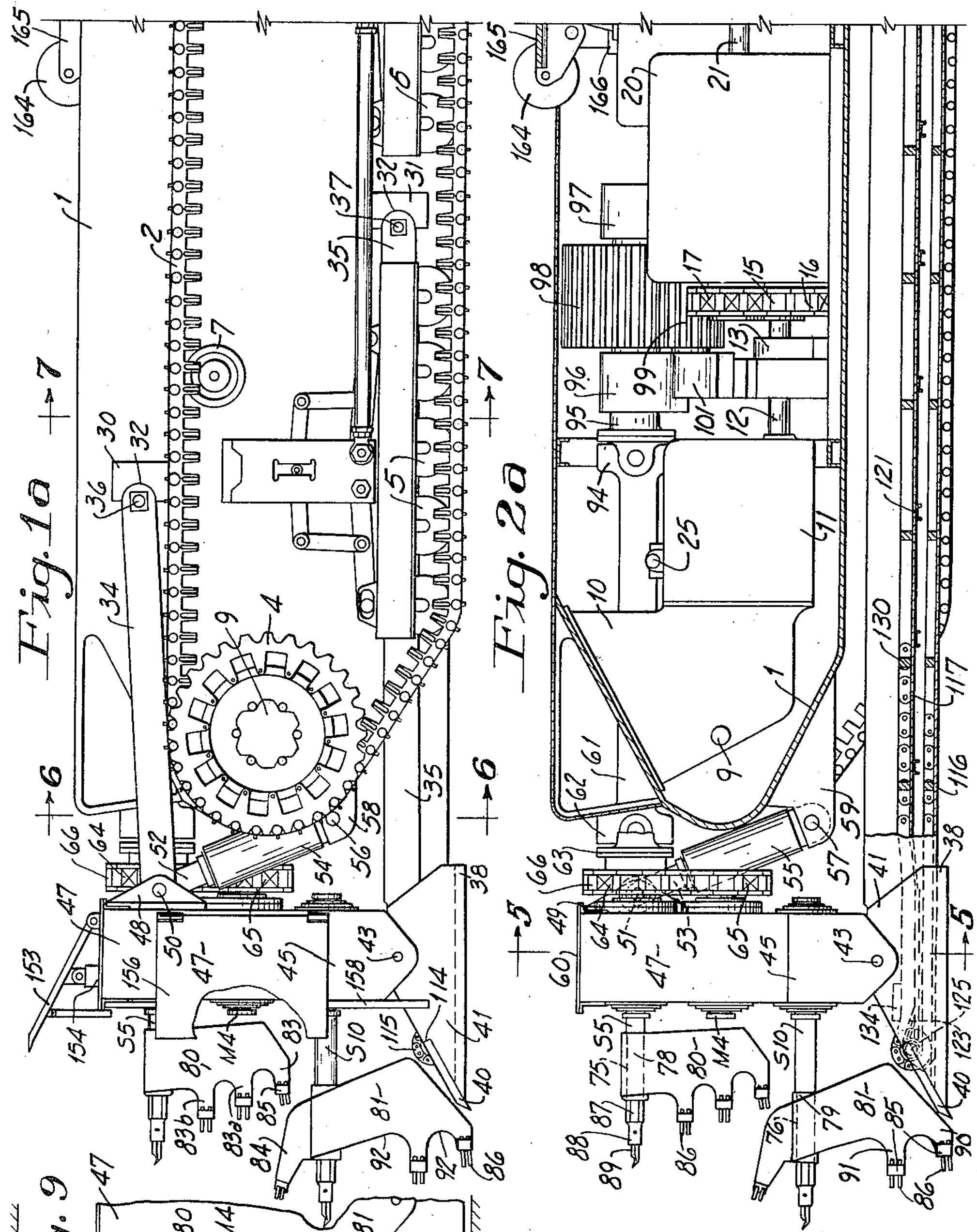
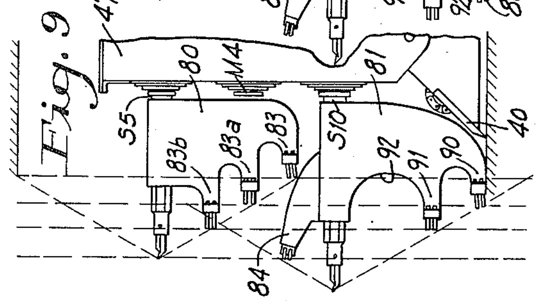
Nov. 16, 1954 C. H. SNYDER ET AL 2,694,562

APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 1





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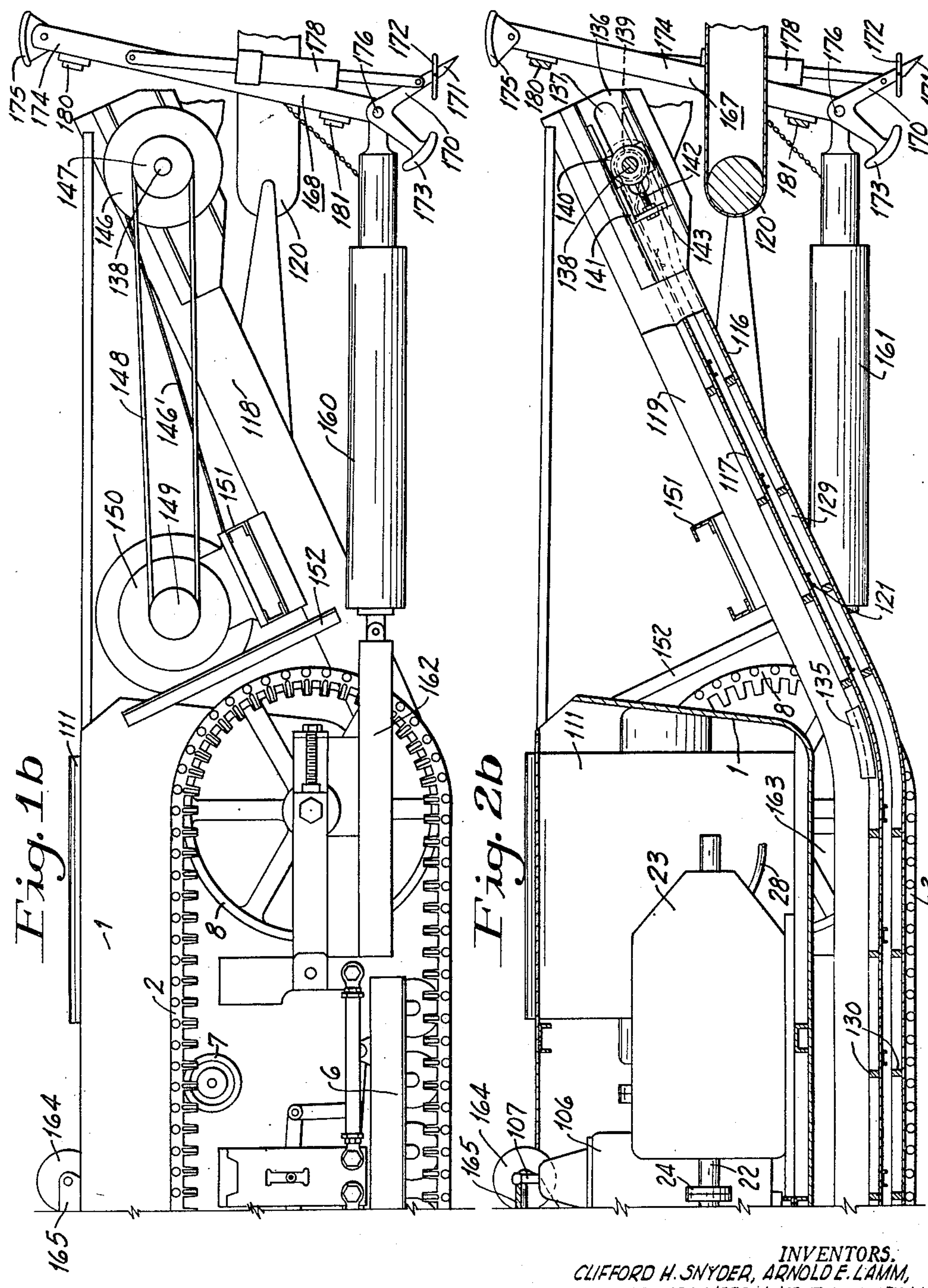
APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 2



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APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 3

Fig. 3a

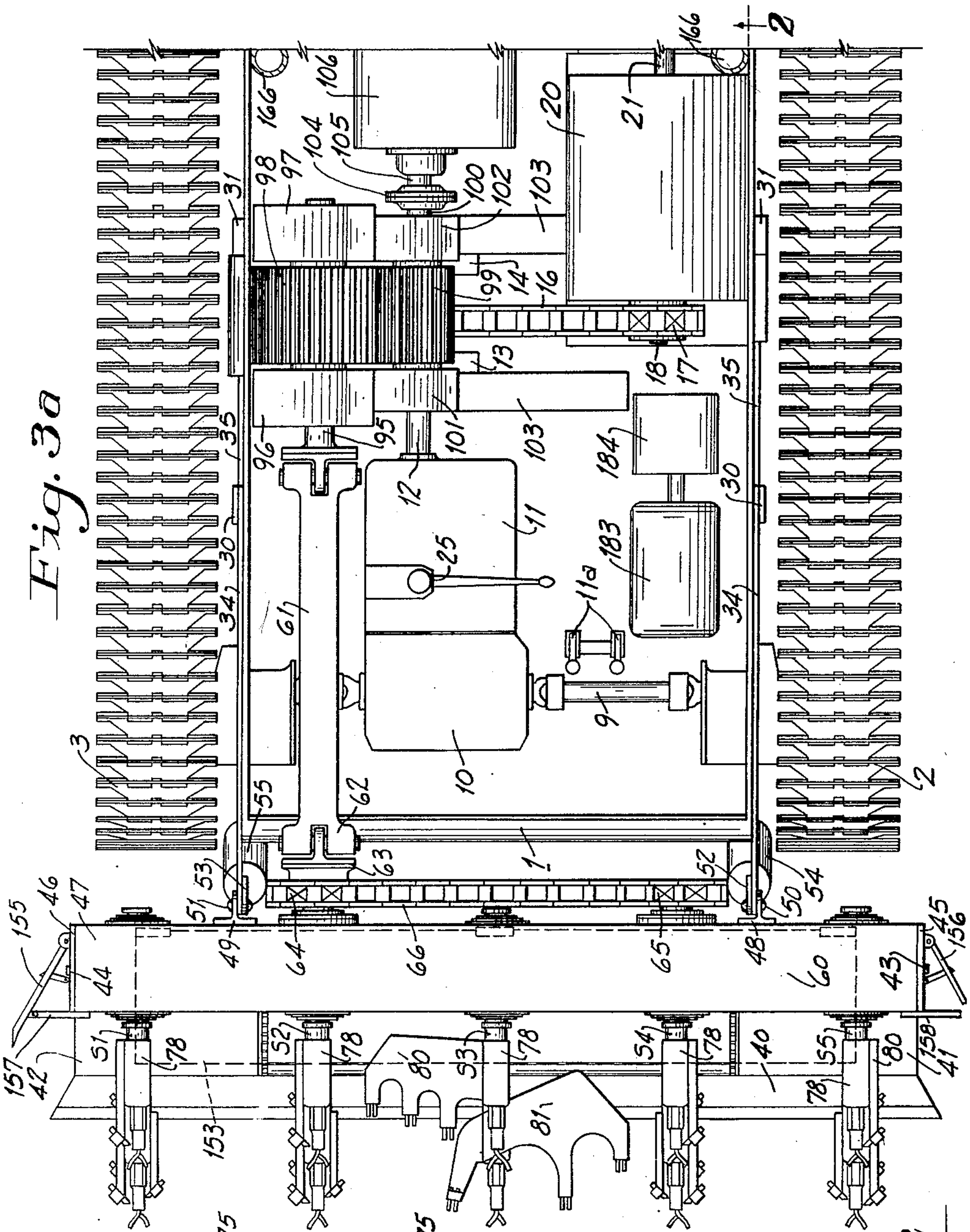
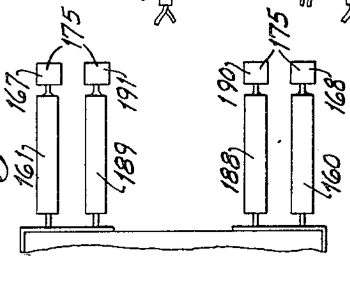


Fig. 11



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APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 4

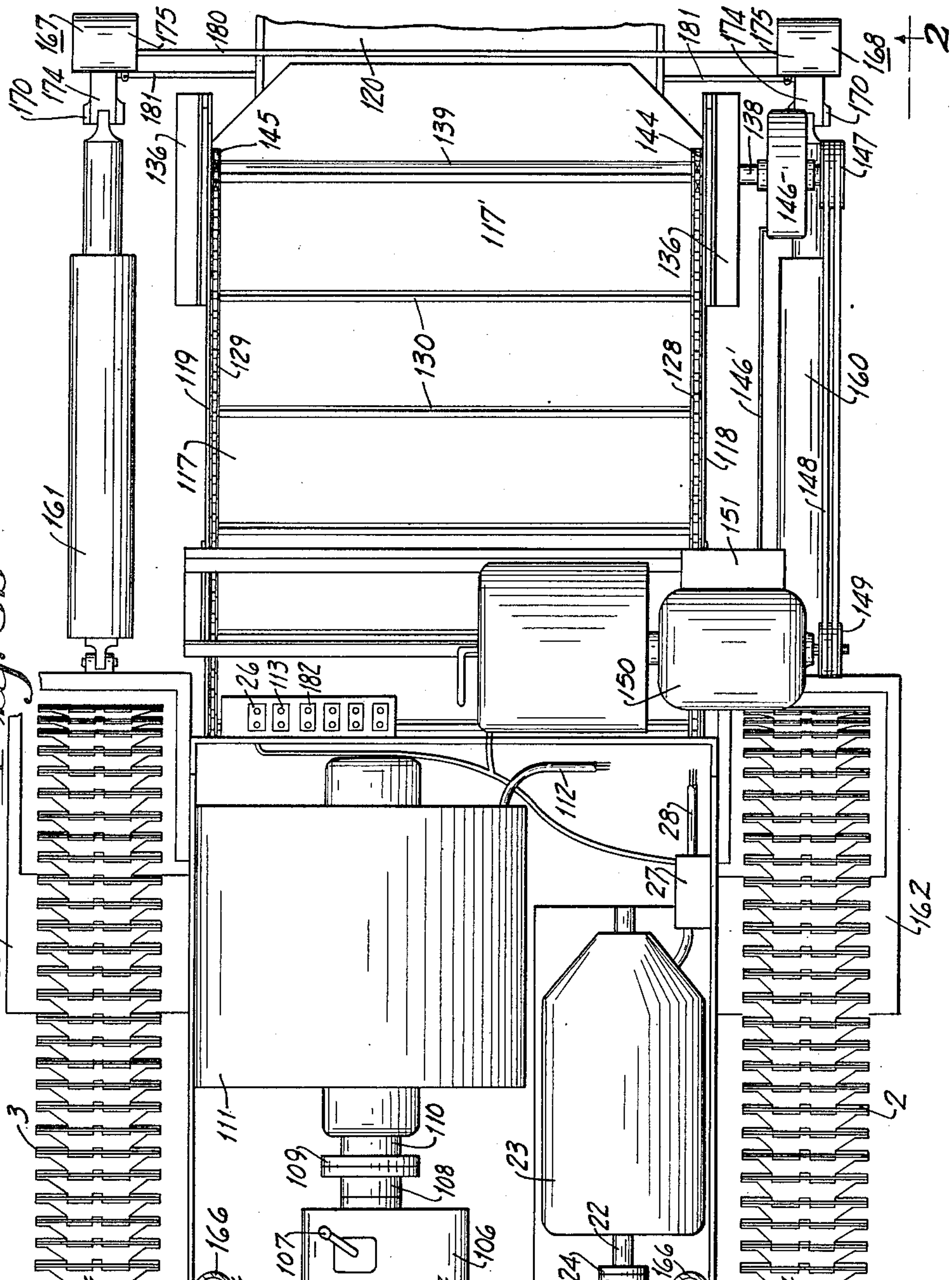

Fig. 3b

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APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 5

Fig. 4

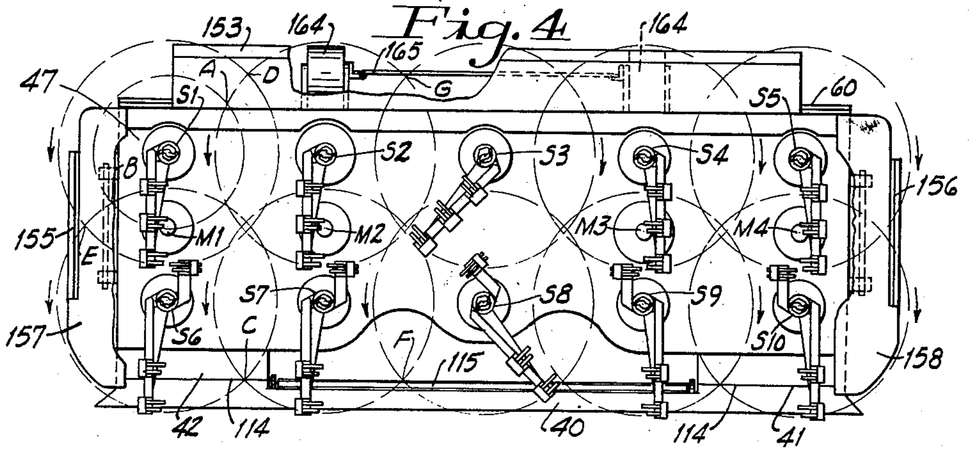


Fig. 5

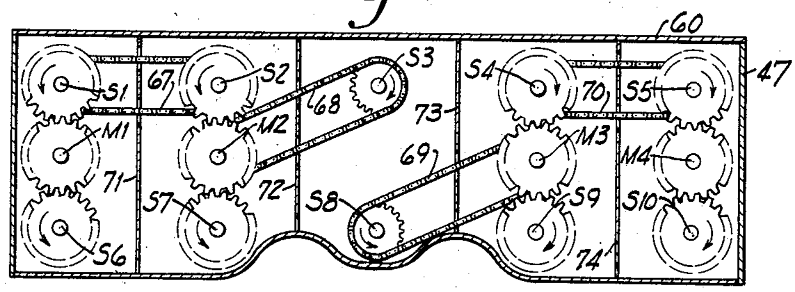


Fig. 8

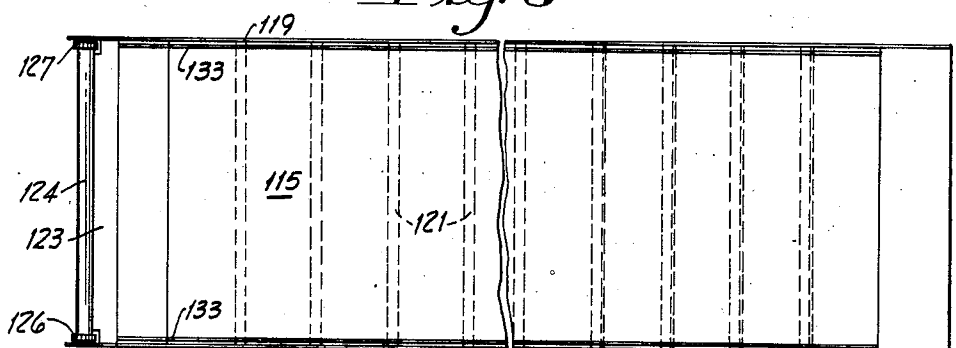
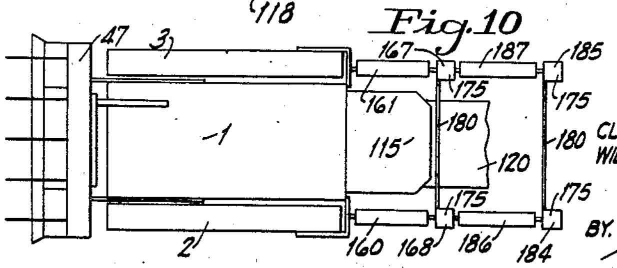


Fig. 10



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APPARATUS FOR CONTINUOUSLY DIGGING COAL

Filed March 2, 1948 6 Sheets-Sheet 6

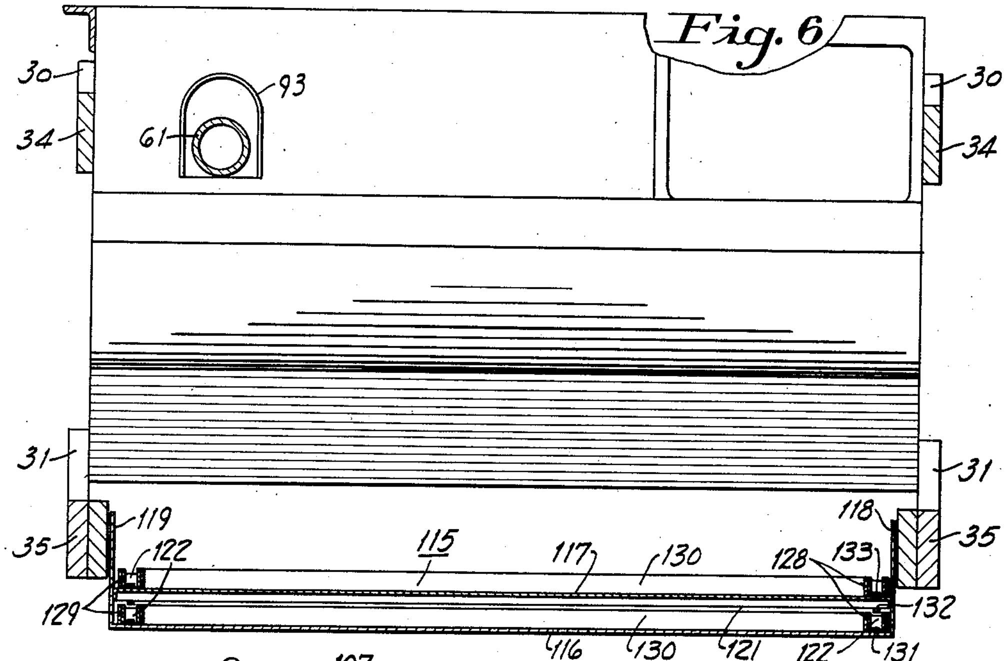

Fig. 6

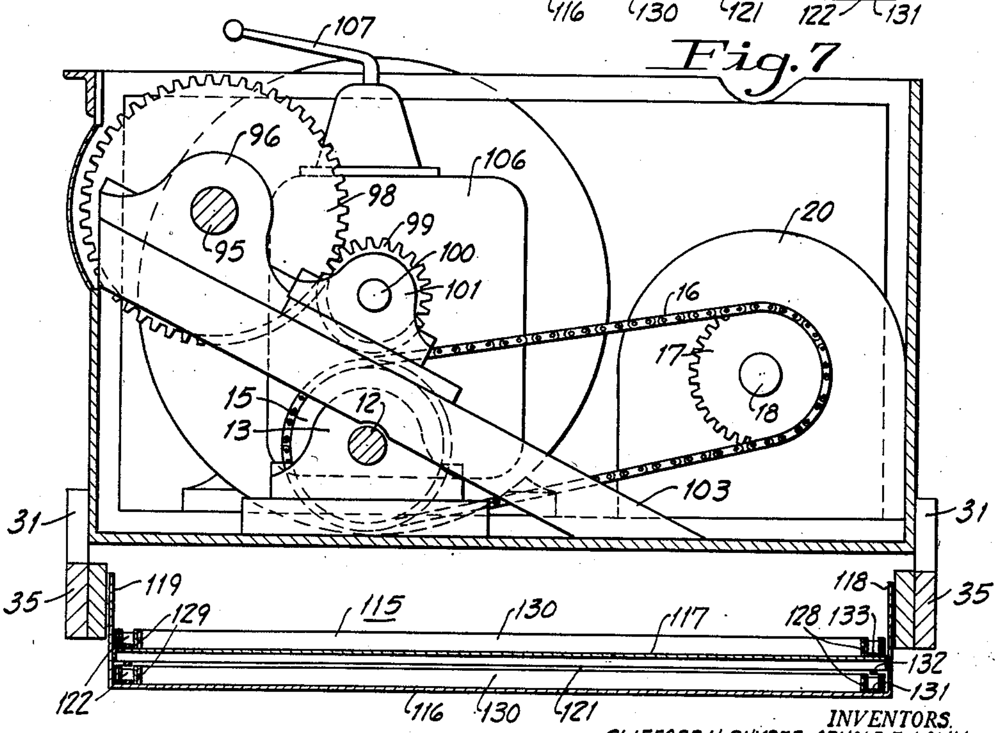

Fig. 7

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APPARATUS FOR CONTINUOUSLY DIGGING COAL

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Application March 2, 1948, Serial No. 12,626

52 Claims. (Cl. 262—9)

This invention relates generally to mining, and more particularly to new and improved apparatus for the mining of coal and in its more specific aspect contemplates the continuous mining of coal.

The present general practice of deep coal mining necessitates a series of steps performed in cycles by the aid of different machines. The first step is effected by cutting bars provided with endless chains containing bits that undercut the coal, which is in reality a milling process producing great quantities of bug-dust or fines that is a source of many mine explosions. The undercutting may be supplemented by side cutting or sometimes top cutting into the face of the coal or both. Most of the coal mined is by undercutting alone, after which the machine is removed and a drilling machine is then brought to the face to drill shot holes, after which this machine is removed and the coal is then blasted either by explosives or compressed gas in these shot holes to expand it and break it down. A loading machine is then brought to the face to load the coal on a conveyor or other means, from whence it is conveyed to the main entries of the mine where it is transported by rail or belt to the surface. Present undercutting practice frequently creates steplike projections or offsets or loose and jagged conditions on both roof and floor which must be taken down, cleaned up and timbered.

Improvements in the art of deep mining coal have been confined principally to improved cutting bar machines, drilling machines, loading machines, bug-dusters and other supplementary equipment employed with such apparatus. However, the present practice and methods of deep mining follow the same cycle of undercutting, drilling blasting, loading and conveying which cycle has been practiced for centuries. Increased production in the past few years is due principally to the improved machines for each individual phase of this coal mining cycle.

The shooting of coal by explosives or otherwise subjecting it to expansion or material vibration seriously damages the earth's structure, which subsequently results in the production of falls that materially add to the hazard of deep mining. Blasting and vibrations incident to the present mining cycle weaken the roof and ribs and create hazards to crews working in other sections of the mine.

Some machines are arranged to undercut a section of coal and then break it down by vibratory picks. The cutting bar and the picks are presented alternately to the coal face. This character of machine operates in cycles with alternate periods of undercutting, then breaking down the coal. It is designed to operate on only a small portion of the face at a given time. The alternate presentation of the undercutter and the picks, together with the fact that it operates on only a partial section of the face, prevents this machine from functioning as a continuously progressing coal mining machine.

Continuous tunneling machines of the rotary cutting type have been suggested in the art for tunneling in combination with a conveyor. Such suggested machines were slow boring tools obviously intended to mill or grind through the earth and their cutters engage and bind on the perimetral surface of the tunnel. Although such machines were suggested they have never been practical. The foremost tunneling engineers still employ manually operated drills for tunneling.

The art has also suggested the use of obviously impractical rotary machines for the mining of coal which have rotary cutters provided with wedges intended to

break the coal but actually prevent the advancement of the cutters into the coal. Also the cutter supports bind against the perimetral surface of the tunnel and thus they could not function as continuously progressing mining machines but represent mere ideas that do not have utility.

This invention overcomes the numerous difficulties inherent in the foregoing processes, and have provided method and apparatus for greatly increasing the production of a highly marketable coal economically and at a uniformly low cost, wherein the high percentage of fines and bug-dust have been eliminated.

The present invention contemplates apparatus for simultaneously cutting, preferably by chipping, removing and loading coal from the entire solid face in one single operation to accomplish what has heretofore required four steps in the mining cycle consisting of undercutting, drilling, shooting and loading. At the same time it eliminates the undesirable milling that produces bug-dust and fines and also the unsafe effects of shooting permitting the carrying out of simultaneous operations throughout the mine that are free from such hazards.

The cutting means, which per se constitutes an inventive feature, is provided with a plurality of cutters, preferably widely spaced radially, preferably progressively receding axially, and preferably connected by rearwardly spaced surfaces which may be sharpened, all mounted on a rotary head that cuts a series of annular concentric kerfs to free the coal from pressure and break it from the face and with the aid of scraping means continuously feed it to a conveyor. The use of such chipping cutters prevents the formation of fines or bug-dust in chipping the kerfs.

The cutting heads are preferably arranged in a plurality of banks with adjacent heads preferably in overlapping relation. Certain of said banks of cutting heads preferably lead others, advantageously in progressive sequence. The opening cut by each head combines with openings cut by adjacent heads in the same or different banks to form a single entry or opening.

Each of the outermost rotary cutting heads on the mining machines, which determine the size of the opening formed, is preferably dimensioned and mounted to cut clearance beyond the limits of the machine and to move to a predetermined position out of contact with the perimetral surface of said opening.

The heads simultaneously sweep the freed coal laterally, preferably from the sides, in opposite directions, across the entire face to a conveyor which rapidly removes the coal. The sweeping action of the heads supplemented by blade scraping means removes all of the coal as the entry or room is driven, leaving a continuously smooth clean floor so that substantially no loose coal is lost or wasted and no manual cleanup is required.

The apparatus herein taught represents a true continuous mining machine as it continuously cuts and removes the coal when forming its entries and rooms as the machine progresses through the coal. These improved mining conditions eliminate the inherent dangers of the slow conventional mining cycle methods wherein the interrupted steps in multiple operations accelerates oxidation and the resultant crumbling roof yet require the repeated return of men and machines to such areas for completing the mining cycle. In the apparatus as taught by this invention, coal is chipped from the solid very rapidly and the freshly cut roofs of the entries or rooms are driven forward at a speed hitherto unknown and are unaffected by oxidation and its resultant degradation, and no men need return or remain in a given area for any length of time as in the heretofore practiced mining cycle.

Other objects and advantages appear in the following description and claims.

The accompanying drawings show, for the purpose of exemplification but without limiting the invention or claims thereto, certain practical embodiments of the invention wherein:

Figs. 1*a* and 1*b* together constitute a side elevation of the machine embodying the invention with portions omitted for simplification;

Figs. 2*a* and 2*b* together constitute a sectional view taken on the line 2—2 of Figs. 3*a* and 3*b* with portions omitted for simplification;

Figs. 3*a* and 3*b* together constitute a plan view of the structure shown in Figs. 1*a* and 1*b* with portions omitted for simplification;

Fig. 4 is a front elevation of the machine;

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 2*a*;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 1*a*;

Fig. 7 is a sectional view taken along the line 7—7 of Fig. 1*a*;

Fig. 8 is a plan view of the conveyor body;

Fig. 9 is a side elevation of a modified arrangement of the cutting heads;

Fig. 10 is a diagrammatic view of the machine having two sets of feed jacks in tandem; and

Fig. 11 is a diagrammatic view of the machine having two sets of feed jacks in parallel.

Referring to the drawings the coal mining machine consists of the hollow vehicle body **1** supported for movement by the independently controlled tracks **2** and **3** propelled by the driving sprockets **4** on each side of the front thereof and supported by the two sets of supports **5** and **6** having five bogie rollers each on each side thereof. The endless tracks are provided with grousers as shown in Fig. 1*a*. The upper flight of each track is supported by a pair of track support rollers **7** which are suitably journaled on the side of the vehicle body **1**. The rear of the body **1** is supported by a pair of track idler wheels, such as illustrated at **8**, one on each side of the body. The front driving sprockets **4** are secured to the outer ends of the axle **9**, the intermediate portion of which is connected through a suitable differential **10** and transmission indicated at **11**. Suitable conventional brake steering members are arranged when operated to lock the corresponding section of the axle **9** for the purpose of stopping one track while the other proceeds in order to turn the vehicle.

The drive shaft **12** extends rearwardly from the transmission **11** and is mounted on the bearings **13** and **14**. Intermediate the bearings **13** and **14** the drive shaft **12** is provided with a sprocket gear **15** and is driven by the driving chain **16** from the drive sprocket **17**. The drive sprocket **17** is mounted on the end of the shaft **18** extending from the gear reducer **20**. The inlet end of the gear reducer **20** is provided with the shaft **21** connected to the shaft **22** of the motor **23** by means of the coupling **24**. The motor **23** is preferably a three-phase alternating current motor, the speed of which may be varied to control the speed of propulsion of the vehicle. However, the conventional transmission **11** is also provided with the gear shift lever **25** for the purpose of controlling the direction and speed of the vehicle. This transmission may be provided with four speeds forward and one speed reverse.

The propulsion motor **23** may be energized from the push button control **26** on a panel at the rear of the machine which functions to operate the line starter member **27**. The trailing cable **28** is arranged to connect energy through the line starter **27** to the motor **23** and the cable extends rearwardly of the machine to any desired distance to a position where it is connected to the source of current for supplying electrical energy to the machine.

As shown in Figs. 1*a* and 3*a* two pairs of swiveled socket members **30** and **31** are secured to the upper and lower sides of the body **1** and are provided with arcuate sockets **32** arranged to receive the correspondingly shaped ends of the upper and lower parallel arms **34** and **35**. The parallel arms **34** and **35** are also provided with aligned openings to receive the pivot pins **36** and **37**, respectively, the center of which is common to the center of the arcuate bearing surfaces of the sockets **32**. The parallel arms **34** and **35** extend forwardly between the body **1** and their respective tracks to beyond the front end of the machine and the forward ends of the lower arms **35** are integrally joined by the base plate **38**. A knife digging blade **40** is secured to the front edge of the plate **38** the assembly of which is referred to in the claims as the digging blade means. The cutting edge of the blade **40** is slightly higher than the outermost teeth of the lower cutter heads. The ends of the knife blade **40** flare outwardly and extend beyond the outermost portion of the tracks on either side of the machine. A pair of spaced box members **41** and **42** are secured at the outer side of the lower arms **35** and

are formed integral with the outer ends of the base plate **38**.

The box members **41** and **42** are each provided with aligned holes for receiving the pivot pins **43** and **44** arranged to extend through aligned holes in the box head plates **45** and **46**. The box head plates are in turn secured to the lower end of the gear box or head **47** which extends substantially the full width of the machine. The rear side of the box is provided with two pairs of spaced lugs **48** and **49** each of which are provided with aligned holes to receive the pins **50** and **51** which pivotally support the front ends of the upper parallel arms **34**. The eyes of the pistons **52** and **53** are also pivotally secured to the pins **50** and **51**. These pistons operate in the hydraulic jack cylinders **54** and **55** respectively which are pivotally attached at their lower ends as shown at **56** and **57** to their respective bracket members **58** and **59** that are secured to the body **1** of the vehicle. These jacks are double acting and provide positive force for raising and lowering the scraping blade and the gear case or head pivotally attached thereto. These double acting jacks thus enable the digging means on the fore part of the machine to be adjusted relative to the body for the purpose of following the coal seam.

As shown in Figs. 4 and 5, the gear box **47** is fabricated from heavy steel plate and is provided with a scalloped bottom. The top of the box is provided with marginal flanges arranged to receive the lid **60** which is removable.

At uniformly spaced positions the front and rear plates of the gear box or head are provided with aligned bearings for receiving the upper and lower rows of forwardly projecting cutter head shafts S_1 to S_{10}, inclusive, and the intermediate shafts M_1 to M_4, inclusive. The shaft S_2 is arranged to receive power directly from the vehicle through the drive shaft **61**, the universal joint **62** and the coupling **63**.

As noted in Fig. 5, the shaft S_2 is provided with a sprocket gear within the gear box which drives the shaft S_1 through the chain **67**. If the shafts S_1 and S_2 are arranged to drive the intermediate idler shafts M_1 and M_2 and the lower shafts S_6 and S_7 through a train of gears as shown, the intermediate shaft M_2 is also arranged to drive the shaft S_3 by means of the chain **68**. Thus, if the drive shaft **61** and the shaft S_2 are rotated in a counter-clockwise direction as viewed in Fig. 5 each of the shafts S_1, S_2, S_6 and S_7 will be likewise rotated in a counter-clockwise direction, whereas the shaft S_3 will be rotated in a clockwise direction owing to the fact that its drive is received from the intermediate shaft M_2.

Between the coupling **63** and the back of the gear box the shaft S_2 is provided with a sprocket gear **64** arranged to drive the sprocket gear **65** on the shaft M_3 by means of the roller chain **66**. The idler shaft M_3 rotates in a counter-clockwise direction. However, this shaft is likewise connected through gears to the shafts S_4 and S_9 and rotate these shafts in a clockwise direction. The intermediate shaft M_3 is also arranged to rotate the shaft S_8 by means of the chain **69** in a counter-clockwise direction. The shaft S_4 is arranged to drive the shaft S_5 in a clockwise direction through the chain **70** and the shaft S_5, being connected by gears through the shaft M_4, is arranged to drive the shaft S_{10} in a clockwise direction. By this arrangement of gear and chain drive both inside and outside of the gear box **47**, five of the ten head shafts are operated in a counter-clockwise direction and the rest are operated in a clockwise direction.

While we have shown two horizontal tiers or banks of five drive shafts each, three or more of such tiers may be employed. By the same token either two or more than five drive shafts may be employed in each tier.

The interior of the box is provided with the cross ribs **71**, **72**, **73**, and **74**, each of which is provided with suitable aligned openings or windows for receiving the upper and lower flights of the chains **67** to **70**, inclusive. The lower ends of the brace ribs **71** to **74**, inclusive, are also provided with windows to permit the inter-communication of oil within the gear box **47**.

As shown in Fig. 2*a*, the upper shaft S_5 does not extend as far beyond the end of the box **47** as does the complementary lower shaft S_{10} and the outer portion of each of these shafts is provided with the hexagonal surface indicated at **75** and **76** for the purpose of receiving the complementary hexagonal socket members **78** and **79** of the upper and lower cutter heads or digging members, arms, or breaker arms **80** and **81**. The heads **80** on the upper row of the shafts S_1 and S_2 are duplicates with teeth arranged to cut counter-clockwise and the heads on shafts S_3, S_4 and S_5 are duplicates with teeth arranged to cut clockwise. Each head **80** is provided with a plate section having three cusps **83**, **83a** and **83b** which are provided with teeth but preferably have socket members **85** for receiving removable pairs of bits **86**. Each successive cusp is positioned rearwardly and outwardly from the next preceding cusp and thus are disposed along a progressively receding angle. The centers of the socket members **75** are provided with central pilot post members **87** having a socket **88** for receiving unitary Y bits **89**.

The lower heads **81** on the shafts S_6, S_7 and S_8 are duplicates of one another with teeth arranged to cut counter-clockwise and those on shafts S_9 and S_{10} are duplicates with teeth arranged to cut clockwise. Each head **81** is likewise provided with the cusps **90** and **91** on one side of the shafts, having the sockets **85** for receiving the removable teeth or pairs of bits **86**. These heads are also provided with the pilot post members **87** having the sockets **88** for receiving the removable unitary Y drill head or bits **89**. The heads **81** are also provided with an opposed plate member **84** providing one cusp arranged to support the socket member **85** on which is mounted a pair of bits **86**. The bits on the opposed plate members **84** are closer to the shaft than the bits on the cusps **91**.

The upper and lower heads **80** and **81** are shown as having a central pilot head mounted on each shaft and at least two cusps which support teeth or pairs of cutting bits. The cusps are preferably offset at different positions relative to the axis of rotation of the cutter head for the purpose of making their pair of bits, with the exception of the pilot bits, cut their own widely spaced annular kerfs in the face of the coal.

It should also be noted that each tooth or cutting bit **86** is disposed at an angle of between fifteen and fifty degrees, preferably approximately thirty degrees to the axis of rotation and that the projection of the longitudinal axis of each bit is disposed in the plane of, and along the chord of, its subtended arc of rotation, which plane is normal to the axis of rotation when viewed from the front of the cutting head.

The plates which form the heads **80** and **81** may be secured to the side of their respective socket members **78** and **79** as by welding, in which case the plates would be offset from the center of the axis of the sockets. The blades which form the heads **80** and **81** as defined in the claims as digging members or digging arms and are mounted eccentrically or non-concentrically on each shaft. Each of said digging means is mounted in an off-center position on its shaft. All of the arm may extend outwardly from one side of the shaft as illustrated in the upper tier or a part of the digging member or arm may extend on opposite sides of the shaft as illustrated in the lower tier. However in each instance the arm is mounted in an off-center position relative to its own length. However, the cutting edges of the teeth or cutting bits **86**, being disposed at an angle relative to the plates, all lie in a plane passing through and extending longitudinally of the socket axis. When the heads are rotated and the vehicle is advanced, each pair of bits cut a helical kerf into the face of the coal. It is preferable to shape each bit so that they will cut a clearance for the shank of the bit. As the vehicle advances and the kerfs cut by the bits become correspondingly deeper, the coal intermediate adjacent bits, unless previously broken away, extends back toward the plate of the cutting head until it is engaged on the sides by the socket members **85** and the sharpened arcuate surfaces **92** between the cusps. The head is constructed so that the cutting bits from the pilot bit radially outwardly are disposed in successively receding positions in a plane axially of the socket. This arrangement of the cutting bits endows each head with a centering action tending to maintain the head in alignment with the axis of each shaft to eliminate lateral thrust. The slow moving central bits which lead the faster moving outer bits and remove the central coal thereby enable the outer bits to function more efficiently in removing the balance of the coal. Much of the coal may be broken away ahead of the cutters due to its cleavage structure and friable nature.

If the coal lying between the concentric kerfs is not fractured by reason of the normal vibration of the machine, the sockets **85** of the bits **86** will strike it on the side of the kerf and wedge it laterally causing it to fracture and fall. The coal does not break away as a single piece but shatters in accordance with its cleavage structure and the action of the bits may sometimes leave a circular protrusion of coal which will be engaged by the sharpened arcuate surfaces **92** between the cusps which chip the coal and knock it out of position.

The lower shafts S_6 to S_{10}, inclusive, are arranged to protrude beyond the upper row of shafts S_1 to S_5, inclusive, so as to provide clearance or an undercutting effect which materially reduces the work of the upper row of cutting heads. To permit maneuvering or withdrawal of the machine from a single cut entry the cutting heads may be rotated to their positions shown in Fig. 4 and the gear box **47** raised by the jacks **54** and **55** completely withdrawing the heads from the perimetral surface of the room or entry cut. The same result may be obtained without manipulation of the jacks by rotating the cutter heads from their positions shown in Fig. 4 through a small angle sufficient to move the outermost teeth of the lower cutter heads slightly above the edge of the blade **40**.

As shown in Figs. 3a and 6, the drive shaft **61** passes through the opening **93** of the front of the vehicle, which opening is suitably shielded to prevent coal from entering the same. The shaft **95** has the gear **98** connected thereto intermediate of the bearings **96** and **97**. This gear is arranged to mesh with the pinion **99** on the intermediate drive shaft **100** carried by the bearings **101** and **102**. The bearings **96**, **97**, **101** and **102** are carried on the triangualr frame members **103**, welded to the interior of the body **1** as shown in Fig. 7. The end of the intermediate shaft **100** is provided with the coupling **104** which connects it to the output shaft **105** of the conventional transmission **106** which may be controlled by the gear shift lever **107**. The input shaft **108** of the transmission is provided with the coupling **109** for engagement with the motor shaft **110** of the motor **111**. The motor **111** is likewise a preferably three-phase alternating current motor arranged to be energized from suitable controls from the same source of power as that of the motor **23**. The motor **111** is supplied with electrical energy by means of the cable **112**. A push button **113** is located on the rear push button panel for remotely controlling the energization of the motor **111** through a starting device adjacent the source of power not shown. The propulsion motor **23** and the rotary arm driving motor **111** together with the interconnected gearing and transmission mechanism for supplying the energy from these motors to the endless tracks and the rotary digging arms, and the other mechanism mounted within the body are enclosed and protected by the reinforced deck or roof on the body as indicated in the drawing.

It will be noted that the cutting edge or blade **40** is located to the rear of the lower row of cutting heads and extends rearwardly to the point indicated at **114** in Figs. 2a and 4, which represents the back edge of this blade lying across the front of the boxes **41** and **42**. The opening between the boxes **41** and **42** on the base plate **38** is arranged to receive the front end of the drag conveyor **115**.

The conveyor **115** as shown in Figs. 2a, 2b, 7 and 8 comprises the spaced lower and upper stationary troughs **116** and **117** respectively with the side walls **118** and **119**. The conveyor **115** extends horizontally from the front to the back of the vehicle and then slopes upwardly for the purpose of raising the coal to a higher elevation to permit the insertion of a second conveyor **120** at the rear of the machine. At spaced intervals the underside of the trough is provided with the channeled cross braces **121**. The forward end of the upper trough **117** of the conveyor is reinforced and is provided with an inclined plate **123**. A tube **124** is secured to the front edges of the trough **117** and the plate **123** and is arranged to house the shaft **125**. The ends of the shaft **125** are provided with the sprockets **126** and **127** for receiving the conveyor roller chains **128** and **129** each consisting of a series of pairs of links connected by crosspins on which rollers **122** are mounted for rotation. At spaced intervals the conveyor chains **128** and **129** are connected by the crossbars **130** which move therewith to drag the coal along the trough **117**. Suitable rails **131** and **132** are welded respectively to the upper surface of lower trough **116** to the underside of the brace members **121** to provide guiding means for each of the chains **128** and **129**. These rails lie between their respective conveyor chain links and may be engaged by the rollers

122 as the chains pass between the upper and lower troughs **116** and **117** to hold the links of the chain out of engagement with the troughs. The clearance between the rails **131** and **132** is sufficient to prevent the chain links and the crossbars **130** from striking the cross braces **121** but the space between the same is greater than the dimension of the roller of the chain to avoid simultaneous contact on the upper and lower surfaces of the rollers. A pair of chain rails **133** is also provided on the upper surface of the upper trough **117** to guide the conveyor chains along its rearward flight. Guide shoes **134**, Fig. 2*a*, are secured to the inner surfaces of the front end of the sides **118** and **119** to hold the conveyor chains with proper clearance as they pass under the gear box **47**. The opening between the scraper blade assembly and the lower side of the gear box is referred to in the claims as an aperture. If the coal that is dug by the rotary digging arms is too large to pass through this aperture the arms break up the coal by sweeping it towards each other and jamming it between themselves and between any part of the machine such as the gear box or the blade assembly or the oppositely rotating arms. When the coal is of sufficient size to pass through the aperture a conveyor will move it to the rear of the machine. A similar shoe **135**, Fig. 2*b*, is placed on both sides at the bend of the conveyor for the purpose of preventing the chains and the crossbars from lifting from the tray of the conveyor as it passes rearwardly on its upward flight.

At the rear end of the conveyor the sides are provided with the crosshead guides **136** having aligned slots **137** through which passes the shaft **138**. Sprockets **144** and **145**, secured to the shaft, are employed to drive the respective chains **128** and **129**. A pair of bearing blocks **140** are grooved on their upper and lower edges to fit and slide along the crosshead track rails **141**. An adjusting screw **142** is threadably engaged in each of the lugs **143** secured to the plates **136** for the purpose of adjusting the shaft **138** to provide a takeup for the conveyor chains. These adjusting screws may also be employed for properly aligning each end of the shaft **138**. The intermediate portion of the shaft extends through the tubular casing **139** which is welded to the adjustable plate **117′** that slides under the upper trough **117** of the conveyor and is guided in spaced relation above the return flight of the conveyor bars.

The shaft **138** extends beyond one side of the conveyor and is provided with a shaft supported speed reducer **146**, the housing of which is held from rotation by the rod **146′** attached to the side of the conveyor. The other side of the speed reducer is provided with a pulley **147** having a plurality of grooves for receiving the V-belts **148** which encircle the drive pulley **149**, operated by the motor **150** supported on the frame **151** secured to the top of the conveyor. The conveyor motor is preferably a three-phase motor of the same voltage as the motors **23** and **111** so that it may be operated from the same source of power but with separate controls as it may be desirable to run the conveyor when the propulsion motor **23** and the cutter motor **111** are not being operated.

The conveyor **115**, with its enclosed return flight and exposed load conveying flight, is arranged to operate at a speed to remove all the coal from the vicinity of the cutting heads at a rate faster than the cutting machine is capable of digging the coal. The front end of the conveyor rests on the base plate **38** between the boxes **41** and **42** and the rear end of the conveyor is supported by the links **152** depending from and secured to the rear of the vehicle. The under tray **116** of the conveyor is supported above the surface of the ground.

Referring again to Fig. 4, it will be noted that the four cutter heads on the shafts S_1, S_2, S_6 and S_7 rotate in a counter-clockwise direction for the purpose of conveying or sweeping the coal from one side of the machine to the conveyor **115** at the center, whereas the cutter heads on the shafts S_4, S_5, S_9 and S_{10} are rotated in a clockwise direction for the purpose of conveying or sweeping the coal in the opposite direction to the conveyor **115** at the center of the machine. Thus, the extreme outer cutting heads of the upper and lower rows not only cut the coal but also act as a conveyor for moving the coal to the center of the machine where it is picked up by the chain conveyor **115**. The heads thus prevent the coal from falling along the side of the machine.

It should also be noted that the cutter heads of the

corner shafts S_1, S_5, S_6 and S_{10} function to cut coal in an arc greater than 180 degrees of their swing owing to their overlap, as shown in Fig. 4. This may be illustrated by the fact that the cutting circle of an intermediate bit of the cutter head on the shaft S_1 cuts from point A to point B which cutting circle may be substantially in the same vertical plane as the cutting circle of the outer bit of the cutter head on shaft S_6 which cuts from point B to point C, as shown in Fig. 9. The outermost bit of the cutter head on the shaft S_1 cuts from the point D to point E. The intermediate cutter heads on the lower shaft S_7 will cut between the points C and F, whereas the outermost part of the cutter head on the shaft S_2 will cut from points G to D. The other intermediate cutting heads will likewise perform a similar cutting action.

As the vehicle is propelled forwardly the upper and lower rows of rotary cutter heads cut a series of corresponding circular openings or kerfs in the coal leaving a series of cusps on the roof, walls and floor of the mine. The cusps formed betwen the lower cutting heads are removed by the cutting blade **40**. The cusps formed between the upper cutting heads may be removed from the roof by the cutting blade **153** which is adjustably positioned on the gear box **47** by means of the hydraulically controlled jacks **154**. However, portions of the cusps of coal formed by the upper cutting heads frequently fall to the conveyor owing to the fact that the vibration fractures the same as the machine proceeds through the coal.

Adjustable cutting blades **155** and **156** may also be employed on the sides of the gear box **47**, as shown in Figs. 3*a* and 4, for cutting the kerfs between the upper and lower cutting heads on shafts S_1, S_6, S_5 and S_{10}, respectively. Thus, by the use of the four knife blades a single tunnel with uniform ceiling, floor and walls may be mined. The cutting knife blades **155** and **156** may be supplemented by the side flaps or shields **157** and **158** for preventing any coal from working beyond the sides of the gear box. These shields guide the coal down toward the mouth of the conveyor **115** and are arranged so that they will extend outwardly to substantially fit the extreme cutting kerfs of the upper and lower cutting heads with a slight clearance but if the machine is retracted or reversed these shields are arranged to fold inwardly toward the gear box to enable maneuvering of the machine.

Each of the shafts S_1 to S_{10}, inclusive, are maintained in timed relation and are preferably provided with, say, hexagonal ends to permit the proper positioning of the cutting heads thereon so that as they rotate they will not interfere with one another because of the overlapping arrangement of the cutting heads as previously disclosed. In order to maneuver the machine when it is not cutting it is preferable to rotate the heads to position them downwardly as indicated in Figs. 1*a*, 2*a* and 4 and energize the jacks **54** and **55** to raise the whole of the front assembly which is guided by the two sets of parallel arms **34** and **35**. Thus, by raising the whole of the front assembly the machine may be maneuvered within the passage that has been cut with sufficient clearance to guide or retrack the machine or to redirect the tunnel at an angular position, horizontally from the previous cut.

The jacks **54** and **55** may also be regulated to raise or lower the front assembly and thereby enable the operator to follow the vein of coal as it changes in elevation.

The term "chipping" is employed herein to designate the action of a tool point in picking, cracking or breaking off as well as cutting its way through virgin coal.

The action of the tool point or bit on the overlapped cutting heads in conjunction with the cleavage planes in the coal cause large chunks of coal to be dislodged from the solid ahead of the bits and conveyed from the machine, particularly when the bits of a cutting head approach the clearance formed by the bits of an adjacent cutting head or enter the coal from the clearance formed by an adjacent cutting head. In fact large chunks of coal are found with half of the bore formed by the pilot bits of the upper cutting heads with virgin coal in front of the end of the bore, which chunks are evidently dislodged when the coal breaks loose due to the advanced position of the lower cutting heads. The majority of large chunks of coal are dislodged by bits other than the pilot bits as they show a single bit mark with no other marks on the lump of coal. The coal removed by this machine has a very low percentage of fines but practically no bug-dust. The large lumps produced by the bits shown are approximately from six to eight inch cubes. The heads function to crush the very large lumps between themselves and between the heads and the gear box or the blade but the actual size of the coal removed can be predetermined to a fair degree of accuracy by regulating the factors which are responsible for the removal of the coal, such as the angular position and the spacing of the bits on each head, the overlap of adjacent heads, the lead of one tier of heads relative to the others, the speed of rotation of the heads, and the speed of advance or feed of the machine into the virgin coal. The chipping helix due to the speed of the heads and the advancing feed may be read by the scoring of the bits on the sides of the entry as well as on some of the chunks of coal removed by the machine. It is apparent that when the rotating heads are advanced into the virgin coal each bit cuts along a predetermined helix and the pitch of the helix varies with the speed of advancement into the virgin coal. It is also evident that the cleavage planes of the coal aid in the removal of the coal as the rotary bits are continually crossing these planes as they advance into the coal.

The feed or advance of the machine may be obtained by one or more modes such as the independently controllable endless tracks **2** and **3** or by a positive feed means such as the double acting jacks **160** and **161**, Figs. 1*b*, 2*b* and 3*b*, which are pivotally secured to the respective saddle members **162** and **163** that bridge the tracks **2** and **3** and are secured to their framework and to the body of the tank. Under some conditions the endless tracks **2** and **3** are capable of providing the necessary feed of the machine into the coal but when the weight of the machine is insufficient the rubber tired roof wheels **164**, rotatably mounted on the elevator **165** operated by the hydraulic jacks **166**, are raised to exert pressure on the roof for the purpose of increasing the traction load on the endless tracks which may be provided with additional spaced cleats, to increase the tractive effort. The connecting section of the elevator **165** that lies across the machine is hinged adjacent the opposite pairs of wheels **164** to permit one pair of roof wheels to be higher than the other to allow for unevenness in the roof structure. The wheels **164** are set to ride in the channels formed by the heads on the shafts S_2 and S_4.

When the supplementary load to increase tractive effort by the heavy hydraulic elevator jacks **166** is not feasible or sufficient, the positive hydraulic feed produced by the feed jacks **160** and **161** may be used alone or in conjunction with the endless tracks **2** and **3** and the elevator **165**. The feed jacks **160** and **161** are arranged to expand against the roof jacks **167** and **168** each of which consists of a lower bell crank leg member **170** having an artillary spade **171** and ground pad **172** on one arm and the skid **173** on the other arm. The upper leg member **174** is the longer and is provided at its end with a hinged roof pad, or shoe, **175**. The upper and lower sets of roof jack legs **174** and **170** are pivotally connected to each other and to the outer end of their respective double-acting feed jacks **160** and **161** by means of the toggle pivot pins **176** and are expanded or contracted against the roof and floor by the double-acting hydraulic jacks **177** and **178**.

The two roof jacks **167** and **168** are tied together by the upper and lower cross members **180** and **181** which are pivotally secured to each roof jack member so as to allow relative movement to each other. When the expansion jacks **177** and **178** are extended to push the roof pad **175** against the roof and the artillary spades **171** into the ground to set the roof jacks, the hydraulic pusher feed jacks **160** and **161** may be expanded to push against the toggle pivots of the roof jacks and move the machine forward. The rate of feed forward may be regulated by the manual control valve at the operator's station. The starter push button **182** functions to energize the motor **183** that operates the hydraulic pump **184** for supplying hydraulic pressure for each of the jacks on the machine. It is preferable to slowly move the machine with the heads rotating into engagement with the face of the coal and when the bits start to cut into the coal the feed pressure is increased gradually until both roof jacks are firmly set and the feed jacks are equally expanded to move the machine into the coal. The hydraulic pressure on the feed jacks is then increased until the machine advances a predetermined number of feet per minute into the virgin coal. By controlling the supply of fluid to only one feed jack the machine may be directed in an arcuate path.

By using only one set of roof and feed jacks the movement of the machine is of course intermittent requiring the roof jacks **167, 168** and the feed jacks **160, 161** to be retracted at the end of each feed stroke but continuous positive feed may be obtained by duplicating the sets of roof and feed jacks so that the first set may be functioning to feed the machine while the second set is being retracted and positioned to enable it to take on the feed before the first pair are fully expanded. With this arrangement one set may be disposed in tandem with the other set as shown diagrammatically in Fig. 10 wherein the rear set of roof jacks **184, 185** and the rear set of feed jacks **186, 187** have been added and the latter being constructed to expand at a faster rate to collapse the first set of feed jacks **160, 161** while continuing to move the machine forward at the same rate of speed imparted to it by said first set of jacks. The alternative is to place the two sets of jacks in parallel as shown in Fig. 11 wherein the set of feed jacks **160, 161** and their roof jacks **167, 168** are placed in parallel with the duplicate set of feed jacks **188, 189** and their roof jacks **190, 191**. These sets are positioned side-by-side but are separately controlled to automatically provide a positive continuous feed motion to the machine. The valves controlling the hydraulic operation of these double-acting jacks are arranged to expand one set of feed jacks and before they reach their ultimate expanded position the other set is placed and the feed jacks expanded so as to operate with the first set during the load transfer. When the load is transferred to the newly added jacks the other set is quickly retracted to be in readiness to again take over the feed load and thus maintain continuous movement of mining machine into the coal.

While, for clarity of explanation, we have shown and described certain preferred embodiments of our invention, it is to be understood that it is capable of many modifications, that changes in construction and arrangement may be made therein and that certain parts may be employed without conjoint use of other parts without departing from the spirit and scope of our invention.

We claim:

1. In a mining machine, the combination of a mobile body, means to propel said body, a plurality of forwardly projecting rotary shafts having digging arms provided with cutter means carried on the forward end of said body for driving a tunnel, each digging arm and its cutter means adjacent the perimeter of said body being eccentrically mounted on its rotary shaft and extending beyond the perimeter of said body to cut the cross-sectional dimension of the tunnel, all of said cutter means being materially and simultaneously out of contact with the floor, ceiling and walls of the tunnel at predetermined positions of rotation of said digging arms.

2. In a mining machine, the combination of a body mounted upon differentially controlled endless propulsion tracks, an upper and a lower pair of parallel arms pivotally mounted on the sides of said body and extending forwardly, a horizontal scraping blade secured to the forward ends of the lower arms with its ends extending beyond the endless tracks, hollow supports secured in spaced relation to the rear side of the scraper blade to form a socket intermediate the ends of the blade, a gear box pivotally supported on the hollow supports and pivotally attached to the forward ends of the upper pair of parallel arms, an upper and lower series of shafts extending from and rotatably mounted to operate in timed relation to the gear box, a motor with reduction for driving said shafts, a conveyor having its forward end stepped in and carried by said socket and extending rearwardly of the body, a motor carried by the body for driving the conveyor, a chipping head on each shaft, the shafts of the outermost chipping heads rotating outwardly and downwardly to sweep the material to the conveyor, and means for raising and lowering the gear box and blade relative to the body.

3. In a mining apparatus, the combination of a mobile machine having two rows of forwardly extending rotary shafts, digging arms having removable bits mounted on said shafts each of said digging arms lying wholly on one side of the shaft on which it is mounted to extend the path of the outer bits beyond the perimeter of the machine, the digging arms in each row having overlapping paths in the same plane and the digging arms of the upper row partially overlapping the paths of the digging arms of the lower row, means to propel said ma-

chine into a coal seam and permit the rotary digging arms to cut a tunnel therein, and a conveyor for removing the coal freed by the rotary digging arms.

4. A continuous coal mining machine comprising a mobile body, means to propel said body, a head mounted on the forward part of said body, a series of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, a digging member eccentrically mounted on each shaft, cutting bits mounted on each digging member, the cutting bits on each digging member travelling in paths concentric to the axis of rotation of the shaft on which said member is mounted, the paths of the outer bits extending beyond the perimeter of said mobile body and said head, said digging members cooperating to mine the whole of the area of the face to cut a tunnel.

5. The structure of claim 4 characterized in that said head is of greater lateral dimension than the body.

6. The structure of claim 4 characterized in that the eccentrically mounted digging members are positioned adjacent to the perimeter of said head.

7. The structure of claim 4 which also includes conveying means carried by the machine, said eccentric arms cooperating to move the coal to the conveyor.

8. The structure of claim 7 which also includes means defining an aperture in the lower portion of said head through which the coal is carried by said conveying means .

9. The structure of claim 4 characterized in that said shafts are so spaced that the paths of the adjacent eccentrically mounted rotary digging members overlap one another in their rotation.

10. The structure of claim 4 characterized in that said shafts with their eccentrically mounted rotary digging members are disposed in upper and lower tiers, the rotary paths of the eccentrically mounted rotary digging members in either tier overlapping the rotary paths of the adjacent rotary digging member of the other tier.

11. The structure of claim 10 characterized in that said lower tier of shafts with their eccentrically mounted digging members are positioned in advance of the upper tier.

12. The structure of claim 4 which also includes adjustable means for moving said head relative to the body.

13. The structure of claim 4 which also includes a floor scraping and digging blade supported on the body and having a cutting edge extending continuously across the front thereof.

14. The structure of claim 13 characterized in that said blade is pivotally attached to be adjustable relative to said body.

15. The structure of claim 4 characterized in that the said power means for driving said shafts is mounted in said mobile body, and a reinforcing deck enclosing the top of said body to protect said power means and other mechanism therein.

16. A continuous mining machine comprising a mobile body, a series of spaced forwardly projecting shafts carried by said body, power means for driving said shafts, an outwardly projecting digging arm mounted non-concentrically on each shaft and provided with spaced bits, the paths of the outer bits extending beyond the perimeter of said mobile body, said arms cooperating to simultaneously mine the whole of the area of the coal face to form a tunnel, said arms so positioned non-concentrically on their respective shafts that they are rotatable to positions where the machine and arms and bits are a substantial distance from the perimeter of said tunnel to permit the machine to move freely therein, and independently driven endless tracks supporting said body and forming a part thereof and providing the means for feeding and guiding the rotary digging arms into the coal seam.

17. The structure of claim 16 characterized in that said endless tracks are constructed to provide extended bearing surface fore and aft of the center of gravity of the machine.

18. The structure of claim 16 which also includes grousers on said endless tracks to provide positive tractive effort in feeding the rotary digging arms.

19. A continuous coal mining machine comprising a main mobile body, means to propel said main body, a gear box having a front face with an opening in the lower portion thereof, pivot means carried by and positioned forwardly of said main body to support said gear box. a plurality of spaced forwardly projecting rotary shafts extending out of the front face of said gear box, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, cutting bits mounted on each digging arm to cut a tunnel, a conveyor carried by said body and having its forward end supported by said gear box opening and movable with the gear box for conveying coal rearwardly from said gear box and means to pivotally move said box and digging arms relative to the body.

20. The structure of claim 19 characterized in that said means to adjust said gear box is a double acting power means to apply positive pressure in adjusting the position of said digging arms relative to said body.

21. The structure of claim 19 characterized in that said power means for driving said shafts on said gearbox is mounted in said main body and includes universal joint means connecting said power means and said shafts on said gearbox.

22. The structure of claim 19 characterized in that said means attaching the said gearbox on the front of said main body comprises arms pivotally attached to both said main body and to said gearbox.

23. A continuous coal mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body and pivoted to said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, a floor digging and scraping blade means extending across the front of said body and pivotally supported on the bottom of said said head and on on said body and projecting forwardly thereof and sufficiently wide to the cut the floor cusps formed between adjacent digging arms, said digging arms cooperating with said digging blade means to dig and feed the coal to a common point, and means to adjust said blade means and head on their pivotal supports to move them relative to said body to tilt said head and blade means while digging a tunnel to facilitate changing the vertical direction of digging.

24. The structure of claim 23 characterized in that said means to adjust the blade means is a double acting power means to apply positive pressure in raising and lowering said head and blade means.

25. A continuous mining machine comprising a mobile body, means to propel said body, a head, pivot means supporting said head at the front of said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, a floor digging and scraping blade means attached to the bottom of said head and sufficiently wide to cut the floor cusps formed between adjacent digging arms and positioned below the forwardly projecting shafts, said digging arms cooperating with said digging blade means to dig and feed coal to a common point, and means to adjust said head and blade means on said pivot means relative to said body, an aperture between said head and said blade means, conveying means carried by the body and having its forward end supported on said blade means in said aperture, said blade means sloping upwardly toward said conveying means, said blade means and said digging arms cooperating to move material to the conveying means.

26. A mining machine comprising a body, a gear case means pivotally secured to the front thereof, a blade means pivotally secured to the forward end of said body, means to pivotally secure the gear case means to said blade means, an aperture between said gear case means and said blade means, a series of spaced forwardly projecting shafts on the front of the gear case means, means to drive said shafts, an arm mounted on each shaft, a conveying means having its forward end supported by said blade means and positioned to convey coal through said aperture, means to propel the machine forward with the arms rotatably engaging and sweeping the material laterally toward the conveying means, the cooperative action of said rotating arms, blade means, gear case means and conveyor crushing any material to a size limited by said aperture.

27. The structure of claim 26 characterized in that the outer of said arms sweep in opposite directions toward the conveying means.

28. The structure of claim 26 characterized in that said gear case means and blade means are adjustable relative to said body.

29. A rotary coal digging head comprising a hub having a bore for mounting on a rotary shaft, an outwardly extending breaker arm eccentrically mounted on said hub, widely spaced cusps on the front edge of said breaker arm, each successive cusp positioned outwardly from the next preceding cusp, bit means mounted on each cusp and cooperating with said breaker arm when in operation to break coal out toward the cavity formed by each preceding bit means, said arm simultaneously sweeping the loose coal.

30. The structure of claim 29 characterized in that the cutting edges of said bits lie in a receding line to a plane normal to the axis of rotation.

31. The structure of claim 29 which also includes a second and shorter breaker arm extending from said hub and having a cusp with bit means.

32. The structure of claim 29 characterized in that said bits are mounted on each cusp at an angle relative to said arm.

33. The structure of claim 29 characterized in that the longitudinal axis of said bits are disposed at an angle to the axis of rotation of said shaft.

34. The structure of claim 33 characterized in that said angle is from sixty to ninety degrees.

35. A continuous mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a series of forwardly projecting rotary shafts in each of a plurality of tiers mounted on said head, interconnecting drive means in said head for rotating said shafts in timed relation to each other, power means for rotating said interconnecting drive means, a digging member mounted on each of said shafts, spaced bits mounted on said digging members which cooperate to mine the whole of the area of the face to cut a tunnel, the combined length from the shaft center of one end of each digging member and its outermost bit being longer than the other end of said digging member and its outermost bit, said shafts being spaced laterally so that the path of the outer bit on each digging member extends beyond the perimeter of said body and overlaps the paths of the outer bits of each laterally adjacent digging member, the intersecting segments of the paths of said outer bits defining the perimeter of the tunnel.

36. The structure of claim 35 characterized in that said tiers are spaced vertically so that the path of the outer bit on each digging member overlaps the paths of the outer bits of the laterally and vertically adjacent digging members.

37. The structure of claim 35 characterized in that the path of the outer bit on each digging member overlaps the paths of the outer bits of the laterally and vertically and diagonally adjacent digging members.

38. The structure of claim 35 characterized in that the path of the outer bit on each corner digging member overlaps the paths of the outer bits of at least three of the adjacent digging members.

39. The structure of claim 35 characterized in that the path of the outer bit on each intermediate digging member overlaps the paths of the outer bits of at least five adjacent digging members.

40. A continuous mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a series of forwardly projecting shafts in each of a plurality of tiers mounted on said head, an eccentric digging member mounted on each of said shafts, spaced bits mounted on said digging members each cooperating to mine the whole of the area of the face to cut a tunnel, the paths of the outer bits extending beyond the perimeter of said mobile body, central passage means in said head to receive material for conveying it rearwardly of the machine, drive means within said head to rotate said shafts and their digging members in groups of a plurality in each tier in opposite directions, the digging members of the upper tier moving the material toward the digging members of the lower tier which in turn sweep the material to said central passage means, and power means for operating said drive means.

41. A continuous mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a series of five forwardly projecting shafts in each of two tiers mounted on said head, an eccentric digging member mounted on each of said shafts, spaced bits mounted on said digging members which cooperate to mine the whole of the area of the face to cut a tunnel, the paths of the outer bits extending beyond the perimeter of said mobile body, central passage means in said head to receive material for conveying it rearwardly of the machine, drive means within said head to rotate the shafts of three digging members in one direction and two digging members in the opposite direction in each of said two tiers, the digging members of the upper tier moving the material toward the digging members of the lower tier which in turn sweep the material to said central passage means, and power means to operate said drive means.

42. A continuous coal mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, scraping blade means pivotally supported about a horizontal axis on the top of said head and sufficiently wide to extend the width of the body to cut the roof cusps formed between adjacent digging arms and means to raise and lower said blade about its pivotal support.

43. A continuous coal mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, a floor digging and scraping blade means pivotally supported about a horizontal axis on the bottom of said head and sufficiently wide to extend the width of the body to cut the floor cusps formed between adjacent digging arms and positioned below the forwardly projecting shafts, a scraping blade means pivotally supported about a vertical axis on each side of said head, and independent means to adjust each of said blade means about their pivotal supports relative to said head as the machine continues to cut a tunnel through the coal.

44. A continuous coal mining machine comprising a mobile body, means to propel said body, a head mounted on the front of said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said head, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft, a floor digging and scraping blade means pivotally supported about a horizontal axis on the bottom of said head and sufficiently wide to extend the width of the body to cut the floor cusps formed between adjacent digging arms and positioned below the forwardly projecting shafts, a scraping blade means pivotally supported about a vertical axis on each side and the top of said head, said digging arms cooperating with said blade means to dig and feed coal to a common point, and independent means to adjust each of said blade means about their pivotal supports relative to said head as the machine continues to cut a tunnel through the coal.

45. A continuous coal mining machine comprising a mobile body, means to propel said body, a plurality of spaced forwardly projecting rotary shafts carried on the front of said body, power means for driving said shafts, an outwardly projecting digging arm mounted on each shaft and having bits to cut a tunnel, means on the side digging arms for mounting them in an off-center position on their respective shafts but permitting them to travel in concentric paths to their shafts, the paths of the outer bits extending beyond the perimeter of said mobile body, said side digging arms being out of contact with the sides of the tunnel at predetermined rotary positions to permit the machine to maneuver laterally in the tunnel.

46. A coal mining machine comprising a body, a substantially vertically disposed dust confining shield protecting substantially the whole of the forward end of said body, a plurality of powered rotary shafts extending out of and projecting forwardly from said shield, digging arms on said shafts, a rigid blade having a continuous cutting edge mounted on the bottom of said shield and sloping downwardly and forwardly to a point lower than the bottom of said shield and effectively extending the same, a throat in the lower portion of said shield to receive and convey coal rearwardly of said body, and powered endless track on each side of said

body to guide and feed said rotary digging arms into the coal face to free the coal and advance the face and simultaneously scrape the cutting edge of said blade along the floor to prepare the floor for said endless tracks and to co-operate with said shield to crowd the loose coal into said throat.

47. The structure of claim 46 which also includes a second rigid blade having a continuous cutting edge and projecting upwardly to a point higher than the top of said shield and for the width thereof to scrape the cusps on the ceiling as the endless tracks feed the body forward and to extend the upper portion of said shield.

48. The structure of claim 46 characterized in that said digging arms are rotated in a selected direction and cooperate with said shield and said blade to move the loose coal toward said throat.

49. The structure of claim 46 characterized in that said endless tracks are operable independently of each other with adjustable speed for mining at an angle to the single hole made by one pass of the machine.

50. The structure of claim 46 characterized in that said endless tracks are provided with grousers which mesh with the mine floor to provide a gear-like traction to feed the mining machine into the coal face.

51. The structure of claim 46 characterized in that the back of said digging arms are shaped to extend in close proximity to the sloping top surface of the blade to cooperate therewith in sweeping the loose coal laterally.

52. A continuous coal mining machine comprising a body, a plurality of forwardly projecting power driven rotary shafts on the forward end of said body, digging arms mounted on said shafts and having cutters for continuously mining the entire face of a tunnel through which the machine can travel, the combined length from the shaft center of one end of each digging arm adjacent the perimeter of said body and its outermost cutter extending beyond the perimeter of said body and being longer than any other part of said digging arm and its outermost cutter, a throat in the forward end of said body for receiving and conveying coal rearwardly of said body, endless track means on each side of said body, means for controlling the speed and direction of said endless track means to control the pressure and direction of said digging arms into the coal face, and means to control each of said track means independent of the other to change the direction of the tunnel while the machine is advancing the coal face.

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