H. L. DOHERTY.

METHOD OF EXCAVATING EARTH.

APPLICATION FILED MAY 15, 1911.

1,166,820.

Patented Jan. 4, 1916.

4 SHEETS—SHEET 1.

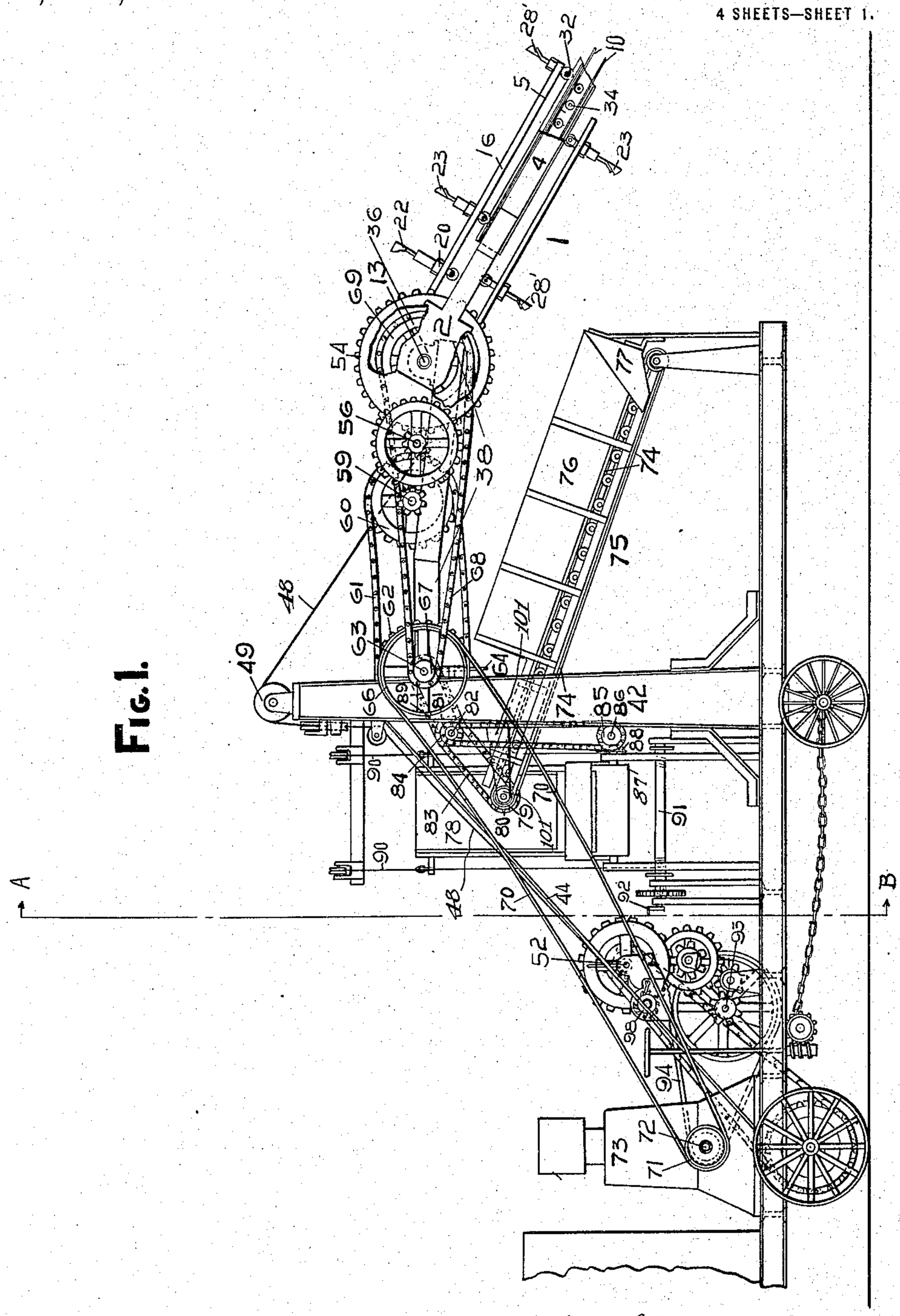

FIG. 1.

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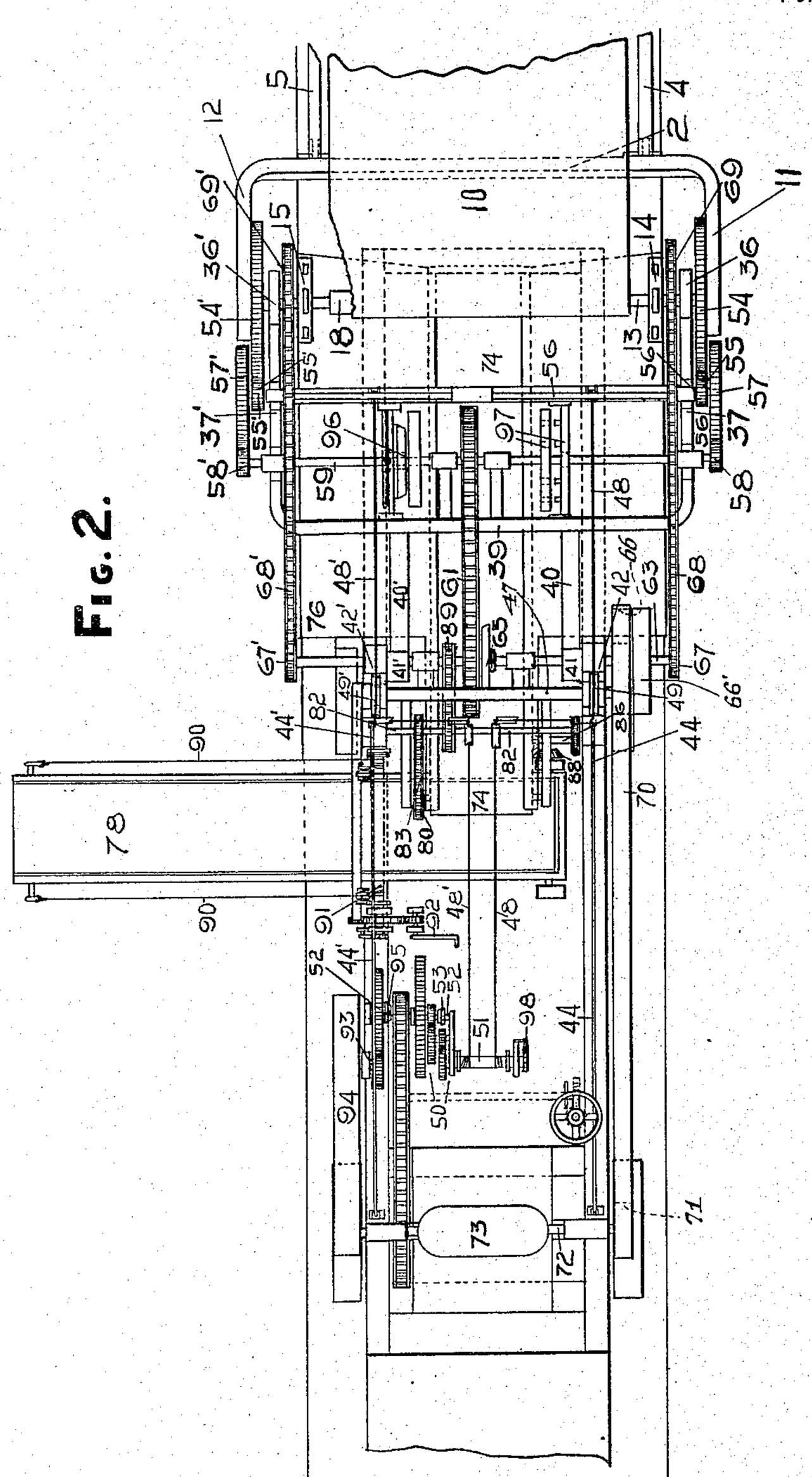
4 SHEETS—SHEET 2.

FIG. 2.



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4 SHEETS—SHEET 3.

FIG. 3.

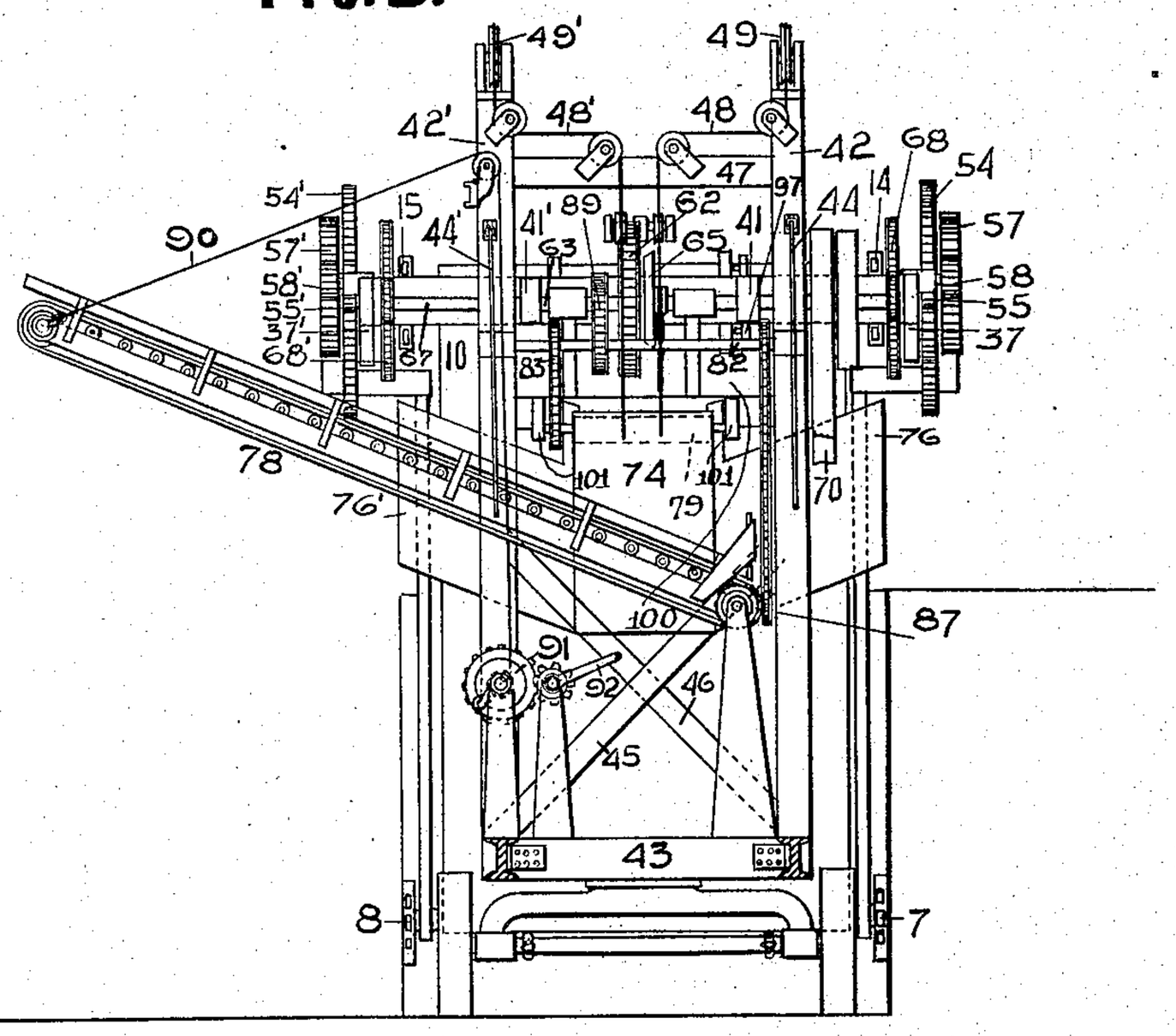
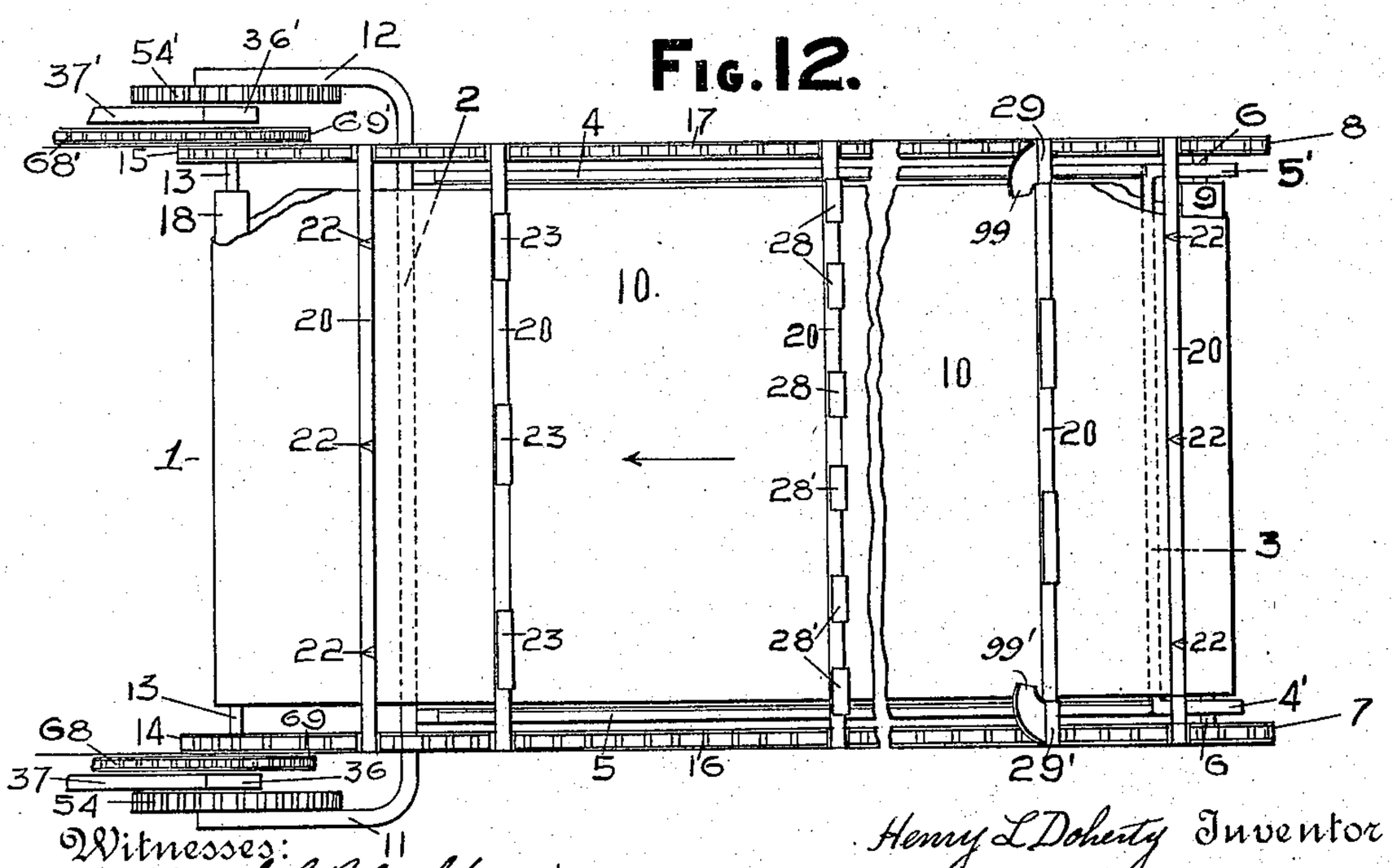


FIG. 12.



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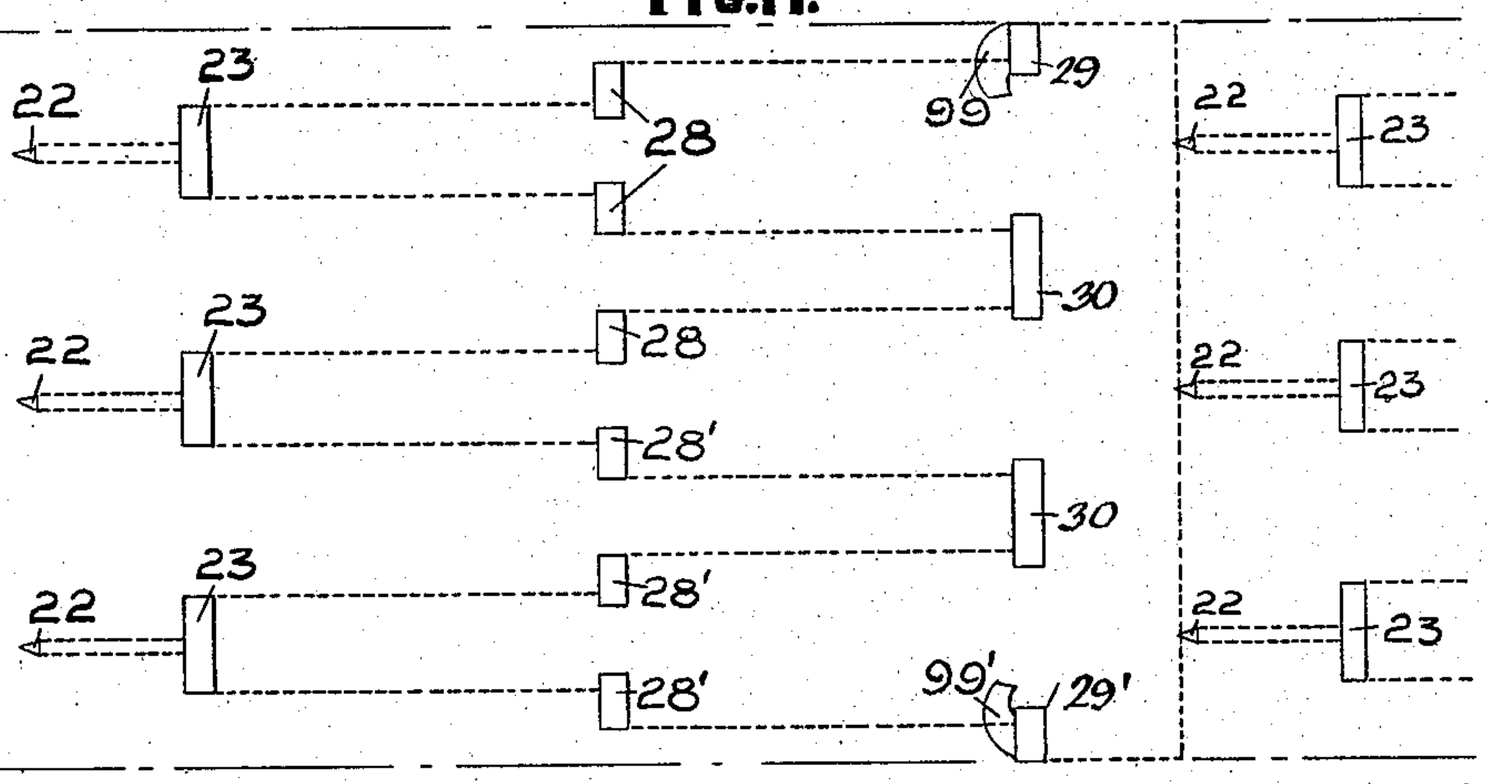
4 SHEETS—SHEET 4.

FIG. 11.



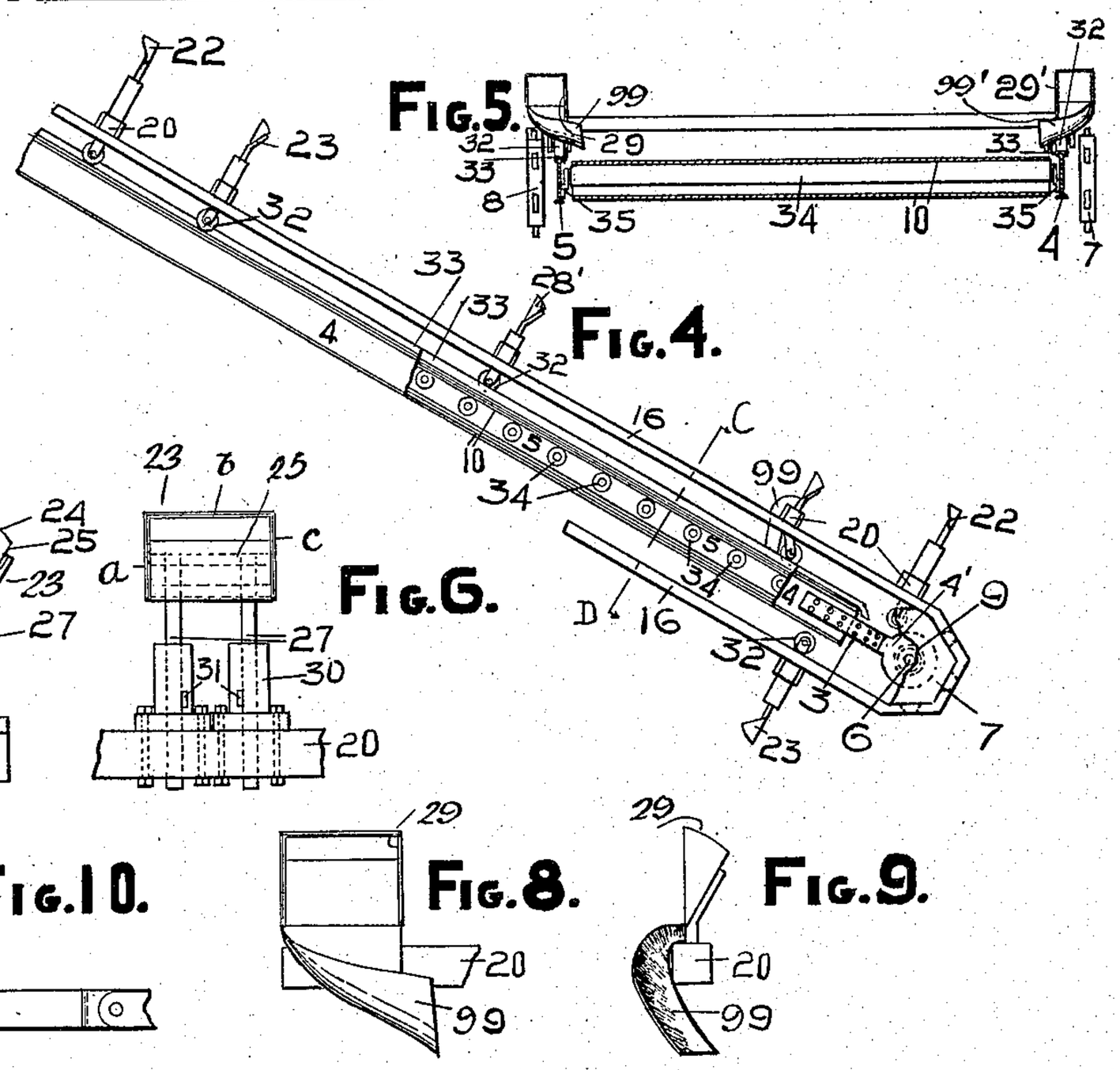


FIG. 4.

FIG. 5.

FIG. 7.

FIG. 6.

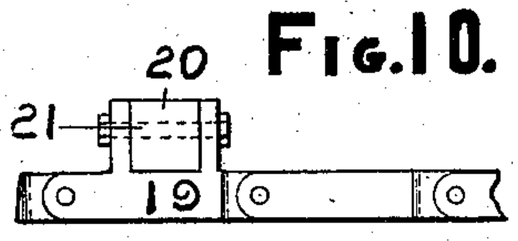


FIG. 10.

FIG. 8.

FIG. 9.

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UNITED STATES PATENT OFFICE.

HENRY L. DOHERTY, OF NEW YORK, N. Y.

METHOD OF EXCAVATING EARTH.

1,166,820. Specification of Letters Patent. Patented Jan. 4, 1916.

Application filed May 15, 1911. Serial No. 627,132.

To all whom it may concern:

Be it known that I, HENRY L. DOHERTY, a citizen of the United States, and a resident of New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of Excavating Earth, of which the following is a specification.

My invention relates to methods of excavating earth.

The object of my invention is to improve present methods of excavating by supplying to the art a method which will permit of the cutting loose of the material and the removal of the same from the excavation with a minimum expenditure of power.

Briefly stated, the important features of my invention are the cutting free of the material on an overhanging face whose angle with the horizontal is less than or equal to the angle of repose of the excavated material, and receiving the excavated material upon and transferring it out of the excavation upon a belt conveyer working substantially parallel to the working face. The material is excavated from the working face in successive layers, each layer being excavated by cutting one or more furrows uniformly spaced relative to the width of the excavation and then successively cutting other furrows right and left from the initial furrows until the full width of the layer has been excavated.

In the accompanying drawings I have shown a form of apparatus capable of applying my invention. The drawings are somewhat diagrammatic in character.

Figure 1 shows a partial side elevation of the apparatus with the winding drums and gear for winding the cables which suspend the boom of the excavating frame omitted. Fig. 2 is a top view of the same showing the winding drums mentioned also. Fig. 3 is a cross-section of apparatus on the line A—B of Fig. 1 showing the forward part of the machine in rear elevation. Fig. 4 is a partial side elevation of the excavating boom. Fig. 5 is a cross-section of the excavating boom on the line C—D. Fig. 6 is a front view on an enlarged scale of an intermediate cutter mounted on its bar. Fig. 7 is a side elevation of the same. Fig. 8 is an enlarged front view of one of the end cutters showing the discharge chute for throwing the excavated material away from the side of the cut on to the conveyer belt. Fig. 9 is a corresponding side elevation of the same. Fig. 10 is a side elevation of the flat linked chain or sprocket chain which carries the cutter bars. Fig. 11 is a diagram of a portion of the working face of the excavation showing a full set of cutters and the way in which the working face is furrowed by the cutters. Fig. 12 is a plan of the frame of the excavator proper.

1 is the excavator proper. It has a rigid frame made up of the heavy end yokes 2 and 3 and longitudinal beams 4 and 5 attached thereto. Journaled in suitable bearings in the projecting arms 4′ and 5′ of the end yoke 3 is a shaft 6 which carries the polygonal drums 7 and 8 over which the sprocket chains of the cutter frame work and the drum 9 over which works the conveyer belt 10. The upper end yoke 2 has the projecting arms 11 and 12 which carry suitable bearings in which is journaled the heavy shaft 13. 13 carries the sprocket wheels 14 and 15, which drive the chains 16 and 17 bearing the cutters, and the drum 18 which drives the conveyer belt 10. At suitable intervals in the sprocket chains 16 and 17 are interposed special links 19, having a yoke socket, which sockets receive the ends of the cutter bars 20. These special links are, of course, spaced at corresponding intervals on the chains 16 and 17 and the chains are mounted so that the corresponding links on each chain come exactly opposite each other. Bolts, 21, fasten the bars 20 in the yokes of links 19.

Mounted on the bars 20 are the cutters. These are of two types. First are the plows 22 which make the initial cuts in the working face. These are simply miniature plows designed to throw a narrow furrow about 2 inches wide and four inches deep. The width and depth of the cut may, of course, be varied in any given case to suit the soil and the conditions by substituting plows designed to give the particular cut desired. Following the plows 22 are the scoop-cutters 23. These each have three cutting edges, *a*, *b* and *c*, so that each cutter makes two vertical cuts and simultaneously a connecting horizontal cut. These cutters 23 are, in reality, each combinations of right and left cutters, and cut two separate furrows on each side of the small furrows made by the plows 22. The upper cutting blade *b* is attached to a hood-like piece 24 having a curvature such that while the cutter bar on

which the cutters are mounted is passing over the polygonal wheels 7 and 8 at the lower end of the excavator they will not contact with the face of the cut made by their cutting edges. A sheet 25 forms the back, and side sheets 26 the sides, of the scoop. The scoops are attached to the stems 27 whose upper parts are bent to hold the scoops in the proper position relative to the working face of the excavation.

Following the cutters 23 are sets of two single cutters 28 and 28′. These are constructed to cut respectively to the right and left of the furrows left by 22 and 23, the right hand cutters being numbered 28 and the left hand cutters 28′. These each make one vertical cut (to the right and left of the initial furrows respectively) and simultaneously one cross-cut joining the vertical cut with the furrow of its coöperating plow 23. Otherwise their construction is substantially similar to that of the first set of cutters 23. Following 28, 28′ are two intermediate scoop-cutters 30 and end cutters 29 and 29′. The cutters 30 are similar to the cutters 23 in shape but have no vertical cutting blades and are made slightly wider so as to overlap the ridges left by the preceding cutters. The end cutters 29 and 29′ are similar to the single cutters 28, 28′ respectively with the addition of dirt chutes 99, 99′ respectively. These chutes 99, 99′, have both a transverse and backward curvature. The backward curvature should be such as to permit the freest movement of the dirt possible, so as to reduce the friction and possibility of clogging the chutes to a minimum. With the shape shown, the forward movement of the chute materially facilitates the discharge of the dirt from the chute, onto the conveying belt 10.

Any form of excavator for accomplishing the process may be used. After a cut with an overhanging face has been made a plurality of longitudinal furrows are cut in the under side of the overhanging face to a certain depth, for instance, by such plows as are shown at 22. Then the under side of the face is furrowed on each side of each of the furrows made by plows 22. One furrow is made on each side of the furrow made by the first plow 22 and at the same time a substantially horizontal cut, or a cut parallel with the working face, is made, connecting the two furrows straddling the furrow made by the first plow. The cutters 23 advantageously make these two furrows and eliminate the earth between them, cutters 23 being provided with cutting edges to connect the vertical cuts to each side of the first furrow and with a cutting edge joining the two vertical cutting edges to make the substantially horizontal cut. After the first furrow has been made and after the second two furrows have been made and the earth between them eliminated, all of which results in the formation of a relatively narrow groove, scoop cutters 28 widen the grooves by making a vertical cut substantially the same depth as the initial furrow and also making a horizontal cut substantially parallel with the working face. This of course widens the groove into what may be termed a channel. The cutters all are spaced such a distance apart and are set in such a way that when the number here shown, for the sake of illustration, are used the last set of cutters 30 and 29—29′ operate to complete the excavation of one layer. Cutters 28 and 28′ having widened the grooves and made a channel have left a series of downwardly projecting ribs. These ribs are in the path of the cutters 30 which need therefore only be provided with a horizontal cutting edge. This advantageously projects upwardly to pare off or slice the rib the same depth as the initial furrow, the second furrows made by cutters 23, and the height of the walls left by the cutters 28 and 28′. Preferably along the same line as cutters 30 cutters 29 and 29′ operate to pare slices of earth from opposing walls left in the overhanging face by extreme cutters 28 and 28′. Cutters 29 and 29′ are similar to the cutters 28 and 28′ except that they are provided with dirt chutes. These dirt chutes direct the dirt inwardly as the cutters 29 and 29′ make their vertical cuts and their cuts parallel with the working face. The earth falls by gravity as it is eliminated from the overhanging face upon the conveyer which conducts it from out of the cut. In other words, first a deep furrow is made, then two other furrows of the same depth are made alongside it and the earth thus loosened is pared off by a cutting edge working in a plane parallel to the plane of the working and at a depth equal to the depth of the first furrows. Then the opposite walls of the groove thus formed are sliced or pared by succeeding cutters. The lateral support of the earth is eliminated so that after the first furrow is made the earth may easily be pared or sliced. It will be noted that after the first furrow is made the earth may easily be pared or sliced. It will also be noted that after the first furrow is made each cutter is operating practically to cut a vertical wall which has support only on one side.

As shown, the cutters of the several groups of cutters in each set or series may be set at variable distances from the bars 20. The stems 27 of the cutters are inserted in the heavy sockets 30 mounted on the bars 20 and pass through openings in the latter when set low. Keys 31, inserted in suitable keyways in the sockets 30, hold the stems 27 in the desired position. By setting the cutters in this way I am enabled, as will be more fully explained hereinafter, to remove lay-

ers of substantially uniform thickness while moving the whole apparatus forward continuously.

The cutters described, taken together, constitute one coöperating set in echelon arrangement and make one full cut across the full width of the excavation. This latter is governed, of course, by the width of the excavator frame and the size and number of the cutters must be arranged accordingly, so that the combined furrows made by the individual cutters will form a clear cut across the working face. The size and arrangement of the cutters constituting a set having been decided upon, the frame and sprocket chains must be made of such length as to permit the mounting of the cutters in full sets. In the arrangement shown, there are four complete sets of cutters mounted on the excavator 1. As shown, the ends of the cutter bars 20 are supported upon rollers 32 which roll along the track formed by the angle irons 33, which latter are in turn supported by the I-beams 4 and 5.

The excavated dirt falls upon the belt 10 and is carried on the belt over the upper driving drum 18 and discharged upon another conveyer which will be described later. Rollers 34, journaled in bearings in the brackets 35 attached to the I-beams 4 and 5, serve to support the belt.

It is apparent that the belt 10 would be unable to pick up the dirt excavated near the bottom of the working face. It is to take care of this point that the scoop form is given to the cutters. With this form of cutter, while the cutter is traveling around the lower polygonal wheels 7 and 8, all the dirt excavated by the cutter falls into the scoop and is carried up and over the drums. The slant of the sheets 25 forming the backs of the scoops relative to the frame of 1 is such that, when the scoops have again assumed a rectilinear motion, the contents of the scoops will discharge, under the influence of gravity, onto the belt 10, which will carry it over the upper drum 18 as above described.

The speed of the cutters should be comparatively high relative to the rate of forward movement of the machine as a whole. The speed of course varies, but in ordinary alluvial ground will usually be at least $5\frac{1}{2}$ ft. per second and may be as high as 8 or 9 ft. per second. If the excavator 1 is working on an overhanging face having an angle of 30° with the horizontal, 2 inches of cut on the working face will mean that the machine as a whole can move forward 4 inches in the same interval of time as is required to make the full cut on the working face 4 inches deep. Now, to give an intermittent motion to the machine so that it would move forward the 4 inches after each full cut and remain at rest during the succeeding cutting period, while practicable from a mechanical point of view, would be very inefficient and awkward in practice. Therefore I prefer to operate the apparatus with a uniform forward motion proportional to the speed at which it is excavating. To secure this condition it is necessary to set the cutters in each group of a set at different distances from their respective cutting bars. The exact distance to which they will be offset depends, in any given case, upon the speed of the cutters and the interval between the adjacent groups. The setting should be such that the following cutters will be nearer the cutting bar than the leading cutters by a distance approximately equal to the forward movement of the machine during the period required for the cutters to traverse a distance on the working face equal to the interval between the leaders and followers. Since the amount of this forward movement depends upon the angle with the horizontal at which the excavator 1 is working, it is evident that the cutters should be reset for any material variation of this angle.

The excavator 1 is supported from the heavy shaft 13 which, in turn, is supported in the bearings 36 and 36′ carried by the arms 37 and 37′ of the boom frame 38. 38 is made up of a yoke-piece 39, having the arms 37 and 37′ and the two supporting arms 40 and 40′. These arms 40 and 40′ are supported by the shaft 63, which in turn is supported by bearings 41 and 41′ carried by the standards 42 and 42′, respectively. These standards rest upon the heavy frame, 43, of the machine. Heavy guy rods, 44 and 44′, respectively, attached to the main frame of the machine counteract the turning moment exerted by the boom and excavator, while cross-braces, 45, 46 and 47, give additional stability to the standards. Suitable cables, 48 and 48′, attached to the boom 38 support the latter in the desired position. The cables, as shown, are carried over pulleys, 49 and 49′, respectively, borne by the standards 42 and 42′, respectively. From 49 and 49′ the cables are carried through appropriate guide pulleys to the winding apparatus 50. This, as shown, comprises a winding drum, 51, rotated through a suitable train of gears by the shaft 52 by shifting the clutch 53 into the proper position.

Rigidly attached to the yoke arms 11 and 12 of the frame of the excavator are the large gears 54 and 54′, respectively. These mesh with the small gears 55 and 55′, respectively, carried on the shaft 56. Carried also on the shaft 56 are the gears 57 and 57′ which mesh with the gears 58 and 58′ on the shaft 59. Mounted on the shaft 59 is the sprocket wheel 60 carrying the sprocket chain 61. The driving sprocket 62 is mounted loosely on the shaft 63. 62 is arranged to be thrown in or out of gear by means of the lever 64 which actuates a clutch, 65. The

shaft 63 is supported in suitable bearings, 41 and 41′, carried on brackets attached to the standards 42 and 42′. 63 also carries the pulley 66 and the driving sprockets 67 and 67′ which drive the main sprocket chains 68 and 68′, respectively, which work, respectively, over the sprocket wheels 69, 69′ attached to the shaft 13. A belt, 70, directly connects the pulley 66 with the pulley 71 on the shaft 72 of engine 73. This latter may be a gasolene engine, as shown, a steam engine or an electric motor, having connection with a trolley working on a trolley wire supported by movable poles mounted on trucks.

The excavated dirt, as before mentioned, is raised by the belt 10 of the excavator, and discharged over the driving drum 18 onto the belt 74 of the conveying mechanism 75. Inclined sheets, 76 and 76′, guide the falling material onto the belt 74. A sheet, 77, prevents any material rolling down the belt, on account of the energy imparted to it by the fall, and off the lower end of the same. The conveyer 75 is of course arranged to work on a less angle than the angle of repose of the material being excavated. Any suitable type of belt conveyer may be used for mechanism 75. The excavated material discharges from the belt 74 onto the conveyer 78. This, like 74, is an ordinary belt conveyer. It is arranged so that it discharges the dirt either into wagons or simply dumps it upon the surface of the ground at a sufficient distance from the ditch to prevent it falling back.

The conveyer 75 is operated from the shaft through a suitable sprocket or other gear. As shown, the driving drum 79 of 75 carries a sprocket, 80, and is driven from the sprocket 81 on shaft 82 through the chain 83. The shaft 82 also carries the sprocket 84 which drives sprocket 85 on shaft 86 which in turn drives the drum 87 of elevator 78 through the bevel gear 88. Shaft 82 is driven from shaft 63 by means of the chain and sprocket gear 89. The other end of the conveyer 78 is supported and the angle on which it works varied by the cables 90 which are carried over suitable pulleys and wound on the hand windlass 91, driven through a suitable gear by the crank 92.

Locomotion of the machine as a whole is effected by means of a chain and sprocket gear attached to the rear axle of the machine and to the shaft 52. 52 is driven through a suitable train of gears from the shaft 93, which latter receives its motion from the crank shaft of engine 73 through the belt 94. By means of the clutch 95 the chain and sprocket gear to the rear axle may be thrown in or out of gear as desired.

My invention may be applied either to making large excavations or simple trenches.

The method of operating the apparatus shown to carry out my invention is as follows: To start the cut, the boom frame 38 is lowered to the proper distance by allowing the cables 48 and 48′ to unwind from the drum 51 until the boom 38 has assumed the position desired. The lock, 97, of the rotating gear of the excavator 1 is now released and under control of the brake, 96, the end of the excavator table 1 is permitted to drop until the end is on the ground. The engine 73 being in operation, and the belt 70 on the tight pulley 66, the mechanism driving the chains 16 and 17 which bear the cutters, and the conveyer belt 10 are set in operation. The cutters mounted on the bars 20 which are carried by the chains 16 and 17 slice or peel off layers of dirt from the overhanging surface, the dirt thus cut loose falling freely downward upon the belt 10 of the excavator 1, which delivers it to conveyer 75, then onto conveyer 78, which latter dumps it, either into a wagon or on the surface of the ground alongside the cut.

As the machine progresses, the boom-frame 38 is gradually lowered so that the cut made by the excavator is made on an incline, the angle of the inclination depending upon the rate at which the boom-frame is lowered. When the front wheels of the truck enter the cut the boom-frame 38 must be raised somewhat in order to keep the bottom of the cut on the proper angle. The raising of the boom-frame is performed by throwing in the clutch 53 of the winding apparatus 50. This winds in the cables 58 and thus raises the boom-frame. By throwing out the clutch 53 and throwing in the pawl (or other locking device) 98 the boom is maintained in the proper position. When the inclined cut has reached the desired depth the boom-frame is again raised so that the excavator will cut on the horizontal. This new position is maintained until the front wheels of the truck have entered upon the horizontal cut. From this position the boom-frame must be again gradually dropped until the rear wheels have also entered upon the horizontal, when the boom-frame may be again adjusted in a fixed position.

During the manipulation of the boom-frame, it is necessary to vary the angular position of the excavator relative to the boom-frame so that the angle which the excavator makes with the horizontal will not exceed the angle of repose of the material being excavated. Otherwise the dirt discharged onto the belt 10 would simply roll back again to the bottom of the trench. This rotation of the excavator is accomplished by throwing in the clutch 65 when the rotation of the shaft 63 causes a rotation of the gears 54 and 54′ rigidly fastened to the frame of the excavator, and hence causes rotation of the latter also.

It is to be noted that in entering the ground the excavator goes in on a V or wedge-shaped cut—the plane angle formed by the hanging roof and the bottom of the cut depending of course upon the angle of inclination of the excavator. This is a very important feature of my invention. It enables me to reduce the power required for the cutting out and removal of the excavated material to a minimum. Instead of being under the necessity of scraping the dirt out of the excavation in the manner which is practised in the case of all of the mechanical excavators of which I have knowledge, and which is very wasteful of power, I remove the excavated material from the trench by carrying it on a belt conveyer—the cheapest known method of handling fine materials.

An extremely important feature of the present invention is the particular method of cutting the dirt from an overhanging surface as described and as carried out, for example, by means of the apparatus here illustrated. With the exception of the initial cutters or plows 22, the cutters which loosen the dirt simply make two knife-cuts at right angles to each other, the other two sides of each prism of dirt being already free, the cutters acting merely as paring or peeling members and not as scrapers. The dirt thus freed simply falls by gravity onto the belt 10. There is thus no digging or scooping necessary on the roof face of the cut. The power required is only that necessary to draw a sharp bladed knife through the earth, and it is evident that it is therefore the least possible, since the cut is made, in each case, only a short distance in from a free face of the dirt prism (four inches as shown) so that the knife, acting as a narrow wedge, easily displaces the dirt laterally.

Having described my invention, what I claim is:

1. The process of excavating earth which comprises first forming an overhanging working face; then making a longitudinal cut in said face; then making a cut along lines each side and parallel to the first cut and also a cut parallel to the working face between the said lines whereby the first cut is widened into a groove; then further widening the groove by making a vertical cut along a line on each side of the groove in the working face and by making cuts each at an angle to said last line and extending to the first two lines; and collecting and conveying away the earth thus severed from said working face.

2. The process of excavating earth which comprises first forming an overhanging working face; then making a longitudinal cut in said face; then making a cut along lines each side and parallel to the first cut and also a cut parallel to the working face between the said lines whereby the first cut is widened into a groove; then further widening the groove by making a vertical cut along a line on each side of the groove in the working face and by making cuts each at an angle to said last line and extending to the first two lines; then paring the earth from the opposite walls of said further widened groove; and collecting and conveying away the earth thus severed from said working face.

3. The process of excavating earth which comprises first forming a cut with an overhanging working face; then making a plurality of furrows to a predetermined depth in said face; then forming grooves by making a plurality of pairs of cuts each parallel to said first furrows and to substantially the same depth, the cuts of each pair straddling one of said first furrows; severing the earth substantially parallel to the working face between the cuts of each pair by cutting on a line extending inwardly from each of last said cuts toward the straddled furrow and substantially parallel with the working face; then widening the so-made grooves by cutting away portions of opposite walls, thus leaving on said overhanging working face a plurality of downwardly projecting longitudinal ribs; then eliminating such ribs by cutting the earth at a depth substantially equal to the depth of first said furrows and parallel to the working face; and collecting earth thus severed and conveying it from under said face outside of said cut.

4. The process of excavating earth which comprises forming a cut with an overhanging working face; then making a plurality of longitudinal furrows to a predetermined depth in said face; then making a cut on each side of the said first furrow and simultaneously cutting away said earth between said last two cuts leaving parallel to the working face grooves having opposite walls; then vertically making a cut in the said face to one side of each of said walls of each groove and simultaneously cutting the earth between said last cuts and said walls leaving wider channels than said grooves, then cutting parallel to and from said face the remaining earth between said channels and at the same time cutting and inwardly directing the earth from said face and the outer walls left by the elimination of the earth in said channels, and collecting and conveying the earth from said face outside of the cut.

5. The process of excavating earth which comprises forming a cut with an overhanging working face; making a plurality of longitudinal furrows to a predetermined depth in said face; making a cut on each side of the said first furrows to substantially the same depth as the first furrows and simultaneously cutting away the earth between said last two cuts parallel to the

working face, thus leaving in said face a plurality of grooves having opposite walls; then vertically making cuts to substantially the same depth as said furrows in said face to one side of each of the said walls of each groove and simultaneously cutting away the earth between the last two cuts parallel to the working face, thus leaving channels wider than said grooves; then cutting parallel to and from the said face the remaining earth between said wider channels and at the same time cutting from and inwardly directing the earth from said face and the outer walls which are left by said channels; and collecting and conveying the earth thus severed from said face outside of the cut.

Signed at New York city, in the county of New York and State of New York this 13th day of May, A. D. 1911.

HENRY L. DOHERTY.

Witnesses:
FRANK L. BLACKBURN,
S. B. SEVERSON.