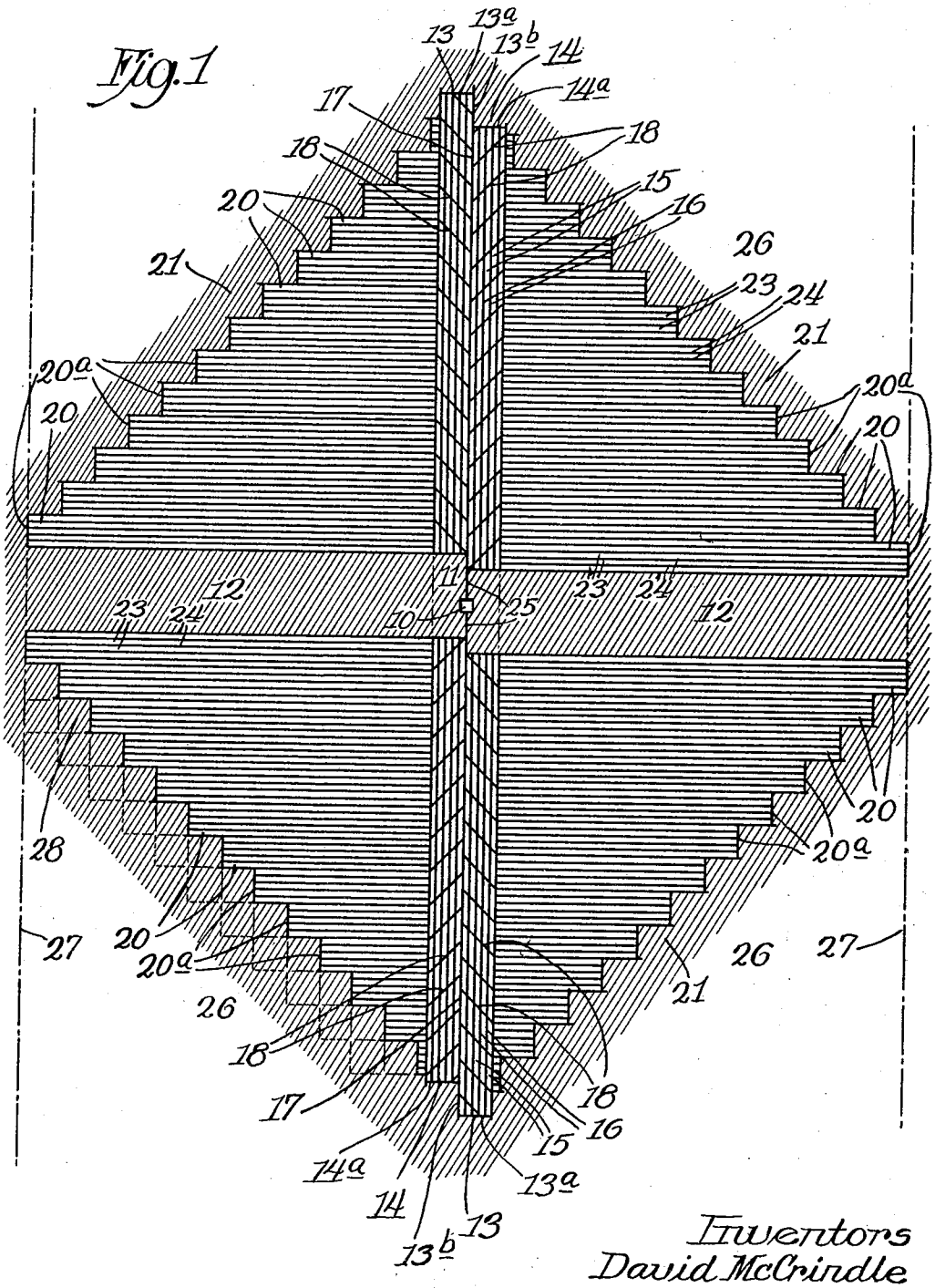
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Fig. 1



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Fig. 2

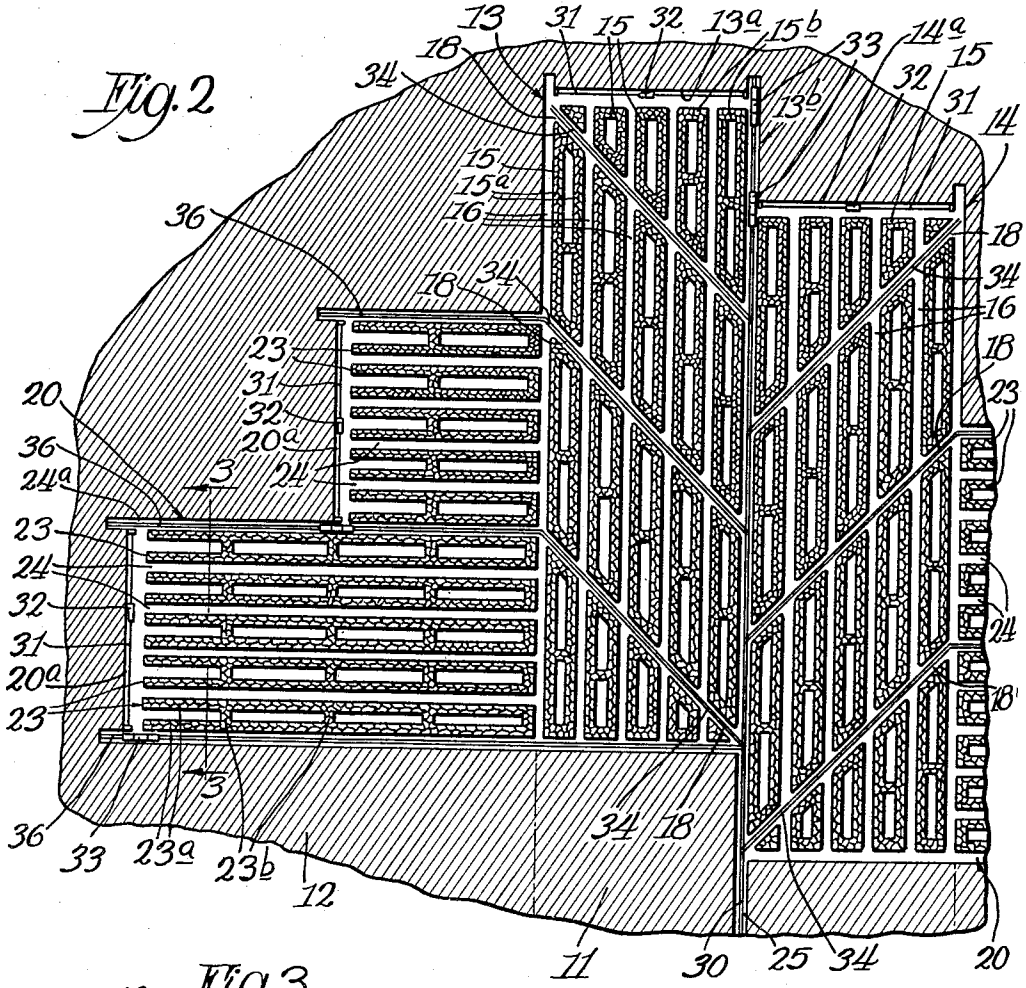


Fig. 3

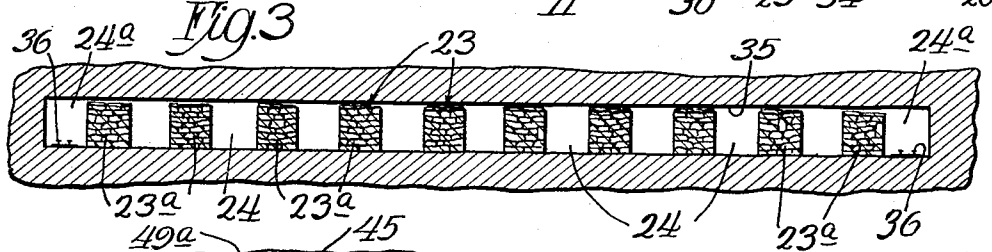
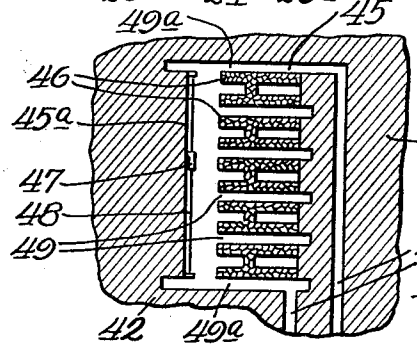


Fig. 4



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UNITED STATES PATENT OFFICE

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METHOD OF MINING

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This invention relates to improvements in methods of mining and its purpose is to provide a method of mining coal or other minerals which makes possible the maximum extraction of the coal or the like while at the same time substantially eliminating the danger of caveins in addition to possessing other advantages.

In the mining of coal, for example, it is usually found that the seam of coal extends over a considerable area of irregular extent located between upper and lower layers of slate or other rock and it is common practice to sink a shaft through the coal seam at a more or less central point and excavate outwardly from this shaft. If the face along which the mining of the coal progresses is extended outwardly in the usual fashion from the central shaft, there is great danger of caveins along the working face and before an opportunity is provided for building an artificial support for the overlying roof of the excavated area and it is often impossible to effect an entire extraction of all of the coal in the seam because of the necessity of leaving pillars of coal of considerable area to maintain natural supports for the roof structure and because of the difficulty of extending the excavations into all parts of the coal seam.

The principal object of the present invention is to provide a step-face method of mining which substantially eliminates the hazards arising from caveins because of the maintenance of a natural support for the roof along the irregular working face where the mining operations are taking place. A further object is to provide an improved method of mining which gives reasonable assurance of roof control not only along the working face but in the previously excavated areas so that there is greater freedom of operations in removing the excavated coal and in providing safety outlets for the escape of workmen in case of unexpected caveins. A further object of the invention is to provide an improved method of mining according to which the operations are extended outwardly from a central shaft area in a progressive step by step fashion, according to which the coal or other mineral is extracted by excavating predetermined units of the seam leaving the boundary of the seam protected by two natural walls. In this step-face method of the present invention, the working face ordinarily has a zigzag formation so that a natural support is provided for the roof along the entire working face and the extension of the working face is carried on in step by step fashion over frontages of relatively limited extent. According to this method, the roof over the excavated area is supported by walls which are built up from slate or other rock as the excavation proceeds and these walls are arranged in regular parallel relation leaving intervening communications, arranged in predetermined fashion, with the central shaft area so that abundant facilities are provided for removing the coal or other mineral by any form of excavating or conveying mechanism as well as providing additional haulage roads in case the excavation is carried on by hand and furnishing air channels through which fresh air may be readily supplied to the working face where operations are being carried on. An important feature of this invention is that the regular plan of excavation thereby provided permits a definite daily output of coal or the like to be maintained regardless of the particular area of the seam being worked. Other objects relate to various features and advantages of the invention which will appear more fully hereinafter.

The nature of the invention will be understood from the following specification taken with the accompanying drawings, in which one example of the improved method is illustrated. In the drawings,

Fig. 1 is a horizontal section through a coal seam of a mine showing a considerable area of the seam as having been excavated along four stepped faces which, taken together, form an enclosure of substantially rectangular form;

Fig. 2 is a horizontal sectional view, on an enlarged scale, of a portion of the structure illustrated in Fig. 1, in the early stages of the mining operations from a central shaft illustrating the plan of extending the working faces in step by step fashion together with the walls which are provided for supporting

purposes in the excavated areas and the haulage roads which are provided between and through the supporting walls;

Fig. 3 is a vertical section on an enlarged scale, taken on the line 3—3 of Fig. 2, showing the method of building the supporting walls in parallel relation in the excavated area; and

Fig. 4 is a horizontal section illustrating a portion of an excavation adjacent the central shaft wherein the method is modified by leaving a more extensive coal pillar adjacent the shaft and behind the extensions which are carried out in step by step fashion away from the shaft.

According to the method of the present invention, a vertical shaft 10 is sunk in a more or less central location in the property where mining operations are permitted and under which the coal seam, for example, is located. Around the shaft 10 there is left a coal pillar 11 of irregular outline which maintains a natural support around the shaft except for such haulage-ways and roads as are provided therethrough. Two other sections or pillars of coal 12 are allowed to remain on opposite sides of the central pillar 11 until the excavation of the entire mining area is substantially completed or until it becomes desirable to take coal from these areas in order to maintain the daily production. The mining of the coal is carried out at the beginning of the operations along two pairs of extensions 13 and 14 which are directed outwardly from the central pillar 11 at right angles to the sections 12. This excavation is carried out in straight lines with the excavations along the front of one extension 13 proceeding ahead of the excavations along the front of the other adjacent parallel extension 14. The extension should preferably be about two hundred feet wide so that the excavations are carried on over a front of two hundred feet along one extension 13 at the same time that excavations are being carried on along a front of equal width in the extension 14 at a point some distance rearwardly. Preferably, the operations on the face of the extension 14 may be carried on at a point two hundred feet in the rear of the working face of the extension 13 so that the area at the outer end of each extension 13 in which excavations are taking place is supported by a natural wall along the working face 13^a and also by a side wall 13^b which forms a part of the future development of the extension 14. As these extensions 13 and 14 are carried outwardly from the central shaft pillar 11, parallel supporting walls 15, known as gob walls, are built up in the excavated area to extend in straight lines outwardly from the central pillar 11. Between the gob walls 15 and at the outer sides thereof, there are thus provided a plurality of parallel passages or haulage-ways 16, some or all of which may be employed for the haulage or conveyance of the excavated coal. In order that the haulage of the excavated coal may be directed inwardly toward the central haulage-way 17 from the lateral boundaries of the extensions 13 and 14, during the subsequent development of extensions which are projected laterally from the sides of the extensions 13 and 14, the gob walls in the extensions 13 and 14 are preferably intersected by a number of diagonal haulage-ways 18 which are formed as the gob walls are built during the progressive development of the extensions 13 and 14 outwardly from the central pillar 11.

After the extensions 13 and 14 have been carried outwardly from the central pillar 11 to a distance of two hundred feet or more, for example, operations are begun along longitudinal extensions 20 extending parallel to the pillars 12. The longitudinal extensions 20 are preferably of uniform width, for example, two hundred feet, and the extensions 20 which are the nearest to the pillars 12 are developed in advance of the more remote extensions. Each extension 20 is preferably developed so that its working face is in advance of the working face of the next adjacent extension a distance equal to the width of each extension so that the new development is carried on in an area of square formation having a natural wall along the working face and also along one side face. As illustrated in Fig. 1, the development of the extensions 20 has been carried on for some distance from the lateral extensions 13 and 14 and the working faces 20^a of these extensions 20, being arranged progressively in advance of each other, form a substantially zigzag or stepped working face designated generally at 21. As each extension 20 is developed away from one of the lateral extensions 13 or 14, the roof in the excavated area is supported by parallel gob walls 23 leaving intervening roads or passageways 24, as in the formation of the extensions 13 and 14. The coal excavated from the working faces 20^a may thus be moved along these roadways 24 to the lateral extensions 13 and 14 where it may be directed inwardly through the diagonal haulage-ways 18 to the central haulage-way 17 which may have communication with the shaft 10 through one or more passages 25 extending through the central pillar 11. As illustrated in Fig. 1, the development of the longitudinal extensions 20 and the corresponding development of the lateral extensions 13 and 14 has been carried on to the point where four zigzag working faces 21 have been formed extending diagonally to the extensions 13 and 14 and forming in a general way a rectangular outer boundary for the excavated area into which the coal pillars 12 project from opposite ends of the mine. The unexcavated coal 26 which lies beyond the zigzag working faces 21 may be

extracted by a further development of the plan outlined above according to which the extensions 20 nearest to the pillars 12 are first extended outwardly to the boundaries 27 which form the allowable limits of the mine. This further development of the extensions 20 takes place progressively in rectangular unit areas 28, as indicated by dotted lines in the lower left-hand part of Fig. 1, so that on the active working face of the mine a zigzag or stepped face is maintained until the entire allowable excavation is completed.

The development of the present method of mining is illustrated more in detail in Figs. 2 and 3, where the road-way 25 from the shaft 10 is shown carrying a narrow gauge railway track 30 which extends out along the central haulage-way 17 located between the two lateral extensions 13 and 14. Along each of the working faces 13^a and 14^a, there extends a laterally moving conveyor illustrated diagrammatically at 31 for moving laterally along each working face the coal which is excavated by the digging apparatus indicated generally at 32. From the end of each conveyor 31, the coal is discharged into cars 33 by which it is conveyed along the track 30 to the shaft 10. The diagonal haulage-ways 18 are provided with similar tracks 34 which communicate with the track 30 so that coal can be carried onto the track 30 from the longitudinal extensions 20 which are developed from the sides of the extensions 13 and 14. The gob walls 15 are preferably formed so that each wall is made up of two parallel walls 15^a united at their ends and also at suitable intermediate intervals by transverse walls 15^b. These walls are built up from slate or other rock which may be derived from the roof above the coal seam, in the manner illustrated in Fig. 3, so that their tops are located closely adjacent to the ceiling of the seam which is located generally at 35. It is ordinarily unnecessary to bring the tops of these gob walls initially into contact with the roof 35 because the roof is adapted to settle as the excavation proceeds until it rests on the tops of the previously built gob walls. As the gob walls 15 are built in the excavation incident to the development of the extensions 13 and 14, the diagonal haulage-ways 18 are formed between sections of the gob walls according to a predetermined plan in order that these diagonal passageways will be provided for subsequent development of the longitudinal extensions 20.

Having developed the extensions 13 and 14 for a suitable distance away from the central pillar 11, the excavation of the longitudinal extensions 20 is begun with the development first of an area two hundred feet square forming the first unit of the extension 20 which is next adjacent to one of the pillars 12. This same extension 20 is then developed to a further distance of two hundred feet along a front of two hundred feet, for example, at the same time that the first unit of the next adjacent extension 20 is excavated over an area two hundred feet square, as illustrated at the left-hand side of Fig. 2. As this development of the extension 20 proceeds, the gob walls 23 are built, preferably with each wall made up of parallel longitudinal wall sections 23^a united by transverse wall sections 23^b. The walls 23 are separated by the intervening spaces or roadways 24, and although all of these roadways may be utilized, if desired, the removal of the coal from the working face 20^a of each extension 20 is preferably carried on over one or both of the roadways 24^a which are located at the sides of each extension 20 and which are provided with tracks 36 adapted to convey the mine cars 33 thereover to the diagonal tracks 34 and the central tracks 30. Along each working face 20^a, there is located a conveyor 31 which conveys laterally across the working face the coal which is excavated by the digging apparatus 32. The coal is discharged by a conveyor onto mine cars 33 located on one of the tracks 36. This plan contemplates the use of digging and conveying apparatus along the working face of the mine with a separate unit of digging and conveying apparatus on each unit 20^a of the working face. However, the plan may be utilized where the excavation is carried on by hand and in that case some or all of the haulage-ways 24 may be employed for conveying toward the central shaft the coal which is excavated from each unit of the working face. Some or all of the passageways 24 may be utilized for conveying air to the working face or as safety passages for the escape of workmen in the case of accident or cavein.

In Fig. 4 of the drawings, there is illustrated a modified plan of development according to the method of the present invention, wherein, instead of forming the lateral extensions 13 and 14 outwardly from the central shaft, coal columns are provided longitudinally from the central shaft and other coal columns 43 are provided laterally therefrom. Haulage-ways 44 are then excavated through these coal columns to the point of commencement of a longitudinal extension 45 which corresponds to one of the extensions 20 illustrated in Figs. 1 and 2. The extension 45 is then developed along a face 45^a extending at right angles to the pillar 42 and as this excavation proceeds, gob walls are built up in parallel relation behind the working face leaving an area which is occupied by the digging apparatus 47 and the conveyor 48 by which the coal is transferred laterally through one of the haulage-ways 49^a located at the sides of the extension 45 and having communication with the haulage-ways 44. In this case, the passages 49 between the gob walls constitute blind roadways which

may be extended through to the haulage-ways 44 in the event that the excavation is carried on manually.

Although one example of the improved method, with a modification thereof, has been set forth herein by way of illustration, it will be understood that the improved method may be practiced in various ways within the scope of the appended claims.

We claim:

1. The method of mining coal and the like which consists in excavating a pair of adjacent parallel lateral extensions outwardly from the region of a vertical shaft, maintaining the working face of one of said lateral extensions in advance of the working face of the other one, building a plurality of parallel supporting walls along the excavated area of each extension to support the roof and form haulage-ways therebetween, forming through said supporting walls a plurality of diagonal haulage-ways directed toward said shaft and communicating with the haulage-ways formed between said supporting walls along the junction of said lateral extensions, excavating extensions in close spaced relation extending longitudinally from the opposite sides of said lateral extensions, maintaining the working face of each longitudinal extension in advance of the working face of the next longitudinal extension which is further removed from the region of said shaft, and building supporting walls in the excavated areas of said longitudinal extensions to form roadways along the junction lines of adjacent extensions to communicate with said diagonal haulage-ways of said lateral extensions.

2. The method of mining coal and the like which consists in excavating a pair of adjacent parallel lateral extensions outwardly from the region of a vertical shaft, maintaining the working face of one of said lateral extensions in advance of the working face of the other one, building a plurality of parallel supporting walls along the excavated area of each extension to support the roof and form a plurality of haulage-ways therebetween, forming through said supporting walls a plurality of diagonal haulage-ways directed toward said shaft and communicating with the haulage-ways formed between said supporting walls along the junction of said lateral extensions, excavating parallel longitudinal extensions in close spaced relation from the opposite sides of said lateral extensions, maintaining the working face of each of said longitudinal extensions at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft, the amount of said advance being substantially equal to the width of that extension, and building parallel supporting walls lengthwise of the excavated area of each longitudinal extension to support the roof thereof and to form roadways extending along the junction lines of adjacent longitudinal extensions and communicating with said diagonal haulage-ways.

3. The method of mining coal and the like which consists in excavating a pair of adjacent parallel lateral extensions outwardly from the region of a vertical shaft, maintaining the working face of one of said lateral extensions in advance of the working face of the other one, building a plurality of parallel supporting walls along the excavated area of each extension to support the roof and form haulage-ways therebetween, forming through said supporting walls a plurality of diagonal haulage-ways directed toward said shaft and communicating with the haulage-ways formed between said supporting walls along the junction of said lateral extensions, excavating parallel longitudinal extensions in close spaced relation from the opposite sides of said lateral extensions, maintaining the working face of each of said longitudinal extensions at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft, the amount of said advance being substantially equal to the width of that extension, and building a plurality of parallel supporting walls lengthwise of the excavated area of each longitudinal extension to form a plurality of parallel passageways and forming roadways between the supporting walls of said longitudinal extensions which communicate with said diagonal haulage-ways of said lateral extensions.

4. The method of mining coal and the like which consists in sinking a vertical shaft through the coal seam in the central portion of the area to be mined, excavating a pair of adjacent parallel lateral extensions through the coal seam from opposite sides of the region of said shaft, building supporting walls in the excavated areas of said lateral extensions to form longitudinal parallel haulage-ways having diagonal haulage-ways intersecting them and communicating with the central haulage-way which is formed between adjacent lateral extensions, and then progressively excavating adjacent parallel longitudinal extensions directed longitudinally from opposite sides of said lateral extensions, said longitudinal extensions being of limited width, and maintaining the working face of each longitudinal extension at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft by an amount which is substantially the same as the width of that extension, thus forming a composite stepped working face along the outer portions

of said longitudinal extensions at each side of each pair of lateral extensions.

5. The method of mining coal and the like which consists in sinking a vertical shaft through the coal seam in the central portion of the area to be mined, excavating a pair of adjacent parallel lateral extensions through the coal seam from opposite sides of the region of said shaft, building supporting walls in the excavated areas of said lateral extensions to form longitudinal parallel haulage-ways having diagonal haulage-ways intersecting them and communicating with the central haulage-way which is formed between adjacent lateral extensions, then progressively excavating adjacent parallel longitudinal extensions directed longitudinally from opposite sides of said lateral extensions, said longitudinal extensions being of limited width, and maintaining the working face of each longitudinal extension at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft by an amount which is substantially the same as the width of that extension, thus forming a composite stepped working face along the outer portions of said longitudinal extensions at each side of each pair of lateral extensions, and building a plurality of parallel supporting walls lengthwise of the excavated area of each longitudinal extension to form a plurality of parallel passageways and parallel roadways along the junction lines of adjacent longitudinal extensions which communicate with said diagonal haulage-ways of said lateral extensions.

6. The method of mining coal and the like which consists in sinking a vertical shaft through the coal seam in the central portion of the area to be mined, excavating a pair of adjacent parallel lateral extensions through the coal seam from opposite sides of the region of said shaft, building supporting walls in the excavated areas of said lateral extensions to form longitudinal parallel haulage-ways having diagonal haulage-ways intersecting them and communicating with the central haulage-way which is formed between adjacent lateral extensions, then progressively excavating adjacent parallel longitudinal extensions directed longitudinally from opposite sides of said lateral extensions, said longitudinal extensions being of limited width, and maintaining the working face of each longitudinal extension at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft by an amount which is substantially the same as the width of that extension, thus forming a composite stepped working face along the outer portions of said longitudinal extensions at each side of each pair of lateral extensions, and maintaining longitudinal coal pillars extending outwardly from the region of said shaft between said longitudinal extensions which are directed outwardly from the lateral extensions on opposite sides of said shaft.

7. The method of mining coal and the like which consists in sinking a vertical shaft through the coal seam in the central portion of the area to be mined, excavating a pair of adjacent parallel lateral extensions through the coal seam from opposite sides of the region of said shaft, building supporting walls in the excavated areas of said lateral extensions to form longitudinal parallel haulage-ways having diagonal haulage-ways intersecting them and communicating with the central haulage-way which is formed between adjacent lateral extensions, then progressively excavating adjacent parallel longitudinal extensions directed longitudinally from opposite sides of said lateral extensions, said longitudinal extensions being of limited width, and maintaining the working face of each longitudinal extension at right angles to its direction of development and in advance of the working face of the next adjacent longitudinal extension which is further removed from the region of said shaft by an amount which is substantially the same as the width of that extension, thus forming a composite stepped working face along the outer portions of said longitudinal extensions at each side of each pair of lateral extensions, maintaining longitudinal coal pillars extending outwardly from the region of said shaft between said longitudinal extensions which are directed outwardly from the lateral extensions on opposite sides of said shaft, and finally excavating said longitudinal coal pillars after said longitudinal extensions have been developed throughout the area of the mine.

In testimony whereof, we have subscribed our names.

DAVID McCRINDLE.
JAMES B. MEDILL.