

July 9, 1957

H. F. SILVER

2,798,706

METHOD OF MINING COAL OR OTHER MINERALS FROM THE
SOLID WITH DEEPLY PENETRATING BITS

Original Filed Feb. 27, 1948

9 Sheets-Sheet 1

Fig. 1.

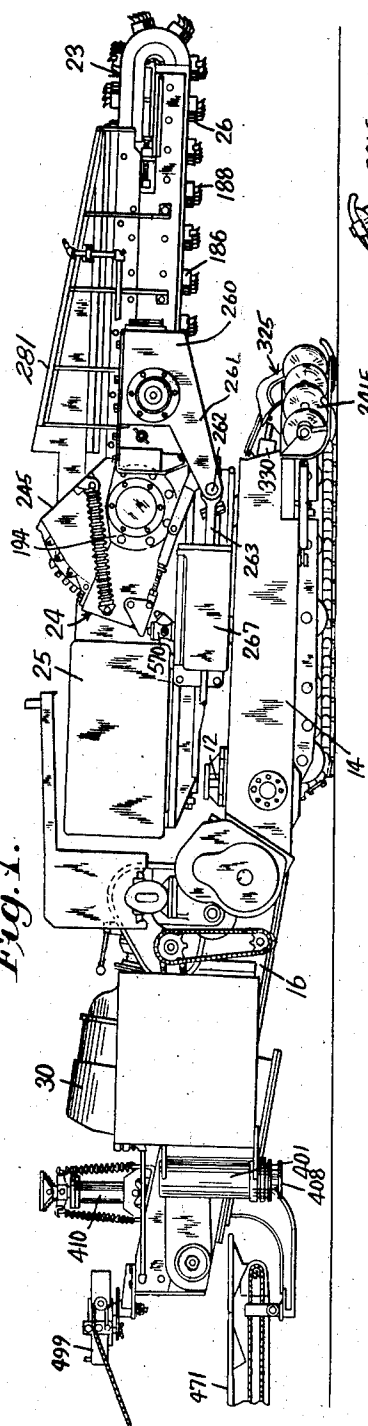
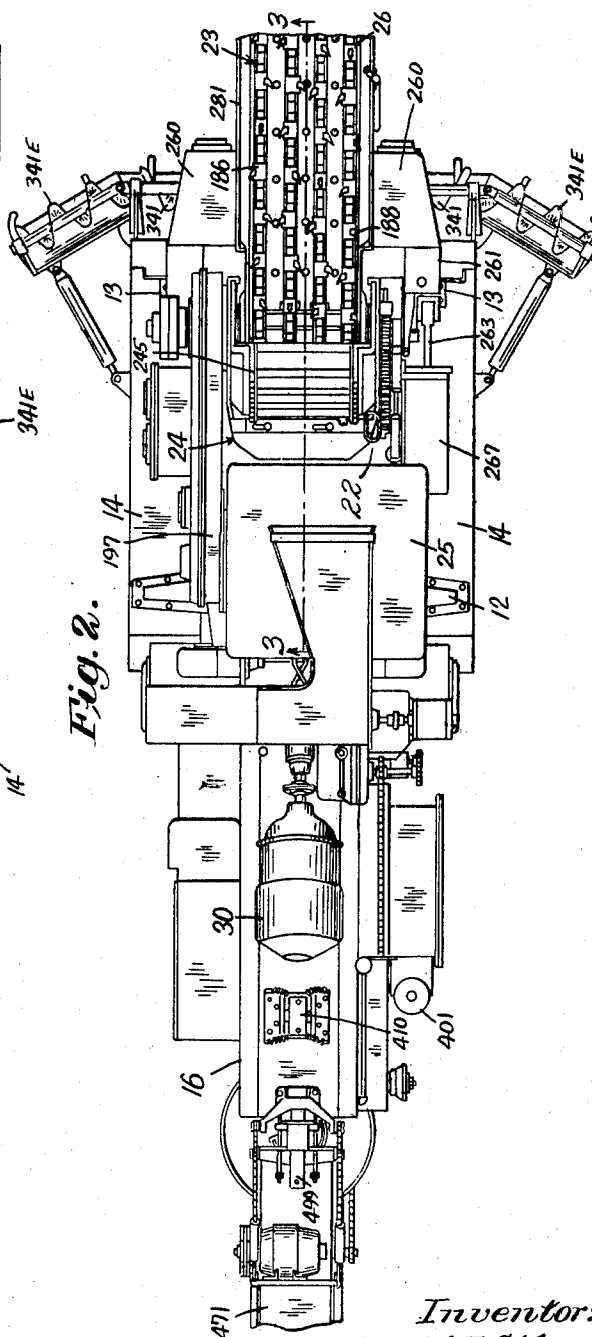


Fig. 2.



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9 Sheets-Sheet 2

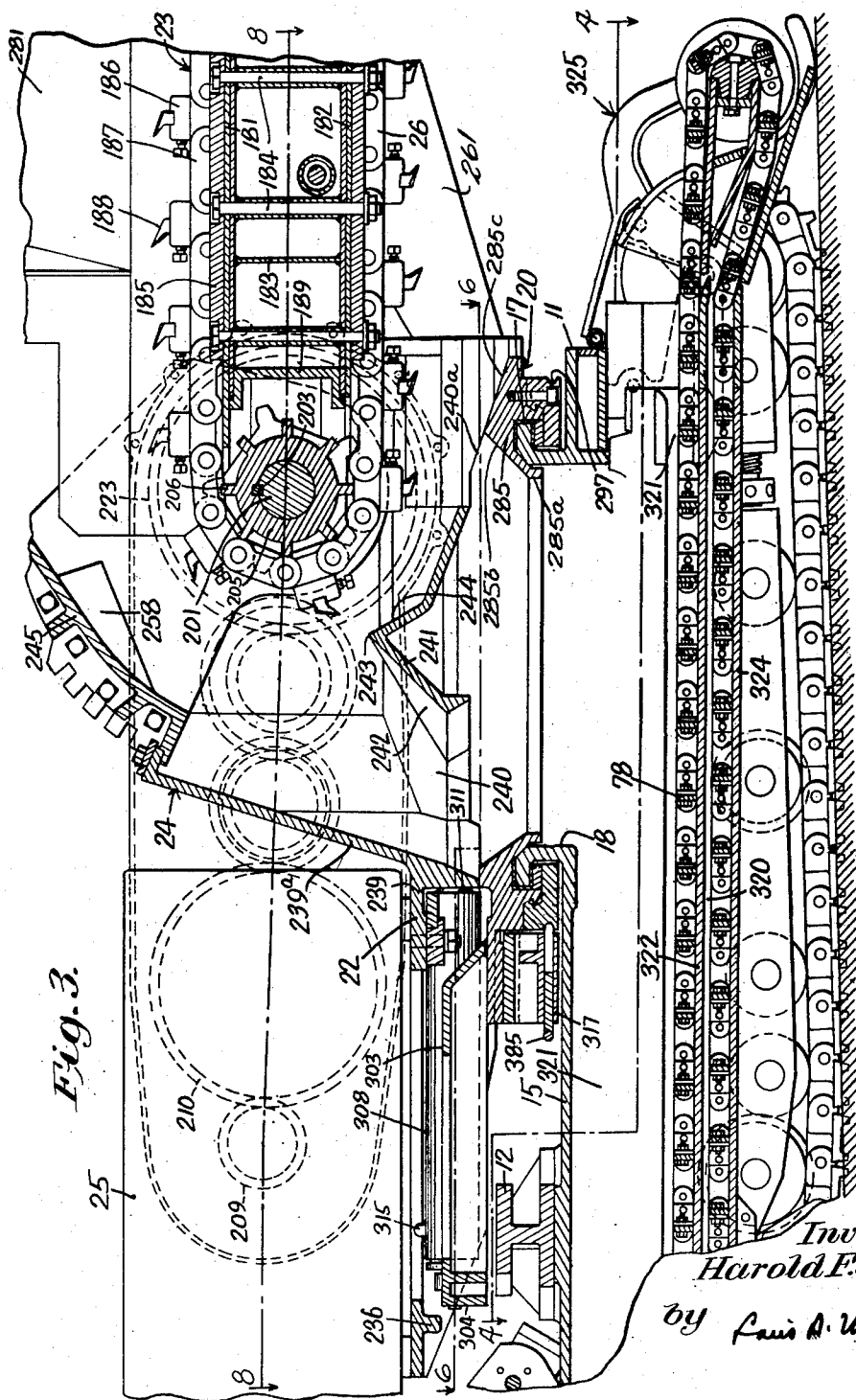


Fig. 3.

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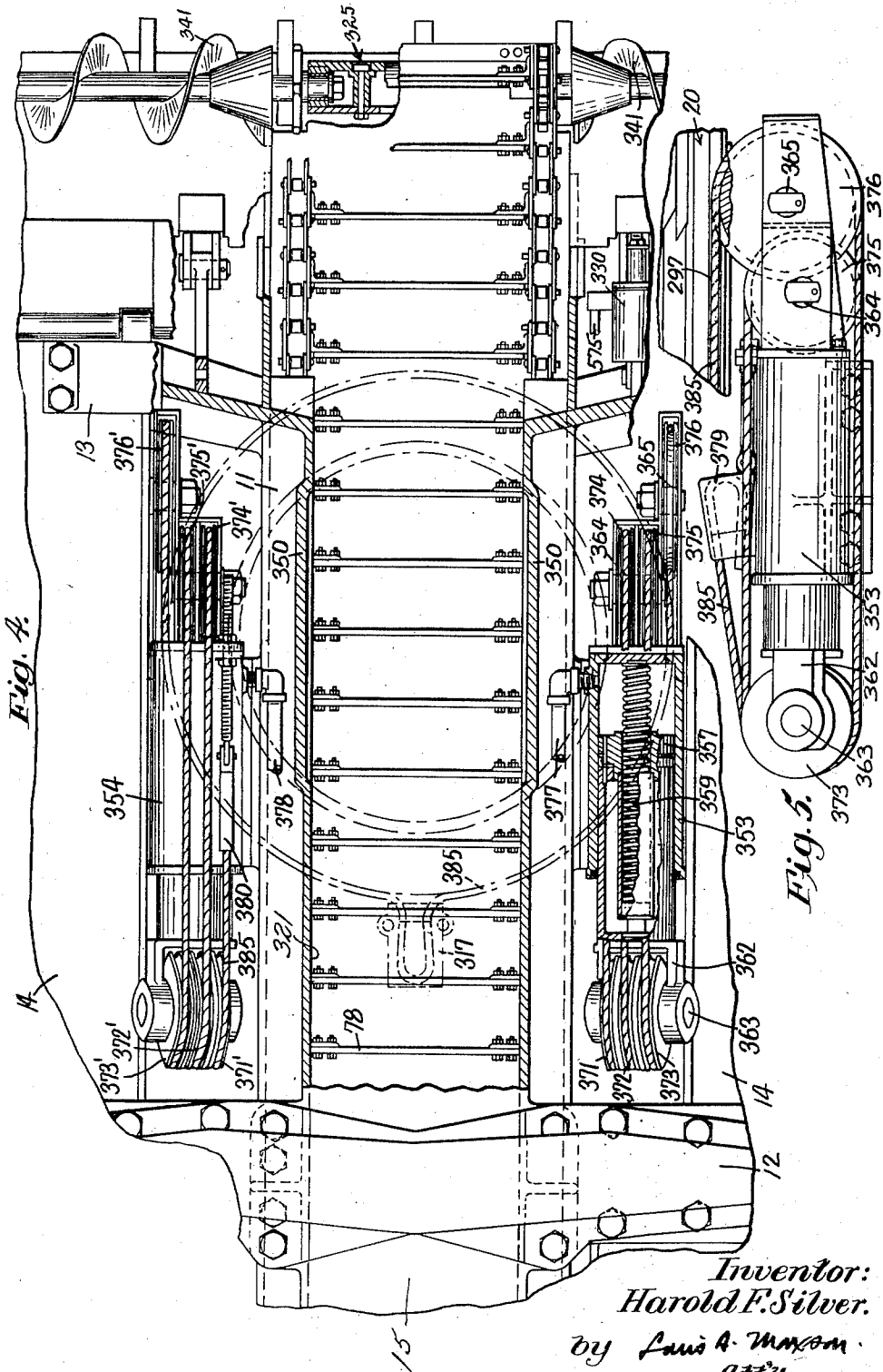
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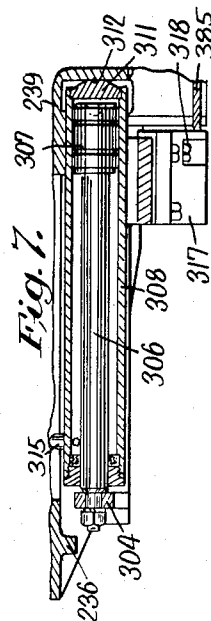
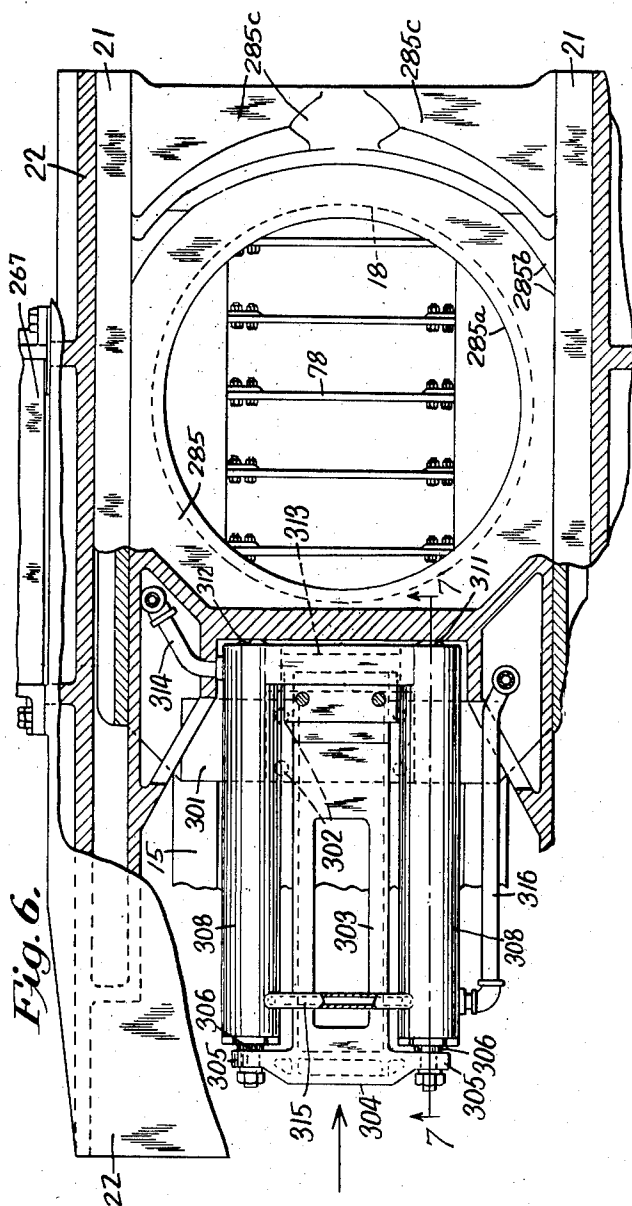
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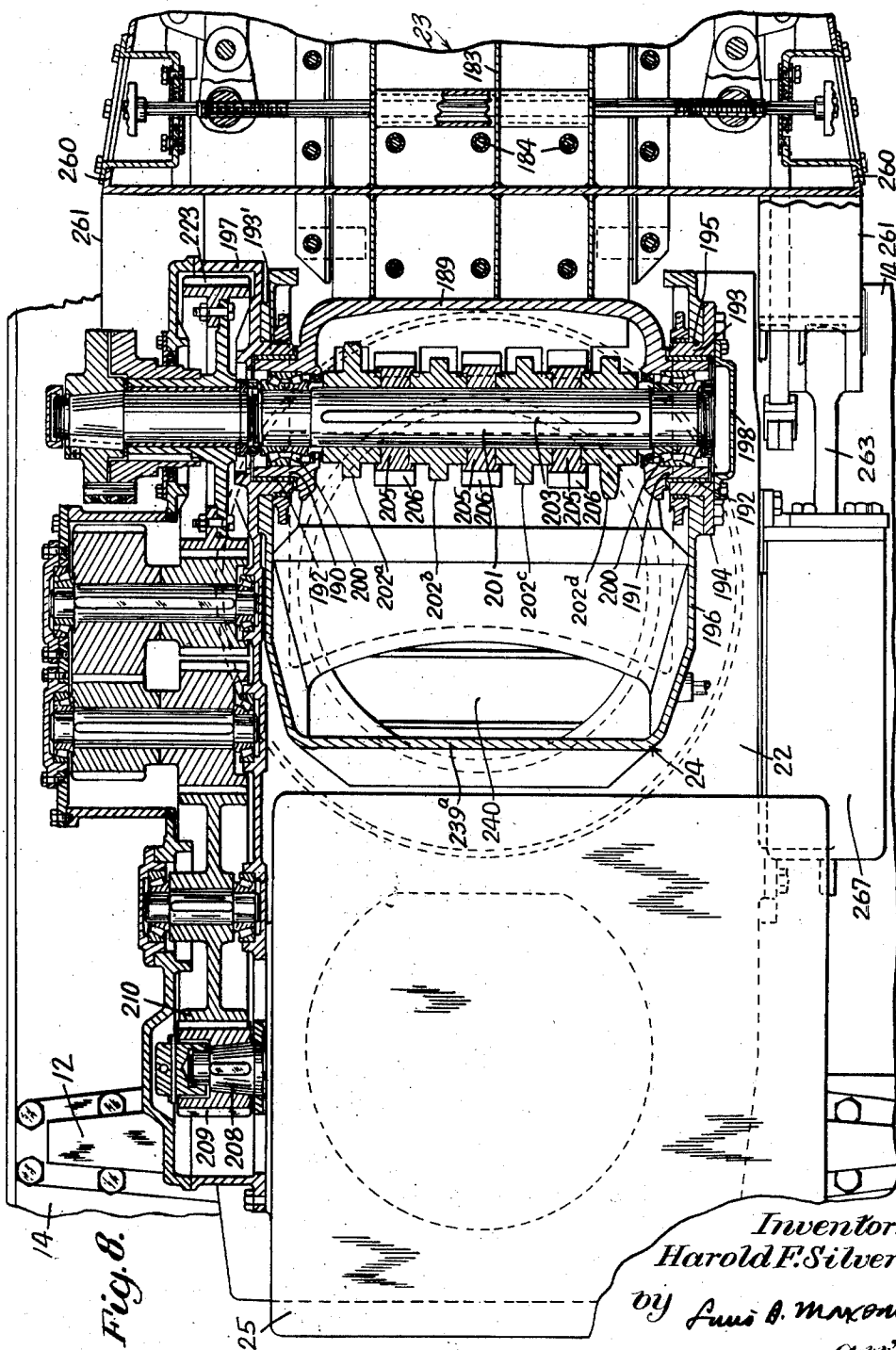
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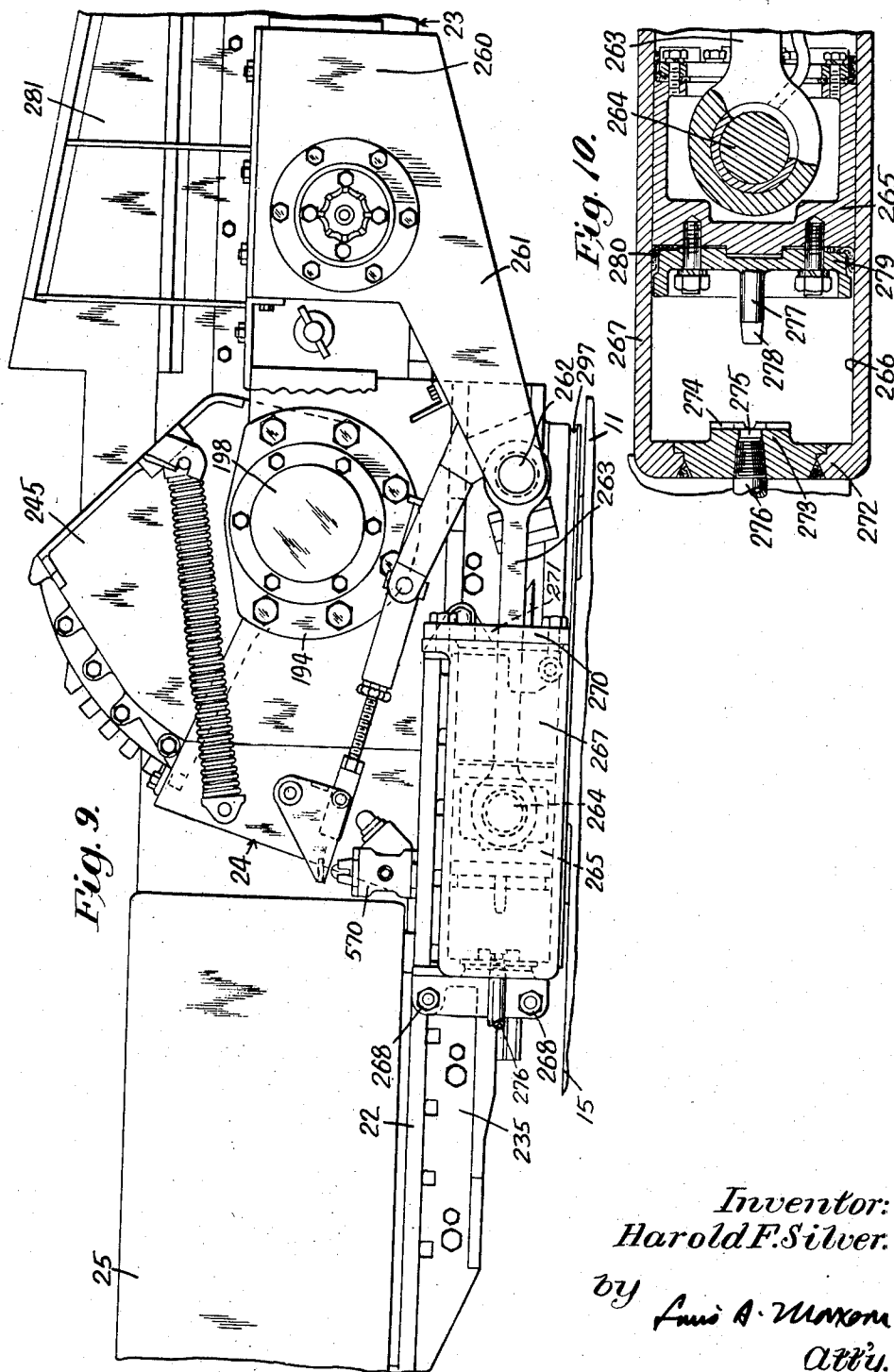
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SOLID WITH DEEPLY PENETRATING BITS

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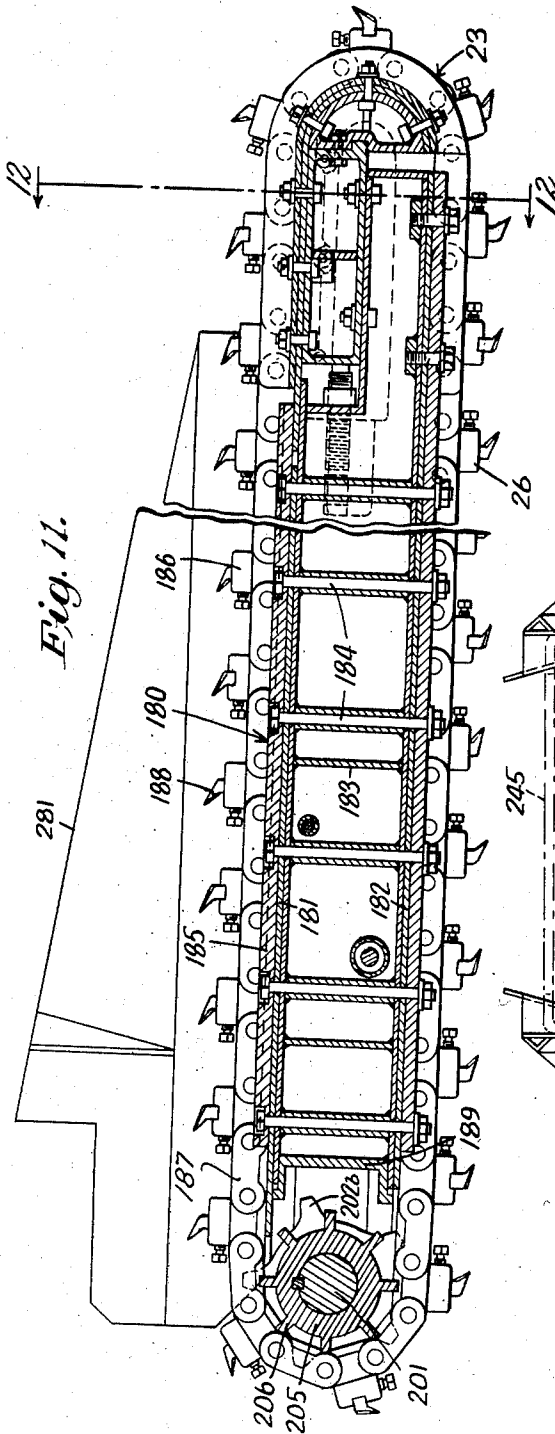


Fig. 11.

Fig. 12.

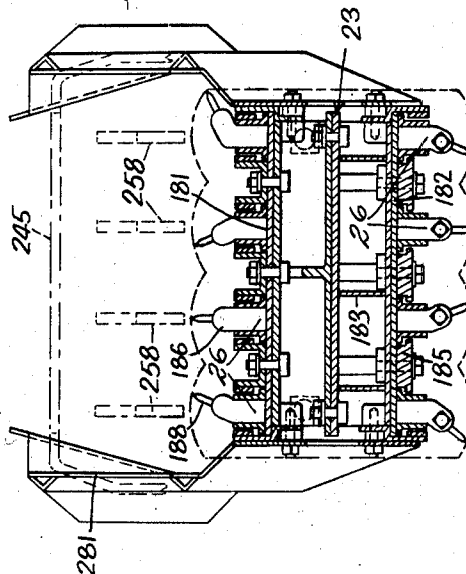
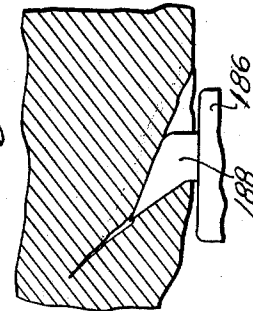


Fig. 16.



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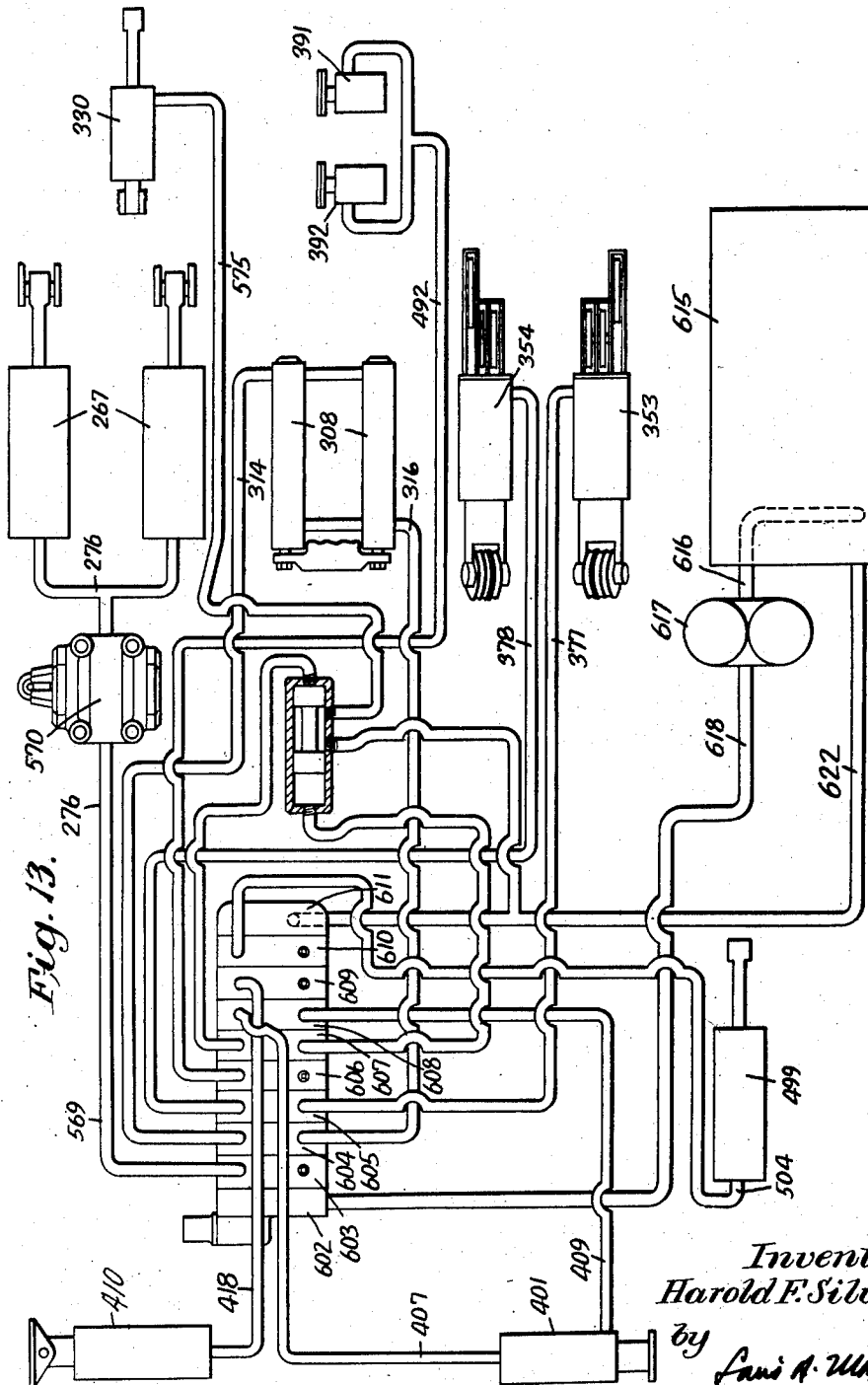


Fig. 13.

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Fig. 14.

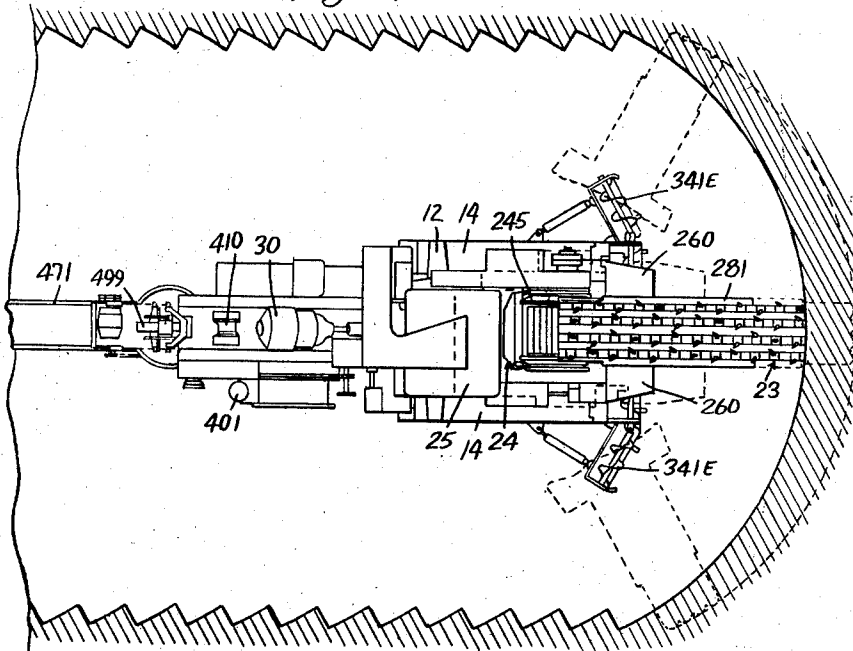
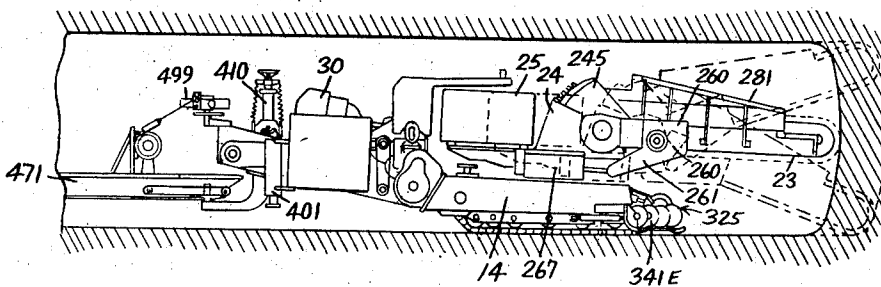


Fig. 15.



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2,798,706

METHOD OF MINING COAL OR OTHER MINERALS FROM THE SOLID WITH DEEPLY PENETRATING BITS

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Application April 17, 1951, Serial No. 221,477

10 Claims. (Cl. 262—1)

My invention relates to improved methods of mining minerals from a vein, avoiding the necessity of manual handling of the mineral, disintegrating the vein throughout the whole portion thereof that it is desired to mine, carrying on the disintegrating process in a sequence of similar operations each involving the penetration of the face at one of the vertical limits thereof—preferably at its bottom—and the disintegrating of the mineral in a vertical band of substantial breadth so that the number of operations may be kept small in a given width, and so handling the disintegrated mineral that the same is substantially all delivered to a desired point regardless of the angle of attack upon the face.

From another aspect the invention relates to improved methods of mining minerals from a vein by which the rate of detachment of the mineral may be speeded up and the proportion thereof of relatively large sized lumps may be increased, and by which there may be effected, notwithstanding the use of cutter bits as disintegrating elements, detachment of the mineral from the solid in large measure by a tearing rather than a cutting operation.

The practice successfully of my method from some, at least, of its aspects, calls for the use of a vein attacking instrument or apparatus capable of working on a wide enough portion of a face so that in a reasonable number of successive operations the necessary width can be covered, but at the same time not so wide that a prohibitive amount of power will be required. It is necessary that means be provided for effecting successive presentation of the vein attacking apparatus to the face in a series of comparatively similar cycles, and it is highly desirable that the characteristics of the cycles be controlled at least to such an extent that an automatic continuation of the mine bottom at the desired level be effected, and also an automatic maintenance of roof height.

The improved method also contemplates the performance of its steps by power, the removal of the whole mass of mineral to be disintegrated and loaded out, the deposit of the mineral separated from the solid in a convenient place, the confinement of the operations within the desired limits, and the use of repetitive operations each of sufficient magnitude to enable their cumulative effect to be practically adequate, but to require no excessive amounts of power.

The improved method in a preferred performance thereof contemplates the penetration of the vein by the forward end of the vein attacking and disintegrating apparatus to such a depth as to avoid the need for excessive power during the ensuing shearing operation and to enable the bits, for example, with which the apparatus may be armed so to act under the forces applied during shearing that the mean rate of disintegration of the vein may exceed that which would result from each bit's operating purely as a cutting instrumentality.

Again, in a preferred performance, the improved method, from one aspect thereof, contemplates, when it

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is applied in suitable minerals such as some coals, the action of such a number of bits on other disintegrating elements in such directions and with such penetration that the product of the effective area of the bits multiplied by the bearing strength of the coal shall exceed the force necessary to overcome the sum of the bonds in shear and in tension holding substantial masses of coal or other mineral in the seam, whereby relatively large pieces may be broken out.

Other aspects of the invention will appear hereinafter.

The primary object of my invention is to provide an improved method for mining coal or other minerals from the solid and effecting the delivery of the mined mineral to a desired point of delivery, and, incidentally thereto, to provide improved steps or series of steps which enter into the method of the more comprehensive object. Other objects will hereinafter more fully appear.

The invention can be most readily further described and understood when an apparatus by which it can be performed has been explained, and accordingly a suitable apparatus for its performance will now be described with the aid of the accompanying drawings and appropriate reference to application Serial No. 11,688, filed February 27, 1948, of which the present application is a division. Application Serial No. 11,688 is a continuation-in-part of my application Serial No. 750,981, filed May 28, 1947, now abandoned.

In the drawings:

Fig. 1 is a side elevational view of an apparatus by which my invention may be practiced.

Fig. 2 is a plan view of the apparatus shown in Fig. 1.

Fig. 3 is an enlarged vertical sectional view taken on the plane of the section line 3—3 of Fig. 2 and with parts omitted.

Fig. 4 is a fragmentary horizontal sectional view taken on the planes of the line 4—4 of Fig. 3 with some parts shown in elevation, and particularly disclosing turntable swing, and material pickup, mechanism.

Fig. 5 is a fragmentary side elevational view showing a detail of the turntable swinging mechanism.

Fig. 6 is a fragmentary horizontal sectional view on the planes of the line 6—6 of Fig. 3, showing, among other things, details of the sumping and withdrawing apparatus.

Fig. 7 is a longitudinal, vertical detail sectional view on the plane of the section line 7—7 of Fig. 6.

Fig. 8 is a fragmentary horizontal sectional view on the plane of the section line 8—8 of Fig. 3, showing details of the disintegrating mechanism, etc.

Fig. 9 is a fragmentary side elevational view of portions of the disintegrating mechanism.

Fig. 10 is an enlarged fragmentary vertical sectional view on the same plane as Fig. 9 through one of the disintegrating bar swing cylinders.

Fig. 11 is a longitudinal view in vertical section through the chain gang or disintegrating mechanism.

Fig. 12 is a transverse vertical section through the disintegrating mechanism of Fig. 11, taken on the plane of the line 12—12 of Fig. 11.

Fig. 13 is a diagrammatic view showing a hydraulic control system.

Fig. 14 is a diagrammatic view illustrating the practice of the invention, being in the nature of a plan view.

Fig. 15 is a diagrammatic view in the nature of a side elevation or a vertical section, showing the practice of the invention.

Fig. 16 is a schematic view showing a disintegrating element penetrating deeply into the mineral according to the present invention and showing a fracture line of a lump of mineral to be removed.

Referring now to the drawings, it will be noted that there is disclosed in them, as a physical means for the

practice of the invention, an apparatus which includes, to provide mobility for it, a tractor or crawler type truck consisting of a body 11 which is supported, by a rear transverse support member 12 and by generally oppositely extending forward foot members 13 (Figs. 2 and 4); on tractor or crawler frames 14. The body 11 comprises (as shown) a passage-forming section or frame 15 through which coal taken from the face is discharged to a delivery conveyor section 16; and the body 11 includes a turntable bearing 17 at its forward end, this bearing projecting above the top of the passage-forming section 15 and having an open bottom, as at 18. Upon the turntable bearing portion there is mounted, for rotation on a vertical axis, a turntable element generally designated 20 which carries guides 21 at its opposite sides and which supports an elongated reciprocable frame portion 22 which is supported by the turntable for reciprocation relative to the latter in horizontal planes and which carries a disintegrating mechanism generally designated 23, a cuttings-receiving and discharge hood or chute section 24, and a driving motor 25 for actuating the several chains 26 which make up the illustrated disintegrating mechanism 23. The apparatus as a whole also includes various operating mechanisms which will be later described, and, in addition to the motor 25 for actuating the disintegrating mechanism, includes another motor 30 for driving the primary conveyor, a lubricant pump, an oil pump supplying fluid to operate various devices, and the crawler or tractor treads.

The apparatus includes supporting and propulsion mechanism which is fully disclosed in application Serial No. 11,688, and which forms the subject matter of divisional application Serial No. 221,474, filed April 17, 1951, now Patent No. 2,787,171.

The apparatus includes supporting and propulsion mechanism for swinging or removing a substantial section of coal from the face and delivering it onto a flight conveyor 78. This mechanism includes, as shown, a suitable frame mounted for swinging on a horizontal axis, driving means for the chains which are carried and guided on the frame, means for imparting predetermined, limited, advancing and retracting movements to the frame, means for swinging the frame, means for receiving the coal that the chain elements bring back as they separate it from the face, means for delivering the coal removed from the face through a turntable mechanism which is provided for the purpose of enabling the several chains to be presented to the face in a sufficient number of angular positions to remove the coal for the full width of the face, means for rotating the turntable, which turntable carries guides for a reciprocable frame supporting the disintegrating mechanism and the driving motor for the latter, and the hood or funnel which receives the coal from the chains and delivers it through the turntable and other mechanism later to be described herein or by reference to application Serial No. 11,688.

The disintegrating mechanism includes means for forming a relatively wide, shallow opening in a face, means for swinging the disintegrating apparatus at a rate suited to maximum rate of material detachment from the face, and means for moving back the disintegrating apparatus to a position for repositioning thereof for a new attack, such backward movement usually attended, except in very low coal, by the disintegration of a small wedge shaped mass of material.

The initial, sumping movement will be of a relatively shallow depth. It may indeed be—and is so disclosed in this application—of such a depth that the distance which the bits, later described, traverse inside the face in rectilinear paths, after rounding the forward end of the disintegrating mechanism 23, is relatively quite short, in the illustrative embodiment shown being only on the order of one-third of the width of the mechanism 23, when this mechanism is horizontal. And the tearing, as contrasted with cutting, of the material from the vein

which attends the upward swinging movement of the mechanism 23 is in part obtained by this limitation of penetration, and in part by controlling the upward force exerted by the swinging means for this mechanism.

A free surface is necessary for the effective cutting or detachment of a mineral from a seam. When coal is cut by a cutter chain in the conventional manner, the inclined bits have a limited penetration, due to the relatively great length of cutter chain in engagement with the coal and the limitations of the feeding force. Except at the mouth of the kerf, the only free surface is the surface forming the instantaneous forward boundary of the kerf. And the penetration of the bits is so small that the free surface that does exist at the face, as the bits emerge, is of little moment or effect. Each bit, when cutting in the conventional manner, usually forms a groove wider than its width at the instantaneous free face just ahead of it, and removes the coal, by reason of the nature of the latter, by springing, or spalling off—so to speak—pieces bounded by surfaces diverging rearwardly from their intersection along a forwardly sloping line extending from the tip of the bit to the free surface and themselves intersecting the free surface along rearwardly diverging lines. The usual bit penetration being small, the disintegrated product, with a standard coal cutting machine, is relatively small, not much running above the size of pea coal. But with the bringing of the free surface of the face close to the point where the run of the chains becomes rectilinear, and close to the point where the bit faces in their curvilinear paths have their forward faces substantially parallel to the face, so that their push is normal to the face, and with the bits advanced in a manner to utilize their full penetration (see Fig. 16), there result conditions in which larger lumps are produced, not only because the tips of the bits penetrate more deeply and thus increase the dimensions of the edges of the pieces of coal detached, but also because there is a new factor provided by the free face so closely related to the commencement of predominantly or wholly outward movement of the bits that a material fraction of the outermost band of coal will be broken out or torn out in the forms of lumps ripped outwardly through the standing face rather than in the forms of smaller fragments broken loose through the instantaneous top wall of the kerf.

To the removal of the coal in relatively large pieces substantial contribution may also be made by arranging the bits in transverse rows, whose width transverse to the median lines of such rows is relatively small compared with the distance between successive median lines, as thereby successive impacts, as distinguished from uniformly spaced attacks by individual bits, can be secured; and also because, in the removal of a body equal in length to the sum of the effective bit spreads of several chains, there will be only two, or, when there is a free side, only one lateral bond of the body to be overcome, so that, with four chains, the action of four bits will be available for overcoming a maximum of two lateral bonds.

There is still another factor which is utilized by the invention. The coal in a seam is under considerable pressure. When an opening is made at the bottom, an upright column of coal extending from the top of the opening to the roof and of a horizontal cross section generally similar to the horizontal projection of the opening is relieved of pressure, and it is believed that this relief of pressure introduces shear strains between the sides of this column and the adjacent body of the coal to which it is attached laterally and rearwardly and which is still under load, and also shear strains within the cross section of the column itself. It is believed that there is a sufficient change in the internal stresses of the column to set up important internal forces and leave the coal in condition to be more easily broken by the cumulative action of the bits as they move upward and outward during subsequent upswing to tear

material from the face. If the coal is of a crystalline construction, as will frequently be the case, it is very likely that the failures may occur along crystal faces, and in any event, the fact that the coal is under stress would make it easier to break along cleavage surfaces regardless of the theory of coal structure entertained. Whether it is made up of cubical crystals or whether it is made up of horizontal strata having cleats between them but without vertical cleats in the virgin condition of the coal, it is believed to be clear that internal forces will be set up in the portion of the coal that is to be attacked by the bits in the upward (or downward) swing of the attacking instrument, and that these forces make it easier to tear off substantial pieces. It seems probable that the internal forces mentioned will facilitate diagonally upward and outward fractures during upswing of the attacking instrument, and this seems to be borne out in practice. Whatever the theory, and I will deal further with certain theoretical considerations at a later point in this specification, I take advantage of the actual phenomena by attacking the coal during swing by repeated impacts and relatively large bit penetration so that, in the application of my invention in the mining of many coals, during the upward swing medium and large sized pieces are torn off of the face, and, following the detachment of a substantial sized piece, the attacking instrument continues to swing upwardly under the overlying (or downwardly over the underlying) ledge and pretty soon gets a good enough bite to tear off another sizable chunk, the surfaces of detachment being probably along upwardly and outwardly inclined zones that are already subject to internal stresses due to the bottom notch—stresses augmented by the continued upward and outward pounding of the bits, thus giving to the operation of the attacking instrument an altogether new and most efficacious and expeditious disintegrating action.

The means shown for severing, dislodging or tearing the coal from the face may best be seen in Figs. 1, 2, 3, 8, 11 and 12. This includes, as illustrated, a structure for supporting a number of chains for movement in orbits which are arranged in vertical planes, and in such proximity to each other that all of the coal for a width equal to the distance between the orbits of the most remotely spaced side bits will be removed from the solid and carried back by the chains. In the structure specifically illustrated, there will be noted at 180 a structure built up of plates 181 and 182 spaced from each other and secured together by plate elements 183, and there are clamped to the plates 181 and 182 by bolts 184, guideways 185, in the form illustrated, for four chains of the block and strap link type, the bit carrying blocks being illustrated at 186, the strap links at 187 and disintegrating instruments herein the bits at 188. This structure is connected to a fork-like element 189 (Fig. 8) which has short sleeve portions 190 and 191 which are received in bearings 192 carried at one side of the machine in a cylindrical portion 193 of a member 194 which is supported in an opening 195 in the side portion 196 of the frame 24, and carried at the other side in a cylindrical portion 193' carried by a gear housing 197. An end closure member 198 is secured to the member 194 as shown in Figs. 8 and 9.

In suitable anti-friction bearings 200 mounted inside of the sleeve portions 190 and 191 there is journaled a shaft 201 whose portions between the bearings 200 carry four chain driving sprockets 202^a, 202^b, 202^c and 202^d, these sprockets being splined, as at 203, to the shaft 201. These sprockets may be variously arranged in the matter of their angular relation to each other, but a desirable arrangement is such that, through the formation of their individual splineways, each may be set slightly differently from each of the others, so that the bit blocks will carry their bits in transverse rows inclined to the planes of the chain orbits, the median lines of which rows perpendicular to the planes of the chain orbits being separated from

each other by much more than the maximum width of the rows transverse to such median line, that is to say, by much more than the distance between lines parallel to said median lines, and passing through the outermost points in the forward faces of the foremost and rearmost bits of each row. For example, by forming the splineways in the sprockets say $13\frac{1}{2}^\circ$ ahead, $4\frac{1}{2}^\circ$ ahead, $4\frac{1}{2}^\circ$ behind and $13\frac{1}{2}^\circ$ behind a given median line, desirable results may be obtained, in that there will be, as it were, spaced, but slightly deadened, impacts of the bits on the coal, and yet all of the bits in any given row can act concurrently to provide thrust on the coal as the bits move rectilinearly towards the face, if they each have penetration in the coal, and, when all have relatively full penetration and the coal is in condition for detachment of a substantial mass—either by reason of internal strains as later explained, or due to the pounding by the bit rows, pieces of substantial size may be torn off and moved out. Between each sprocket and the next there is mounted a paddle-carrying spacer disc or bladed impeller 205 of which the paddles or blades 206 serve for the more effective discharge of the coal. The chute portion 24 is a part of the elongated frame portion 22 hereinbefore mentioned, and the frame 22 has suitably bolted to it the motor 25, whose power shaft 208 carries a driving pinion 209 which drives a gear 210 and through other cooperating gearing a gear 223 which is connected by way of a coupling and shear pin mechanism to the shaft 201 to drive the latter. By rearrangement of the gearing between the gears 210 and 223 as disclosed in application Serial No. 11,688, it will be possible to effect a drive of the chains at a much higher rate than with the parts assembled as shown; and many other gear combinations of proper pitch diameters can be used to get almost any desired chain speeds. A chain speed of 550 feet per minute is mentioned in the illustrative example hereinafter described.

The structure of the elongated frame portion 22 may now be somewhat further noted. It will be seen that it includes relatively widely spaced guide portions 235 which are connected together at their rear ends by transverse frame portions 236 and 239. The portion 239 extends between the opposite guide portions approximately midway of their length. Forwardly of the transverse portion 239 is another transverse frame or web portion 241 which includes a generally arcuate, rearwardly sloping wall portion 242 which combines with the forward face of the transverse portion 239 to form an opening 240 which is elongated in a direction normal to the direction in which the disintegrating apparatus moves toward the material to be mined. The frame or web portion 241 also includes a forwardly sloping wall portion 244 which at its crest 243 joins the wall portion 242 and which slopes forwardly and downwardly in a double inclination and ends just to the rear of a vertical plane in which the axis of rotation of the shaft 201 lies. The forward end of the wall portion 244 forms the rearward boundary of a second discharge opening 240^a which exists in advance of the discharge opening 240 when the frame 22 is in its rearward position. The guide portions 235 are shaped to cooperate with other guides 21 formed on the turntable element 20.

Projecting upwardly from the transverse portion 239 there is a wall 239^a which extends across the frame and then forwardly adjacent the sides of the latter and which cooperates with the frame or web portion 241 to form the discharge hood or chute section 24, which is spaced from and surrounds the rear portions of the orbits of the chains, and this discharge hood or chute section communicates through the opening 240 formed between the transverse portions 239 and 241 with the space below the reciprocable frame, and specifically with the opening later described in the turntable 20. With the hood or chute section 24 there cooperates an upwardly and downwardly adjustable hood section 245 the structure and operation thereof being fully disclosed in application Serial No.

11,688. Associated with the adjustable hood section 245 is breaker or sizing means for breaking up or sizing any large lumps, and this means includes a series of breaker lugs 258 secured to the upper wall of the hood section and projecting inwardly toward the chains. The lugs co-operate with the chains so that any unduly large lumps carried back by the chains are engaged by the breaker lugs and thus reduced in size, so that they may readily pass through the chute to the turntable hopper.

It will be observed that secured to the opposite sides of the side frames of the gang of chains there are plate elements 260 having rearwardly extending arms 261 to which there are pivotally connected, by pins 262, the forward ends of pitmans 263 whose other ends are pivotally supported on the wrist pins 264 of piston structures 265, each of which is reciprocable in a bore 266 of a cylinder structure 267. There is one of these cylinder structures bolted, as at 268, to each of the side frame portions 235, and slotted front cover plates 270 are secured to the forward ends of the cylinders and provide slots 271 in which the pitmans 263 are swingably and reciprocably movable. The rear head 272 of each cylinder structure 267 has an inward projection 273 whose face is radially slotted, as at 274, and which is traversed by an opening 275 to which a fluid supply conduit 276 extends. A projection 277, having a tapered end 278, is secured to each piston structure 265 for movement with the latter, being formed integral, as shown, with a plate 279 between which and the main body of the piston structure a packing 280 is clamped. The projection 277 is small enough to enter the opening 275 without completely plugging the latter, but yet is of such relative size that it provides a very efficient throttling of the escape of fluid from the chamber within the cylinder structures to the left of the piston structures 265 in Fig. 10, and thus aids in bringing the chain gang to rest in lowered position without excessive shock. The control of fluid to the conduits 276 will later be explained. The working area of the piston structures 265 and the hydraulic pressures to which they are subjected are such as to effect, in the illustrative example hereinafter described, swing through a height of about 5 feet in a period of about eighteen seconds against the resistance opposed by the disintegration of the coal. It will be apparent from the foregoing that the disintegrating bar will be moved substantially constantly by the piston structure 265 at a rapid rate.

Along the opposite sides of the gang of chains there extend outwardly diverging side boards 281 which increase in width toward the rear end of the chain gang. This side board arrangement prevents the dislodged coal from falling off the top runs of the chains and, through the increase in carrying capacity towards the mouth of the adjustable chute section 245, provides insurance against lateral escape of coal in the event that any lumps entering the throat of the chute section temporarily partially obstruct the discharge down through the turntable, as later described.

Underlying and supporting the elongated frame 22 there is the turntable element, generally designated 20, which turntable element is mounted on the frame 15 for rotation on a vertical axis and carries guides 21 for cooperation with the guide portions 235 of the elongated frame 22, and also supports mechanism for effecting the reciprocation of the elongated frame 22 relative to the turntable and so also relative to the base of the machine on which the turntable is supported. This turntable element 20 includes a circular portion 285 which is rotatably supported upon the turntable bearing 17 carried integrally by the frame 15. The circular portion 285 has a circular open center 285a which communicates with a larger opening 285b, with which the discharge opening 240 previously mentioned, communicates. The opening 285b is of a dimension, crosswise of the disintegrating apparatus, greater than the corresponding dimension of

the discharge opening 240; and the discharge opening 240 is of a dimension, in the direction in which the disintegrating apparatus moves towards the material to be mined, which is less than the corresponding dimension of the opening 285b, the latter opening being so formed that during the movement of the disintegrating apparatus towards and from the material to be mined the discharge opening 240 will at all times be in a position to discharge to the open center 285a of the turntable structure. Said second discharge opening 240a, which exists in the rearward position of the disintegrating apparatus between the forward edge of the wall portion 244 and the forward boundary of the opening 285b in advance of the open center 285a, is in discharge relation with the open center 285a while said opening 240a subsists. When forward movement of the frame 22 extinguishes the opening 240a, material passing over the forward end of the wall portion 244 is directed by the upper forward surface 285c of the circular portion 285 of the turntable, towards the conveyor means. The sloping walls of the turntable element 20, extending between the openings 285b and 285a, form the periphery of a hopper for receiving disintegrated material from the opening 240 in all positions of the latter. An annular groove 297 is formed on the periphery of the lower portion of the turntable element 20 to receive a cable, later described, for use in effecting turntable rotation. At the opposite sides of the turntable member 20 are the integral guideways 21. Between the rear ends of the guideways 21 a web 301 extends. To this web there is secured, as by screws 302, a thrust member 303, at whose rear end there is an upstanding portion 304 providing ears 305 to which piston rods 306 are secured. Upon these piston rods there are mounted pistons 307 which are disposed in cylinders 308. The heads 311 of the cylinders 308 engage an upright surface 312 formed on a depending portion of the transverse portion 239. The bores of the cylinders 308 are connected in communication with each other at their ends adjacent the surface 312 by a cross pipe 313, and fluid can be supplied to this end of the cylinders by a conduit 314 opening into the left hand cylinder, looking forward. The other ends of the cylinder bores are also connected in communication with each other by a cross pipe 315; and a conduit 316 is provided to supply pressure fluid to move the cylinders rearwardly with respect to the piston rods. A cable clamp 317, later referred to again, is secured as by screws 318 to the bottom of the transverse web 301. The lengths of the cylinders 308 are such that they have a feeding and retracting range on the order of 18 inches in the apparatus herein disclosed, and their areas are such as, under the hydraulic pressures available, to effect sumping, in the illustrative example hereinafter described, in about 8 seconds and retraction in about 4½ seconds. The body 11 may desirably be of welded construction, and has its interior divided into a relatively shallow lower chamber 320, and a considerably higher material conveying chamber 321, by a partition 322. The flight conveyor chain 78 is adapted to travel rearwardly over the top of the partition 322, and forwardly beneath the partition while resting on the bottom wall 324 of the body 11. The drive for the flight conveyor chain is shown and described in my copending application Serial No. 11,688.

The front end of the main frame pivotally supports a shovel and nose piece arrangement generally designated 325. This nose piece is provided with scrolls or helical conveyors 341 and 341E for cleaning up loose material from the mine bottom immediately ahead of the crawlers and between the sides of the latter and the ribs as clearly disclosed and described in application Serial No. 11,688.

With reference to Fig. 4, it will be observed, noting the section upon which this view was taken, that the passage 321 is widened at its forward end as at 350 to provide

a circular opening at the turntable bearing 17. Turntable rotating cylinders 353 and 354 are mounted on the sides of the body 11. These cylinders are of similar construction and each contains an elongated piston 357 whose "rod" is of the full diameter of the bore of the associated cylinder. At the rear end of the respective piston rod, there is mounted a support 362 for a transverse shaft 363 upon which a series (three as shown) of sheaves are rotatably supported. The forward cylinder head has rigidly fixed to it a frame upon which, upon a relatively rearwardly supported shaft 364, there are supported two sheaves similar in size to the three rearward sheaves, and a shaft 365 disposed forwardly of the shaft 364 and slightly higher carries rotatably thereon a larger sheave so positioned that a certain tangent to its pitch circle is also tangent to the pitch circle of the groove 297 previously mentioned. The cable sheaves at the rear of the cylinder 353 are, numbering from the side of the frame 11 outwardly, identified as 371, 372, 373. The corresponding sheaves associated with the cylinder 354 are 371', 372' and 373'. The two sheaves ahead of and nearer the cylinder 353 are 374 and 375, while the corresponding sheaves at the other side of the machine are 374' and 375'. The larger sheaves are 376 and 376'. Conduits 377 and 378 are provided to supply fluid to the cylinders 353 and 354 respectively. A cable clamp is supported by each of the cylinders 353 and 354, the one at the right of the machine, looking forward, numbered 379, the other 380. The cable clamp 317, it will be recalled, is fixed to the turntable element, so that angular movement of the clamp 317 will be attended by angular movement of the turntable. A cable 385 has its ends fixed to the cable clamps 379 and 380 and its center to the cable clamp 317. Specific details of the manner in which the cable is reeved may be noted by reference to application Serial No. 11,688. Admission of fluid to conduit 377 will cause counterclockwise rotation of the turntable in Fig. 4; to conduit 378, clockwise rotation. Springs 359 normally act to keep slack out of the cable.

To hold the turntable element 20 firmly against rotation except when it is desired to turn it, brake or lock devices are mounted on the frame 11 just beneath the turntable element 20. These brake devices may be either of the hydraulic pressure applied type or of the spring applied, hydraulic pressure released type, as described and shown in application Serial No. 11,688. These two devices are numbered 391 and 392 respectively. Conduits 387 and 388 are provided to deliver hydraulic fluid to the devices 391 and 392 respectively, and to vent such fluid. When fluid is supplied, the turntable is free for turning; when fluid is vented, the springs 359 exert their pressure and the turntable will be locked or braked.

To hold the machine stable during sumping and withdrawing, it is provided with a pair of jacks 401 and 410, one adapted to engage the mine bottom and the other the mine roof. The details of these jacks may be had by reference to application Serial No. 11,688.

It is desirable to maintain the roof level the same from side to side of the entry or room in which the apparatus is working, and it is frequently desirable to maintain the roof level uniform for substantial distances, and, in order to accomplish these objectives, means are provided for automatically interrupting, at desired times, the supply of fluid to the conduit 276 leading to the upward swing cylinders 267 for the disintegrating device, which cylinders contain the pistons 265 which act through the connecting rods 263 upon the arms 261 to raise the disintegrating mechanism. This is accomplished by providing, in the conduit 276, a valve 570 which is movable downwardly to interrupt the delivery of fluid through the conduit 276, but which, as is fully described in the aforementioned application Serial No. 11,688, will permit venting of the fluid from the cylinder bores 266, even though

in the position of the controlling valve mentioned no further fluid could be delivered into these bores. Evidently, if means be provided for interrupting the flow of fluid through the conduit 276 each time the upwardly swinging disintegrating apparatus has its point attain to a predetermined elevation, a uniform ceiling level can be obtained, and, if means be provided whereby the elevation of the highest point in the disintegrating apparatus at the time the fluid to the disintegrating apparatus elevation cylinders is to be cut off can be varied, then any (reasonably) desired roof level can be maintained. This is accomplished by the mechanism shown in Fig. 9, and in detail in Figs. 36, 37 and 38 in application Serial No. 11,688.

It is also desirable to maintain a level mine bottom, and to vary that level when desired, and so there is included means for limiting the extreme downward position of the tip of the disintegrating apparatus, and provided, as a supplement to the means heretofore described for securing a gentle termination of the downward swing of the disintegrating apparatus, an adjustable abutment or stop means for predetermining precisely the lower limit of the swinging movement of the disintegrating apparatus. Figs. 39, 40, 41, 25 and 26 of application Serial No. 11,688 clearly show this arrangement.

While a delivery conveyor may not be requisite under some conditions, one is a useful adjunct, and may be important, when loading is to be done, for example, onto a shaker or other conveyor, and also when a number of forward movements of the apparatus may be desired between lengthenings of the conveyor line, or, again, when operations in a fairly wide room may result in a positioning of the apparatus at different times in different relations laterally of the face with respect to a conveyor line; and those skilled in the art will readily visualize other circumstances under which a tail or delivery conveyor would be useful. Accordingly, a tail conveyor 471 which is adapted to be employed with the apparatus so far described when the practice of the invention will be facilitated by its presence and use and which is shown and described in my application Serial No. 11,688 may be used.

From the foregoing description it will be seen that there are, including a tail conveyor elevating cylinder, when a tail conveyor is used, eight hydraulically controlled mechanisms which may be availed of by a machine runner to meet various contingencies and to perform various necessary operations. These include the two chain gang raising cylinders 267. These are single-acting cylinders; and they may have fluid supplied to them and vented from them through a branched connection of conduit 276 communicating with a common supply and exhaust line 569. There are also the sumping and withdrawing cylinders 308. There are two of these, and they are double-acting. Fluid is supplied to the forward ends of these cylinders to effect sumping and to the rearward ends to effect withdrawal. A single line 314 supplies and vents fluid relative to the front ends of both cylinders; and a single line 316 supplies and exhausts fluid with respect to the rearward ends of these cylinders. There are also the pair of swing cylinders 353 and 354. These are single-acting cylinders, and fluid is supplied to them one at a time, one of these cylinders being vented while the other is having actuating fluid delivered to it. The fluid conduits for the cylinders 353 and 354 are numbered 377 and 378 respectively. There are two turntable brake devices 391 and 392. These have fluid supplied to their cylinders concurrently, and when fluid is to be vented from them they are simultaneously connected to exhaust. Their common fluid conduit is 492. These brake cylinders may be controlled entirely independently of all of the other cylinders, or, as is illustrated and described in application Serial No. 11,688, but as need not be herein disclosed in detail they may have a control device associated with them which is so connected with the control

for the swing cylinders that the brakes are automatically applied when the supply of fluid to both of the swing cylinders is cut off, and that the brakes are automatically released when fluid is supplied to either of the swing cylinders. Mechanism for lifting the front end of the gathering conveyor and the scrolls is provided in order that these parts may be raised during tramping and this is fully disclosed in application Serial No. 11,688. The bottom jack mechanism 401 is a double-acting mechanism, and fluid is supplied to raise the jack out of contact with the mine bottom through the connection 409, and to force the jack solidly into contact with the mine bottom and to elevate the rear end of the main frame of the machine, when this is desirable, through the conduit 407. The top or roof jack 410 is a single-acting device, and fluid may be supplied to its lower end by the conduit 418, which also serves for the venting of the pressure from this jack. The tail conveyor when one is used as mentioned above has a single-acting cylinder 499 for raising its delivery end, and fluid may be supplied to and vented from this cylinder by the conduit 504.

Appropriate controls for the various devices which have been described may obviously assume different forms, and I shall now describe a control system making use of conventional valve devices of a character which permits the avoidance of substantial back pressures on the hydraulic pump at all times except when power is required for effecting the operation of a controlled mechanism. Various modifications of the controlling apparatus may be made, and two are shown in Serial No. 11,688, but not illustrated herein.

In Fig. 13, there is shown a conventional control valve unit 601 consisting of a supply and relief valve section 602, eight control valve sections, respectively numbered 603 to 610, and a discharge section 611. The valve sections 603 to 610 respectively control the hydraulic mechanisms above enumerated, in the order in which they are enumerated. These may be tabulated, however, as follows:

Valve mechanism:	Controls
603-----	Disintegrating mechanism raising cylinders.
604-----	Sumping and withdrawing cylinders.
605-----	Lateral swinging cylinders.
606-----	Brake cylinders.
607-----	Conveyor nose lifting cylinder (or cylinders).
608-----	Bottom jack.
609-----	Top jack.
610-----	Tail conveyor raising cylinder.

A reservoir 615 serves as a source of operating fluid for the various hydraulic operating mechanisms. A suction connection 616 leads to a suitably driven pump 617, herein the pump driven by the shaft 39. The pump discharge line 618 leads into the valve section 602 and communicates with a chamber in such section. The section 611 has a chamber therein connected by an exhaust line 622 back to the reservoir 615. The section 602 has a second chamber in it, and a differential-type relief valve is movable, when the pressure in the first chamber of section 602 exceeds the desired supply pressure, to connect the first chamber with the second chamber in section 602, and so with the return line 622 to the tank 615. For a detailed description and disclosure of the inner structure of the valve unit 601 see application Serial No. 11,688.

The valve section 603 controls the raising cylinders 267 for the disintegrating mechanism; the valve section 604 controls the sumping and withdrawing cylinders 308; the valve section 605 controls the lateral swing cylinders 353 and 354; the valve section 606 controls the brake devices 391 and 392; the valve section 607 controls the lifting cylinder 330 for the conveyor nose, the valve section 608 controls the bottom jack 401, the valve section 609 con-

trols the top jack 411 and the valve section 610 controls the tail conveyor raising cylinder 499.

The method invention of this application may now be readily understood, as one apparatus by which it can be practiced has now been disclosed in some detail. By the suitable control of the crawlers the apparatus may be brought into such relation to the working face that the forward end of the disintegrating apparatus, in the retracted position of such disintegrating apparatus, is closely adjacent to the center of the working face. To start operations at the left hand rib, fluid is admitted through the valve section 605 to the conduit 377, thus supplying fluid to the cylinder 353, and causing the disintegrating apparatus to swing to the left, looking forwardly, until it reaches the rib. To permit this swing to take place, the brake devices 391 and 392 will have had the valve of the section 606 operated to admit fluid through the conduit 492 to release the brakes. With the structure shown in Fig. 13, the valve mechanisms 605 and 606 are controlled to briefly vent fluid through the conduit 492 and back to the reservoir 615. The operation and detailed structures of these valve mechanisms or sections are clearly disclosed in application Serial No. 11,688.

If the disintegrating apparatus was not at proper floor level, the operator would, by means of the valve section 603, vent fluid through the conduit 569, from the branch connections of conduit 276 leading to the cylinders 267, and allow the disintegrating device to reach the desired bottom position. The fluid would pass freely through the valve mechanism 570. When the desired bottom position was reached, the valve of section 603 would be returned to neutral position. Fluid would then be supplied under the control of the valve of section 604 to the forward ends of the cylinders 308 through the connection 314, and the cross connection between the cylinders, and the disintegrating mechanism would be sumped in at the bottom of the face. If there was occasion for so doing, the operator would supply fluid through the conduit 407, under control of valve section 608, to the top of the bottom jack 401 to effect a proper angle in altitude of the apparatus so that the sumping would be performed at the desired level to continue the floor. At the end of the sumping operation, the valve of section 604 would be moved to cut off communication between the supply and the conduit 314. Fluid would then be admitted, under control of valve section 603, to the line 569 and pass through the valve mechanism 570 and the branch conduits 276 into the disintegrating device raising cylinders 267, and a vertical band of material would be removed from the face. When the desired height was attained by the front end of the disintegrating device, the valve mechanism 570 would be operated automatically as heretofore described and cut off the supply of fluid through the conduit 569, though the operator might not yet have returned the valve of the section 603 to center position. The operator would then manipulate the valve of the section 604 in the opposite direction from its central position to admit fluid to the rear ends of the sumping and withdrawing cylinders 308 by way of the conduit 316, and withdrawal at the ceiling or roof would be made, thus completing the removal of a vertical band. When this withdrawing operation was completed, the valve in the section 604 would be returned to mid position. The brakes would then again be released, and fluid supplied to the cylinder 354 through the conduit 378 under control of the valve of section 605—desirably after somewhat lowering the disintegrating apparatus to insure freedom of lateral swing, and when the left side of the disintegrating unit reached the right hand vertical wall of mineral left by the completion of the first attack, a new band would be removed by operations similar to those already described, and successive bands would thereafter be removed to the requisite number to complete the width of the face. If, for any reason, it were desired to supply fluid to the

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roof jack 410, this could be affected under the control of the valve in section 609, and if the elevation of the tail conveyor required change, the valve in the section 610 could be manipulated to admit fluid to the conduit 504 if raising were called for, or to vent fluid through the conduit if lowering were called for. To tram the machine a substantial distance, fluid would be admitted to the cylinder 330 through a conduit 575 under the control of the section 607. During mere advance between successive extensions of the face, this would not be done, as it would be desirable to clean up the bottom as the apparatus moved forward the short distance involved. The operation and control of the clean-up mechanism 325 is clearly disclosed in application Serial No. 11,688.

An example of a specific series of operations performed in the practice of the present invention may now be considered.

The apparatus disclosed has four bit equipped chains. These chains may be such as to provide for example seven bit positions on each chain. The bits on successive blocks may be about seven inches apart. The bits are arranged in generally transverse rows with the median lines of the rows spaced apart a distance equal to the pitch of a chain block end with the bits of the individual rows some slightly in advance and some slightly to the rear, as hereinabove described, of said median lines. As illustrated, the bit rows are slightly diagonal, and there is a difference in position, in the direction of orbital movement, of seven-eighths ($\frac{7}{8}$ "') between each bit and the next one in the row. The ratio between row widths and distances between the median lines of successive rows is not perfectly shown in the drawings of which the small scale does not lend itself to a precise illustration of this subject matter. The chains may have an orbital speed on the order of 550' per minute. The outermost points in the bit orbits at the parallel upper and lower sides of the disintegrating apparatus may be about 20 inches apart, and the radius of curvature of the paths of the outermost bit tips at the curved forward ends of the disintegrating apparatus may be about 10 inches. The depth of penetration of the disintegrating apparatus into the face—midway of its height—may be about 17 inches, of which, calling this 17 inches D, and calling the 10 inch radius of curvature mentioned R, we shall have as D-R a distance of 7 inches, which will be the length of the straight outward travel of the bit tips before emerging from the face when the disintegrating apparatus is approximately horizontal. With this arrangement it is apparent that only one complete bit row at a time will be disposed within the portion of the bit orbits between the arcuate portion thereof and the face of the vein. It may be noted that this is on the order of the pitch length of one bit carrying chain block. During the last quadrant of upward and outward bit movement, due to the inclination of the bit faces there will be a generally upward and outward pressure applied to the coal during upswing. The disintegrating apparatus in initiating its attack, in this illustrative example of the practice of the process, may be sumped in at the bottom of the face roughly 17", and its upward swing in 7' coal may be about 5'. The sumping operation takes about 8 seconds in this illustrative operation. Because of the arrangements of the bits in relatively widely spaced rows—i. e. with relatively wide spacing as compared with the overall widths of the rows transversely to their median lines, there will be provided, as it were, a succession of severing impacts applied by the bits to the coal.

The coal in the seam is generally under a very considerable pressure, ranging from a very small pressure, when the seam is near the surface of the ground, to a very high pressure when the seam is a great distance below the surface. There are also other special conditions—as along pillars or along longwall faces—where very high pressures are encountered. When sumping is effected, whether at the top or the bottom of a seam, there will

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be a very marked change in the internal stresses of the coal above or below the opening formed by sumping, depending on whether that opening is at the bottom or the top of the seam. The column of coal extending from one edge of the seam to the adjacent bounding surface of the sump-produced opening is obviously relieved of pressure, and this occasions marked internal stressing of this column of coal. It seems probable that there is enough change to set up important internal stresses which will leave the coal in a condition to be more easily broken by the cumulative action of the bits as these move either upward and outward or downward and outward in a direction to tear material from the face. If the coal is of a crystalline construction with cubical crystals, conditions will be established which will facilitate detachment between adjacent crystals, and if the coal is simply horizontally stratified and has only horizontal cleats, it is by no means impossible that there will be produced strains in vertical planes which will enable, with the presence of the horizontal cleats, much more ready detachment of chunks of coal of substantial size. The particular point of importance is that, whether the load be removed from the coal by making an initial opening at the bottom or at the top, internal forces will be set up in the portion of the coal that is to be attacked by the bits in the upward or downward swing of the attacking instrument, which will make it much easier to tear off substantial pieces. This condition is utilized in the present invention to the full, through supplementing the disintegrating stresses by repeated impacts on the coal by the lines of bits and/or by forcing the bits into maximum possible penetration (see Fig. 16), so that their tearing action may be augmented, and/or by causing a plurality of bits to exert forces on the relatively limited thickness of coal, as they move outwardly, with a resultant reduction in the forces needed to detach the coal because the bonds at the ends (or one end in most cases) will have a plurality of bits cooperating in exerting the force necessary to effect their severance. It is believed that diagonally upward and outward fractures may be facilitated during upward movement of the disintegrating apparatus, bearing in mind particularly the fact that, during a portion of the last quadrant of their upward and outward movement, the forces exerted by the faces of the bits are directed upwardly and outwardly.

It has been shown that the sumping operation in a measure readies the coal, in the column at one end of which sumping is performed, for easier detachment. The shearing portion of the attacking cycle may next be considered in some detail. This is preferably performed by upswing. In connection with this portion of the cycle, it should be borne in mind, however, that, if the sumping is at the top of the vein, shearing may be effected by downswing, and it should be borne in mind also that if, instead of using a swinging attacking instrument, one adjusted as by a parallel link motion were employed, there might be rectilinear bodily up or down movements of the disintegrating instrument.

To effect this next portion of the operation—the shearing portion—it is desirable to apply a swinging force of such magnitude that the attacking instrument will be moved in a given period further than the bits would penetrate by an ordinary cutting operation, but it is undesirable to have the attacking instrument moved so rapidly that the chains proper will rub on the coal. The complete upswing operation requires about 18 seconds for a 5' upswing, according to the example above given. When the shearing (upswing) operation is completed, a withdrawal operation will be performed, and this may require about $4\frac{1}{2}$ seconds in the illustrative example now being considered. In the example now being considered, the bits have been so set that they have a projection of about 1" from their mountings. In the particular example mentioned, the chains were of the so-called "Prox" type and the bits in these chains had about a 1" projec-

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tion above the abutments on the block, which means, on side-positioned bits, an actual projection in the direction of bit advance of roughly .6 inch, though "center" bits have the full 1" projection. In the apparatus shown to facilitate understanding of the invention, conventional cutter bits and cutter chain blocks are shown, as the invention may be practiced with many types of bits.

Now, with a chain speed of 550' per minute, during the period of upswing (18 seconds) each chain will travel 165' all told, and, assuming that there is a seven-position chain being employed with each guideway, a bit in each bit position on the chain will emerge from the face about forty times during the period of upswing, and this will mean that a bit, in each of the many positions on the chain, will have, say, forty opportunities to engage the coal, and since these bits have a maximum projection from their settings of 1" they could, if they cut the full projection of the center bits, cut out only about 40 inches of coal. However the upswing of structure 180 is 60 inches during this period in which even the bits with maximum projection could cut only about 40 inches, and therefore it is very evident that the practice of my invention, in the example presented, provided a rate of removal of coal from the solid during the upswing at least 1½ times as rapid as the bits would actually cut the coal if their action were simply a cutting one. By virtue of the character of the piston structure 265 and the rate and pressure at which fluid is supplied to the cylinders of this structure, as hereinbefore described, it will be clear that the rate of upswing of the bar structure will substantially constantly greatly exceed the maximum upswing possible if the coal were removed by a simple cutting action. The evidence that a tearing action, as distinguished from a cutting action, is provided, is therefore clear, for, with a conventional cutting action, the total upward movement of the bar gang in the 18 seconds actually required for a 5' upswing would be only 40" at the portion of the bar immediately to the rear of the curved forward portion of the bar gang, if a full one-inch projection existed for all bits, which is by no means the case for the side bits. This increased rate of coal removal I believe to be explained by the fact that the D-R distance above mentioned is so relatively short that much of the detaching action of the coal is not in the form of a cutting action which causes the coal to break out inwardly towards the free top face of the kerf, but to be broken off towards the free face of the seam, and these conclusions are further strengthened by the fact that, in certain instances, with the practice of my invention the percentage of "over 1'" coal is 36% to 40%, and the percentage of "over 2'" coal is 18% to 22%, conditions which would not occur, even were it possible to perform a normal cutting operation, with a 1" projection of the center bits; and the actual normal penetration of bits in ordinary kerf cutting only runs on the order of ½", being kept down by the reduced penetration of the side bits. The upswing time is definitely reduced, in very many coals, by the detachment periodically of chunks of substantial size due to the fact that the increased areas of bit contact with the coal and the short distance D-R may enable the bits to operate to break out chunks of coal larger than would be detached by single bits with normal penetration. The factor of increased area of contact produced by the forcing of the bits a greater distance into the coal cannot be overlooked, for when the area of a bit's contact with the coal in a plane more or less perpendicular to the direction in which a lump of coal can be broken out, multiplied by the bearing strength of the coal, exceeds the sum of the forces necessary to free the bonds of a lump to the seam, then that lump will be torn out.

While I do not wish to be restricted to this theory of operation, it is my opinion that the completion of the upswing in a period so much shorter than would ordinarily

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occur if the coal were simply being cut out in accordance with normal cutting conditions—during which period the penetration of the individual bits would probably be on the order of ½", instead of the observed mean coal removal of 1½" on the average, in the example cited, for each action of each bit on the coal—is possible (a) because no central bits will cut less than their full projection if there is coal ahead of them to cut; (b) because some bits, as when the coal is partially fractured by the action of one or more preceding bits, may break and tear out the coal without any cutting action at all, (c) because the periodic attacks by the transverse rows of bits will augment the disintegrating action by weakening the coal, and (d) because at times, and especially in the upper positions of the bar, where the bits are working towards an overhanging lip of coal, there will frequently be dislodged blocks of coal a plurality of chain widths in lateral length. Frequently lumps of coal actually come out so large that the breakers are essential, and occasionally, where the large lumps may escape to the floor and be picked up, or may get past the breakers endwise without sufficient fracture, there may even be momentarily a stalling of the primary conveyor until the coal is broken up. Thus I have an action in the practice of my improved method quite different from that of the prior art, and the combination of a relatively short D-R distance, plus an internal stressing of the coal in the columns at the ends of which sumping is performed, plus a force adequate fully to utilize the potential penetration of the bits gives a combination of reduction in maximum breaking forces requisite to detachment of the coal and of increases in pulling or tearing action as distinguished from cutting action, sufficient to break or tear out a very substantial amount of coal rather than to have the bits cut out all of the coal as their primary mode of operation.

While the values given in the illustrative example are actual and have been found to be satisfactory under a particular condition of service, it is to be understood that these values may be varied not only to meet the requirements of different bodies of coal but also under any given conditions of service to obtain like results by effecting complementary changes in involved factors upon change in other factors.

Before a final summary, it may be noted that such features as motor controls, headlights, lubrication, hoses, electrical conductors, water spray, controllers, location and control arrangements, etc. did not require description for the purposes of this case, but have been fully disclosed in Serial No. 11,688.

In Figs. 14 and 15 I have provided operating diagrams, the first in the form of a top view and the second in the form of a side elevation, to show the mining of coal by the practice of the invention. Some of what follows is by way of recapitulation.

By means of the crawlers, the apparatus will be moved into the place where work is to be performed, and during the transit of the apparatus, the nose of the main conveyor and the scrolls will be lifted out of contact with the bottom. Where the work is to be performed in a relatively narrow compartment, as for example, in an entry, the apparatus will be moved along the center line of the mine chamber and brought up to a position in which the forward end of the disintegrating device, when in horizontal position, will be substantially at the face. The disintegrating device will then be moved to adjacency to the rib at which the initial operation in crossing the face is to be performed—say the left hand rib; and, the disintegrating device having been brought down to the level of the bottom, and the floor jack at the rear end of the apparatus having, when circumstances so indicate, been supplied with fluid under pressure to maintain the disintegrating device at the desired height at its forward end, a sumping operation will be performed by feeding the disintegrating apparatus radially of the turntable. During sumping to the requisite depth—a depth normally

determined by the effective length of the sumping and withdrawing cylinders—the brake devices, which will have been released during the lateral swinging of the disintegrating apparatus, will hold the turntable against rotation; and these brake devices will continue to function during the ensuing upward swing of the disintegrating apparatus by the lifting cylinders to such a point as may have been determined for the desired roof height. After this, noting that this height may be automatically controlled, a withdrawing operation may be performed, and the disintegrating apparatus may be moved outwardly and clear away the small depending angular shaped mass of coal at the roof between the top position of the disintegrating apparatus at the end of the upward swinging movement thereof and the level of the roof outside the face. After one vertical band has been removed, the turntable brakes will be released, the disintegrating apparatus turned, clockwise in the case assumed, through the necessary angle to position it for an attack on the next adjacent vertical course of coal; and, after the disintegrating device is lowered, the operations of sumping, upward swinging, and withdrawal will be repeated. This will be continued in successive steps until a "layer" the full width of the face has been removed, and then, after the jack or jacks are released, the apparatus will be moved forward a short distance—something less than the potential sumping feed—and the next section of the face removed in similar steps. It will be observed that the face will be arcuate in horizontal section and arcuate in vertical section, and that the operations can be performed with great rapidity. The roof jack may supplement the action of the floor jack in locking the parts, as during sumping, and may also be used, when desired, to effect an adjustment in altitude not practicable with the floor jack, which can raise the rearward end of the apparatus but not force it down.

Substantially all of the material detached and disintegrated by the operation of the disintegrating apparatus will be carried rearwardly and dumped through the hood and through the turntable onto the main conveyor, and be delivered at the rear of the latter either onto a suitable material-handling apparatus or, where a tail conveyor is used, onto the latter; and the tail conveyor may be adjusted vertically at its rear end and also horizontally at its rear end—vertically by power and horizontally manually—so as to permit the discharge of the mined material to a conveyor, or to a shuttle car, or to any other apparatus which may be used for the expeditious handling of the large production of coal or other mineral by the apparatus which forms the subject of this application.

The bottom will be normally cleared of coal in advance of the apparatus, as the same moves forward; the material directly in front of the main conveyor being picked up by the forward end of the latter; the material in front of the crawlers being moved by the inner scrolls laterally and then handled by the main conveyor; and the loose material between the sides of the crawlers and the ribs will be picked up by the yieldably mounted side scroll sections and their associated plates and moved into the zone of operation of the inner scrolls and then conveyed by these latter to the main conveyor.

The disintegrating apparatus moves the coal between its side boards and discharges it into the hood and any large lumps will be ordinarily broken up by the breaker devices.

When it is desired to turn off at an angle, the face disintegration may be confined to one side or the other of the chamber, and as the angle of the crawlers to the face is changed, an entry may be turned off very quickly.

Substantially all of the coal or other mineral brought back from the face will be delivered to the hood, will pass through the turntable, and will be delivered by the main conveyor at the rear end of the latter or at such other point as its exit may be provided for.

Because of the upward operation of the disintegrating apparatus, it will be enabled to collect a very large part of the material disintegrated from the vein. Because of the width of the band mined out at any time, the number of vertical courses having to be made in any mine chamber before the apparatus will be moved forward to a new position will not be large. Because the turntable is enabled to receive at all times the material brought back by the disintegrating apparatus and to discharge it onto the main conveyor, there will be very little occasion for shoveling, particularly since the scrolls and the forward end of the main conveyor will keep the floor practically clean both in front of and at the sides of the apparatus. It is evident that the method of my invention is practiced in the operations described.

It is evident that the invention provides a very effective method of mining coal from the solid, but the advantages inherent in the methods herein described need not be catalogued here.

While I have in this application specifically shown and described illustrative practices of the method of my invention, it will be understood that these were shown and described for purposes of illustration only, and that the invention may be modified without departing from its spirit or the scope of the appended claims.

What is claimed is:

1. The method of freeing relatively large bodies of mineral from the solid mineral in a seam of which a forward surface lies in an upright working face, which method includes subjecting successive bodies of the mineral at different points spaced transversely of the face along the length of each such body measured transversely of the face, and inwardly of the working face, to the actions successively of series of orbitally moving bits disposed in rows extending transversely of the face and each successively moving outwardly in a direction substantially normal to the face, with the bits of each row at all such times being at a mean distance from the face less than the spacing between such row and the next succeeding row, and with said bits at substantially all such times engaging the mineral with a much greater penetration than would prevail if the bits were simply removing the mineral by a cutting action, so that said bits have such a cumulative face contact with the mineral that the product of the cumulative area of the projections, on planes perpendicular to the direction of bit movement, of the areas of face contact of such bits with the mineral multiplied by the bearing strength of the mineral exceeds the sum of the bonds with the seam of the body acted upon by said bits.

2. The method of increasing the rate of mineral disintegration and effecting periodic detachment of mineral from the solid in substantial lumps during the shearing portion of an attack on an upright face which includes first a sumping operation and then a shearing operation, which method includes subjecting, during shearing, the mineral at the advancing surface of an opening initially produced by sumping and extended by shearing, to the action of chain supported bits carried by more than two mutually adjacent chains and traveling in upright planes in orbits of which the portions disposed within the mineral are essentially parallel and of each of which orbits at least the portion disposed most deeply in the mineral is substantially arcuate, which orbits are spaced apart laterally substantially equally but yet so close to each other than the cumulative action of said bits, through the formation of individual grooves of a depth less than sufficient to provide the tearing action hereinafter specified, would remove the mineral at said advancing surface by a substantially purely cutting action if the individual bits had such small mineral penetration that they could act only individually in detachment of mineral from the solid, said bits being arranged in rows extending transversely of the fact and having the individual bits of each of the several rows spaced from

the bits most nearly directly behind them in the next succeeding transversely extending row by an amount substantially equal to the distance from the face to the nearer ends of the arcuate portions of the orbits of said bits, and effecting at substantially all times a depth of penetration of the bits in the mineral. Substantially exceeding that which would be possible were the bits simply removing the mineral by a cutting action to cause the product of the cumulative effective area of contact of the bits with the mineral ahead of them as they travel towards the face, multiplied by the bearing strength of the mineral, periodically to exceed the force necessary to detach a lump of mineral of a width a plurality of times the mean distance apart of the bits in a given row and thereby to effect a tearing loose of such a lump.

3. The method of increasing the rate of mineral disintegration and effecting periodic detachment of mineral from the solid in substantial lumps during the shearing portion of an attack on an upright face which includes first a sumping operation and then a shearing operation, which method includes subjecting, during shearing, the mineral at the advancing surface of an opening initially produced by sumping and extended by shearing to the action of many disintegrating elements traveling in upright planes in orbits of which the portions disposed within the mineral are essentially parallel and of each of which orbits at least the portion disposed most deeply in the mineral is substantially arcuate, which orbits are spaced apart laterally substantially equally but yet so close to each other that the cumulative action of said disintegrating elements, through the formation of individual grooves of a depth less than sufficient to provide the tearing action hereinafter specified, would remove the mineral at said advancing surface by a substantially purely cutting action if the individual disintegrating elements had such small mineral penetration that they could act only individually in detachment of mineral from the solid, said disintegrating elements arranged in rows extending transversely of the face, said rows being spaced, in the direction of the travel of the disintegrating elements toward the face, so that when the midpoint, transversely of the face, of one row moving towards the face is disposed midway between the face and the ends of the arcuate portions of the disintegrating element orbits which are nearer the face, the midpoint of the next succeeding row is still in said arcuate portions, whereby each row is for a time the only row acting upon the mineral in the portions of the orbits of its disintegrating elements between said arcuate portions and the face, and the several disintegrating elements in each row being spaced a mean distance apart corresponding to the main distances apart of bits on parallel cutter chains cutting without overlap of the bit orbits on different chains an opening of a width—the sum of the widths of the kerfs cut by the bits of such parallel chains when acting as kerf-cutters—equal to the total width of mineral removed by said many disintegrating elements, and maintaining at substantially all times a depth of penetration of the disintegrating elements in the mineral so greatly exceeding that which would be possible if said elements were removing the mineral by a simple cutting action as to cause the product of the cumulative effective area of working contact of the disintegrating elements with the mineral, multiplied by the bearing strength of the mineral, periodically to exceed the force necessary to detach a lump of mineral of a width a plurality of times the mean distance apart of the disintegrating elements in a given row and thereby to tear loose a lump of such width.

4. The method of increasing the rate of mineral disintegration and effecting periodic detachment of mineral from the solid in substantial lumps during the shearing portion of an attack on an upright face, which attack includes first a sumping operation and then a shearing operation, which method includes subjecting during

shearing, the mineral at the advancing surface of an opening initially produced by sumping and extended by shearing to the action of obliquely transversely extending rows of chain supported bits carried by more than two mutually adjacent chains and traveling in upright planes in orbits of which the portions disposed within the mineral are essentially parallel and of each of which orbits the portion disposed most deeply in the mineral is substantially arcuate and which orbits include another portion between such arcuate portion and the face along which last portion said bits move outwardly toward the face, said orbits being spaced apart laterally substantially equally but yet so close to each other that the cumulative action of said bits, through the cutting of individual grooves would remove the mineral at said advancing surface, if the individual bits had such small mineral penetration that they could act only individually in detachment of mineral from the solid, the obliquity of said rows being such that all of the bits in any row may act concurrently upon the mineral while traversing the second mentioned portion of their respective orbits, and the spacing of said rows being such that all the bits in two consecutive rows cannot act simultaneously on the mineral while moving in the second mentioned portion of their respective orbits, and effecting at substantially all times a depth of penetration of the bits in the mineral so greatly exceeding the depth of mineral penetration possible if the bits were simply removing the mineral by a cutting action as to bring the product of the cumulative effective area of working contact of the bits in a row with the mineral ahead of them as they travel toward the face, multiplied by the bearing strength of the mineral, at least some of the time to a cumulative force exceeding the bonds to the vein of a lump of mineral of a width a plurality of times the width of one of the chains by which said bits are supported, thereby to effect a tearing loose of a lump of mineral of such width.

5. The method of increasing the rate of mineral disintegration and effecting periodic detachment of mineral from the solid in substantial lumps during the shearing portion of an attack on an upright face which includes first a sumping operation and then a shearing operation, and which method includes, during shearing, (a) subjecting the mineral, at the advancing surface of an opening initially produced by the sumping operation and extended by the shearing operation to the action of many bits traveling in upright planes in orbits of which the portions disposed within the mineral are essentially parallel and of each of which orbits at least the portion disposed most deeply in the mineral is substantially arcuate and which orbits are spaced apart laterally substantially equally but yet so close to each other that the cumulative action of said bits, through the formation of individual grooves of a depth less than sufficient to provide the tearing action hereinafter specified, would remove the mineral at said advancing surface by a substantially purely cutting action if the individual bits had such small mineral penetration that they could act only individually in detachment of mineral from the solid, said bits being arranged in rows extending transversely of the face and said rows being so spaced, in the direction of the travel of the bits toward the face, that when the midpoint, transversely of the face, of one row moving toward the face is disposed midway between the face and the ends of the arcuate portions of the bit orbits which are nearer the face, the midpoint of the next succeeding row is still in said arcuate portions, whereby each row is for a time the only row acting upon the mineral in the portions of the orbits of its bits between said arcuate portions and the face, and in each row there being a forwardmost bit and a plurality of other bits each of which is spaced a different distance to the rear of said forwardmost one, and (b) maintaining at substantially all times a depth of penetration of the bits in the mineral so far exceeding that which would be possible if the bits were removing the mineral by a simple

cutting action as to cause the bits to cease an individual grooving action and to cause the product of the cumulative effective area of contact of the bits with the mineral, multiplied by the bearing strength of the mineral, periodically to exceed the force necessary to detach a lump of mineral of a width a plurality of times the mean distance apart of the bits in a given row and thereby to tear loose a lump of such width.

6. A method of high speed removal of mineral from a solid mine vein having an upright working face, which method involves successively removing by ripping operations relatively wide vertical bands of mineral by subjecting the mineral within a band at points spaced transversely and inward of the working face, to the action of a plurality of projecting bits, said bits traveling in noncircular orbits spaced laterally in relation to each other, said bits being disposed in successive rows extending transversely of the face and each moving outwardly in a direction substantially perpendicular to and toward the face, with the bits of each row at all such times being at a limited mean distance from the face, and moving said bits in their orbits outwardly toward the face and simultaneously in a direction generally normal to the direction of bit movement toward the face at relative rates so coordinated that the bits are moved at substantially all times throughout their range of movement in a direction generally normal to the direction of orbital movement at a rate substantially exceeding that which would be possible if the mineral were removed by a simple cutting action.

7. A method of high speed removal of mineral from a solid mine vein of which a forward surface lies in an upright working face, which method involves removing by a ripping action a relatively wide band of mineral by subjecting the mineral within the band at different points spaced transversely and inward of the working face, to the action of a plurality of projecting bits, said bits traveling in orbits which are partially within and partially outside of said vein and which are spaced laterally in relation to each other, the bits being disposed in successive rows extending transversely of the face and the portions of the orbits within the vein being maintained in parallel planes, and moving said bits in their orbits and simultaneously moving the portions of said orbits within the vein in their planes at relative rates so coordinated that the portions of said orbits within said vein are moved in their planes through the mineral substantially constantly at a rate materially exceeding the rate at which said portions of the orbits would move if the mineral were removed by a simple cutting action of the bits.

8. A method of high speed removal of mineral from a solid mine vein which method involves the successive removal of relatively wide strips of mineral from the mine face, comprising first effecting the formation of an opening, of a width of the strip to be removed, at one end of a strip, then progressively removing the strip by ripping away the mineral forming the boundary of said opening remote from said one end of the strip, and finally completing the removal of the strip by the removal of the portion of the strip between the face and the end of the opening formed by the ripping operation, including effecting such ripping operation by forced movement longitudinally of said strip of laterally offset orbits of groups of orbitally moving projecting bits substantially constantly at a rate which greatly exceeds that which would be possible if the mineral were removed by said bits by a simple cutting action.

9. A method of high speed removal of mineral from a solid mine vein by a ripping operation, which method in-

volves successively disintegrating relatively wide vertical bands of mineral from the solid at the face of a vein and comprises sumping a disintegrating member into the vein and moving such member to cause the portion thereof that is sumped inside the face to move generally vertically through the vein, tearing out mineral from the vein by projecting vein-attacking elements carried for orbital movement by the disintegrating member, a plurality of such elements moving in spaced relation in each of a plurality of upright, at least partially arcuate orbits, applying power to move the portion of said disintegrating member which is inside the face generally vertically and to move the vein-attacking elements in their orbits at coordinated speeds such that the portion of said disintegrating member inside the face so moves generally vertically through the vein that its instantaneous rate at substantially all times is materially faster than would be possible if the mineral were removed by said elements by a simple cutting action.

10. A method of high speed removal of mineral from a solid mine vein by effecting successive removal, largely by ripping operations, of relatively wide strips of mineral from the solid, which operation includes a sumping operation followed by a shearing operation, both said sumping operation and said shearing operation employing disintegrating elements having carrying means from which they project and by which they are moved in transversely spaced orbits including arcuate portions which are disposed at the end of sumping within the mineral inwardly of the working face, the shearing operation involving movement of the orbits generally longitudinally of the strip to be removed, which method includes the following procedures: (1) maintaining during the shearing operation movement of said elements through said arcuate portions in the several orbits at substantially equal linear speeds and relatively uniform angular rates, (2) limiting the depth of sumping to such an extent as to minimize the number of elements in all of said orbits concurrently acting on the mineral, thereby increasing the mineral penetration, under a given total shearing movement-effecting force, of the elements nearest the face as they move outwardly towards the latter with no other elements between them and the face, and (3) applying a predetermined force during the shearing operation in a manner to move the portions of said orbits within the mineral at a rate coordinated with the rate of movement of the disintegrating elements in their orbits, the instantaneous rate of such movement of said portions of said orbits being substantially at all times materially faster than that which would be possible if the bits removed the mineral by a simple cutting action.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,798,706

July 9, 1957

Harold F. Silver

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 30, for "suporting" read -- supporting --; line 35, before "includes" insert -- illustrated --; same line, strike out "supporting and propulsion mech-" and insert instead -- mechanism for dis-; column 15, line 17, after "cut" insert -- to --; column 18, line 66, for "than" read -- that --; line 74, for "fact" read -- face --; column 19, line 52, for "main" read -- mean --; column 20, line 19, for "robs" read -- rows --.

Signed and sealed this 24th day of September, 1957.

(SEAL)

Attest:
KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents