Aug. 4, 1942. R. S. WEIMER ET AL 2,291,669

METHOD OF STRIP MINING

Filed March 14, 1941 2 Sheets-Sheet 1

Fig. 1

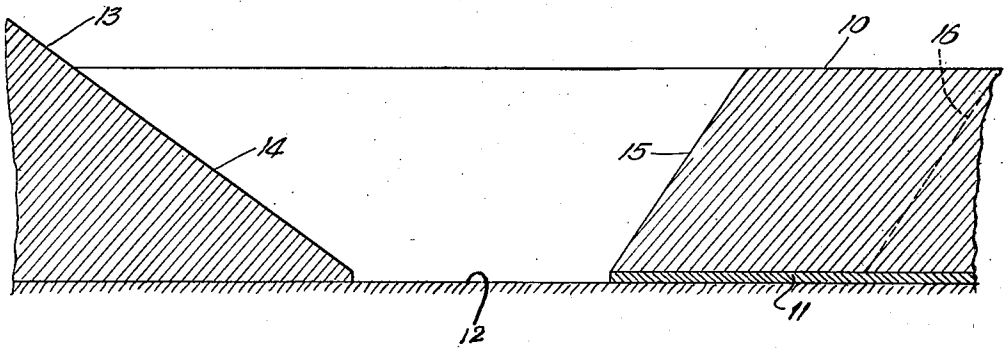



Fig. 2

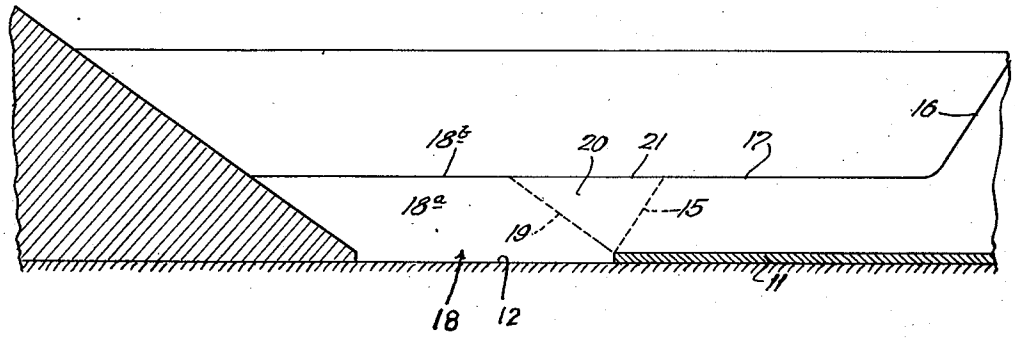
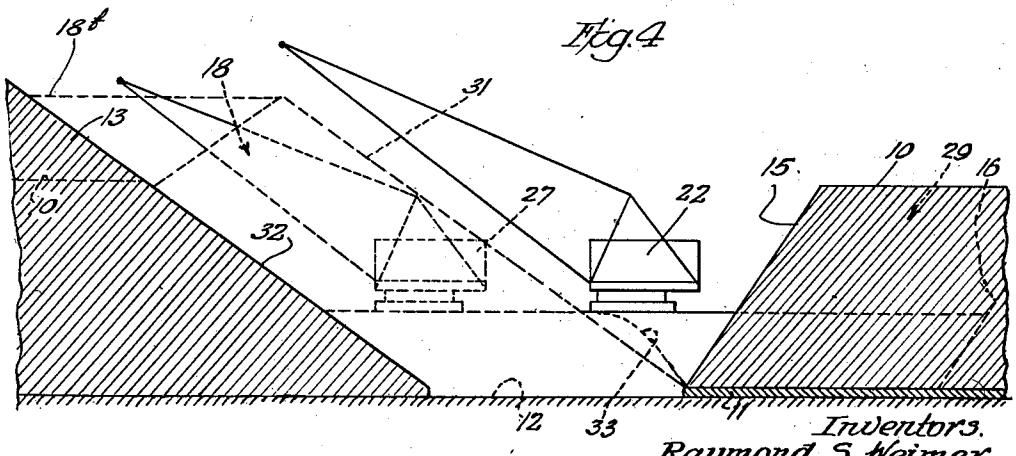



Fig. 4




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Fig. 3

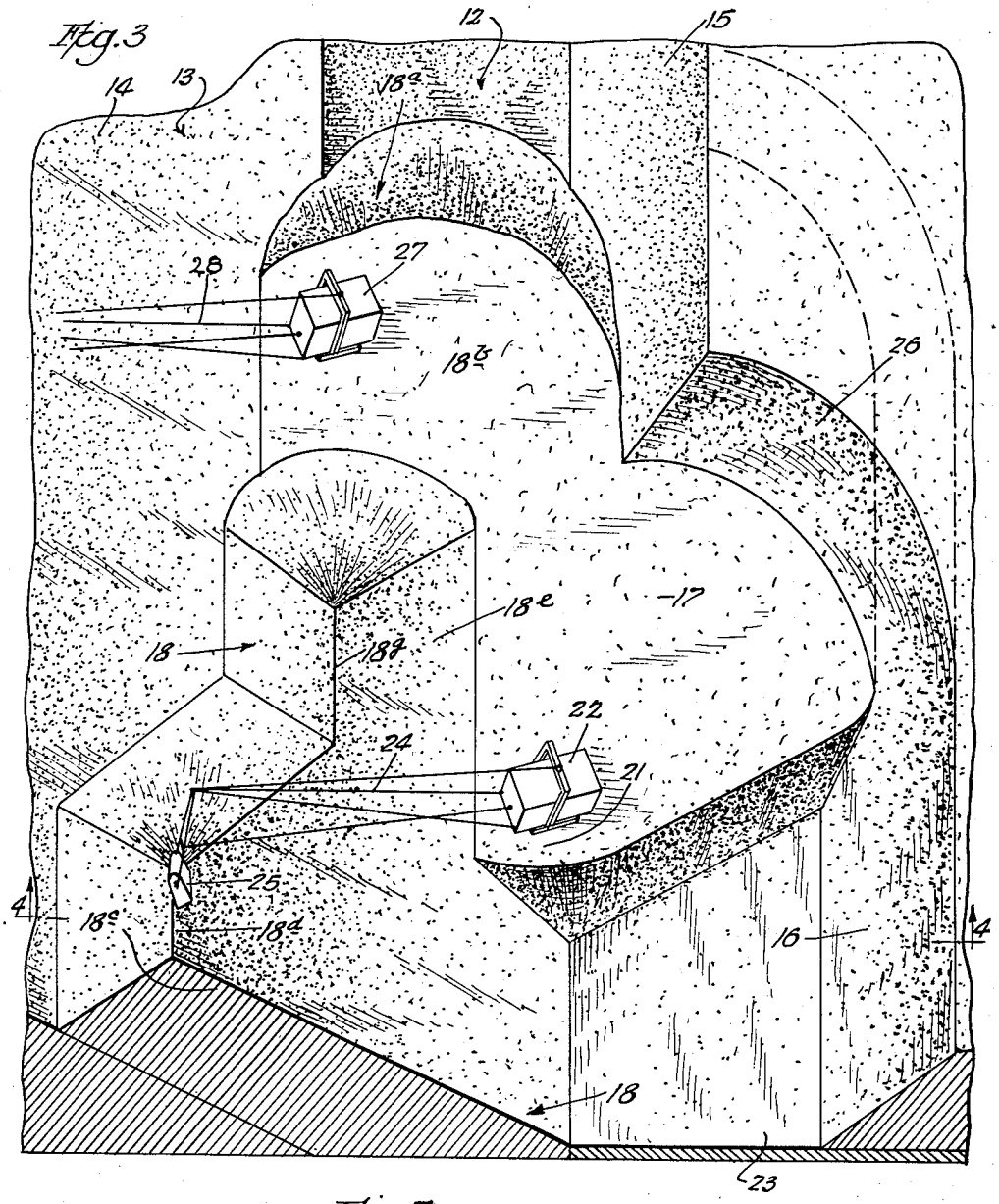
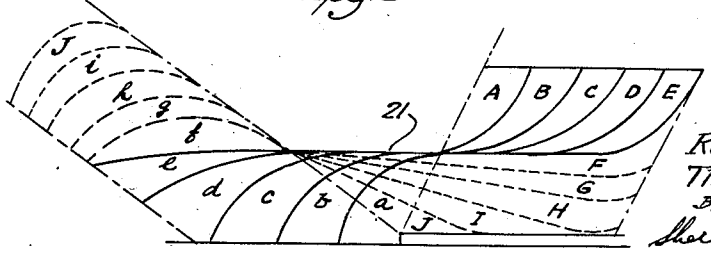



Fig. 5




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# UNITED STATES PATENT OFFICE

2,291,669

## METHOD OF STRIP MINING

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Application March 14, 1941, Serial No. 383,252

13 Claims. (Cl. 37—195)

This invention relates to improvements in the method of removing earth or overburden from valuable deposits of coal or other mineral.

One object of the invention is to provide an improved method of excavating which increases the effective capacities of earth moving machines and effects economies in mining operations.

The improvements have been developed in connection with the art of so-called "strip" mining of coal and the invention will be described in that connection for illustrative purposes.

In the art of strip mining the overburden or earth overlying a strip of coal is removed and usually is piled along one side of the cut so made. Power shovels or drag line equipment generally are the means principally employed in removing the overburden and depositing the same in spoil piles. When one cut has been made and the coal removed therefrom a second cut generally is made alongside the first cut on the side opposite the spoil pile and the earth or overburden removed in making the second cut is deposited in the first cut.

In removing and depositing the overburden upon the spoil pile the material is loosened from its original compact condition and increases in volume. For example, the "swell" of the material frequently is from twenty to twenty-five per cent of the original volume. Hence, if the second cut is of the same width and depth as the first cut, the material of the second cut will more than fill the first cut and the spoil pile formed by the removal of the material will extend substantially above the surface of the terrain. When the cut is about forty feet in depth, for example, the spoil pile formed of material from that cut may extend substantially above the level of the terrain, due in part to the swell of the loosened material and in part to the fact that the spoil pile of such cut is narrower from face to face (measured in a direction normal to a face) than the base of the spoil pile, due to the inclination of the latter, such inclination being necessary to prevent slides of material back into the cut being made. The slope of the exposed face of the spoil pile, that is, the surface adjacent the cut being formed, cannot be greater than the angle of repose of material that is being removed. The bank of the cut on the side opposite the spoil pile may be nearly, if not, vertical, depending on the nature of the overburden, but the angle of repose of the loosened material in the spoil pile is much less, that is, it frequently is approximately 35° to the horizontal. Hence, as the spoil pile increases in height the crest thereof moves farther and farther from the base of the cut from which the material is being removed. Where the earth moving apparatus (such as power shovel or drag line equipment) is stationed at the bottom of the cut, the distance from the machine to the crest of the spoil pile increases with the deepening of the cut. Hence, the boom of the excavating apparatus, if the latter is located on the bottom of the cut, must be of such length or have such reach as to enable the material to be removed from the level corresponding to the surface of the coal in the bottom of the cut to and slightly beyond the crest of the spoil pile which, as stated, not only increases in elevation as the cut progresses, but moves laterally of the cut by reason of the angle of repose of the material of the spoil pile.

A machine with a boom of a given length may make a cut of a given depth and of a certain width at the base (such width corresponding to the width of the strip of coal that may be removed) and deposit the waste directly upon a spoil pile, but the deeper the cut that must be made by that machine to uncover the coal (other conditions remaining the same), the narrower the cut must be at the bottom if the machine is to cast the waste directly upon the spoil pile. The width of the cut at the base determines the quantity of coal that will be made accessible for removal from the uncovered portion of the seam.

It will be appreciated that it may be possible to increase the length of a boom of a given machine to give it the reach required in depositing the bucket loads directly on the remote side of the crest of the spoil pile, but such alteration generally necessitates the use of a smaller bucket and introduces other engineering and mechanical problems that may slow up the process of removing the overburden to the point where operations become uneconomical. Such factors and others, such as the depth of the coal vein, limit the depth at which it is commercially feasible to carry on strip mining operations. An excavating machine of a particular power rating may have a boom of a certain maximum length and a bucket or scoop of a certain maximum capacity but if the length of the boom can be decreased not only can a bucket of greater capacity be used but the swinging movements of the machine can be accelerated safely to decrease the interval between loads. Such advantages and others can be attained by means of the present improvements which gives to a boom of a given length

the effective reach of a substantially longer boom.

In utilizing the present improvements to the greatest extent advantage is taken of the tendency of the loosened or dislodged cover of the overburden of a face of an excavation to gravitate toward the base thereof. At nearly every loading stroke of an excavator-dipper or bucket earth is loosened which rolls or slides down the face into which the bucket is cutting. During the course of an average day's strip mining operation actually many tons of such material are loosened and move downwardly to a greater or lesser distance from the original positions thereof. If such downward movement is toward the spoil pile such gravitational shifting of the material represents valuable work done and is of substantial advantage economically, whereas, if the movement of the loosened material is away from the machine or away from the spoil pile or even parallel to the spoil pile its recovery by the bucket entails additional work and hence increases the cost of operation. In order that the tendency of the dislodged material to move gravitationally can be taken advantage of to the maximum degree it is desirable that the loading strokes of the machine bucket generally be in a direction toward the spoil pile which thus augments the tendency of dislodged material to move by gravity or to be pushed by the bucket toward the position of final deposit. While the advantages mentioned, of course, are not available during the complete process of removing overburden and casting it directly upon the spoil pile they are available generally during a substantial portion of such operations and they and other advantages are of such importance that in order to benefit more fully from them it is, paradoxically, as will appear hereinafter, advantageous to deposit some of the overburden within the confines of the cut being made although it is necessary later to remove the same. In order words, to gain the advantage resulting from locating the machine in certain advantageous positions otherwise impossible, a fill is made of excavated material which later must be partially or wholly removed, as will be more specifically described herein.

Other advantages of the present improvements will be apparent from a consideration of the following specification and accompanying drawings, wherein

Figure 1 is a diagrammatic cross section of a strip mine showing a cut from the base of which the coal has been removed;

Figure 2 is a similar sectional view illustrating the partial formation of a second cut with the removed overburden deposited within the first cut;

Figure 3 is a broken, perspective view of a strip mine illustrating progressive steps in the formation of the second cut above referred to;

Figure 4 is a transverse section of a mine illustrating excavating machines in different advantageous positions; and

Figure 5 is a diagrammatic view illustrating generally the sequence of removal of sections of overburden from a cut and the disposal thereof.

Referring to Figure 1, the surface of the terrain is indicated by the line 10 and the vein or seam of coal 11 may be assumed to be at any usual distance beneath the surface which is within the range at which strip mining operations are feasible. In the drawings 12 indicates the base of a cut which has been completed and the waste or overburden removed therefrom having been deposited to form a spoil pile 13 at one side thereof and the coal removed from the bottom of the cut. The formation of this first cut 12 may have been effected by conventional methods, such not being important to the understanding of the present improvements, which generally are applicable primarily to the formation of cuts following the first one. Making the initial cut in opening up a strip mine may be, of course, more difficult than making subsequent ones generally, since the waste or overburden must be disposed of generally by piling the same upon the surface of the terrain as indicated at 13 in the drawings. In making subsequent cuts each previously made cut is available for receiving the spoil and hence such cuts, as compared with the first cut, are more economically formed, other conditions remaining the same. It will be noted that the angle of the face 14 of the cut 12 is approximately 35 degrees to the horizontal, such angle being the angle of repose of the loosened material of which the spoil pile may be assumed to be formed. The angle of repose varies with different materials as is well understood. The surface 15 of the opposite bank of the cut is shown as being somewhat steeper than the face 14, which generally is feasible since the material of the surface 15 has been undisturbed and remains in compact condition. When the second cut is to be made, that is, after the coal has been removed from the bottom of the first cut, advantage can be more fully taken of the present improvements. Instead of locating an excavating machine in the bottom of the first formed section of the second cut, as has heretofore been common practice, for the purpose of cutting away the overburden and swinging successive bucket loads laterally to deposit the same in the cut 12, a bench is formed in the overburden which is to be removed in forming the second cut and upon which bench the excavating machine operates.

In Figure 1 line 16 indicates the plane which will be occupied by the right-hand face of the second cut when the latter has been completed. In making the second cut an upper section of the overburden thereof is removed to form an approximately horizontal machine supporting surface. This surface preferably is in a plane located about ⅜ of the vertical distance measured from the coal 11 to the surface of the terrain 10. The surface of the bench so formed is indicated at 17 in Figure 3, which figure indicates that the upper portion of the overburden of the second cut has been removed down to the plane of line 17 and has been deposited in cut 12, thus starting a second spoil pile 18 the base of which corresponds to the base of the cut 12. The final angle of repose of the spoil pile 18 is indicated by the line 19 and if prior methods were employed the spoil pile would be built up along the plane indicated by the line 19 until all the overburden from the second cut had been removed. It will be seen, however, that where this method is followed a V-shaped channel would remain between the planes indicated by the lines 15 and 19 and that were an excavating machine to be located on the surface of the bench indicated by line 17 the excavator necessarily would have to be kept at a distance to the right from the edge of the bench to avoid the possibility of causing the latter to slide and possibly wreck the machine. Hence, in accordance with the present improvements, instead of leaving a channel between

the places indicated by lines 15 and 19 the upper portion of the overburden is deposited not only in a position to initiate the formation of the spoil pile 18 but some of it is deposited also in the V-shaped channel 20 between the planes of surfaces indicated by the lines 15 and 19 and thus is formed a lateral extension of the surface of the bench 17, the surface of which extension is indicated by the line 21. Hence it will be seen that not only is the face 15 laterally supported by the filled in material 20, but the latter receives lateral support also by the initial portion 18a of the spoil pile 18. Hence a machine operating on the bench may move laterally beyond the plane of the face 15 and onto the surface 21 which constitute a lateral extension of the bench and may for convenience be designated a shelf upon which the machine is free to move into the space of the first cut and thus take a position adjacent the plane of the face 19 of the spoil pile.

By operating from the supporting plane of the line 17 the machine has the advantage of such elevated position and hence the vertical reach of its boom is effectively increased an extent not less than the vertical distance between the surface of the coal and the top surface of the bench. If a single machine is located on the surface of the bench 17 and on the extension or shelf 21, it can, as indicated at Figure 3, by removing overburden above the plane of the bench, extend the latter longitudinally of the cut to be formed and, by operating from the opposite end of the bench, remove the material of which the bench is composed down to the surface of the coal and thus uncover the same. In thus removing the bench material the machine can also remove the material of the extension or shelf 21, depositing such material on the spoil pile. This method of operation is pictorially illustrated in Figure 3 of the drawings.

Referring to Figure 3 of the drawings, 12 is the cut from which the coal has been removed, the material of the cut having been deposited in a spoil pile 13 at one side of the cut, the face of the cut opposite the spoil pile being indicated by numeral 14, as above described. The second cut to be made by utilizing the present improvements will extend parallel to cut 12, and this second cut is shown as being partially formed in Figure 3. In this figure it will be observed that the bench 17 has been formed by removing an upper portion of the overburden as above described and depositing the same in the cut 12 to form the initial portion 18a of the spoil pile 18. A shelf 21 has been formed also of the material removed in forming the bench which enables an excavating machine 22 to move laterally to the left in Figure 3 beyond the plane of the face 18e. In fact the machine 22 can move to positions adjacent the face 14 of spoil pile 13 by traveling upon the surface 18b of the initial portion 18a of the spoil pile 18 where such portion has been formed in advance of rearward and more elevated portions thereof as will be explained later. In the foreground of Figure 3 the second cut is shown as completed at one end, that is, the material of the bench 17 and shelf 21 has been removed by the machine 22, and the material deposited upon the initial portion 18a of the spoil pile 18, thus forming the upper portion 18c of the pile and exposing the coal 23.

The machine 22 is shown as being of the dragline type and is provided with a boom 24 of such length that when the machine is located on the bench or shelf adjacent the spoil pile 18, as shown, the bucket 25 can be moved outwardly of the boom to the point where its load can be discharged at or beyond the crest 18d of the completed portion of the pile. As the machine progresses along the plane of the bench longitudinally of the strip of coal the material of the bench and shelf are removed to uncover the coal and the portion 18c of the spoil pile of maximum height is, of course, extended by the deposition of the material upon the previously formed sections of the pile 18. The machine 22 by operating at the opposite end of the bench by cutting into the bank or face 26, can advance the bench longitudinally, the material so removed being deposited in the cut 12 and thus advancing the initial section 18a of the spoil pile and likewise extending the shelf 21. Hence, by alternately extending the bench and shelf as described and later removing the bench and shelf material at the first mentioned end thereof the coal will be uncovered, the machine operating always from the plane defined by the surface of the bench, shelf and initial portion of the spoil pile.

In removing the upper portion of the material of the cut to form the bench and shelf and the initial portion 18a of the spoil pile, surplus material not required in forming the shelf and initial portion 18a is deposited upon the portion 18a and may form an intermediate portion 18e of the spoil pile. However the surface 18b of the initial portion of the pile preferably is advanced beyond the section 18e whereby a machine such as the machine 22 can travel from the bench 17 across the shelf 21 and take a position adjacent the face 14 of the first formed spoil pile 13. From this advantageous position afforded by the elevation of the surface 18b the machine may deposit material upon or beyond the crest of the first spoil pile 13, in many instances if desired, and can also deposit waste in the V-shaped channel lying between the contiguous faces of adjacent piles thus leveling off the terrain as indicated by line 18f in Figure 4. Generally the spoil piles of territory that has been strip-mined by conventional method consists of a series of ridges which render the surface practically useless thereafter. The V-shaped valleys between the ridges represent valuable spoil-receiving space which if filled during the excavating operation would leave the terrain in a more desirable condition for future use and result in the formation of spoil piles of lower elevation.

In Figure 3 of the drawings a machine 27 is shown in the position above mentioned, that is one the surface 18b of portion 18a of the second pile 18 and adjacent the face 14 of the pile 13 from which position the machine may deposit spoil upon the pile 13 or in the V-shaped channels between the upper portions of piles 13 and 18.

The second machine 27 may be employed merely for the purpose of advancing the bench, shelf and initial portion 18a of the spoil pile. By cutting away at the face 15 and depositing the material in the cut 12 the first section 18a of the spoil pile 18 and likewise the bench 17 and the shelf 21 can be extended longitudinally of the cut. With two machines operating, the latter machine 27 may, of course, be provided with a boom 28 substantially shorter than the boom of the first machine, since such machine is required only to deposit material upon or beyond the crest 18g of the intermediate portion 18e of the spoil pile 18 and to advance the forma-

tion of the portion 18a. Since the crest 18g of the section 18e of the spoil pile is closer to the face 16 than is the crest 18d of the highest section 18c of the spoil pile, the boom 28 of machine 27 may be substantially shorter than the boom of machine 22 and preferably is of such length only as to enable it to drop the bucket into the upper portion of the face 16 and to deposit the load upon or beyond the crest 18g.

The machine 27 like machine 22 when the latter only is used, can be moved to different positions on the surface formed by the bench 17, shelf 21, and the initial portion 18a of the spoil pile and when either is in a position of machine 27 as is shown in Figure 3 and in dotted lines in Figure 4, the bucket can be dropped into the overburden in advance of the bench and can be hauled substantially transversely of the cut, thereby moving the load in the shortest route to the place of deposit. Material loosened by the bucket can gravitate down the slope of the face 15 toward the place of deposit when the bucket is cutting into the face and in many instances will slide into the space of the cut 12. The movement of such material by gravity reduces the cost of operations. When the bucket is cutting into the bench material such quantities of the loosened material as are moved or pushed by the bucket during the loading operation but which do not actually enter the bucket are moved toward the place of deposit and hence the energy so consumed is not entirely wasted.

Referring to Figure 4, which is a vertical section through a mine of the character under consideration, line 10 indicates the surface of the terrain, while 11 indicates a vein of coal which may be assumed to be 80 feet beneath the surface. This figure indicates that a first cut 12 was made and the waste material thereof deposited in a spoil pile 13 upon the surface of the earth at one side of the cut. The cross sectional area of the second cut to be made, indicated by the numeral 29, extends from the face 15 to the plane 16. If it be assumed that the width of the first cut was 100 feet at the base and that of the second cut 29 is also to be 100 feet at the base, the cross-sectional area of the second cut 29 will be about 8,000 square feet. However, since the material when loosened by the excavator will swell or increase in volume by approximately 25 per cent, such loosened material, when moved to a spoil pile 18 will have a cross-sectional area of about 10,000 square feet. While the base of the spoil pile 18 will be 100 feet wide, the distance between the faces 31 and 32 of the spoil pile, measured in a direction normal to the faces, will be substantially less than 100 feet, for example, about 60 feet, due to the inclination of such faces which constitute the angle of repose of such loosened material. The spoil pile 18 therefore, under the conditions assumed, will have a face approximately 200 feet in height measuring from the surface of the coal 11 to the crest 18d of the spoil pile. Should an excavating machine 22 be located adjacent the base of the spoil pile 18 upon the coal, as has been common practice heretofore, its boom would have to be sufficiently long (not less than 200 feet) to enable it to deposit the material upon or beyond the crest 18d of the spoil pile unless recasting or other methods were employed in disposing of the waste. A boom of such length would be much in excess of that required in removing the material lying between the faces 15 and 16. Since the direct deposit of the removed material by the excavating machine generally is more economical than such recasting or rehandling methods, it is desirable to avoid such more expensive methods where possible and by utilizing the present improvements a machine having a boom of 150 feet in length can be employed under the conditions presented in Figure 4 for directly casting the last portions of removed material upon or beyond the crest of the spoil pile 18. Such boom is of sufficient length that by pivoting or turning the machine upon its base in the customary manner, but without moving the machine from the location shown, the bucket can be dropped into the upper portion of the face 16 opposite the machine. Where the second machine 27 is employed the boom thereof need be no more than 135 feet in length under the conditions assumed in Figure 4 to enable it to advance the formation of the bench 17, the shelf 21 and the initial portion 18a of the spoil pile. Since such machine can shift its position laterally of the cut over a substantial range and a shorter boom thereby employed, a larger capacity bucket can be used.

If it be assumed that the surface of the bench 17 is 30 feet above the surface of the coal 11 and the machine 22 has been moved over upon the shelf 21 to the approximate position shown in full lines in Figure 4, a boom 150 feet in length is adequate to enable the machine 22 to deposit the removed material upon or beyond the crest 18d of the spoil pile 18. Were the surface of the bench and shelf located 40 feet above the coal, that is, at the horizontal median plane of the overburden or between the surface 10 and the coal, an advantage would be gained insofar as the effective reach of the boom is concerned with reference to the crest of the spoil pile, but substantially more material would be required to form the shelf and since the material of the shelf generally must be later removed it has been found advantageous to locate the plane of the shelf at about ⅜ of the vertical distance measured from the coal to the surface of the terrain. However, in the final removal of the material constituting the bench and the shelf, such material must be elevated wholly by the machine and little or no advantage is attained from the free gravitational movement of the material which occurs when the upper portion of the cut is made, that is, in removing the overburden that lies above the plane of the bench. In the instance under consideration the first 50 feet of the overburden can be removed by the machine or machines under conditions wherein the movement of the drag-line bucket or buckets is level or downwardly toward the machine and hence the material which is loosened by the bucket will gravitate toward the machine, or toward the cut into which the material is to be deposited.

In the making of the upper portion of the cut adjacent a previously made cut, it is not necessary that the material be moved wholly by the excavating machine or machines shown in the drawings since much of the overburden can be deposited in the first cut by other means or types of equipment. Thus, referring to Figure 3, it will be seen that in extending the bench and shelf 17 and 21 of the second cut, instead of moving all the material above the plane of the bench by means of the machine 26, scrapers or bulldozers (not shown) or other means, such as blasting or in some instances even hydraulic means may be resorted to for removing a portion of the overburden into the first cut 12 by

causing the material to gravitate down the face 15. The removal of the upper section of the overburden of any cut without actually lifting and shifting the material by mechanical means represents substantial economies in the earth moving operations.

In taking advantage of the tendency of loosened material to slide and roll down the face of a cut, it is desirable that the loading strokes of the excavating machine be such as to cause such loosened material to move toward the machine or, where possible, to gravitate directly toward the position of final deposit. Where such loosened material slides down the face of the cut, for example, toward the machine, the succeeding stroke of the machine in picking up such loosened material will be shorter and hence less time will be required in taking on the load and depositing it in the spoil pile than would be the case had such loosened material moved away from the machine or had remained in its original position.

As contrasted with prior strip mining methods wherein an excavating machine initially digs down to the surface of the coal and from that level continues the removal of the overburden along the strip of coal to be uncovered, the present method effects substantial economies. Of major importance is the fact that by means of the new method the length of the boom of the excavator need not be of such length as to enable it to reach from the bottom of the cut to and beyond the crest of the spoil pile since, in carrying out the novel method, the machine is maintained at an advantageous level which is above the plane of the coal. Since the use of a shorter boom on a machine enables the use of a bucket or scoop of greater capacity and permits of greater acceleration and deceleration of swinging movements of the boom, larger and more frequent loads can be handled by the machine. The utilization of the machine-supporting shelf or bench-extension and the initial portion of the spoil pile to enable the machine to be moved laterally to a position close to the face of the spoil pile being formed or close to the face of the previously formed spoil pile as above described, thus giving the boom a greater effective length, has been found to be of substantial advantage, notwithstanding that the material of which the shelf is formed generally must be later removed. Frequently not all the shelf material must be finally removed, depending on the characteristics thereof, since the movement of the machine upon the shelf packs some materials so firmly that a portion of it may be left in position at the base of the spoil pile, as indicated by the dotted line 33 in Figure 4, without likelihood of its sliding down upon the coal.

In Figure 4 the combined width of the bench and shelf is approximately 150 feet and during the removal of the bench material with the machine 22 located near the face 31 of the spoil pile, as shown in full lines, the bucket can be dropped onto the remote side of the bench and in being drawn toward the machine on the loading stroke will push loose material toward the spoil pile. Hence, when the strokes of the machine are in a transverse or partially transverse direction of the cut, the movement by the bucket of the material which does not enter the bucket does not represent wholly wasted energy since the movement of such material is toward the spoil pile. Where a machine is located on the surface of the coal and its loading strokes to a large extent are longitudinally of the strip, the gravitational movement of the loose materials, which may be toward the machine, are not toward the spoil pile and in recovering those materials that slide or roll longitudinally of the strip the bucket must be moved through a larger range, which requires additional time and results in increased costs. Hence filling in the V-shaped space to form the shelf, in addition to enabling the use of a shorter boom on a machine and a larger bucket, enables the machine to be located generally at the side of the cut adjacent the spoil pile and sufficiently removed from the opposite side of the cut that a substantial portion of the operating strokes of the bucket can be made in a direction transverse the cut, rather than lengthwise, thereby rendering advantageous the loosening and displacement of the waste by the bucket during loading operations. The machine 22 may also be moved laterally beyond the bench 21 if desired, to or adjacent the face 14 of the pile 13, that is, to the position of the machine indicated by dotted lines in Figure 4. The machine in such position will be located upon the initial portion 18a of the pile 18 in advance of the more elevated or completed portions of the pile and when in such position can, in loading, haul its bucket transversely of the cut and deposit the loads upon the pile 13 or the pile 18 or directly within the V-shaped spaces between the crests of those piles, thus leveling off the terrain. Where the machine 22 having a boom 150 feet in length is in approximately the position of the machine shown in dotted lines in Figure 4, the bucket can be swung to discharging position which will be more than 250 feet from the left hand edge of the coal seam 11. Hence the improved method increases to a very substantial extent the effective length of a machine boom, enabling it to deposit material a distance so remote from the cut being formed that it becomes practicable to strip-mine to greater depths or to make substantially wider cuts and without re-casting the removed material and without increasing the likelihood that loose spoil pile material will slide down upon the coal. Utilizing the V-shaped spaces between spoil piles, as mentioned, results in the formation of spoil piles of lesser elevation (other things being equal) and hence permits the use of shorter booms and of larger capacity shovels than would otherwise be required under like conditions if prior methods were employed.

Figure 5 illustrates diagrammatically the direction of movement of successive portions of the overburden of a strip into an adjacent cut to form a spoil pile. Upper case letters A to E, inclusive, indicate arbitrary divisions of the upper portions of the overburden, while letters F to J, inclusive, indicate similar arbitrary sections of the overburden which constitute the bench and shelf. As indicated, the section A is moved to the position *a*, while sections B, C, D, and E are moved to the positions *b*, *c*, *d*, and *e*, respectively, thus forming the shelf 21 and forming the first or initial portion 18a of the spoil pile. The movement of sections A to E can be effected without any substantial elevation of the materials as will be seen and, if desired, by means other than drag-line apparatus as mentioned above. Section A, for example, will practically gravitate into the position *a* when loosened and may be so loosened by blasting, for example. The materials of sections A to E are thus movable economically since the material thereof, when loosened, will tend to gravitate toward the spoil pile and will tend to

be moved in that direction by the bucket of dragline apparatus located upon the shelf 21 or upon an advanced portion 18a of a spoil pile and making its loading strokes from right to left transversely or substantially transversely of the cut or at some transverse component of such direction.

Sections F to J must be elevated to the positions *f* to *j*, respectively, and hence removal of those sections is less economical but since the machine can be located on the shelf, laterally of those portions of sections F to J being excavated, economies over prior practice are effected due to the advantageous position of the machine at the elevation of the bench and reduction in time required in completing the bucket loading and dumping cycles resulting from the employment of the shorter boom than would be required in following conventional practices.

It will be noted that by the described method the material of the upper portion of a section of overburden becomes generally the lower portion of the section of the spoil pile directly, or substantially directly, opposite the place of origin of the material and that the lower portion of that section of overburden becomes the upper portion of said section of the spoil pile. The movement of the successive portions of overburden into positions of deposit opposite or substantially opposite the positions of origin, that is, by the shortest routes, rather than into positions substantially in advance of the respective positions of origin, enables loading operations to be accelerated and reduces the costs thereof.

By means of the present improvements the effective reach of the boom or booms of excavating apparatus is substantially increased in that such apparatus operates not only from an advantageous elevation above the mineral but from advantageous lateral positions as well. Advantage is taken of the tendency of substantial quantities of the material, when loosened by the buckets to gravitate toward the place of deposit and of the known fact that during loading strokes the buckets push substantial quantities of material along in front of them but which do not enter the buckets. Where the loading strokes are transverse or partially transverse with respect to the cut being formed such movement of the material entails less loss of power or energy than should the movement of such material be away from the positions of final deposit. Furthermore, by increasing the effective length of the boom, larger buckets can be employed on machines of given power ratings without increasing the loads on the machines and hence the overburden can be removed at a lower cost per ton by utilizing the present improvements.

We claim:

1. The method of removing overburden from a strip of mineral contiguous one side of a previously formed cut which comprises removing an upper portion of the overburden to a level intermediate the surface of the terrain and the mineral to provide a machine-supporting bench and depositing said removed overburden in said cut to form a spoil pile and also depositing a portion of the material alongside the bench intermediate the same and said spoil pile to provide a shelf co-planar with and extending laterally from the bench to the spoil pile for receiving lateral support from the latter and providing lateral support for the bench, placing an excavating machine on the bench and manipulating the same thereon and on the shelf for removing the bench and shelf material to uncover the strip at one side of the machine by excavating strokes thereof moving generally in a direction transverse with respect to the bench and shelf and toward the spoil pile, and by similar operating strokes advancing the bench and shelf formation on the other side of the machine to enable the machine to advance at said level toward the other end of the strip as the material of the strip is uncovered on the first mentioned side of the machine.

2. The method of removing overburden from a strip of mineral contiguous one side of a previously made cut which comprises removing an upper portion of the overburden down to a selected level between the surface and the mineral to provide a bench and depositing the overburden in said cut to form a spoil pile and depositing also a portion of such overburden between the spoil pile and the adjacent face of the bench to provide a co-planar shelf, and thereafter progressively removing successive portions of the bench and shelf material and depositing the same on the spoil pile by means of an excavating machine operating on the bench and shelf in advance of the portions being removed.

3. The method of removing overburden from a strip of mineral contiguous one side of a previously made cut which comprises removing an upper portion of the overburden down to a selected level below the mid-plane of the overburden to provide a bench and depositing the overburden in said cut to form a spoil pile and depositing also a portion of such overburden between the spoil pile and the adjacent face of the bench to provide a co-planar shelf, and thereafter progressively removing successive portions of the bench and shelf material and depositing the same on the spoil pile by means of an excavating machine operating on the bench and shelf in advance of the portions being removed.

4. The method of removing overburden from a strip of mineral contiguous one side of a previously made cut which comprises removing an upper portion of the overburden down to a level spaced above the mineral a distance corresponding approximately to three-eighths the vertical distance between the mineral and the original surface of the overburden to form a spoil pile and depositing also a portion of such overburden between the spoil pile and the adjacent face of the bench to provide a co-planar shelf, and thereafter progressively removing successive portions of the bench and shelf material and depositing the same on the spoil pile by means of an excavating machine operating on the bench and shelf in advance of the portions being removed.

5. The method of increasing the effective capacity of a boom-provided excavating machine in removing overburden from a strip of mineral contiguous a previously opened cut and in casting the overburden directly in said cut to form a spoil pile which comprises forming a machine supporting bench above the strip by removing an upper portion of the overburden down to a predetermined level and depositing the spoil so removed in the cut to initiate the formation of a spoil pile and form a shelf for laterally supporting the bench and for receiving lateral support by the spoil pile, and locating an excavating machine on said bench and shelf and operating the same to progressively remove the portions of the bench and shelf at one side of the machine and casting upon the spoil pile the material so removed by the machine while operating at the ele-

vation and lateral position afforded by the bench and shelf.

6. The method of removing overburden from a strip of mineral contiguous a previously formed cut which comprises forming a supporting bench for a boom-type excavating machine at an elevation intermediate the surface of the terrain and the strip of mineral by moving that portion of the overburden above said level into the cut to initiate the formation of a spoil pile and providing from some of such removed material a shelf intermediate the bench and spoil pile and co-planar with the bench for extending the machine supporting surface of the bench laterally to the spoil pile and upon which extension the machine can move for increasing the effective reach of the boom thereof in casting spoil upon or beyond the crest of the pile, and operating the machine while on said bench and shelf for removing the bench and shelf material at one side of the machine to uncover the mineral strip and advancing the machine longitudinally of the bench and shelf intermittently as the uncovering of the mineral progresses.

7. The method of removing overburden from a strip of mineral contiguous a previously formed cut which comprises moving an upper portion of the overburden laterally into the cut to form a spoil pile and to provide a horizontal bench above the strip at a level intermediate the surface of the terrain and said mineral and depositing a portion of such overburden contiguous the bench to provide lateral support for the bench and to provide also a lateral extension of the surface thereof extending into the original space of the cut and upon which surface extension a boom-type excavating machine can be placed at a distance sufficiently remote from the opposite side of the bench to enable the machine to be so operated that the loading strokes thereof are substantially in a transverse direction with respect to the bench and toward the cut and to increase the distance from the bench at which the machine can discharge the loads, and placing such a machine on the bench and extension for operation as stated in removing the remaining overburden constituting the bench and bench extension.

8. The method of removing overburden from a strip of mineral alongside a previously formed cut which comprises removing a portion of the overburden down to a plane intermediate the surface of the terrain and the strip to form a supporting bench for an excavating machine, depositing the material so removed in said cut to initiate the formation of a spoil pile and forming also a machine-supporting shelf co-planar with the bench and extending laterally to the adjacent face of said spoil pile, and operating drag line equipment on the surface of said bench and shelf at the side thereof adjacent the spoil pile for extending the formation of the supporting surface at one side of the equipment and removing the bench and shelf material at the other side thereof whereby the machine is able to deposit its loads directly upon or beyond the crest of the pile and is sufficiently remote from the opposite side of the supporting surface to enable the loading strokes of the machine to be in a direction substantially transverse the cut being made.

9. The method of removing overburden from a strip of mineral adjacent a previously formed cut which comprises removing an upper portion of the overburden from a longitudinal section of the cut to form a machine-supporting bench above the strip and depositing the removed material in said cut to form a lateral machine-supporting extension of the bench extending from the bench across the cut to the opposite side thereof, and operating excavating apparatus on the bench and bench extension to extend the formation of the bench and extension in advance of the apparatus and to remove successive portions of the bench at the other side of the machine to uncover the mineral.

10. The method of removing overburden from a strip of mineral adjacent a previously formed cut which comprises removing an upper portion of a section of the overburden to form a machine-supporting bench, depositing the material so removed in said cut to form a supporting extension for excavating apparatus co-planar with respect to the bench and extending across the cut, and operating excavating apparatus on the bench and bench extension to remove the upper portions of successive sections of the overburden for extending the bench and bench extension longitudinally of the strip and cut respectively in advance of the apparatus and for removing the bench at the other side of the machine and depositing the removed bench material upon the extension substantially opposite the place of removal.

11. The method of removing overburden from a strip of mineral adjacent a previously formed cut which comprises removing an upper portion of a section of the overburden to form a supporting bench at a level below the horizontal median plane of the overburden, depositing overburden material so removed in said cut to form a co-planar bench extension, positioning drag-line apparatus on the bench extension and operating the bucket or buckets thereof in directions substantially transverse the bench during the loading strokes to remove the bench material and depositing the material so removed upon said extension.

12. The method of removing overburden from a strip of mineral adjacent a previously formed cut which comprises removing an upper portion of a section of the overburden to form a supporting bench at a level not above the horizontal median plane of the overburden, depositing material so removed in the cut to form a co-planar extension of the bench extending from the bench to the remote side of the cut, and removing the material of the bench by boom-type excavating apparatus located on the extension at positions laterally remote from the bench whereby such removed bench material can be deposited in positions in a spoil pile laterally beyond the range of the boom of said apparatus when located on the bench.

13. The method of removing overburden from a strip of mineral adjacent a previously formed cut the spoil of which is located alongside the cut on the side remote from the bench, which comprises removing an upper portion of a section of the overburden to form a bench at a level not above the longitudinal median plane of the overburden, depositing the material so removed in said cut to form an extension of the bench co-planar with the latter, operating boom-type excavating apparatus on the extension to remove additional upper portions of contiguous sections of the overburden and depositing the removed material in the cut to extend the bench and bench-extension longitudinally of the strip and cut respectively, removing by said apparatus por-

tions of the first formed section of the bench and depositing the removed material on the first formed portion of the bench extension to form a spoil pile, and moving the apparatus to positions on said bench extension in advance of the upper portion of the spoil pile and operating the same for removing additional portions of the overburden and depositing the same between said upper portion of the last mentioned spoil pile and the adjacent face of said first mentioned spoil pile.

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