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

This invention is an improvement on the invention as disclosed in United States Letters Patent 2,694,562.  

The height of a coal seam in a designated vein may vary considerably in some mining fields and in adjacent fields it may remain fairly constant. Sometimes the coal seam lies substantially horizontal and other times it drifts or slopes up or down. It may also dip and rise within a relatively short distance.  

In deep mining coal it is desirable to remove all the good coal and at the same time to not remove any shale, slate, rock, fire clay, bone or other foreign materials that are found above and below the good coal seam.  

To deep mine coal with a continuously moving mining machine that simultaneously cuts the whole face of the tunnel as it progresses through the coal, this invention contemplates apparatus for spreading and retracting the coal digging mechanism to follow the variations in the height of the coal seam. This enables the operator of the machine to regulate the height of the opening to cut all the coal and only the coal and avoid the removal of the undesirable foreign materials that border the vein.  

This invention also contemplates the method and structure for tilting of the coal digging mechanism relative to the body of the machine for the purpose of aiding in digging up or down in following the rolls, pitches and dips in continuously mining an opening through a varying seam of coal.  

Another object is the provision of a plurality of gear boxes carrying shafts for supporting a series of overlapping rotary chipping heads wherein the shafts of each box are connected by a constantly meshed train of gears and the shafts of the different boxes are connected through a pair of external timing means to maintain the rotary cutting members in timed relation.  

Another object is the provision of an articulated mechanism for supporting the digging mechanism for raising, lowering, spreading, contracting and tilting which provides flexibility in operation of a continuously mining machine.  

Another object is the provision of a plurality of overlapping rotary cutting members or chipping heads expandable and retractable as units relative to one another wherein each unit is independently driven hydraulically, yet connected together to maintain operative timed relation with each other.  

Another object is the provision of a liquid spray projected simultaneously on the area cut by a plurality of rotary coal chipping heads and on the loose coal as it is chipped from the seam to prevent the production of dust. When the coal is sprayed as it is being chipped by rotary chipping heads and as the coal is being released from the solid face, less water per ton of coal is required over that of any other method of mining.  

Another object is the provision of a continuous mining machine having a plurality of units of overlapping rotary chipping heads supported for articulation on the front of a continuous mining machine having an opening forming a coal seam and supporting the fore end of a conveyor flexibly joined to the machine for removal of coal from the face.  

Another object is the provision of a plurality of overlapping rotary chipping heads each continuously chipping a series of spaced helical kerf or kerf as they dig an opening through the coal seam, the end heads being followed by flexible ears that catch the loose coal and deflect it to a position intermediate of the heads where it is conveyed from the vicinity of the face.  

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

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

Fig. 1 is a sectional view of the fore part of the machine as taken on the line 1—1 of Fig. 4;  

Fig. 2 is a side elevation of the fore part of the machine as taken on the line 2—2 of Fig. 4;  

Fig. 3 is a sectional view of the timing gear box as taken on the line 3—3 of Fig. 4;  

Fig. 4 is a top plan view of the fore part of the machine as shown in Fig. 1;  

Fig. 5 is a front elevation of the rotary chipping heads as shown on the line 5—5 of Fig. 4, a portion of the chipping heads being shown in section;  

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 4 to illustrate the relative position of the motors which drive the rotary chipping heads;  

Fig. 7 is a view in front elevation of the coal mining machine having a modified form of cusp cutter;  

Fig. 8 is a top plan view of the structure shown in Fig. 7; and  

Fig. 9 is a vertical sectional view of the structure shown in Fig. 7;  

Referring to Figs. 1, 2 and 4 of the drawings, the machine consists of the vehicular or mobile body 1 supported for movement by the independently controlled endless tracks 2 and 3 which are propelled by independent hydraulic motors driving the endless tracks through sprockets at the rear end of the machine. The track rollers 4 and the idler sprockets 5, which support the front end of the endless tracks 2 and 3, are mounted on a heavy frame including spaced upright side frame plates 6 and 7 which form the sides of the vehicular body. Channel members 8 are secured to the sides of the body and extend substantially the full length of the endless tracks for aiding in supporting the track rollers and idler sprockets and also for receiving a shield or armor plate which is detachably secured to the channel members 8 for the purpose of enclosing the mechanism within the endless tracks 2 and 3.  

The front ends of the side frame members 6 and 7 are provided with lateral extensions 10 and 11 as shown in Fig. 4. These extensions are arranged to support the whole of the cutting mechanisms on the front of the machine for up and down adjustment. As shown in Figs. 2 and 4, the extensions have mounted thereon vertically disposed jacks 12 and 13, the upper ends of which are connected to the head of the elevator, while the lower ends of the same are pivotally connected to the spaced parallel pairs of arms 18 and 19, which extend downward as indicated in Fig. 2 and support the sloping cross plate 20 together with the under plate 21. The sloping cross plate 20 and the under plate 21 are rigidly attached together and to the arms 18 and 19.
Said plates 20 and 21 extend continuously across the front of the machine between the pairs of arms 18 and 19 and are closed at their ends by the vertically disposed plates 22 as shown in Fig. 2. This bottom front cross member 20, 21 has a pair of laterally spaced thrust bars or arms 18a and 19a pivotally attached at their rear ends to the frame plates 6 and 7, respectively, the pivotal attachment of arm 19a being seen at 195 of Fig. 2 of the drawings. These members thus constitute a support means on the front of the body connected for raising and lowering by power means 12 and 13 relative to the body 1 or endless tracks 2 and 3. The upper ends of the plates 22 carry pivot pins 23 cooperating with spaced lugs 24 depending from the underside of the lower gear box 25 thereby supporting it on cross member 20, 21. Thus the pivot means 23 on the support means functions to mount the gearbox means from said body for movement relative to said body. The upper gear box 26 is supported by and movable relative to the lower gear box 25 as shown in Fig. 6, wherein the lower gear box is provided with a pair of vertically disposed guide members 27 and 28 which are fixed at 29 and lower ends to the lower gear box 25 and are slidably received in openings 29 and 30 through the upper gear box 26 as shown in Figs. 4 and 6. Since the vertical guide posts 27 and 28 are fixed relative to the lower gear box 25 and are slidable through the openings 29 and 30 of the upper gear box 26, the jacks 31 and 32, as shown in Fig. 6, may be expanded and contracted to raise and lower the upper gear box 26 relative to the lower gear box 25 owing to the fact that the outer end of the pistons of these jacks are pivotally supported as indicated at 33 and 34 to spaced ears formed integral with the casting of the upper gear box 26. Thus the jacks 31 and 32 function as power means to vary the spacing between the parallel axes of the rotary cutting members for changing the dimensions of the advancing face while mining a tunnel by separating the distance between the gearboxes 25 and 26.

Referring to Figs. 1, 2 and 4, the upper gear box 26 has spaced brackets 35 and 36 which are provided with aligned openings for pivotally receiving the end of the pistons 37 and 38 that extend from the cylinders 39 and 40. The cylinders 39 and 40 are in turn pivotally hinged to the cross member 41 as indicated at 42 and 43. The cylinders 39 and 40 constitute the power means connecting the body and gearbox means for tilting the gearbox means to the rotary shafts extending therefrom relative to the body or the endless tracks 2 and 3 at rest on the tunnel floor. Thus, by expanding the cylinders 12 and 13, the whole of the cutting mechanism on the front of the machine may be raised while swinging about the horizontal pivotal axis of arms 18a and 19a. This adjustment will also give the blade 44 a different height. If it is desired to tilt the cutting heads or cutting members on the gear boxes 25 and 26 in either direction, the pistons 37 and 38 may be retracted or expanded. The gear boxes 25 and 26 may be tilted so that they face downwardly relative to the normal longitudinal axis of the machine. If the pistons of the jacks 12 and 13 are lowered and the pistons 37 and 38 of the cylinders 39 and 40 are retracted, the gear boxes 25 and 26 are tilted back with their cutting mechanism facing upwardly. This flexible action or articulate support permits the gear boxes to be raised or lowered by cylinders 12 and 13 or tilted in either direction by cylinders 39 and 40 relative to the body 1 and regardless of the relative expansion or retraction of the gear box 26 to the gear box 25. Regardless of the tilting or vertical adjustments of the cutting members each axis of each cutting member will be in all positions of adjustment retained in a plane parallel with a plane that includes the longitudinal axis of the mobile body. The bottom cups are removed by the blade 44 on the sloping plate 20 which is disposed at substantially the same angle as plate 20. The scraping forces of the blade 44 aid in directing the up or down movement of the coal digging mechanism on the front of the machine.

The top of the upper gear box 26 may be provided with a plurality of projecting arms 45 which have secured thereto the upper scraping blade 46 as disposed at an angle to the horizontal which is substantially the same as the lower cutting blade 44 and is provided to trim or remove a part of the roof cups formed between the rotary chipping heads or rotary cutting members. The cutting blade 44 is designed to move by power means supported from the body cutting an increased cross-sectional tunnel area than that defined by the combined sweep of the rotary cutting members.

As shown in Fig. 5, the upper gear box 26 is provided with five rotary cutting members or chipping heads, 51, 52, 53, 54 and 55; whereas the lower gear box is provided with an equal number of chipping heads 56 to 60, inclusive. It will be noted that each of these chipping heads overlaps its adjacent chipping head regardless of whether they are mounted on the same gear box or on the other gear box.

Each associated chipping head part is indicated by the respective chipping head reference number and a letter. Each cutting member is detachably secured to the projecting end of a rotary shaft indicated by a and journaled in spaced bearings b and c mounted in the front and rear walls of the respective gear box. It will be noted that the shafts a lie parallel to each other and are forwardly projecting on the front of the mining machine and the shafts in the upper and lower gearboxes support the rotary cutting members in horizontal rows. A spur gear d is fixed on each shaft intermediate of the bearings b and c and meshes with laterally adjacent gears in the box that makes up a train which constitutes a driving means or a transmission means that keeps the rotary cutting members of each row operating in time relation relative to each other.

As shown in Fig. 6 the means for driving the rotary cutting members is the hydraulic motor 61 which is mounted on the upper gear box 26 and drives the shaft 62 having the worm 63 engaging the worm gear 64 on the shaft 65 having the spur pinion 66 meshing with the spur gear 67 in the chipping head train of spur gears d in the gear box 26. The spur gear 67 meshes with 51d and 52d. The latter meshes with the train of chipping head spur and idler gears 69, 70, 53d, 71, 54d, 72 and the end spur gear 55d.

In like manner the means for driving the rotary cutting members is the hydraulic motor 61' which is mounted on the lower gear box 25 and drives the shaft 62' having the worm 63' engaging the gear 64' on the shaft 65' having the spur pinion 66' meshing with the spur gear 67' in the chipping head train of spur gears d in the gear box 25. The spur gear 67' meshes with 59d and 59d. The latter meshes with the train of chipping head spur and idler gears 69', 70', 58d, 71a, 71b, 71c, 57d, 72' and the end spur gear 55d. The reason for using the three idler gears 71a, 71b and 71c in the lower gear box in place of a single large gear such as 72 in the upper gear box is for the purpose of providing the upwardly open offsets in the bottom of the gear box 25 on each side of the central spur gear 58d which allows more headroom for the passage of coal. The motors 61 and 61' are, together with the housing covering their associated shafts and gears, attached to and carried by their respective gear box body 1 and 2, respectively, without, in the neighborhood of the teeth, any relation to the mouth of the tunnel. In order to maintain the upper and lower rotary cutting members or chipping heads operating in timed relation, regardless of their expanded or retracted position relative to each other, it is necessary to provide a timing means in a form of a flexible timing arrangement between the two gear boxes such as a telescoped drive shaft with universal joints. As shown in Figs. 1 to 4 and 6, the timing arrangement is obtained by the use of...
spur gears 73 and 73' on the shafts 65 and 65' which mesh with the respective gears 74, 74' on the shafts 75 and 75' that are connected to the forward ends of the universally jointed telescoped shafts 76 and 76' that in turn are connected to the end gears 5 of a straight gear train 77 housed in the timing gear box 78 and box cover 41 supported on side frame members 6 and 7. The universal joints of the telescoping shafts 76 and 76' permit the articulating movement of the gear boxes and the timing train of gears keep the upper and lower chipping heads in rotary timed relation.

The upper gear box 26 is provided with depending shield means in the form of the plates 79 which telescope over the outer surface of the lower gear box 25 to keep coal and foreign matter from getting between the gear boxes which would prevent them from fully collapsing or moving together.

As shown in Fig. 1, the rotary cutting members or chipping heads are made up of a flat blade or arm 80 secured to a hub 81 and acts like a paddle to propel the coal toward the center of the gear boxes. The chipping head shafts have a frusto conical portion 82 and a portion of the hub is bored to fit on this conical surface. Beyond the section 82 the shafts are splined as shown at 83 to receive the short complementary splined bore of the hub. The combination of the complementary tightly fitting conical and splined portions of the shafts and hubs provide an improved structure for mounting the chipping heads. The heads are held on the shafts by the nuts 84, which threadedly engage a threaded section beyond the spline, and are locked by a lock washer not shown. The conical portion of the shaft is sized to prevent the shoulder on the inner end of the splined bore of the hub from engaging a shoulder on the shaft.

The outer threaded portions of the chipping head shafts are covered by the cap nuts 85 which clamp over the head of the pilot bit socket 86 that removable supports the pilot bit 87.

The bifurcated teeth 90 are removably secured in spaced sockets that are mounted on spaced cusps of the arm 80 and support the tooth cutting edges at progressively receding positions relative to a transverse plane normal to the axis of the shaft. The cutting edges of the teeth are in a common line disposed in a plane longitudinal to the axis of rotation. The arms 80 are sharpened between cusps to dig out the coal if it does not chip free of the face ahead of the teeth. Owing to the fact that the teeth of each chipping head are rotated in a circular path that overlaps the path of each adjacent chipping head, an arcuate clearance is clipped or cut in the coal face for adjacent chipping heads. This clearance aids the coal in breaking away from the face as it is approached by the teeth.

As the chipping heads or rotary cutting members, with their bits, revolve about their rotary axes the bits are constantly crossing the vertical and horizontal cleavage planes of the coal which aids in breaking the coal free from the face ahead of the bits and also determines in part the size of the coal removed. If the cleavage planes are not vertical and close the coal is of course smaller in size. If the prominent cleavage planes are spaced relatively far apart, the chunks of coal are larger. If the coal breaks free in very large lumps, the arms batter and crush it into sufficiently small pieces that it may be readily handled. The combination of the cleavage structure of coal and the wide radial spacing of the bits on the rotary overlapping chipping heads breaks the coal free ahead of the bits but also dislodges large sulphur balls with little or no damage to the heads. The hydraulic drive of the heads provides a pressure cushion. A sufficient pressure builds up gradually to dislodge the object before the breaking point of the machine.

The lower tier of chipping heads extends forwardly beyond the upper tier to provide space in front of the gear box for the coal removed by the upper tier of heads 75 to provide chipping clearance for the upper chipping heads.

As the coal is freed from the face the arms of the cutting members act as paddles in conveying it to the center of the gear box where it is picked up by the nose of the conveyor 90c that rests in the pocket formed between the depending plates 22, the under plate 21 and the notched sloping plate 20. The conveyor is a drag type made up of three independent chains 91, 92 and 93, as shown in Fig. 4, each chain having spaced cross flights 94. The center chain conveyor 92 is supported from the outer conveyor chains by the upstanding guides 95 and 96. This conveyor is provided with an upper and lower plate surfaces 97 and 98 as shown in Fig. 1 for conveying and return flights of the drag chain conveyor. These plate surfaces are connected at their side edges to upstanding walls 100 and 101 which enclose the return flight and form an upwardly open trough for the conveying flight. The conveyor chains pass up the chipping shaft 102 journaled in a sectioned tube carried by the upper floor 97 and walls 100 and 101. The shaft is provided with suitable sprockets for the chains.

As shown in Figs. 1, 2, 4 and 5 the gear box at the front of the machine carries the spray nozzles 5 which are positioned above and to one side of the axes of the rotary chipping heads in the top row. These spray nozzles are supplied with a suitable liquid under pressure, such as water, to wet down the coal face and the coal being removed and conveyed to prevent the formation of dust from chipping and conveying action.

The conveyor side walls 100 and 101 and the flight separators 95 and 96 are provided with overhanging cross flight guide rails 103, 104, 105 and 106 which extend from the initial horizontal portion of the conveyor, past the upturned head and most of the inclined portion of the conveyor for the purpose of maintaining the crossflights relatively close to the upper floor 97 as they pass the bend. At the upper end of the inclined section, the conveyor extends horizontally rearwardly over the top of the machine and the end of the inclined section is hingedly joined to this top horizontal section as indicated at 107 in Figs. 1 and 4. The floor plates are tipped in the direction of movement of the conveyor chain so that the moving parts will not catch thereon. The conveyor chains pass to the rear of the machine and down around sprockets affixed to a drive shaft operated by hydraulic motors. The entire operation of this mining machine is obtained through a hydraulic medium provided from a pump and pump means illustrated by the hydraulic pump motor 110 operated by the electric motor 110. Each of the endless tracks 2 and 3 are independently controlled as to direction and speed to provide complete maneuverability in turning, swinging and otherwise guiding its movement in a forward and reverse direction. The hydraulic motors 61 and 61' are operated in unison at fixed or variable speeds for actuating the chipping heads 102 in conjunction with the forward movement or feed of the machine. The control cylinders 31 and 32 for separating or expanding the chipping heads are likewise operated in unison. The cylinders 12 and 13 are actuated together to raise and lower the heads. The cylinders 39 and 40 are for the purpose of tilting the whole cutting head assembly. The use of hydraulic power in operating the wide spaced chipping heads and the propulsion of this machine has a particular advantage in that the load experienced in this character of operation frequently changes. When a sulphur ball or other type of high resistant structure occurs in the coal, the chipping heads are momentarily slowed down by such a change in load causing the pressure to rapidly build up and overcome this increased or varying load. The teeth or bits on the chipping heads are made very strong but they are the weakest link in the system and if the peak load is too much for the teeth they will fracture. However, in the majority of cases, the hydraulic pressure builds up substantially instantaneously with the increasing load.
and the load drops by breaking the high resistant structure from the coal face before the ultimate breaking of the bits is reached. A relief valve is employed to stall the machine before the pressure gets too high. This load fluctuations are transmitted to the traction unit as well as to the chopping heads but the latter are required to assume the maximum portion of these fluctuating loads as they operate at a relatively higher speed and the radial position of the bits offer a considerably less mechanical advantage. The traction, on the other hand, may slip on the ground when the traction loss exceeds the traction effort to support the total weight of the machine. This construction thus provides a material advancement in the art of chopping coal and represents an important object of this invention.

The end chopping heads 55 and 60 in the bottom row are followed by the flexible ears 110 and 111 shaped to substantially fit the outer or marginal concentric kof forming a portion of the tunnel to scoop any coal that is not piddled to the center of the machine by the arms of these outer chopping heads. These ears are not only flexible but they are hinged at 112 to fold forwardly and inwardly upon the retraction of the machine from the face. These chopping heads 55 and 60 may be provided with the rearward extension paddles 113 and 114, respectively, as shown in Figs. 1 and 2 for aiding in propelling the coal toward the conveyor 90.

The coal cusps depending from the roof are formed between the rotary chopping heads 51 to 55 of the top row. These cusps may be chopped off by the spaced cusp cutting teeth 115 as shown in Figs. 7 to 9. These cusp cutting teeth are gyrated in a circular path as indicated by the small dotted circles shown in Fig. 7. This gyrating action is obtained by the eccentrics 51e to 55e which are mounted on their respective shafts 51a to 55a and secured to their respective heads by the studs 116. Each eccentric is set with its greatest radius extending downwardly when the rotary chopping heads are folded or rotated to be disposed within the dimensions of the gear boxes. This provides the greatest clearance between the machine and the tunnel that it digs thus permitting generous maneuverability of this continuous mining machine. Each eccentric has an annular shoulder 117 which is converted into an annular groove by the ring 118 bolted to the face of the eccentric.

The shafts 51a and 52a rotate in unison in the same direction and their eccentrics 51e and 52e are thus rotated in phase with each other. A plate 120 is provided with large holes in opposite directions and the plate 121 is each gyrated in opposite directions and the plates must be cut along clearance lines as indicated at 122 and 123 so that they will not strike one another as they approach each other on their upward stroke.

The plate 120 is provided with a clamping bar 124. The plate 121 is provided with three clamping bars 125, 126 and 127. Each of these bars is provided with a series of four sockets to receive the teeth or bits 115 which are clamped in place by the bolts 128 as shown in Fig. 9. The number of teeth on each chopping head may be increased to bring about a reduction in the size of the cusps left by the chopping heads. The teeth 115 are bent to extend forwardly and to the right or left depending upon which plate they are to be mounted. The forward and angular bend in the teeth 115 permits them to cut the cusps as indicated in Fig. 7 and ahead of the plates on which they are mounted. Thus, as the rotary chopping heads revolve to chip the coal from the face, these cusp cutters remove the cusp or a majority thereof immediately behind the chopping heads and form an auxiliary cutting mechanism supported from the body for cutting an increased cross-sectional tunnel area over that defined by the combined sweep of the spaced cutting heads or chopping heads regardless of the position of the machine.

The traction, on the other hand, may slip or a majority thereof immediately behind the chopping heads and form an auxiliary cutting mechanism supported from the body for cutting an increased cross-sectional tunnel area over that defined by the combined sweep of the spaced cutting heads or chopping heads regardless of the position of the machine. This gyroscopic action of the cusp cutters chips off the cusps with very little expenditure of energy as compared to that required to dig with the blade 46. The combination of rotatory chopping and gyroatory action thus provide a uniform roof that may easily be timbered if necessary.

Whether the bits rotate or gyrate, they chip the coal by a rotary chopping action.

In the operation of the machine it will be fed generally forward in a rectilinear manner by the endless crawlers 2 and 3 while the two tiers of rotary chopping heads 51 to 60 rotate in the directions suggested by the arrows in Fig. 5 or Fig. 7 of the drawings. During this operation the solid coal will be chopped loose by said chopping heads so as to provide a room, entry or cut having the configuration in elevation at right angles to the direction of movement of the machine as suggested in Figs. 1 and 2 of the drawings. The general configuration of the cut in an upright manner and its relative to the movement of the machine is suggested in Fig. 7 of the drawings. The top or roof cusps will be removed, at least in part, either by the blades 46 if the modification of Figs. 1 to 4, etc., is employed, or by the teeth or bits 115 if the modification of Figs. 7, 8 and 9 is employed. The bottom cusps are removed by the lower cutting blade 44. It is to be noted that the lower tier of rotating heads 56 to 60, inclusive, not only chips away the solid coal but the two outside pairs of these heads, that is, heads 51, 55, 56 and 60, rotate in opposite directions, that is, the first two counter-clockwise and the last two clockwise, as viewed by a person directly in front of them, and they operate to sweep the loosened coal toward the center of the head section where it will be readily picked up by the forward reach of the conveyor including the chains 91 to 95 and associated flights 94.

As clearly illustrated in Figs. 1 and 2 of the drawings, said drag or scraper conveyor has its forward extremity generally below and slightly forward of the gear boxes 25 and 26 and space is provided directly above said drag conveyor and below the bottom portion of the gear box 25 through which the loosened coal can readily pass under the influence of said drag conveyor. It is further to be noted that in contradistinction to the method of conveying material disclosed in the above mentioned United States Letters Patent 2,694,562, the drag conveyor 91, 92, 93, 97, etc., is so constructed that the coal is elevated along an incline, clearly illustrated in Fig. 1 of the drawings, which begins immediately after the coal passes under the head section 24. In other words, the conveyor which conveys the coal rearwardly elevates it above the primary driving motor 109 and hydraulic pump 108 so that said coal is carried along the top of the unit beginning at a position slightly to the rear of the adjustable head section. During the forward travel of the machine the head section is controlled to follow variations in the thickness and pitch of the coal seam by raising and lowering the complete head section together with the bottom scraper blade 44 by swinging it on a transverse horizontal axis to which the arms or thrust members 18a and 19a are pivoted. Vertical contractions and expansion of the conveyor is provided by the hydraulic jacks 31 and 32 to compensate for variations in the height or thickness of the coal seam. Tilting adjustment of the head section about a transverse horizontal axis provided by the pins 23, under the control of hydraulic jacks 39 and 40, is also provided. While, for clarity of explanation, embodiments of this invention have been shown and described, it is to be understood that this invention is capable of many modifications, and changes in the con-
2,877,999

struction and arrangement may be made therein and cer-
tain parts may be employed without conjoint use of other
parts and without departing from the spirit and scope of
this invention.

We claim:
1. A coal mining machine adapted to cut and remove
the mined material in advancing the whole face to form
a tunnel as the machine moves forward comprising a
mobile body, a plurality of rotary cutting members
mounted on said body projecting parallel axes on
the front of said body, each axis of each
rotary cutting member being in all positions of adjust-
ment retained in a plane parallel with a plane that in-
cludes the longitudinal axis of said mobile body, means
generally known as the rotary cutting members of each row in
timed relation to each other, means for varying the spac-
ing between selected rows to change the overall vertical
cutting dimensions of the cutting members while their
rotation subsists, and timing means flexibly connecting
the rotary cutting members of different rows to main-
tain all the cutting members rotating in timed relation
with each other.

2. A coal mining machine adapted to cut and remove
the mined material in advancing the whole face to form
a tunnel as the machine moves forward comprising a
mobile body, a plurality of rotary cutting members
mounted on said body projecting parallel axes on
the front of said body, continuously cut along progressive
parallel helical cuts forming cups therebetween, drive
shafts for said cutting members, a plate connected to said
shafts for gyration movement in union with the rotation of
said cutting member, and cutting members mounted
on said plate.

3. A coal mining machine adapted to cut and remove
the mined material in advancing the whole face to form
a tunnel as the machine moves forward comprising a
mobile body, a plurality of rotary shafts supported from
said body, cutting members mounted on said shafts to con-
tinuously cut along parallel helical cuts forming
cups therebetween, eccentrics mounted on said shafts
and fixed to rotate therewith, a plate having openings to
receive two or more of said eccentrics to gyrate the plate
as the shafts rotate, and cutting means mounted on said
plate to cut the cups as the machine progresses.

4. A continuous mining machine including a frame
with a head section movable mounted as a unit on the
forward end thereof, a plurality of subjacent tiers mount-
ed on said head section and connected for adjustment
to expand and contract relative to each other, rotary
cutting members carried by the tiers on said head section,
each cutting member mounted for rotation on a generally
longitudinal forward extending axis, each axis of each
rotary cutting member being in all positions of adjust-
ment retained in a plane parallel with a plane that in-
cludes the longitudinal axis of said mobile body, power
operated means for rotating said cutting members to cut
away the whole of the solid coal face simultaneously
from a point defined as the sweep of said cutting
members, means interconnecting said cutting members in
the lower tier whereby they rotate to sweep loose coal
until the center of said head section adjacent the mine
floor, a conveyer carried by said frame adapted to con-
vey loose coal rearwardly, said conveyer having a for-
ward receiving portion located adjacent said head sec-
tion whereby the coal will be received and conveyed
rearwardly, said conveyer sloping upwardly and rear-
wardly of said head section whereby said conveyer ex-
tends along the upper portion of said machine through its
rearward extension beginning at a position adjacent the
forward part of the complete machine, motor means
for driving said conveyer, said motor means being
supported from said frame, and power operated mecha-
nism for raising and lowering the complete head section
and for expanding and contracting said head.

5. A mining machine adapted to cut and remove the
mined material in advancing the whole face to form a
tunnel as the machine moves forward comprising a
powered mobile body, a plurality of adjacent gear box
means connected for movement relative to each other
and mounted on the forward end of said body, rotary
shafts extending from each gearbox means, cutting mem-
bers mounted on said shafts, each axis of each rotary
cutting member being in all positions of adjustment re-
tained in a plane parallel with a plane that includes the
longitudinal axis of said mobile body, drive means in
each gearbox means for rotating said shafts in timed re-
lation, timing means connecting the drive means of each
gearbox means, motor means supported from said mobile
body to actuate said drive means, and power means to
change the proximity of one gearbox relative to the other
while the rotation of said cutting members sub-
stant and the machine advances to alter the cross-sectional
pattern of the combined overall cut made by said cutting
members.

6. The structure of claim 5 which also includes a
shield means secured to one gearbox and sliding over
the adjacent gearbox means in telescopic relation.

7. A mining machine adapted to cut and remove
the mined material in advancing the whole face to form a
tunnel as the machine moves forward comprising a
body supported on powered endless tracks, pivot shafts
carried on the forward end of said body, gearbox means
on the front of the machine mounted to move on said
pivot shafts, rotary shafts extending forwardly from the
gearbox means, cutting members mounted on said shafts,
drive means in said gearbox means for rotating said
shafts, motor means supported from said mobile body to
actuate said drive means, and power means connecting
said body and said gearbox means to tilt said gearbox
means back and forth on said pivot means while the rota-
tion of said cutting members subsists and the mining
machine is moving forward, thereby to follow rolls,
pitches and dips while mining a varying seam.

8. The structure of claim 7 characterized in that said
gearbox means includes a plurality of gearboxes con-
ected for movement relative to each other, timing means
interposed in said drive means between the plurality of
gear boxes, and power means to change the proximity
of one gearbox relative to the other while the rotation
of said cutting members subsists and the machine ad-
vances to alter the cross-sectional pattern of the com-
bined overall cut made by said cutting members.

9. A mining machine adapted to cut and remove
the mined material in advancing the whole face to form a
tunnel as the machine moves forward comprising a pow-
ered mobile body, support means on the front of said
body and connected for raising and lowering movement
relative to said body, power means carried by said body
to raise and lower said support means, a plurality of sub-
jective gearbox means connected together for relative
movement to each other with the lower gearbox means
mounted on said support means, power means carried
by said lower gearbox means to change the proximity
of one gearbox relative to the other, rotary shafts
having cutting members and extending from each gear-
box means, each axis of each rotary cutting member be-
ing in all positions of adjustment retained in a plane
parallel with a plane that includes the longitudinal axis
of said mobile body, drive means in each gearbox means
for rotating said shafts in timed relation, timing means
connecting the drive means of each gearbox means, and
motor means supported by said mobile body to actuate
said drive means.

10. A mining machine adapted to cut and remove
the mined material in advancing the whole face to form
a tunnel as the machine moves forward comprising a
powered mobile body on endless tracks, support means
carried from said body and connected for raising and
lowering movement relative to said body, power means
carried by said body to raise and lower said support
means, pivot means carried by said support means, gear-box means mounted on said pivot means, rotary shafts having cutting members and extending from the gearbox means, drive means in said gearbox means for rotating said shafts, motor means supported by said mobile body to actuate said drive means, and power means connected between said body and said gearbox means to tilt it back and forth on said pivot means relative to said endless tracks regardless of the elevation of said support means.

11. The structure of claim 1 characterized in that the means for driving the rotary cutting members of each row in timed relation to each other includes a hydraulic motor means for each row of cutting members that is mounted to travel with each respective row.

12. The structure of claim 1 characterized in that the means for driving the rotary cutting members of each row in timed relation with each other includes a hydraulic motor for each row of cutting members that is mounted to travel with each respective row, and motor and pump means carried by said mobile body for supplying liquid under pressure to said hydraulic motors.

13. In a mining machine, a mobile traveling unit supported on and self-propelled by endless tracks, a frame mounted for up and down movement on said traveling unit, gear-box means supported on said frame for tilting forward and backward, a plurality of cutting rotors arranged on generally parallel axes supported by and extending from said gearbox means to make circular cuts and adapted for advancement axially, in the general direction of movement of said unit, to mine the whole face in cutting a tunnel as the machine moves forward into the body of material to be mined, transmission means enclosed in said gearbox means to operate said cutting rotors, power means supported from said traveling unit and flexibly connected to operate said transmission means in said tiltable gearbox means, a cutting mechanism adapted to make spaced-apart straight cuts lying in planes which are substantially tangent to said circular cuts and being supported from said frame, power means connected between said gearbox means and said traveling unit to tilt said gearbox means and the cutting rotors extending therefrom, and power means operative to adjust said frame relative to said traveling unit as said traveling unit advances, whereby said cutting rotors and said cutting mechanism may all be adjusted together relative to said traveling unit while mining a tunnel.

14. In a mining machine, a mobile traveling unit supported on and self-propelled by endless tracks, gear-box means supported from said traveling unit for tilting forward and backward, second gearbox means mounted to move toward and away from said first gearbox means, a plurality of cutting rotors arranged on generally parallel axes extending from said gearbox means to make circular cuts and adapted for advancement axially, in the general direction of movement of said unit, to mine the whole face in cutting a tunnel as the machine moves forward in the body of material to be mined, transmission means enclosed in each gearbox means to operate said cutting rotors a cutting mechanism adapted to make spaced-apart straight cuts lying in planes which are substantially tangent to said circular cuts, power means supported from said traveling unit and flexibly connected to drive each of said transmission means for operating said cutting rotors and mechanism for altering the cross-sectional pattern of the combined overall cut made by said cutting rotors and cutting mechanism as said mobile unit advances, comprising power-actuated means for changing the spacing between said first and second gearbox means to move the parallel axes of their respective cutting rotors relative to each other during such advancement.

15. The mining machine of claim 7 characterized in that said drive means in said gearbox means includes a hydraulic motor means supported by said gearbox means, and said motor means supported from said mobile body includes a hydraulic pump means supported on said mobile body to actuate said hydraulic motor means.

16. The mining machine of claim 7 which also includes auxiliary cutting means supported from said body for cutting an increased cross-sectional tunnel area over that defined by the combined sweep of said rotary cutting members.

17. The mining machine of claim 16 characterized by additional power means for retracting said auxiliary cutting means from their cutting position.

18. The structure of claim 7 characterized in that said gearbox means includes a plurality of gearboxes mounted for movement relative to each other, and power means to change the proximity of one gearbox relative to the other while said cutting members rotate and the machine is mining, thereby to alter the cross-sectional area of the overall cut made by said cutting members.

19. A mining machine adapted to advance the whole face and remove the mined material forming a tunnel as the machine moves forward comprising a body supported on and self-propelled by endless tracks, gearbox means supported from said body and positioned forward of said body and mounted to raise and lower and to tilt back and forth relative to said endless tracks, a plurality of spaced rotary shafts extending forward from the gearbox means, cutting members mounted on said shafts, drive means in said gearbox means for rotating said shafts, motor means supported from said body to actuate said drive means, power actuated means for gradually raising and lowering said gearbox means and said cutting members relative to said endless tracks while said cutting members are mining and said machine is moving forward, power-actuated means for gradually tilting said gearbox means and the rotary shafts extending therefrom to incline the rotary shafts and their cutting members upwardly and downwardly relative to said endless tracks while said cutting members are mining and said machine is moving forward, thereby to follow rolls, pitches and dips of a varying seam.

20. The mining machine of claim 19 characterized in that said gearbox means is separable, and power means to vary the spacing between the separable gearbox means to change the dimensions of the advancing face mined by said cutting members.

21. The mining machine of claim 19 which also includes auxiliary cutting means supported from said body for cutting an increased cross-sectional tunnel area over that defined by the combined sweep of said rotary cutting members.

22. A mobile mining machine adapted to advance the whole face and remove the mined material forming a tunnel as the machine moves forward, comprising a body with a plurality of forwardly positioned and vertically separable gearbox means, each gearbox means supporting a plurality of spaced rotary cutting members disposed on generally forwardly projecting parallel axes to mine the whole face in front of the machine when forming the tunnel through which the machine travels, characterized by each axis of each rotary cutting member being in all positions of adjustment retained in a plane parallel with a plane that includes the longitudinal axis of said mobile body, drive means in each of said gear-box means for rotating the cutting members supported thereby, and power means supported from said body to vary the vertical spacing between said gearbox means while mining and while the machine moves forward to effect a gradual change in the dimensions of the advancing face of the tunnel.

23. The mining machine of claim 22 characterized by pivot means interposed in the support of said gearbox means on said body, and power means connected to tilt said gearbox means on said pivot means to change the axial tilt of said rotary cutting members relative to the tunnel floor cut by said mining machine.

24. The mining machine of claim 23 characterized by
mounting means for supporting said gearbox means for raising and lowering the same relative to said body, and additional power means connected to said gearbox means to raise and lower said gearbox means relative to said mining machine to change the direction of the tunnel while mining.

25. The mining machine of claim 24 which also includes auxiliary cutting means supported from said body for cutting an increased cross-sectional area over that defined by the combined sweep of said cutting members.

26. The mining machine of claim 22 characterized by additional power means connected to said gearbox means to raise and lower said gearbox means relative to said mining machine to change the tunnel while mining.

27. The mining machine of claim 22 characterized by a shield means spanning the varying gap formed between the separable gearbox means when changing the spacing between said gearbox means to effect a change in the spacing between the axes of the rotary cutting members.

28. The mining machine of claim 22 characterized by timing means interconnecting said drive means in the separable gearbox means to maintain the rotary cutting members in operative timed relation regardless of the spacing between said gearbox means.

29. The mining machine of claim 22 characterized by an auxiliary cutting mechanism supported from said body for cutting an increased cross-sectional tunnel area over that defined by the combined sweep of said spaced rotary cutting members regardless of the spacing between the axes of said rotary cutting members.

30. A mining machine adapted to cut and remove the mined material in advancing the whole face to form a tunnel as the machine moves forward, comprising a body supported on powered endless tracks, a pivot supported from the forward end of said body, gearbox means on the front of the machine mounted to move on said pivot relative to said endless tracks, rotary shafts extending forwardly from the gearbox means, cutting members mounted on said shafts, drive means in said gearbox means for rotating said shafts, motor means supported from said mobile body to actuate said drive means, and power means connecting said body and said gearbox means to tilt said gearbox means back and forth on said pivot while the rotation of said cutting members subsists and the mining machine is moving forward, thereby to follow rolls, pitches and dips while mining a varying seam.

References Cited in the file of this patent

UNITED STATES PATENTS

454,895 Wyman --------------- June 30, 1891
504,179 Stanley --------------- Aug. 29, 1893
531,334 Ross --------------- Dec. 25, 1894
887,325 Hansen --------------- May 12, 1908
1,442,659 Groene --------------- Jan. 16, 1923
1,567,329 Peale --------------- Dec. 29, 1925
1,603,621 McKinlay --------------- Oct. 19, 1926
1,645,007 Johansen --------------- Oct. 11, 1927
1,675,723 Morgan --------------- July 3, 1928
1,726,963 McKinlay --------------- Sept. 3, 1929
1,888,085 Levin --------------- July 22, 1930
1,953,327 Hummel --------------- Nov. 15, 1932
2,046,517 Jones --------------- July 7, 1936
2,083,834 Galuppo et al. --------------- June 15, 1937
2,105,505 Ramsay --------------- Jan. 18, 1938
2,229,086 Joy --------------- Jan. 21, 1941
2,261,160 Joy --------------- Nov. 4, 1941
2,320,653 Ramsay --------------- June 1, 1943
2,329,875 Cartlidge --------------- Sept. 21, 1943
2,384,447 Baldwin et al. --------------- Sept. 11, 1944
2,466,709 Karr --------------- Apr. 12, 1949
2,512,241 Bradner --------------- June 20, 1950
2,546,899 McCarthy --------------- Mar. 27, 1951
2,570,400 Stein --------------- Oct. 9, 1951
2,572,403 Stevenson --------------- Oct. 23, 1951
2,582,521 Bataille --------------- Jan. 15, 1952
2,599,042 Bannister --------------- June 3, 1952
2,694,562 Snyder et al. --------------- Nov. 16, 1954

FOREIGN PATENTS

26,289 France --------------- June 12, 1923

OTHER REFERENCES

"Coal Age," April 1933, pp. 111, 112 and 127.
"Coal Age," December 1948, pp. 84–87.
"Coal Mining," February 1949, pp. 15–18.