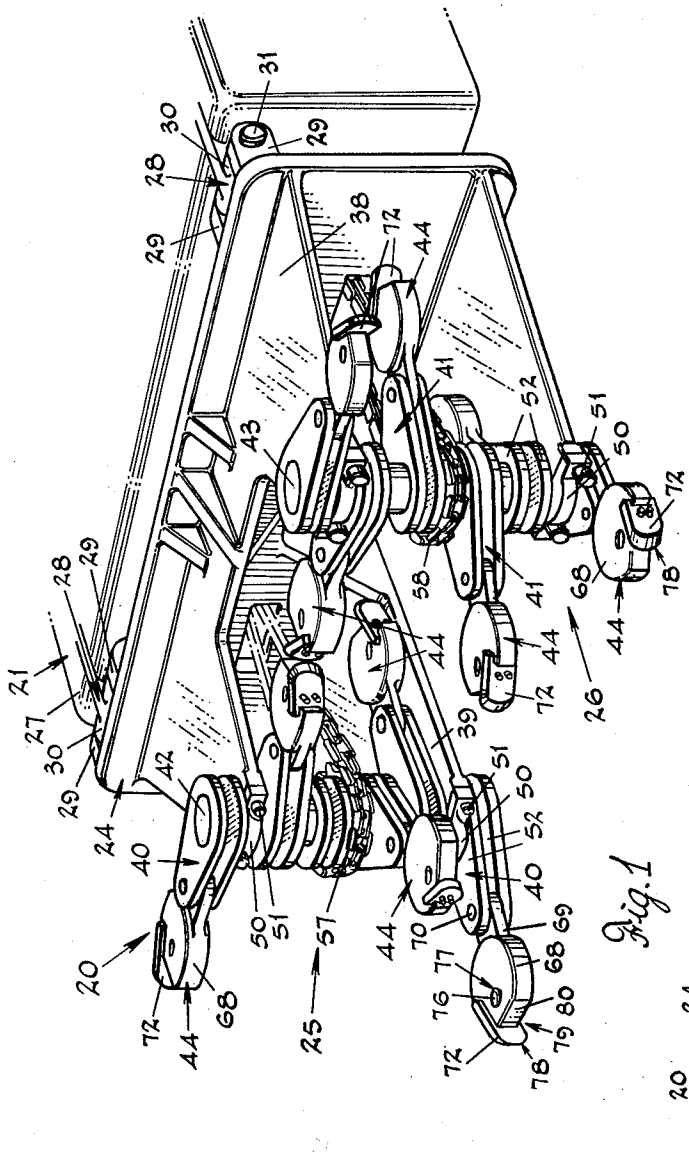

Fig. 1

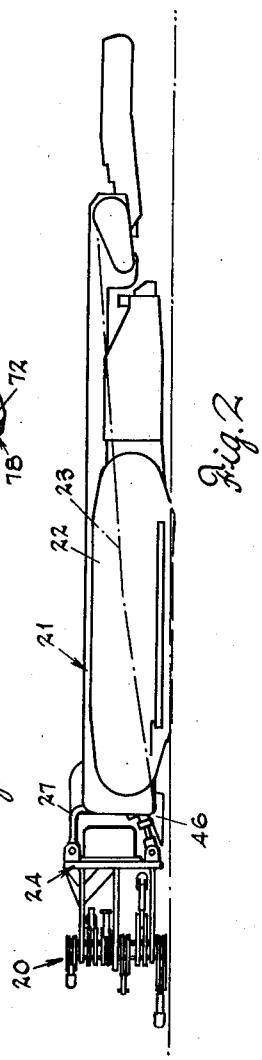

Fig. 2

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Filed Aug. 25, 1958 4 Sheets-Sheet 2

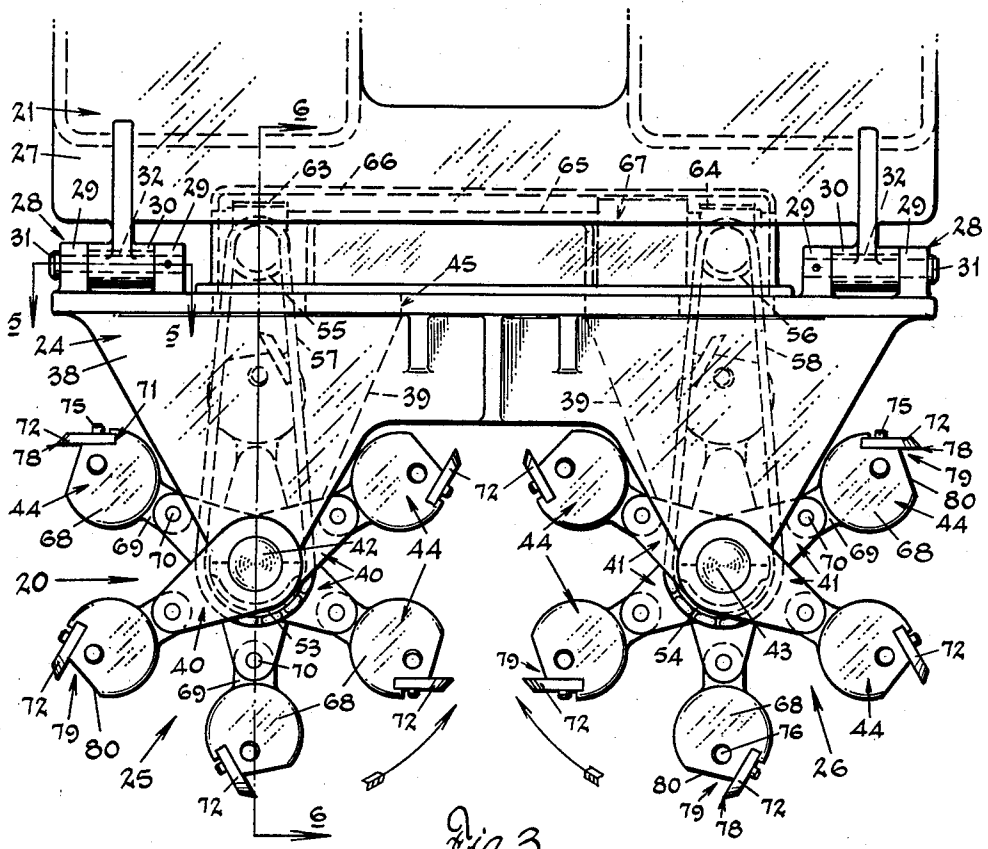

Fig. 3

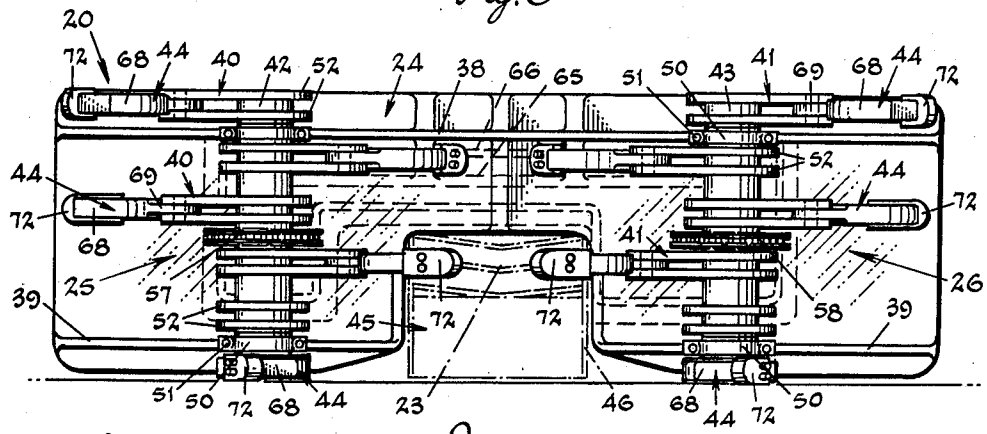

Fig. 4

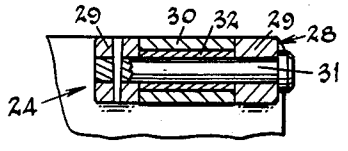

Fig. 5

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IMPACT TYPE CUTTING DEVICE FOR EXCAVATING MACHINERY

Filed Aug. 25, 1958 4 Sheets-Sheet 3

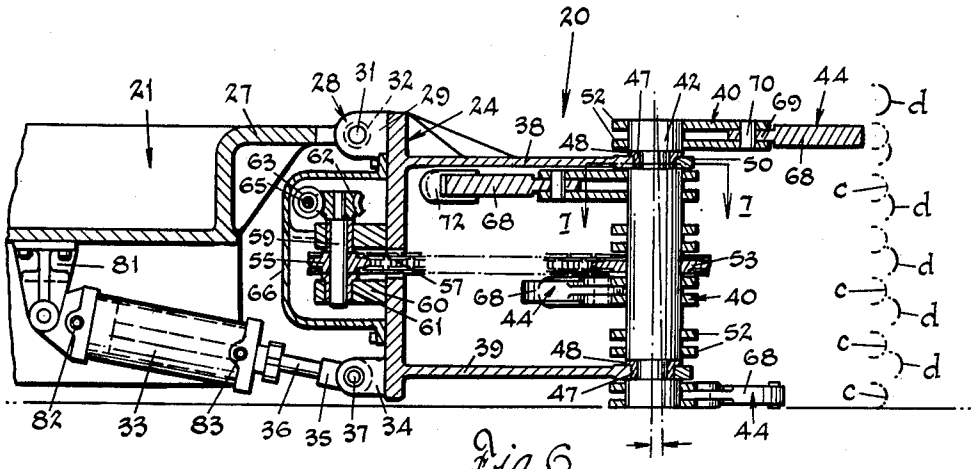

Fig. 6

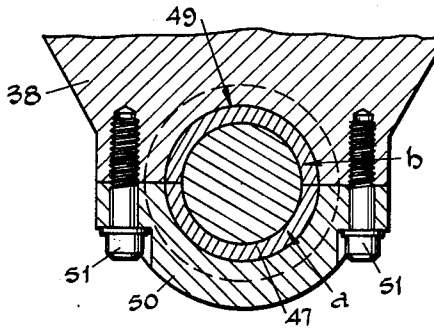

Fig. 7

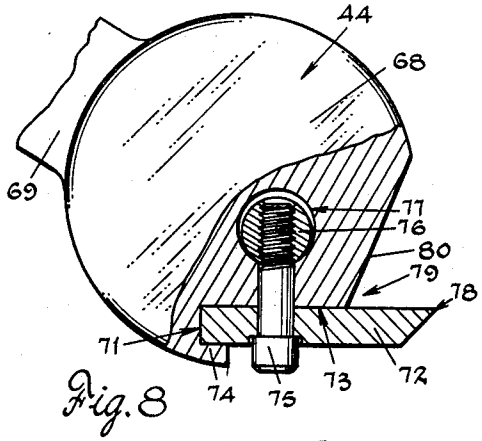

Fig. 8

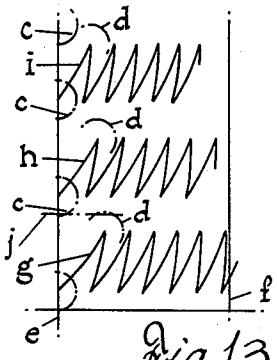

Fig. 13

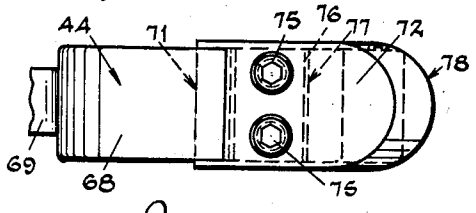

Fig. 9

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IMPACT TYPE CUTTING DEVICE FOR EXCAVATING MACHINERY

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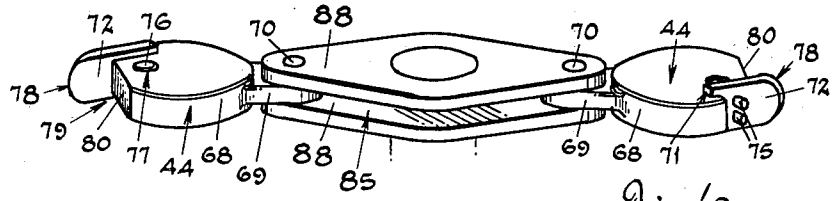

Fig. 10

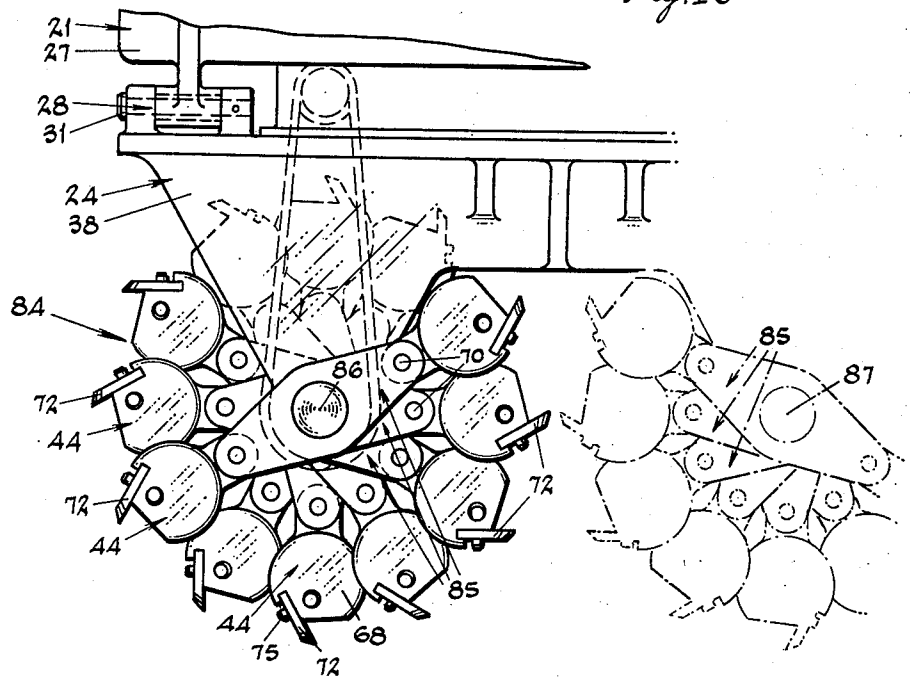

Fig. 11

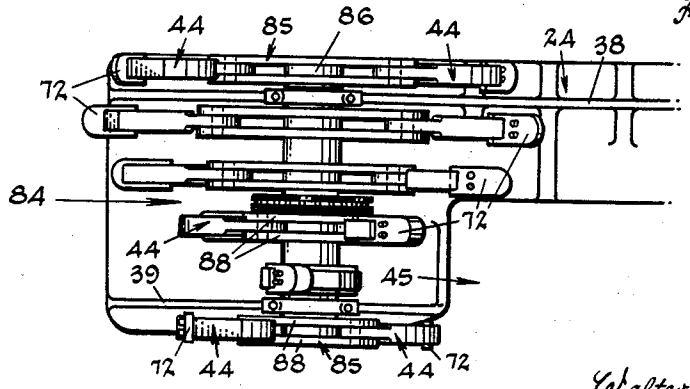

Fig. 12

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2,923,536

IMPACT TYPE CUTTING DEVICE FOR EXCAVATING MACHINERY

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Application August 25, 1958, Serial No. 756,877

10 Claims. (Cl. 262—6)

This invention relates broadly to the art of excavating earth materials, such as coal and like minerals, and is more particularly concerned with an improved apparatus for advancing a plurality of cutter elements in continuous forward and reciprocally directed motions.

According to this invention, an improvement in the cost and useful life of cutting devices for excavating machinery has been found in the provision of a novel cutting head which is centrifugally carried into a stratum or seam of coal or other ores at a relatively high rate of speed and at a high degree of impact. By employing several such heads in spaced relation, there will be a series of rapidly occurring impacts carried out in closely adjoining paths with a resultant shattering of the coal or other mineral deposits by transitory vibrations through the embedded mass of coal. However, to remove the problem of individual operation in substantially closed work paths, the several cutting heads are mounted in common to be reciprocally swung arcuately forwardly and rearwardly to the end that each cutter head carries out a rising and falling path of motion which, together with its motion in a circular path while it is being gradually urged forwardly, continually reduces the spaced relationship of the paths of the cutting tools. In other words, during the forward swinging motion of the cutter heads, each will repetitively cut into a thickness of coal that is reduced with each working stroke.

A principal object of the invention therefore is to provide an improved apparatus for excavating deposits of coal or like mineral ores which resides in the entry of the cutting tools into a coal vein in circular forwardly directed paths of motion and with the paths of motion being oriented to intersect the circular orbit of an adjacent path.

Another object of the invention is to provide an apparatus for excavating deposits of coal wherein a plurality of cutting tools, while traversing a circular orbit of motion at a relatively high rate of speed, are caused to engage said deposit of coal with centrifugally induced strokes of high impact.

Another object of the invention is to provide an apparatus of the above character in which during the forward motion of the cutting tools, they traverse circular orbits of motion in paths in substantially parallel planes while being carried reciprocally upwardly and downwardly whereby the centrifugally induced cutting path of one cutting tool will approach a plane through the path cut by an adjacent cutting tool.

Another object of the invention is to provide a novel cutting head for excavating deposits of coal which includes a plurality of cutting tools mounted to rotate through circular paths about reversely turning shafts to impart centrifugally induced strokes of high impact and with means for swinging said cutting tools whereby a rising and falling motion will be combined to correlate the cutting strokes of adjacent cutting tools.

Another object of the invention is to provide a cutter head having a plurality of radially arranged supporting

means and cutting tools rotatably carried thereon, and means for rotating the plurality of supporting means to centrifugally swing the cutting tools thereon into a coal deposit with a stroke of major impact.

A further object of the invention is to provide a cutter head for mining coal or like mineral deposits having a plurality of cutting elements adapted to be rotated at high velocities to develop maximum cutting impacts by individual centrifugally induced rotation.

A still further object of the invention is to provide a cutter head of the above character wherein a plurality of cutting elements are arranged in vertically spaced relation and rotated at high velocities to be centrifugally swung with considerable impact into the coal deposit and simultaneously reciprocally swung upwardly and downwardly whereby the thickness of a coal deposit remaining between each of the spaced cutting elements will be progressively reduced and continuously disintegrated by the upwardly and downwardly swinging movements.

Other objects and advantages of the invention will become apparent during the course of the following description when read in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

Fig. 1 is a perspective view of cutting apparatus constructed in accordance with the present invention;

Fig. 2 is a side elevation of the cutting apparatus shown in connection with a mining machine;

Fig. 3 is a plan view of the cutting apparatus;

Fig. 4 is a front elevation thereof;

Fig. 5 is a horizontal sectional view taken on line 5—5 in Fig. 3;

Fig. 6 is a vertical sectional view taken on line 6—6 of Fig. 3;

Fig. 7 is a horizontal sectional view taken on line 7—7 of Fig. 6;

Fig. 8 is an enlarged plan view of one of the cutting heads partly in section;

Fig. 9 is a side view of the cutting head;

Fig. 10 is a perspective view of a modified form of support arm for the cutting head;

Fig. 11 is a plan view of a cutting device in which the support arms of Fig. 10 are employed;

Fig. 12 is a front elevational view of the cutting device of Fig. 11; and

Fig. 13 is a diagrammatic view of the working path of the cutting tools.

As herein disclosed, the excavating cutter of the present invention is equipped with a plurality of radially disposed cutter heads which are caused to move in circular paths and at a high rate of speed. These cutter heads are arranged in reversely moving groups to the end that their combined cutting action is effective to not only progressively work into a vein of coal or like mineral across an area of considerable width but to collect the broken coal into a centrally disposed removal area. The work stroke of each cutter head is carried out in a highly effective impact due to centrifugally created motion in an upward as well as a forward direction. Then during the completion of each work stroke there occurs a downward and rearwardly directed course of motion that accomplishes rapid clearing of the work area.

Referring now to the drawings and particularly to Figs. 1 and 2, there is shown a cutter device constructed in accordance with the present invention and designated in its entirety by the numeral **20**. The cutter device **20** is rigidly mounted on the forward end of a mining machine **21** and by which it is carried forwardly into the seam or vein of coal to be removed. Excavating machines of the character herein disclosed schematically are well-known in the art and usually are equipped with for-

wardly moving caterpillar-type tractor belts 22 and a rearwardly moving and centrally disposed conveyor 23 which is adapted to collect the broken chunks or lumps of coal at the forward end of the machine and convey the same rearwardly to a point where it is deposited in conventionally employed cars.

The mining or excavating cutter device 20 is essentially comprised of a planular, vertically disposed frame or base 24 and cutter heads generally designated by the numerals 25 and 26. The frame 24 is carried on the forward end of the body or carriage 27 of the mining machine 21. According to our invention, the frame 24 is adapted to be mounted for vertical reciprocal movement relative to the carriage 27 and for this purpose is equipped with trunnions 28 having spaced pairs of ears 29 along its upper edge, which ears interfit with complementary ears 30 formed integral with and projecting forwardly from the carriage 27. The ears 29 are suitably drilled to receive stub axles 31 that are journaled in sleeves 32 fitted into the ears 30.

Associated with the frame 24 are suitable pneumatic pressure means, such as the cylinders 33 (Fig. 6), which operate to reciprocally swing the frame forward and rearwardly upon stub axles 31, which motions cause the cutter heads 25 and 26 to not only carry out their mining function, as the machine 21 is progressively moved forward by the tractor belts 22, but to also traverse arcuate paths that sequentially overlap adjoining areas to be worked. As will be more fully hereinafter disclosed, the cutter heads 25 and 26 accordingly completely cut into and disintegrate the coal deposit to be removed by upwardly and forwardly directed strokes and operate to remove the broken coal during the downwardly and rearwardly directed portions of their travel. To effect the swinging movements of the frame 24, it is provided on its rear surface and along the lower margin thereof with spaced pairs of ears 34 between which are received the outer ends 35 of piston rods 36 associated with the cylinders 33. Axles 37, supported at their ends in the ears 34, connect the ends 35 of the piston rods to the frame 24 (Fig. 6).

In the form of the invention shown in Figs. 1 to 6, the cutter heads 25 and 26 are mounted on the outer or forwardly directed surface of the frame or base 24 by means of horizontally disposed and integrally formed upper and lower flanges 38 and 39. More particularly, the cutter heads comprise spaced pairs of arms 40 and 41 fixedly mounted on vertically disposed shafts 42 and 43 respectively and supporting at their outer ends the cutter blade holders 44. As will be seen in Figs. 3 and 4, the vertical shafts 42 and 43 are adapted to be rotated in contra directions in order that the cutter holders 44 will be revolved in opposite directions through spaced orbits of motion whereby each will enter the coal deposit while being swung forwardly and then, while swinging rearwardly, will approach each other to guide the broken coal toward the entry end of the conveyor 23. For this purpose, the frame 24 may be centrally formed to provide a passageway 45 through which the broken coal can freely pass onto a gathering pan or trough 46 at the entry end of conveyor 23.

The shafts 42 and 43 are rotatably mounted on the flanges 38 and 39 by bearings 47 that are of the split sleeve variety and formed to function both as thrust bearings and rotary bearings. As shown in Fig. 7, the bearings 47 have similar half portions *a* and *b*, each of which has a flange 48 formed on the upper end thereof. The base flanges 38 and 39, as shown in Figs. 6 and 7, are provided with semi-circular cavities 49 in which the bearings are received and contained therein by retainer caps 50 mounted by bolts 51.

The cutter arms 40 and 41, carried by shafts 42 and 43, comprise spaced pairs of shaped plates 52 that are rigidly secured to the shafts in axially spaced relation between the ends thereof and project radially outwardly therefrom. As shown in Figs. 3 and 4, one example of such positioning, which is not intended to limit the scope of the invention, embodies arranging the several arms 40 and 41 in radially spaced relation from one another according to the number of pairs of diametrically aligned plates 52 to be mounted on the shafts.

As herein disclosed, six individual arms are arranged along the respective shafts 42 and 43 so that, in plan, as in Fig. 3, they will be radially disposed at included angles of about 60 degrees from one another. Also, the arms 40 and 41 are axially arranged so that the cutting actions carried out by the cutting tools mounted in the cutter holders 44 will be balanced between the ends of each shaft 42 or 43. For this purpose, the six arms of each cutter head 25 and 26 are arranged in three diametrically aligned pairs. Thus during one complete revolution, two cutting strokes will be made at the opposite ends of the shafts as well as medially therebetween. However, it is contemplated that as many as eight, ten or twelve arms may be employed according to the desired working height of the cutter. This will of course reduce the angular relation or radial spacing, without essentially changing the vertical spacing of the arms although this may be a matter of mechanical preference.

To maintain an equilibrium of shaft rotation, it has been found preferable to mount one of the arms 40 and 41 above the uppermost bearings 47, one of each arms beneath lowermost bearings 47, and the remaining arms equally between the bearings 47 and sprockets 53 and 54 on the shafts 42 and 43. Each of the suitably keyed sprockets 53 and 54 is coupled to a related drive sprocket 55 and 56 by means of chains 57 and 58 entrained thereabout. As will be seen in Fig. 6, sprockets 55 and 56 are mounted on similar vertical shafts 59 rotatably carried in brackets 60 by means of journal sleeves 61. Keyed to the upper end of each shaft 59 is a worm gear 62.

Now, since it is intended that the shafts 42 and 43 rotate in contra or reverse directions, the worm gears 62 are meshed with worms 63 and 64 fixedly mounted on a common shaft 65. The worms are provided with conventional spiral teeth formed "right" and "left" hand so that upon rotation of shaft 65, said worms will drive the worm gears 62 in opposite directions. This will rotate shaft 42 counter-clockwise, as viewed in Fig. 3, while the shaft 43 will be rotated clockwise. While not indicated in detail, the shaft 65 is suitably mounted by journals in the opposite end walls of a housing 66 and operatively driven by a suitable source of power, such as the motorized gear reduction unit 67.

Carried at the outer end of each arm 40 and 41 is a cutter blade holder 44 so mounted that rotation of the related arm will effect a centrifugally created cutting action. To this end, each cutter holder 44 comprises a substantially circular body 68 (Figs. 8 and 9) equipped with a radially extending lug 69 that is rotatably mounted between the plates 52 of the respective arms 40 or 41 by means of a vertical pin 70. The annular body 68 is notched or recessed as at 71 to receive the inner end of a cutting tool or blade or bit 72 of a suitable tool-hardened cutting steel.

The recess or notch 71, as seen best in Fig. 8, provides a flat base surface 73 which is disposed at a suitable angle, such as approximately 60 degrees, to an axial line through the center of the body 68 and the integrally formed lug 69 thereof. The surface 73 terminates at one end in the recess 71 which is provided with a short retaining flange 74 having its inner surface parallel to the base surface 73.

Each cutting element or bit 72 is secured to its related cutter head 68 by "stepping" one end of said bit into the recess 71 and securing the same therein by means of bolts 75, with the major length of the bit positioned against the base surface 73. The bolts 75 are threaded at their inner ends into a cylindrical plug 76 contained within a bore 77 provided in the body portion 68. The

plugs 76 are preferably slightly smaller in diameter than the bore 77 to enable easy insertion and to allow the same to freely move therein as the bolts are turned inwardly to secure the cutter blades. As well, the metal of the plugs is selected to reduce, if not eliminate, rusting or "freezing" of the bolts therein since it is recognized that under normal working conditions the equipment will be subjected to a considerable amount of water and/or ambient moisture.

The cutter elements or blades 72 are provided at their outer ends with a suitably shaped and ground cutting edge 78 which is disposed outwardly from the body 68 to present an adequate area of cutting surface. Ample clearance for the cutting edge 78 of the bit is afforded by a relieved area 79 formed in the body portion 68 of each cutter head by an inwardly directed surface 80. By mounting the cutter bits 72 in this manner, the "heel" end of each blade will be rigidly fitted into the cutter body 68 and held therein by bolts 75. Also during the working stroke performed by the bits, this manner of mounting will operate to resist any tendency toward loosening as the edge 78 of the cutting element is carried into the mineral vein with a high degree of impact.

The cylinders 33 (Fig. 6) are pivotally mounted by means of similar brackets 81 on the framework 27 of the mining machine 21. While not herein disclosed in detail, it is to be understood that the opposed cylinders are connected through flexible conduits indicated at 82 and 83, to a valve controlled source of fluid power to effect the desired swinging movement of the frame 24 through the piston rods 36. Preferably the valve for this purpose is an automatically reversible type so that continuous and alternative action of the cylinders during the mining operation is obtained. This action of the cylinders will produce forward and rearward swinging movement of the frame 24 to thereby carry or urge the cutter elements into the embedded coal deposit with a cushioning force of controllable magnitude.

As hereinabove described, the cutter device 20 of this invention includes a pivotally mounted frame 24 that is adapted to be carried forwardly by the tractor belts 22 of the mining machine 21 and simultaneously swung forwardly and rearwardly by the cylinders 33 upon shafts 31. The cutter heads 25 and 26, carried by the frame 24, are accordingly steadily urged forwardly into a seam or vein of coal with the cutting bits 72 thereof describing operative strokes in spaced circular paths during which the cutter bodies 68 are caused to swing upon pins 70 under a centrifugal force and thereby disintegrate the coal with considerable impact. Due to the novel mounting of the cutting tools the heretofore commonly experienced damage to the tools will be herein obviated since, while the cutter bodies, by reason of their weight, will actively force the bits 72 into the coal, in the event that a harder mineral seam is encountered, the body 68 will swing freely rearwardly on its pin 70 thereby by-passing the section of hard mineral. Also, by reason of the novel features of this invention, the circular working paths of the cutters, indicated at *c* in Fig. 6, which are in equally spaced planes are not the actual cutting areas through which the cutting bits 72 are carried. Thus, as indicated by the paths *d*, the frame 24, in being reciprocated forwardly, actually causes the bits to move simultaneously upwardly during the cutting or disintegration of the coal. Upon comparison of the paths *c* and *d*, it becomes quite apparent that each cutter, in successive revolutions, gradually undercuts the working areas of the adjoining bits.

In considering more specific aspects of a mining machine embodying the novel features of this invention, it is believed that the practical utility thereof will become readily apparent. As graphically indicated in Figs. 6 and 13, and by way of example only without imposing any restriction on the invention, the cutting heads 25 and 26 are adapted to carry the cutting tools 72 thereof about circular paths substantially 58 inches in diameter. As viewed in Fig. 3, the combined working areas therefore cut an area having a width of approximately nine feet, nine inches. Simultaneously, the amount of coal removed would result in a cut area having a height of slightly less than three feet, in the event that the cutter blades or bits 72 are caused to traverse substantially spaced circular paths; each being in a generally horizontal plane as indicated at *c* in Fig. 6. However, one of the important advantages of the invention resides in the fact that while the blades 72 are rotated through their spaced circular paths, the frame 24 is swung reciprocally forward and backward which causes the blades to actually follow an upwardly directed arcuate path of sufficient length as to progressively undercut and "work-out" the margin of coal normally untouched by cutting devices working in closed circuitous paths. This greatly reduces the amount of resistance that is encountered by each cutting blade since the adjoining blades, either disposed above or below, will have gradually reduced the amount of coal deposit remaining therebetween. Under normally expected conditions, the swinging of the frame 24, by means of cylinders 33, through a relatively small arc or angle, as for example from 2 to 5 degrees, will achieve this end. That is to say, each blade will traverse an upwardly directed stroke which will "work-out" coal in a span of 5 or 6 inches or any preferred distance between the blades in their mounted relation.

As herein disclosed, each cutter head 25 and 26 is provided with six cutting tools 72 carried by arms 40 or 41 that are fixed to the respective shaft 42 or 43. The arms are arranged in pairs that are diametrically aligned so that there will be a radial spacing of about 60 degrees between adjacent pairs of arms. At least three cutting blades or bits 72 will be maintained in the working area and carrying out the cutting operation while the remaining cutting blades will be in a substantially non-cutting position. By means of this arrangement, during a complete cutting cycle, or upon one full rotation of the shafts 42 and 43, an upwardly and downwardly spiralling cutting action will be effected. This operates to maintain an equilibrium of balance during rotation of the shafts 42 and 43 which greatly reduces, if not eliminates, vibratory wearing of the bearings in which they are journaled.

Now the actual force of the cutting stroke of each cutting tool, as aforementioned, is produced by rotation of the arms 40—41 at a high rate of speed which causes the cutter holders 44 to be centrifugally swung to carry the attached cutting bits 72 into the coal deposit with a considerable impact. This centrifugal force, by way of example, is induced by the mass or weight of the cutter holder 68 and the distance thereof from the axis of the respective shaft 42 or 43. By way of example, where each cutter holder is approximately 10 inches in diameter and 2 inches thick, it will have a weight of about 44.5 pounds. The radial length of the arms 40—41 will be about 13 inches to pin 70 and 9 inches to the center of mass of the cutter holder 68. This will establish an over-all radius of 29 inches at the cutting edge 78 and consequently a circularly described work path of approximately 58 inches. Thus, it may be determined that when the shafts 42—43 are rotated at approximately 200 r.p.m., there will be a potential force of 770 foot pounds with which each cutting blade will be directed into the mineral or coal deposit. This amount of force has been found entirely adequate to disintegrate a vein of solid coal. During the mining operation, each blade is not responsible for a cutting action equal to its entire width but only that portion of the cut encountered as the frame 24 is swung forwardly to urge the cutting blades arcuately upwardly into an exposed undersurface of the remaining coal and until the working area of the adjacent blade above it is approached. In the event that any of the cutting blades encounters a harder vein of mineral that it cannot dislodge, the cutter holder will be permitted to swing rear-

wardly about pin 70 to allow the cutting blade to pass beyond the harder vein of material.

The graph shown in Fig. 13 depicts the lines of motion generated by a plurality of cutting blades 72 when arranged as shown either in Figs. 3 and 4. As the mining machine 21 is propelled forwardly at a rate of about 10 inches per minute, as from vertical line *e* to line *f*, and the frame 24 is swung forwardly six times during the same period, the highest and lowest points in the movement of the blades 72 will produce rising and falling curved cutting paths as indicated at *g*, *h*, and *i*. It will also be noted that the highest point of each path approaches or passes through the lowest point of the path of the cutter immediately thereabove as indicated by the horizontal line *j*.

By varying the rate of forward motion of the machine or the rate of reciprocal motion of the cutters, the generated lines *g* to *i* inclusive will of course vary in their generated curves. It is likewise to be expected that a cutting stroke will be carried out during the rising sectors of each curve and while the cutting blades are rotating forwardly and that a clearing and coal removing action will occur when the cutters are rotating rearwardly in a downwardly directed course. Since the shafts 42 and 43 are rotatably driven in contra or reverse direction, the combined action of the rearwardly rotating cutting blades will effect a directing operation to carry the broken coal into the entry end of the conveyor 23 by which the coal is carried to cars at the rear end of the mining machine.

While the lines *g* to *i* inclusive have been illustrated as continuous rising and falling curves, it will be appreciated that according to the invention disclosed particularly in Figs. 3, 4 and 6, each cutting tool 72 carries out approximately ten forwardly and arcuately directed work strokes in the event that, as above stated, the frame 24 is reciprocally swung six times during ten inches forward movement of the cutters.

In Figs. 10, 11 and 12 is disclosed a modified form of cutter device 84 which is provided with diametrically arranged cutter holders 44 whereby two work strokes will be carried out by any of the vertically spaced arms 85 and during one full rotation of the shafts 86 and 87 on which they are fixedly mounted. Such a structure can be used to advantage in mining operations which require considerably more cutting effort to be exerted. This is particularly true in mining or excavating harder minerals than coal and which characteristically have a greater resistance to disintegration.

For this purpose, the arms 85 may be formed by pairs of spaced plates 88 that are equipped at their diametrically opposed ends with suitably aligned openings for receiving the axle pins 70 on which the cutter holders 44 are mounted. Two cutter holders will accordingly traverse the same circular cutting path. This will materially reduce the active cutting or disintegrating effort of each cutting tool since actual width of mineral deposit to be removed by a cutting blade or bit during its circular and upwardly induced path of movement will be acted upon by two such cutting tools; one operating to progressively produce a cutting stroke slightly above the other tool operating in the same working path.

As viewed in Figs. 11 and 12, it will become apparent that by reason of the fact two cutter holders 44 are rotatably mounted on each arm 85, the radial or angular spacing of such modified arms will be reduced to the end that whereas the arms 40 or 41 of Figs. 3 and 4 appear in plan to be radially arranged at an angle of approximately 60 degrees from one another, the arms 85 will be arranged at a lesser angle as for example of about 30 degrees. Accordingly a greater amount of material can be removed during each rotation of the cutter heads without materially increasing the power factors required to carry the cutter device 84, generally forwardly and to drive the cutter arms thereof in circular paths while simultaneously reciprocally moving the same.

Referring again to Fig. 13, the curved paths of movement, indicated by lines *g* to *i* inclusive, will generally be the same when two cutter holders 44 are mounted according to the modified form of cutter heads shown in Figs. 11 and 12, and the efficiency of the cutter heads will practically be doubled by reason of the fact that there will be substantially two work strokes carried out in about the same path of circular cut. Since the double cutting action will reduce the amount of coal or other minerals engaged by the cutter blades on any of the arms 85, it will become apparent that less resistance to disintegration will be encountered in the mining of hard minerals and as a comparably more rapid mining of coal can be effected.

While the utility of the cutter device of this invention has been particularly described in connection with the continuous mining of such deposits as coal, analogous uses will be found in the removal of minerals having relatively softer physical characteristics and even seams of a more or less rock and earth formation. Thus the cutter device may be employed to similar advantage in the continuous excavation of clay or dirt and rock substances in the preparation of a subterranean tunnel or like passageway. Likewise, excavations at surface levels can be made to remove coal deposits according to such methods known as "strip mining." Otherwise, where desired, surface level excavation work can provide substantially rectangularly formed ditches or other openings.

It is to be understood that the forms of the invention herewith shown and described are to be taken as illustrative embodiments only of the same, and that various changes in the shape, size and arrangement of parts, as well as various procedural changes may be resorted to without departing from the spirit of the invention of the scope of the subjoined claims.

We claim:

1. An apparatus for excavating materials, comprising a cutter head, means for mounting said cutter head to rotate about a substantially vertical axis, a plurality of tool holders carried by said cutter head for free turning movement about substantially vertical axes, a cutting tool carried by each holder, means for rotating said cutter head to cause the cutting tools carried by said holders to be urged by centrifugal force into cutting engagement with the material to be removed, and means for swinging the cutter head forwardly and rearwardly through a vertical arcuate path simultaneous with the rotation thereof.

2. An apparatus for excavating materials as claimed in claim 1, in which the first-mentioned means includes a frame mounted for pivotal movement about a substantially horizontal axis and on which the said cutter head is mounted for rotation about a vertical axis.

3. An apparatus for excavating materials as claimed in claim 2, in which the frame is pivotally supported along its upper end, and the means for swinging the cutter head forwardly and rearwardly includes a hydraulic cylinder and a piston rod associated therewith, and means operatively connecting one end of the piston rod to the frame for swinging said frame about a substantially horizontal axis to move the said cutter head forwardly and rearwardly through a vertical arcuate path simultaneous with the rotation thereof.

4. An apparatus for excavating materials as claimed in claim 1, in which the cutter head includes a vertically disposed shaft and support arms for the tool holders carried by said shaft, said support arms being equally spaced along said shaft between the ends thereof and in radially angular relation to one another, with each alternate support arm being arranged in diametrical alignment with an adjacent arm.

5. An apparatus for excavating materials as claimed

in claim 4, in which the support arms are so located upon said shaft that the distance of forwardly and upwardly swinging movement of each of the cutting tools while in cutting engagement with the material to be removed is at least equal to the spacing between the cutting tools on said shaft.

6. An apparatus for excavating materials as claimed in claim 1, in which the cutter head includes a vertically disposed shaft and support arms for the tool holders carried by said shaft, said support arm being equally spaced along said shaft between the ends thereof and in radially angular relation to one another, the diametrically opposed ends of each support arm being equally spaced from the axis of said shaft and a tool holder being pivotally mounted on each end of each support arm for free swinging movement about a vertical axis.

7. An apparatus for excavating materials, comprising a pair of cutter heads, means for mounting said cutter heads in side-by-side relation to rotate about substantially vertical axes, each of said cutter heads including a plurality of horizontal support arms, a tool holder carried by each of said support arms for free turning movement relative thereto about a vertical axis, a cutting tool carried by each holder, means for rotating said cutter heads in opposite directions to cause the cutting tools carried by said holders to be urged by centrifugal force into cutting engagement with the material to be removed, and means for swinging said mounting means forwardly and rearwardly to move the cutter heads through vertical arcuate paths simultaneous with the rotation thereof.

8. An apparatus for excavating materials as claimed in claim 7, in which the last-mentioned means includes a pair of hydraulically operable cylinders and piston rods associated therewith, and means operatively connecting one end of each piston rod to the said cutter mounting means to swing the said cutter heads forwardly

and rearwardly through vertical arcuate paths simultaneous with the rotation thereof in opposite directions.

9. An apparatus for excavating materials, comprising a vertically disposed supporting frame hinged along its upper edge and having forwardly directed horizontally disposed flanges, a pair of cutter heads arranged side by side, each including a vertically disposed shaft rotatably supported in said flanges, a plurality of horizontal support arms fixed to each shaft, a tool holder carried by each of said arms for free turning movement about a substantially vertical axis, a cutting tool carried by each holder and having a cutting edge facing in the direction of rotation of the respective cutter head, means for rotating said shafts in opposite directions to cause the cutting tools carried by said holders to be urged by centrifugal force into cutting engagement with the material to be removed, means for swinging said supporting frame forwardly and rearwardly about its upper edge to move the cutter holders and cutting tools carried thereby through a vertical arcuate path simultaneous with the rotation thereof, and means for moving the cutter heads bodily forwardly.

10. An apparatus for excavating materials as defined in claim 9, in which the support arms for the tool holders are equally spaced along each of said shafts between the ends thereof and in radially angular relation to one another.

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