No. 667,314. Patented Feb. 5, 1901.

O. HETLESAETER.

EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.) 8 Sheets—Sheet 1.

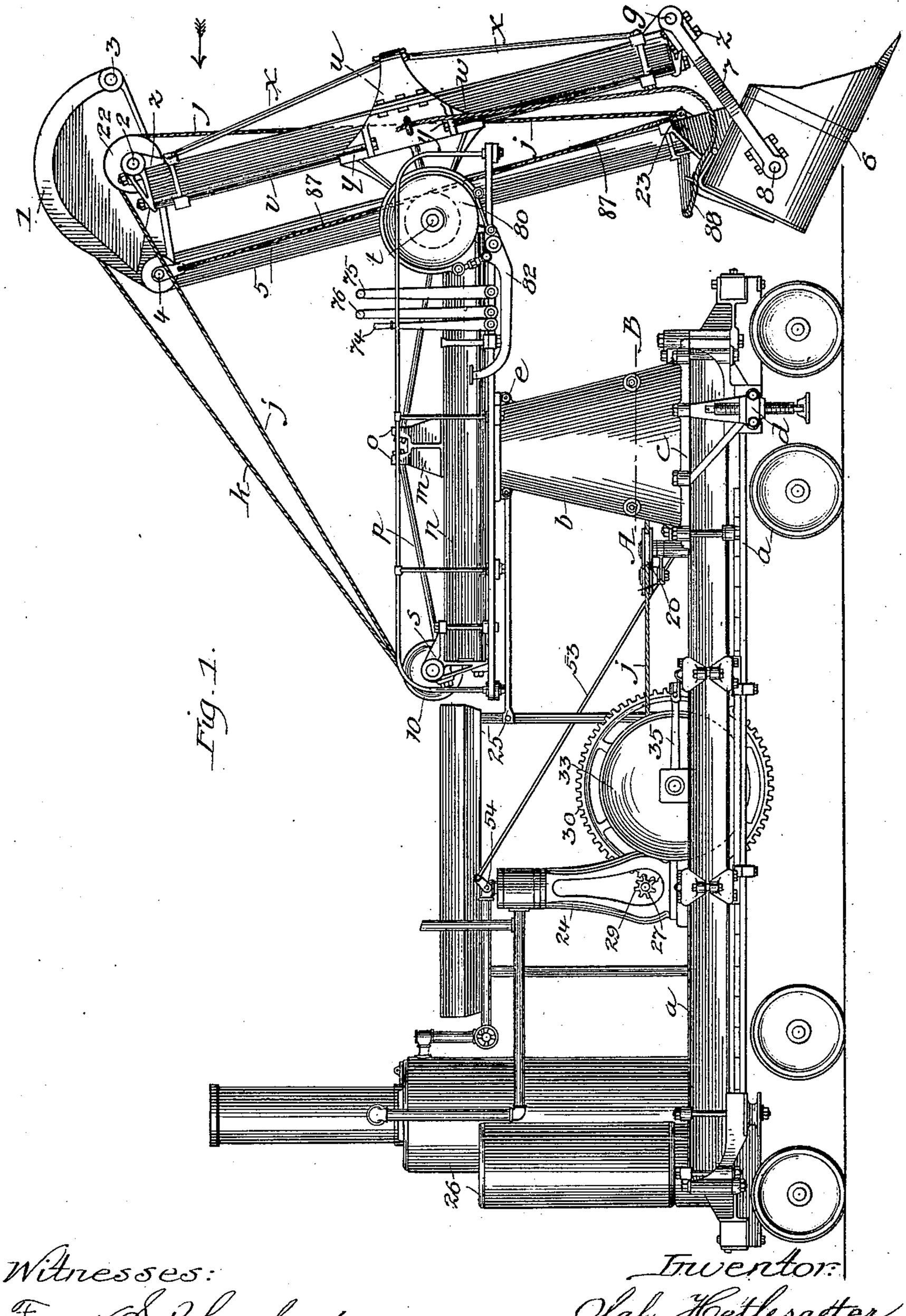

Fig. 1.

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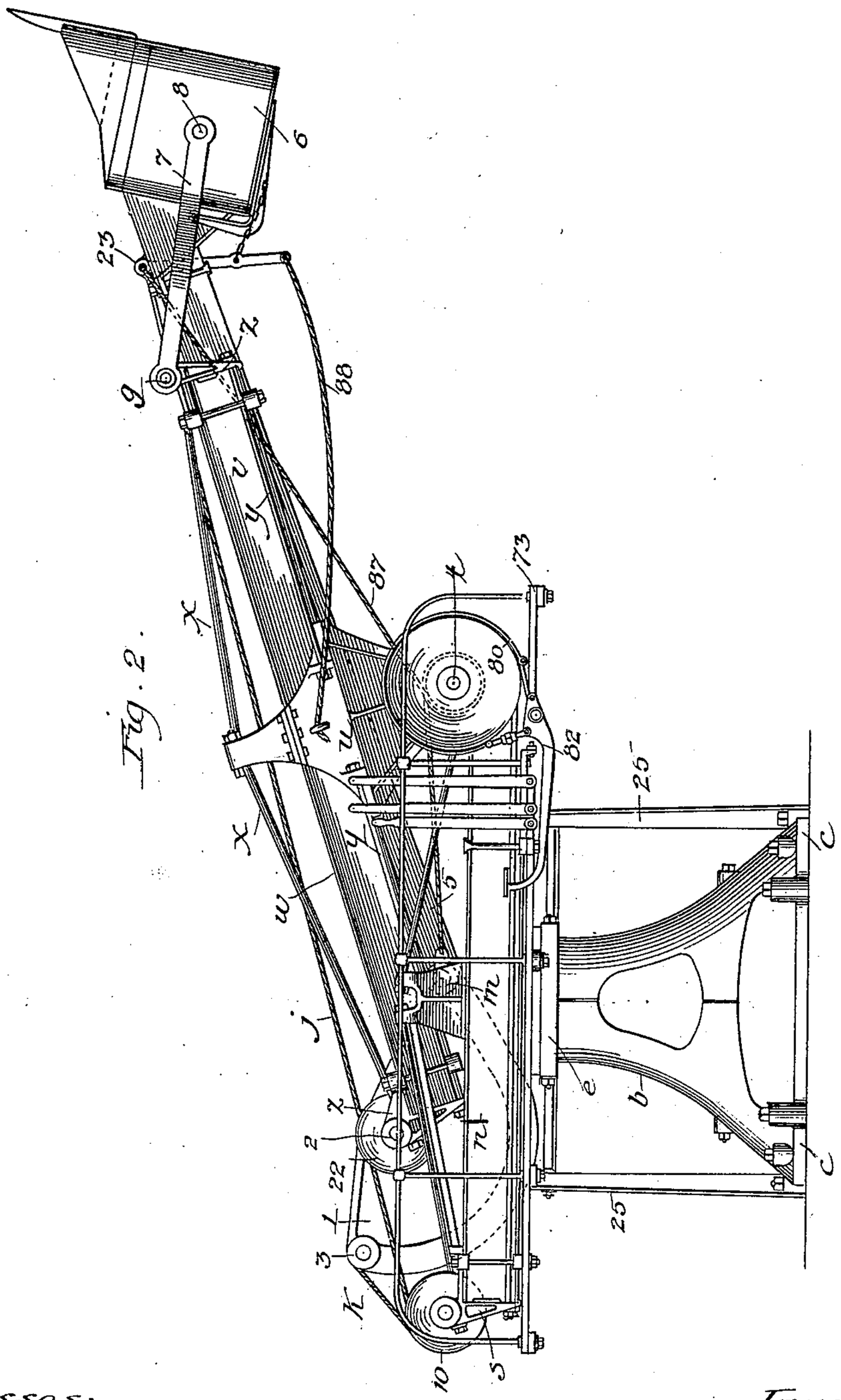

Fig. 2.

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(No Model.) 8 Sheets—Sheet 3.

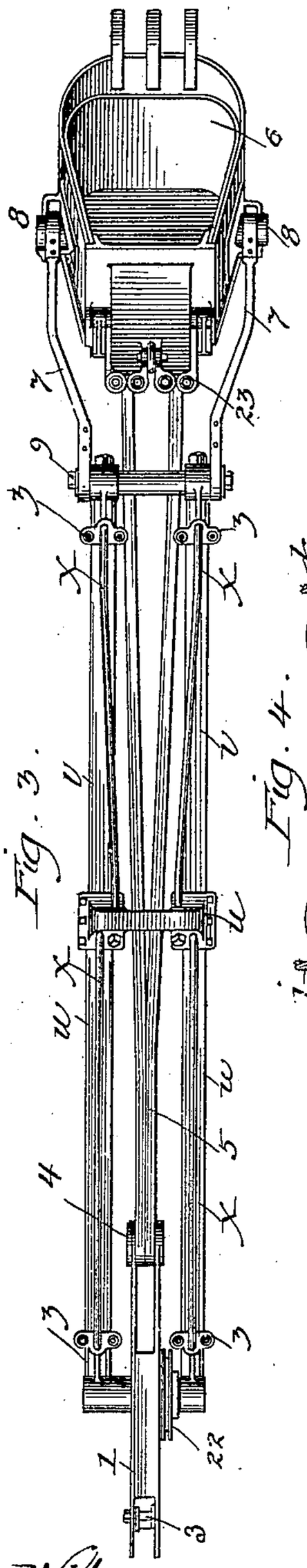

Fig. 3.

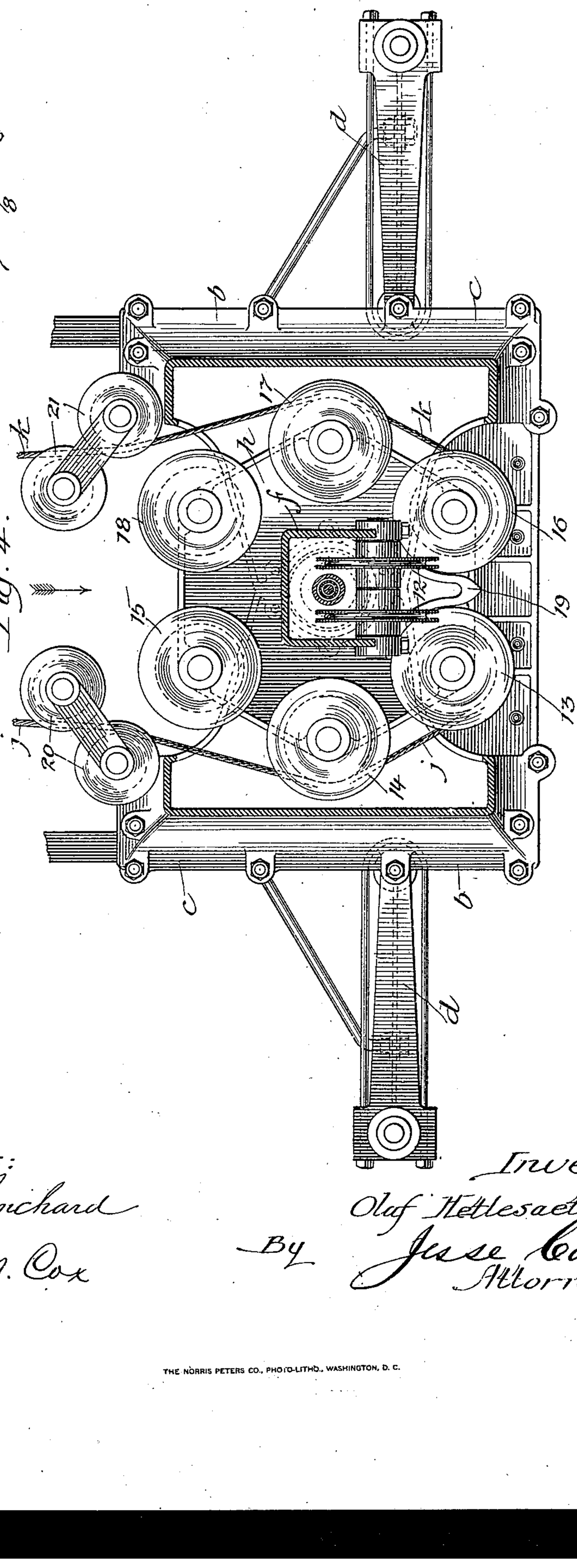

Fig. 4.

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EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.)

8 Sheets—Sheet 4.

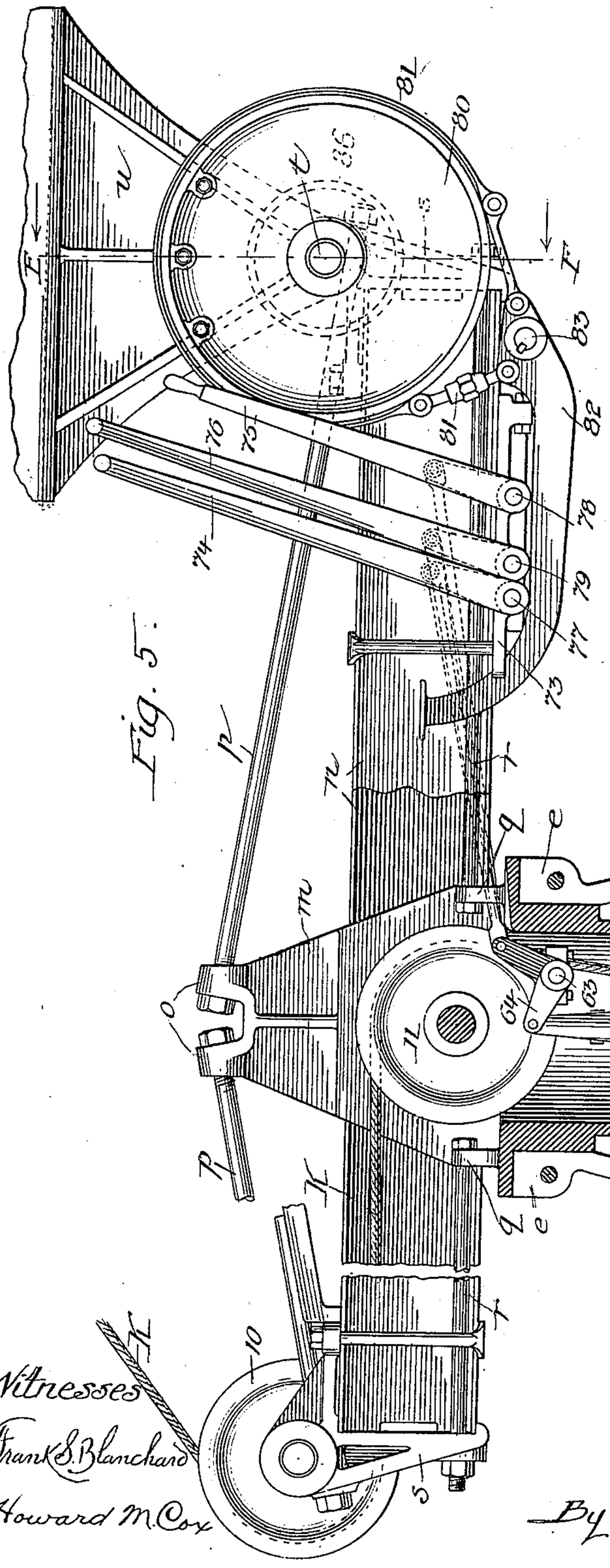

Fig. 5.

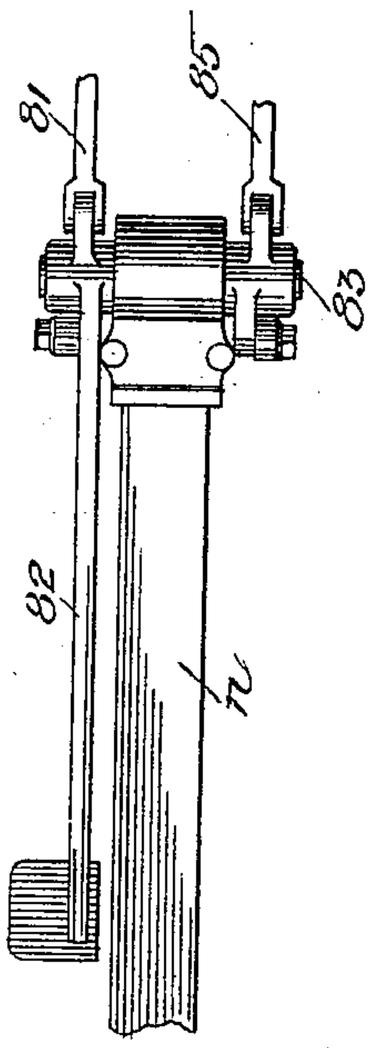

Fig. 6.

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EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.) 8 Sheets—Sheet 5.

Fig. 7.

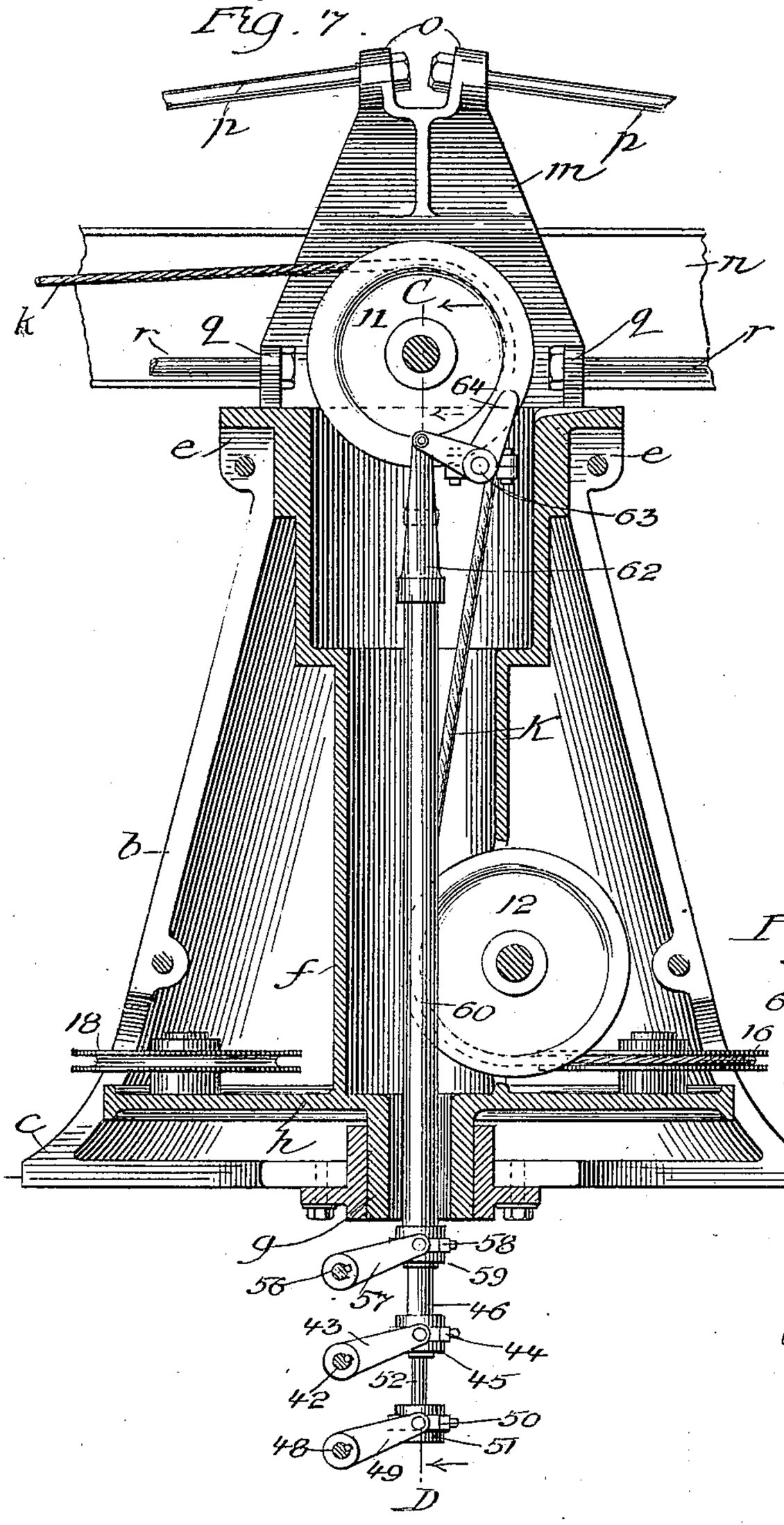


Fig. 9

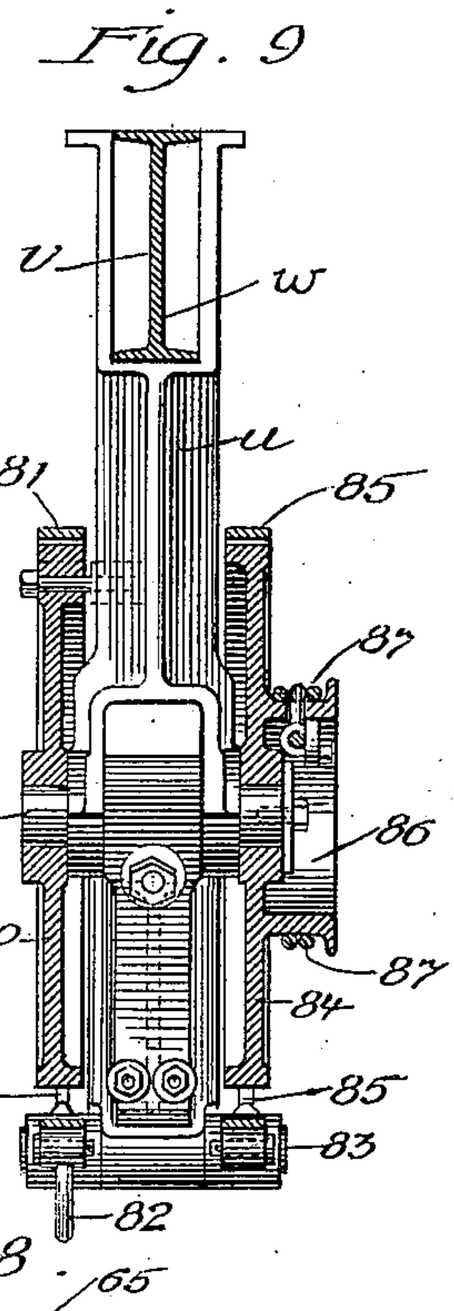
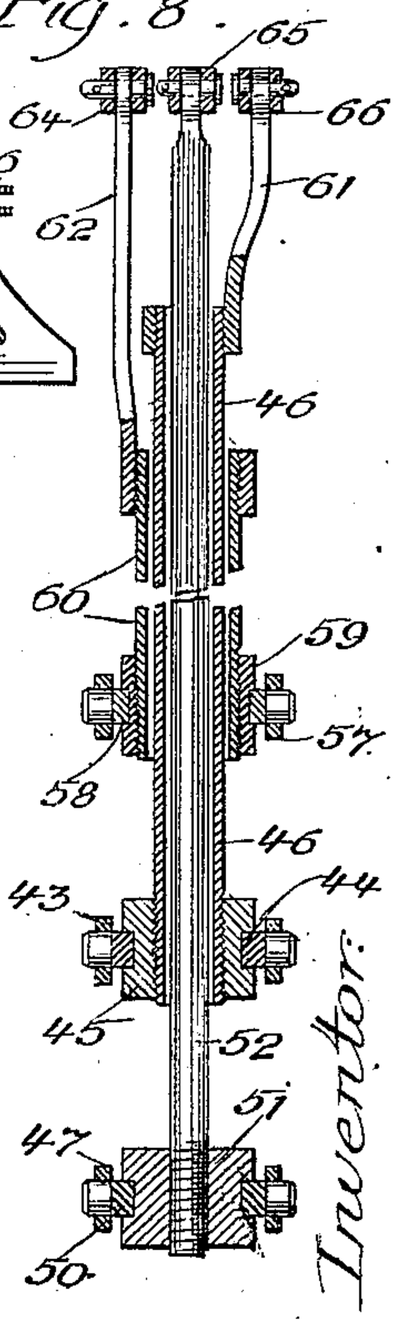


Fig. 8.



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No. 667,314. Patented Feb. 5, 1901.

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EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.) 8 Sheets—Sheet 6.

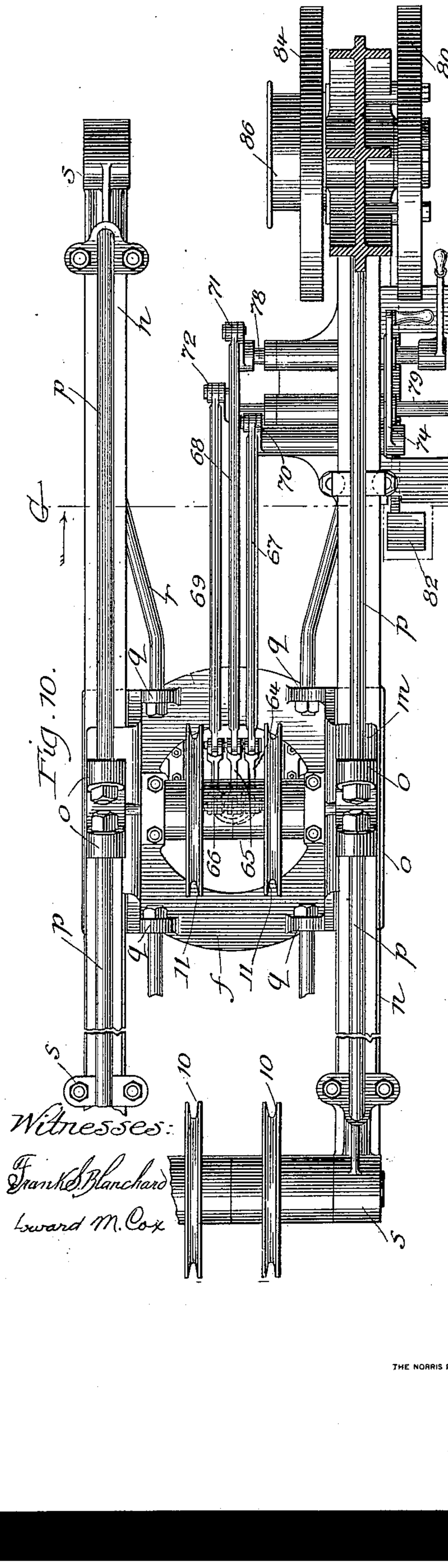

Fig. 10.

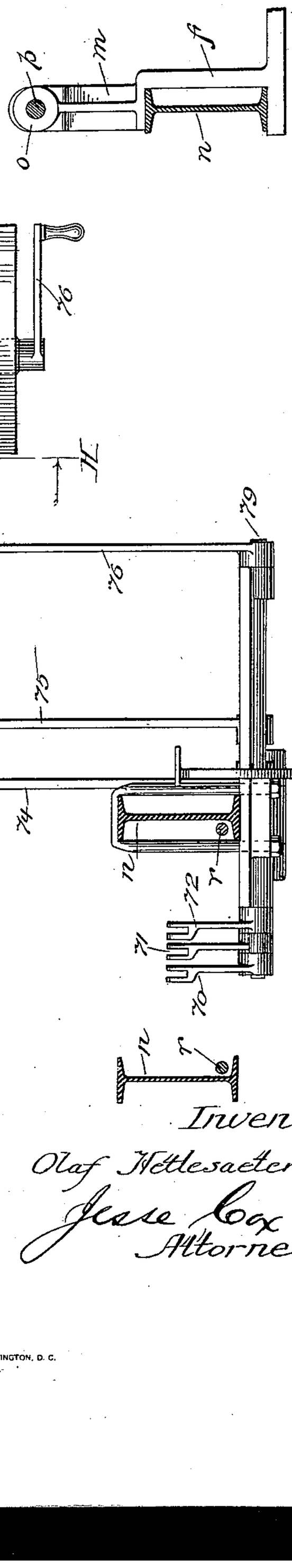

Fig. 11.

Fig. 12.

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No. 667,314. Patented Feb. 5, 1901.

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EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.) 8 Sheets—Sheet 7.

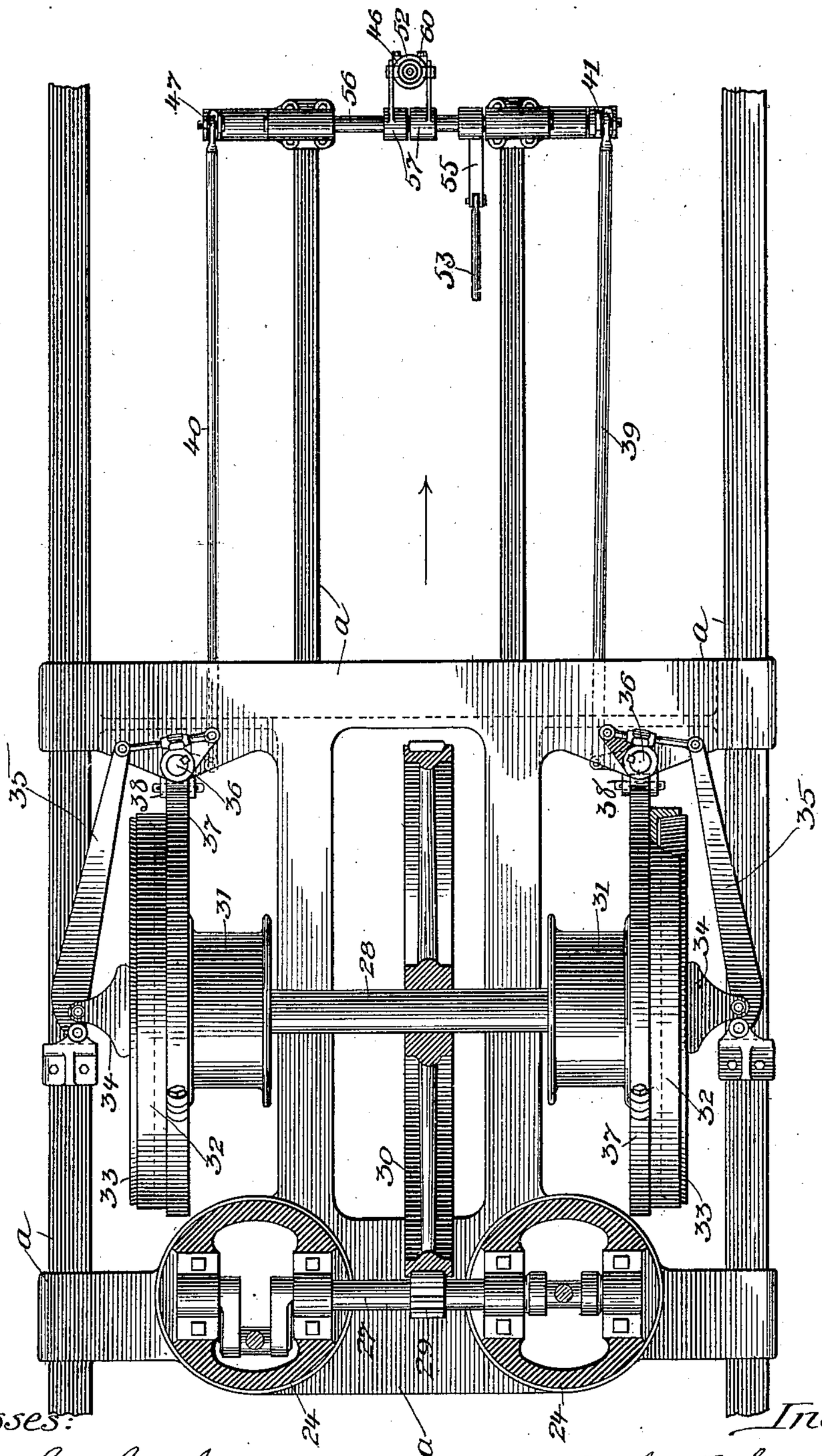

Fig. 13.

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EXCAVATOR.

(Application filed May 7, 1900.)

(No Model.) 8 Sheets—Sheet 8.

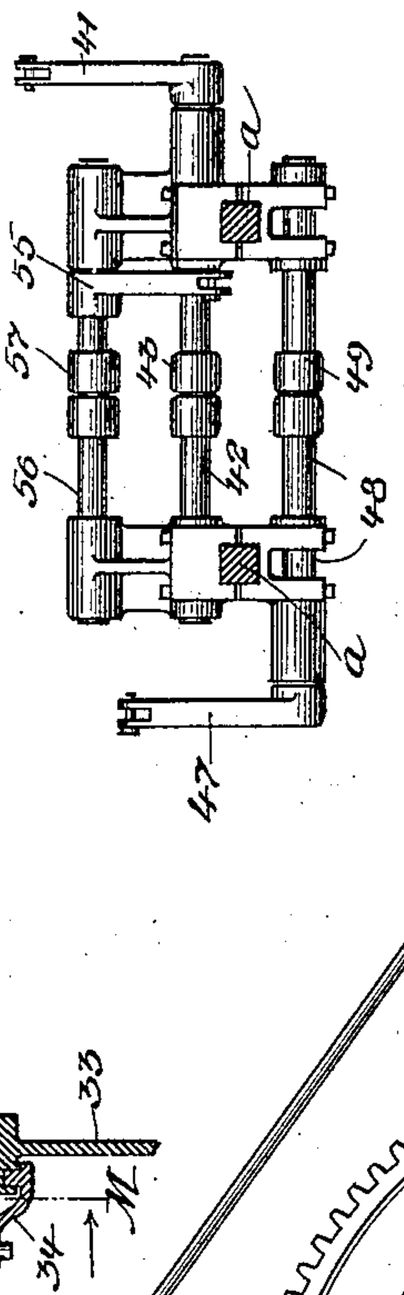

Fig. 15.

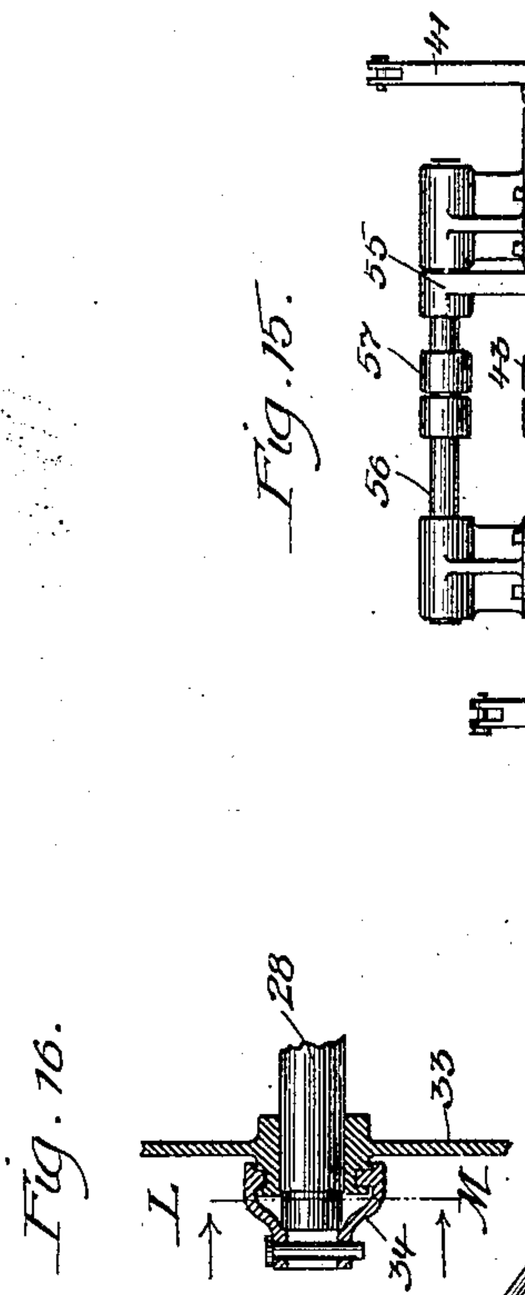

Fig. 16.

Fig. 17.

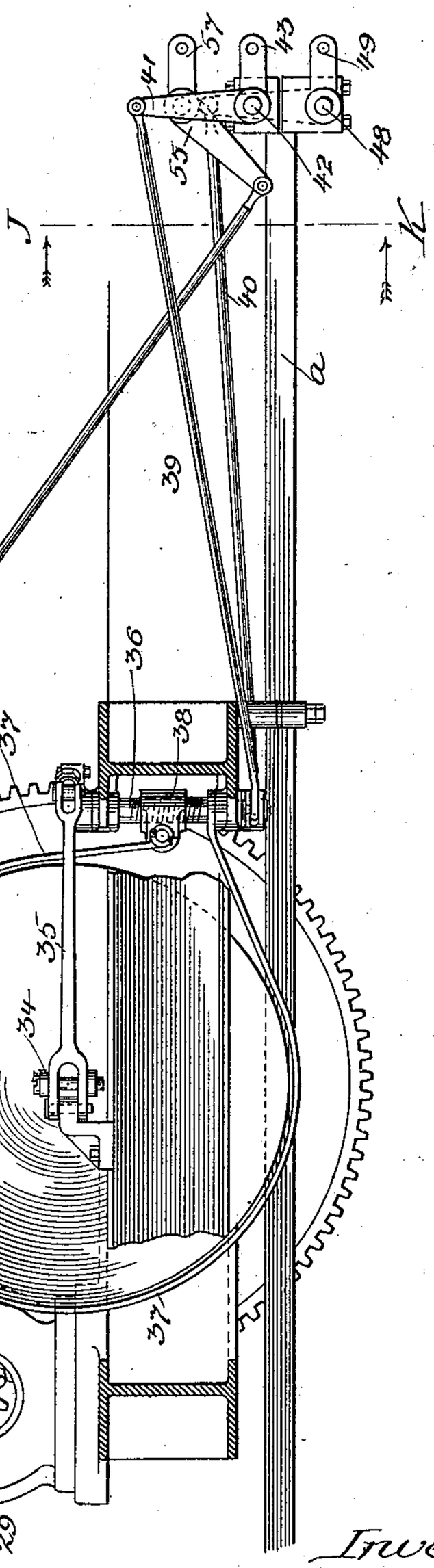

Fig. 14.

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UNITED STATES PATENT OFFICE.

OLAF HETLESAETER, OF CHICAGO, ILLINOIS.

EXCAVATOR.

SPECIFICATION forming part of Letters Patent No. 667,314, dated February 5, 1901.

Application filed May 7, 1900. Serial No. 15,705. (No model.)

To all whom it may concern:

Be it known that I, OLAF HETLESAETER, a citizen of the United States, residing in the city of Chicago, county of Cook, and State of Illinois, have invented a new and useful Improvement in Excavators, of which the following is a specification.

My invention relates to excavators, especially of the type wherein the bucket-arm is composed of members which are movable relatively to each other, and wherein the relative motion of said members affects the position of the excavator-bucket.

The objects of my invention are, first, to provide means whereby two cables may accomplish the thrusting, digging, and hoisting of the bucket and also the lateral swinging of the crane; second, to provide means whereby the swinging of the crane may be effected by said cables when the bucket-arm lies at any angle with respect to the vertical; third, to provide means whereby the operation of the bucket, including thrusting, hoisting, and digging and also the lateral swinging of the crane, may be controlled by a single operator, and, fourth, to provide certain details of construction, as will hereinafter appear. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a general view, in side elevation, of a complete excavator embodying my invention in the form of a steam-shovel. Fig. 2 is a front elevation of the turret with the crane and bucket-arm swung to a transverse position substantially at right angles to the length of the car, thus showing the side of the crane and bucket-arm. In said figure the bucket is shown hoisted to its highest position. Fig. 3 is a front view of the bucket-arm and bucket looking in the direction of the arrow, Fig. 1. Fig. 4 is a sectional plan view of the turret and crane-pivot, taken on the line A B, Fig. 1. Fig. 5 is a side view, partly in section, showing the operator's platform and controlling devices at the forward extremity of the crane, and also showing a portion of the crane-pivot and turret. Fig. 6 is a view of the foot-lever and its adjuncts looking from beneath. Fig. 7 is a view chiefly in vertical section from front to rear through the axis of the crane-pivot and shows the turret, the crane-pivot and its adjuncts, a portion of the crane, and parts of the controlling devices within said pivot. Fig. 8 is a sectional view taken on the line C D, Fig. 7, showing certain shafts and collars of the controlling devices. Fig. 9 is a sectional view of the pivot-blocks, friction-drum, and adjacent parts, taken on the line E F, Fig. 5, looking in the direction of the arrows. Fig. 10 is a top view of the crane, showing the operator's platform, the controlling-levers, and rods connecting therewith. Fig. 11 is a detail view, in vertical section, taken on the line G H, Fig. 10, looking in the direction of the arrows and showing the controlling-levers and adjacent parts at the forward extremity of the crane. Fig. 12 is a detail view taken transversely to the crane-beams, showing the crane-post and the beams in position therein. Fig. 13 is a plan view of the driving mechanism, showing the hoisting-engines and drums, the friction-drives, and portions of the controlling mechanism. Fig. 14 is a side elevation of the driving mechanism and controlling mechanism, as in Fig. 12. Fig. 15 is a detail of the bell-crank levers and rock-shafts which form parts of the controlling mechanism. The view is taken looking in the direction of the arrows at the line J K, Fig. 14. Fig. 16 is a view of the shifting collars of the main friction drives or clutches and is taken in section through the axis of the drum-shaft. Fig. 17 is a view of the shifting collar, taken on the line L M, Fig. 16, and looking in the direction of the arrows in said figure.

Similar characters refer to similar parts throughout the several views.

a represents a railway-car whereon the driving and excavating machinery is mounted. The turret *b*, which forms the support for the laterally-swinging parts, is rigidly secured to said car *a* at the forward extremity thereof. Said turret consists, preferably, of a frame of cast metal, which for convenience of manufacture is constructed in two sections, said sections being joined at a vertical plane passing through the center of said turret in the direction of the length of the car *a*. Said turret when viewed from the front has a laterally-spreading base *c*, which increases its security of position and also affords means of attachment for the jack-arms *d d*. Said jack-

arms serve as side braces or shores for the machine when in operation. At the upper extremity of the turret *b* is the annular bearing *e*, which supports the crane-pivot *f* and permits the latter to rotate about a vertical axis.

The collar *g* is bolted to the base *c* of the turret *b* and forms a bearing for laterally bracing the lower extremity of the pivot *f*. Said crane-pivot *f* consists of a hollow shaft having different diameters at different portions of its length. Near its lower extremity said pivot has the plate or turn-table *h*, which extends horizontally and affords means for mounting a set of sheaves for guiding the operating-cables *j* and *k* in the manner hereinafter described.

The crane-post *m* is secured to the upper extremity of the pivot *f* and supports the crane-beams *n n* in such a manner that said beams may slide longitudinally in said post. Said post is provided at its upper extremity with bosses *o o* for the tension-rods *p p* and at its lower portion with lugs or bosses *q q* for the rods *r r*. At the extremities of the beams *n n* are the end caps *s s*, to which said rods *p* and *r* are attached. By means of said tension-rods *p p* and the post *m* said crane-beams are braced or trussed, thereby increasing the strength of the crane. Moreover, by changing the relative lengths of the rods *p* and *r* on opposite sides of said post *m* and correspondingly sliding said beams *n* in said post the crane may be adjusted upon the turret *b* in the direction of the length of said crane. It is obvious that the virtual lengths of said rods may be changed by threading the same and employing nuts thereon which may be adjusted lengthwise on said rods, or other rods of different lengths may be substituted.

The shafts *t* are mounted at the forward extremity of the crane and form the pivotal support for the blocks *u u*, to which the oscillating lever *v* is attached. Said lever, which forms one of the members of the bucket-arm, consists of the substantially parallel beams *w w*. The attachment of the lever-beams *w* to the pivot-blocks *u* is similar to the attachment of the crane-beams *n* to the crane-post *m*, in that said beams *w* are adjustable lengthwise in said pivot-blocks and are held in position by means of the rods *x x* and *y y*, which are attached to said blocks and also to the end caps *z z*, located at the extremities of said beams *w*.

The construction herein shown, whereby the beams *n n* of the crane and the beams *w w* of the oscillating lever are adjustable in their respective pivot-blocks, is shown and claimed by me in a separate application numbered as "2" in a series of four applications filed this day, Serial No. 15,703. The object of these two adjustments is to afford means for increasing or decreasing the distance between the shafts *t* and the turret *b* and also for increasing or decreasing the distance between the excavator-bucket and the said shafts *t*. The latter adjustment varies the power leverage and the load leverage of the bucket-arm, while both of said adjustments affect the distance to which the bucket may reach for discharging, as will be apparent from the further description of the parts concerned.

The bucket-arm is similar in principle of construction and operation to the bucket-arm shown and described by me in an application for Letters Patent of the United States filed September 7, 1899, Serial No. 729,706.

The thrust-segment *l* is pivotally supported at the upper extremity of the lever *v* and is approximately semicircular in outline, with the supporting-pivot 2 at the center of curvature. The curved portion of the periphery of the segment *l* is grooved to receive the hoisting-cable *k* and lies in such a position as to be convex upward—that is, in a direction away from the supporting-pivot *t* of the bucket-arm. At the point 3 at the forward extremity of the segment *l* is attached the hoisting-cable *k*, and at the point 4 at the rear extremity of said segment is pivotally attached the bucket-handle 5. Said handle extends in the general direction of the oscillating lever *v* and has the excavator-bucket 6 rigidly secured to its lower extremity. Said bucket is of the ordinary type of bucket or scoop used with steam shovels and dredges. The bucket-links 7 7 extend from the trunnions 8 8, located symmetrically upon opposite sides of the bucket 6, to the pin 9 at the lower extremity of the lever *v*. By reason of the rigid connection of the bucket 6 to the handle 5 said bucket and handle virtually constitute a single member of the bucket-arm. It follows, therefore, that the bucket-arm consists of an articulating linkwork comprising a pair of longitudinal members *v* and 5, connected at their upper extremities by a transverse link 1 and having at their lower extremities connections with the excavator-bucket. The distance of said bucket from the arm-supporting pivot *t* is varied by varying the positions of the members of the bucket-arm relatively to each other, while the hoisting of the bucket to a position for discharging is accomplished by rotating the bucket-arm about said supporting-pivot *t*. The manipulation of the bucket with respect to these last two mentioned motions and in addition the lateral swinging of the bucket and crane is accomplished by means of the two cables *j* and *k*, and I will now describe the course of these cables and also the means for guiding and operating them.

The guide-sheaves 10 10 are mounted side by side at the rear extremity of the crane-beams *n* for guiding the cables *j* and *k*. The guide-sheaves 11 11 are similarly mounted for the same purpose at the upper extremity of the crane-pivot F. Near the lower extremity of said pivot *f* are the guide-sheaves 12 12, which rotate in a vertical plane and are so located in relation to said sheaves 11 11 that

the cables trained thereon extend through the center of said pivot.

The plate *h* above mentioned has the guide-sheaves 13 14 15 16 17 18 symmetrically mounted at different points in its periphery, the sheaves 13 14 15 lying to the right and the sheaves 16 17 18 lying to the left of a central line drawn lengthwise of the crane through the axis of the crane-pivot *f* looking toward the front of the excavator—that is, in the direction of the arrow, Fig. 4. Said sheaves lie and rotate in a horizontal plane located approximately tangential to the lowest point of the grooved peripheries of the sheaves 12 12. The sheaves 13 and 16, lying foremost on their respective sides of the plate *h*, are so located that the mutually adjacent points on their peripheries lie in the planes of rotation of the sheaves 12 12. By this construction the cables may run in either direction between said horizontal and vertical sheaves without becoming untrained. The guard 19 (shown in Fig. 4) is located near said sheaves 13 and 16 and prevents the cables from leaving said sheaves when the crane is rotated beyond the usual working limits of the machine.

At the rear of the turret *b* are stationary guide-sheaves 20, located upon the right, and sheaves 21 similarly located upon the left for guiding the cables as they extend toward the driving mechanism.

The sheave 22, located at the upper extremity of the oscillating lever *v* at the side of the thrust-segment *l*, rotates upon the shaft 2 and guides the retracting-cable *j*. Said cable *j* is attached to the bucket-handle 5 at the point 23 thereon located near the bucket 6. From said point of attachment 23 said cable *j* passes over the sheave 22 at the upper extremity of the lever *v*, over one of the sheaves 10 at the rear extremity of the crane, over one of the sheaves 11 at the upper extremity of the crane-pivot *f*, through said pivot, and beneath one of the sheaves 12 near the lower extremity of said pivot. From the sheave 12, lying upon the right, said cable *j* passes around the sheaves 13 and 14 in the order named, thence to the sheaves 20, and finally extends rearwardly to the driving mechanism hereinafter described.

The hoisting-cable *k* extends from the point of attachment 3, at the forward extremity of the segment *l*, rearwardly along the grooved periphery of said segment and then trains upon the sheaves 10 11 12, which are not employed by the cable *j*. From the sheave 12 said cable *k* trains upon the sheaves 16 17 in order, thence to the sheaves 21, and rearwardly to the driving mechanism.

The driving mechanism above mentioned and the devices for controlling the same are especially adapted for use in connection with my present machine and will now be described.

The driving-engines 24 24, located toward the rear extremity of the car *a* and shown in Figs. 1, 13, and 14, are housed in the upper works 25 of said car and receive steam from the steam-generators 26. The motion of the engine-shaft 27 is transmitted to the drum-shaft 28 by means of the pinion 29, secured to said engine-shaft and intermeshing with the gear 30, secured to said drum-shaft. The drums 31 31 are mounted on said shaft 28 in such a manner as to rotate thereon independently thereof, but so as to be immovable lengthwise of said drum-shaft. The one of said drums lying toward the right looking in the direction of the arrow, Fig. 13, operates the retracting-cable *j*, and the drum upon the left operates the hoisting-cable *k*. At the outer extremities of said drums are formed the interiorly-beveled flanged disks 32 32, which are preferably of greater diameter than said drums and are adapted to receive and engage the correspondingly-beveled driving-disks 33 33. Said disks 33 33 are secured by means of splines or feathers to the shaft 28 in such a manner as to rotate therewith and be movable lengthwise thereon. When the driving-disks 33 33 are forced into the flanged disks 32 32, the rotary motion of the former is imparted to the latter. Said driving-disks 33 33 are shifted upon said drum-shaft by means of the collars 34 34, operated by the shifting levers 35 35. The vertical shafts 36 36 have a crank-and-link connection with said shifting levers 35 35, so that the rotation of said shafts operates the friction clutches or drives composed of the disks 32 and 33. The peripheral faces of said disks 32 32 are cylindrical and are encircled by the brake-bands 37 37. Said bands are fixed at one extremity and at the other are attached to nuts 38 38, which are screwed upon threaded portions of said shafts 36. Said nuts are prevented from rotating, and therefore the rotation of said shafts 36 causes a vertical motion of said nuts, with the result that said bands 37 clutch and release said disks 32. The parts are so arranged and adjusted that when the shafts 36 are at one extremity of their throw the disks 33 are disengaged from the disks 32 and permit the independent rotation of said disks. At the same time the brake-bands 37 clutch said disks 32 and hold the same stationary. The drums 31 thus become "set" and the operating-cables which are attached thereto are held fast. When the shafts 36 are at the other extremity of their throw, the conditions are reversed, the brake-bands 37 being released and the bevel-frictions 32 33 being in engagement and imparting a rotary motion to the drums 31 in such a direction as to wind up said cables. When the shafts 36 are in an intermediate position, said bevel-frictions are disengaged and the tension in said cables, due to the weight of the bucket-arm, causes the drums 31 to rotate in such a direction as to let said cables run out. The rod 39, lying upon the right, and the rod 40, lying upon the left, each has a crank connection with one of said shafts

36 for controlling the same, the rod 39 therefor operating the cable *j* and the rod 40 operating the cable *k*. The forward extremity of the controlling-rod 39 is connected to the crank 41 upon the rock-shaft 42 in the manner shown in Figs. 7, 8, 13, 14, and 15. The crank 43 also is keyed or otherwise secured to said shaft 42 and is pivotally attached to the split shifting collar 44, said collar entering the grooved block 45, secured to the lower extremity of the hollow shaft 46. Said shaft 46 extends upward through the crane-pivot *f* and coincides with the axis of rotation thereof. The connection between said shaft and the crank 43 is such that the vertical motion of said shaft causes the rocking of said crank, while the rotation of said shaft, due to the swinging of the crane, is not imparted to said crank. In a similar manner the rod 40 is connected to the crank 47, which is keyed to the rock-shaft 48. The crank 49 also is keyed to said shaft 48 and is pivotally attached at its extremity to the split shifting collar 50, which enters the grooved block 51. The vertical shaft 52 extends within the said shaft 46 and has said block 51 rigidly attached to its lower extremity. The parts are so arranged that the vertical motion of the shaft 52 causes the rocking of the lever 49, and consequently of the lever 47; but the rotation of said vertical shaft 52 does not affect said cranks. The rod 53 (shown in Figs. 1 and 13) connects at one extremity with the throttle-valve 54, whereby the passage of steam to the engines 24 is controlled. At its other extremity said rod 53 is connected with the crank 55, keyed to the rock-shaft 56, as best shown in Fig. 15. The crank 57, which is also keyed to said rock-shaft 56, is pivotally attached to the split shifting collar 58. Said collar 58 enters the grooved periphery of the block 59, rigidly secured to the lower extremity of the vertical hollow shaft 60. The parts are so constructed that the vertical motion of the shaft 60 causes the rocking of the crank 57, and consequently of the crank 55, thereby controlling the throttle-valve 54. The cranks 43, 49, and 57, above described, are preferably split for convenience of manufacture. Said vertical shafts 46, 52, and 60 are so constructed that the shaft 46 projects below the shaft 60 and the shaft 52 projects below the shaft 46 sufficient distances to permit the necessary vertical motion of said shafts during the operation of the machine. Said vertical shafts are independent of each other and may be moved vertically in the same or opposite directions. The greater portions of said shafts are inclosed within the pivot *f*, thereby being well guarded against danger of injury from exposure. As best shown in Figs. 7, 8, and 10, the shaft 46 has at its upper extremity an arm 61, branching in one direction, and the shaft 60 has an arm 62, branching in the opposite direction in such a manner that the upper extremities of said branches will lie laterally adjacent to the upper extremity of the inner shaft 52. By this construction a single shaft 63, located near the upper extremity of the pivot *f*, may serve as a fulcrum for three bell-crank levers 64, 65, and 66. Said levers are connected to the upper extremities of the parts 62, 52, and 61, respectively. Lying preferably between the crane-beams *n n* are the rods 67, 68, and 69, which are connected to the said levers 64 65 66, respectively, and extend from said levers to a point near the forward extremity of the crane. As shown in Figs. 5, 10, and 11, said rods 67, 68, and 69 are connected at their forward extremities to the cranks 70, 71, and 72, respectively.

The operator's platform 73 is secured to the crane, at the side thereof, and extends, preferably, the entire length of said crane, as shown in Figs. 1 and 2. Located in convenient positions near the forward extremity of said platform are the controlling hand-levers 74, 75, and 76, which are mounted upon and operate the rock-shafts 77, 78, and 79, respectively. The said cranks 70, 71, and 72 are mounted upon and operated by said rock-shafts 77, 78, and 79, respectively. It follows that said hand-lever 74 controls the throttle-valve 54, the lever 75 toward the left controls the cable *k* also toward the left, and the lever 76 toward the right controls the cable *j* also toward the right.

As will hereinafter more fully appear, in order for the cables *j* and *k* to positively effect the lateral swinging of the crane it is necessary that the bucket-arm be immovable with respect to rotation in a vertical plane about the crane-pivot *t*. The bucket-arm is practically immovable when the bucket is hoisted to its highest point, as shown in Fig. 2; but I have provided means whereby the bucket-arm may be rendered immovable when in any position, thus making it possible to swing the crane without the necessity of hoisting the bucket to said extreme position.

In swinging the crane one of the cables *j* or *k* exerts more force than the other one thereof, and as the first tendency of either of said cables is to alter the configuration of the bucket-arm I have also provided means for preventing such change in configuration. Said means of fixing the members of the bucket-arm relatively to each other and said means of fixing the bucket-arm relatively to the crane will now be described.

Referring to Figs. 5, 9, and 10 for details, the friction drum or ring 80 is mounted upon one of the shafts *t* concentrically therewith and is bolted or otherwise secured to one of the pivot-blocks *u*. The adjustable brake-band 81 encircles said drum 80 and is operated by the foot-lever 82, keyed upon the shaft 83. Said shaft 83 is fixed relatively to the crane and is rotated in its bearings by means of the foot-lever 82. The parts are so arranged that when said lever 82 is forced downward the brake-band 81 is set, and the rotation of the drum 80, and consequently

of the oscillating lever *v*, is prevented. The drum 84 is also mounted upon the shaft *t*, but is located on the side of the block *u* opposite to said drum 80 and is revoluble upon said shaft *t* independently thereof. Said drum 84 is encircled by the brake-band 85. Said brake-band is operated by said shaft 83 and lever 82 in such a manner that when said foot-lever 82 is forced downward the brake 85 is also set and the rotation of the drum 84 is prevented. At the side of said friction-drum 84 is rigidly attached the drum 86, around which the controlling-cable 87 takes a few turns and to which said cable is fastened. One extremity of said cable 87 is fastened to the bucket-handle 5 at a point near the bucket 6, and the other extremity of said cable is fastened to said bucket-handle at a point near the thrust-segment *l*. As said cable 87 may wind and unwind onto and from said drum 86, but is fastened to said drum at at least one point thereon, it follows that if said drum is free to rotate upon the shaft *t* the motion of the bucket-handle 5 in a direction transverse to the length of said shaft *t* will cause said drum 86 to rotate; but as said handle forms one of the members of the bucket-arm, which is also pivoted upon said shaft *t*, it is evident that when the brake-band 85 is set the motion of said handle transversely to said shaft is prevented and the members of the bucket-arm become fixed relatively to each other. As said drum is of comparatively small diameter and is pivoted on said shaft *t*, said drum has comparatively no effect upon said handle, as far as rotation about said shaft is concerned, either when the brake-band 85 is set or released.

The rope 88, which draws the bucket-latch and permits the discharge of the bucket, is brought to a point adjacent to the controlling-levers 74, 75, 76, and 82, and consequently all the controlling devices necessary for the operation of the excavator are so located as to be within reach of a single operator, who is advantageously situated at the forward extremity of the crane.

In the operation of the excavator when the lever 76 is thrown forward the rod 69 is moved forward and causes the shaft 46 to be raised. This by means of the lever 43, rock-shaft 42, and lever 41 causes the rod 39 to move rearwardly and rotate the shaft 36 in such a direction that the adjoined shifting lever 35 forces its beveled driving-disk 33 into the adjacent disk 32. The engagement of said disks which lie upon the right causes the rotation of the drum 31, also upon the right, and operates the cable *j*. The same rotation of said shaft 36 causes the nut 38 thereon to move upward and release the brake-band 37, connected thereto. Therefore when the lever 76 is forward tension is exerted in the cable *j*, with the result that said cable is wound upon its drum 31. Reversedly, when said lever 76 is thrown backward the said disk 33 is disengaged from said disk 32, and at the same time said brake-band 37 is tightened upon its disk 33 and the right drum 31 is prevented from rotating, thereby holding the cable *j* fast. When the lever 76 is in a middle position, the connected controlling parts are also in a middle position and said band 37 is released, while the said disks 32 and 33 are out of contact. Hence when the lever 76 is in a middle position the drum 31 upon the right is free to rotate upon the drum-shaft 28 independently thereof and independently of the brake-band 37. Under this condition, in which the drum is free, the cable *j* is free to run out, causing said drum to rotate in the opposite direction to the rotation which would be imparted to said drum by the driving-engines. The running out of the cable *j* is terminated by throwing the lever 76 rearwardly and setting the brake-band 37 in the manner above described. Similarly when the hand-lever 75 is thrown forward the rod 68 is caused to move forward, and the vertical shaft 52 is raised by means of the bell-crank 65, connecting said rod and shaft. Said shaft 52 moves independently of the inclosing hollow shafts 46 and 60, and when said shaft 52 is raised the rod 40 is moved rearwardly by means of the connecting-levers 49 and 47 on the rock-shaft 48. The rearward motion of the rod 40 causes the shaft 36 upon the left to rotate, so as to cause the engagement of the disk 32 with the adjacent disk 33 and at the same time release the brake-band 37 from its said disk 32. This causes the drum 31 upon the left to be rotated, so as to wind in the cable *k*, attached thereto. Reversedly, throwing the lever 75 backward moves the rod 40 forward and withdraws the disk 33 upon the left of the machine from the adjacent disk 32, at the same time setting the brake-band 37 upon said disk 32, thus holding fast the left drum 31 and the cable *k*, attached thereto. When said hand-lever 75 is moved to the middle position, the said disks 32 and 33 are out of engagement and the said brake-band 37 is released, thereby permitting the left drum 31 to run free and the cable *k* to unwind therefrom. The motion back or forth of the throttle-controlling lever 74 causes a rotation of the shaft 77 and a consequent reciprocation of the rod 67. By means of the bell-crank lever 64 the reciprocation of the rod 67 causes a reciprocation in a vertical direction of the hollow shaft 60, which latter reciprocation causes a corresponding motion of the crank 57, rock-shaft 56, and crank 55. The oscillation of said crank 55 causes a corresponding reciprocation of the rod 53, which operates the throttle 54. As said throttle controls the supply of steam to the driving-engines 24, the operator from his position upon the crane starts and stops said engines by means of said lever 74. When the driving mechanism exerts tension in the cable *k*, the force of said cable acting upon the segment *l* is resolved into two components, one of which tends to rotate the

bucket-arm about the supporting-shafts *t* and the other of which tends to rotate said segment *l* about the shaft 2. The first mentioned of said components tends to force the bucket 6 in a forward direction, so as to take a cut, and subsequently to hoist said bucket to a position for discharging. The last mentioned of said components tends to thrust or crowd said bucket directly into the bank, thereby regulating the thickness of the cut. When tension is exerted in the cable *j*, the force thereof tends to cause said bucket to approach the sheave 22 at the upper extremity of the lever *v*, thereby retracting said bucket directly out of the bank. Said force also tends to rotate the bucket-arm about the shafts *t*, so as to drive the bucket in a forward direction, this latter effect resulting from the fact that said shafts *t* lie between the bucket and the sheave 22. It is apparent, therefore, that the forces of the cables *j* and *k* are supplementary in so far as cutting and hoisting are concerned, but are oppositely directed with reference to thrusting and retracting. As the power-transmitting clutches, comprising the disks 31 32, operate by friction, the relative tensions in the two cables *j* and *k* may be varied in such a manner that the desired relative amounts of thrust and retraction of the bucket may be attained. When the bucket 6 has been hoisted to the highest point and the segment *l* has reached the limit of its motion, as shown in Fig. 2, the effect upon the cables *j* and *k* is the same as if said cables were fastened at their forward extremities to some portion of the crane. In the present case when the parts are in the position shown in Figs. 2 and 4 the virtual point of attachment of the cable *j* to said crane is the point of tangency of said cable to the sheave 14, and the virtual point of attachment of the cable *k* to said crane is the point of tangency of said cable *k* to the sheave 17. The bucket-arm may be maintained in this extreme position by either one of the cables *j* or *k*, and if under such conditions the cable *j* is put under tension and the cable *k* is slackened off the sheave 14 will tend to move toward the rear and the crane will be swung toward the right. Reversedly, when the cable *j* is slackened and the cable *k* put under tension the crane will be swung toward the left. If now it is desired to swing the crane when the bucket-arm is not in the extreme position, the operator applies the brake-band 81 to the drum 80 by means of the foot-lever 82, thus preventing the rotation of the oscillating lever *v* about the shafts *t*. The same motion of the foot-lever 82 applies the brake-band 85 to the friction-drum 84, thereby rigidly holding the drum 86, around which is wound the locking-cable 87. As said cable 87 is thus held by said drum 86 the bucket-handle 5 is prevented from moving transversely to said shafts *t*, and as the lever *v* is prevented from rotating the bucket-arm is prevented from rotating and the members thereof are prevented from moving relatively to each other. Therefore when the foot-lever 82 is operated so as to set the said brakes 81 and 85 the effect upon the bucket-arm and upon the cables *j* and *k* is practically the same as if said arm were in the extreme position above mentioned, and the crane may be swung by said cables in the manner described. The center of gravity of the bucket-arm is so located that said arm tends to rotate in such a direction as to lower the bucket and cause the same to approach the car *a*. Moreover, when the members of the bucket-arm are free to move relatively to each other the bucket-handle and bucket tend to drop downward. Therefore when it is desired to lower the bucket into a position for taking a cut the brake-bands 81 and 85 are slackened off and the friction devices affecting the drums 31 31 are released, so that said drums are free to rotate. This permits the cables *j* and *k* to unwind from said drums, and in running out said cables permit the bucket to be lowered by gravity.

The brake-drums 80 and 84 and their adjuncts are useful in that the bucket-arm may be locked in any position independently of the cables *j* and *k*, thus enabling the operator to hold the bucket aloft or in any other position in cases of emergency—for example, parting or detachment of one or both of said cables or damage to the driving machinery.

When it is desired that the working length of the crane be extended—that is, that the distance between the shafts *t* and the turret *b* be increased—all of the rods *p* and *r* are removed and the crane-beams *n n* are moved forward in the crane-post *m* until the proper working length of the crane is secured. When the desired position is reached, the said rods *p* and *r* are replaced by other rods of lengths which will be suitable to the new position of said crane-beams in said pivot, the rods nearest said shafts *t* being longer and the rods upon the opposite or rear end of the crane being correspondingly shorter than said rods *p* and *r*. If rods *p* and *r*, having an extended threaded portion at their extremities, are employed, the adjustment above described may be effected by merely changing the positions of the nuts on said rods instead of substituting new rods therefor. In the same way when it is desired to increase the depth to which the bucket may work in the bank or to increase the distance to which the bucket may reach for discharging the lever *v* is adjusted in the pivot-blocks *u u* by removing the rods *x x* and *y y* and then sliding the beams *w w* in said blocks *u*, so that the distance between the bucket 6 and said shafts *t* is as great as is required. The rods *x* and *y* are then replaced by other rods of suitable lengths. Said rods *x* and *y* may, if desired, have extended threaded portions, so as to permit adjustment of the bucket-arm without the necessity of substituting other rods for said rods *x* and *y*. When the crane-beams *n n* are adjusted in the post *m*, the controlling-

rods 67, 68, and 69 are removed and other rods of suitable length substituted therefor.

Although I have herein referred to the bucket-arm as a "linkwork" and the bucket-arm shown and described consists of four links, I do not confine myself to a four-linked structure, for the precise number of links in the bucket-arm is immaterial. In the description and claims the term "linkwork" is applied generically as referring to a structure having not less than three members pivotally connected together in such a manner as to be movable relatively to each other. An example of such other means for connecting the links at the lower extremity of a linkwork bucket-arm is shown and described by me in a separate application for Letters Patent numbered as "3" in a series of four applications filed this day, Serial No. 15,704, the links therein shown having a sliding connection.

Certain features of the crane-support and crane herein shown are described and claimed by me in a separate application numbered as "1" in a series of four applications filed this day, Serial No. 15,702.

It will be evident to those skilled in the art that the horizontally-extending part *h*, with the sheaves thereon, may be referred to or at least forms an equivalent to the parts variously known as "turn-tables," "sluing-circles," and "swinging sheaves," and it will be obvious also that the construction and the location of the crane-swinging device may be greatly varied without departing from my invention. Moreover, the manner of leading the cables from the arm to the crane-swinging part may be varied without changing the principle of operation herein shown.

Although my machine is herein referred to as an "excavator" and a bucket is shown attached to the linkwork arm, said machine is well adapted for use as a derrick or lifting-machine. For instance, by substituting hooks or crabs for the bucket said machine may be employed for shifting building or other material, for loading the same on cars, or may be used as a so-called "wrecking-machine."

I wish to call particular attention in my present device to the general feature whereby two cables are enabled to accomplish three operations—namely, the controllable varying of the configuration of the bucket-arm, the hoisting of the bucket or other mechanism attached to said arm, and the swinging of the crane.

What I claim as new, and desire to secure by Letters Patent, is—

1. In an excavator, the combination of a bucket-arm supported intermediate of its extremities and composed of a plurality of members, two of which are pivotally connected to a third member; said third member affording means for varying the configuration of said arm; and a plurality of independently-operated power devices for operating said arm, applying power thereto on the same side of the point of support thereof.

2. In an excavator, the combination of a linkwork bucket-arm, one of the members of which is a power-receiving link and two of the other members of which are pivotally connected to said power-receiving link, said two last-mentioned members having connections to the excavator-bucket, and one of said last-mentioned members being pivotally supported and forming the support for the bucket-arm; a power device connected with said power-receiving link and exerting power in a line other than that of the line through the pivots of said power-receiving link; and a second power device making contact with and applying power to two different members of said arm, one of the points of power application of said second power device lying upon the same side of the point of support of said arm as lies said power-receiving link.

3. In an excavator, the combination of a linkwork bucket-arm, one of the members of which is a power-receiving link, and two of the other members of which are pivotally connected to said power-receiving link, said two last-mentioned members having connections to the excavator-bucket; bearings for pivotally supporting one of said two last-mentioned members and thereby supporting said arm; a power device connected with said transverse link and exerting its power in a line other than that of the line through the pivots of said transverse link; and a cable forming a second power device, said cable being fastened to one of the members of said arm and being deflected at a point located upon another of the members of said arm, said point of deflection being upon the same side of the point of support of said arm as is said transverse link.

4. In an excavator, a linkwork bucket-arm comprising an oscillating lever pivotally supported between its extremities, a thrust-segment pivotally supported at the upper extremity of said lever, a third member pivotally connected to said thrust-segment, said lever and third member having at their lower extremities connections to the excavator-bucket; in combination with a cable connected with said thrust-segment, and exerting its power in a line other than that of the line through the pivots of said thrust-segment; and a second cable having a guide at the upper extremity of said oscillating lever, said second cable being also connected to a member of the bucket-arm other than said oscillating lever.

5. In an excavator, a link-work bucket-arm comprising an oscillating lever pivotally supported between its extremities; a thrust-segment pivotally supported at the upper extremity of said lever; a third member pivotally connected to said thrust-segment, said lever and third member having at their lower extremities connections to the excavator-bucket; in combination with an operating-cable, a guide-sheave mounted at the upper extremity of said oscillating lever, and a second operating-cable training over said guide-

sheave, and being fastened at or near said bucket to a member of the bucket-arm other than said oscillating lever.

6. In an excavator, the combination of a pivoted crane, crane-swinging guides connected to said crane on opposite sides of the axis of rotation thereof, a linkwork bucket-arm supported on said crane, a pair of cables for operating said arm, means for directing said cables respectively to said guides on opposite sides of the crane-axis for swinging said crane, and means for operating said cables.

7. In an excavator, the combination of a laterally-swinging crane, a bucket-arm pivotally supported between its extremities upon said crane, and having at one side of its point of support an excavator-bucket, and at the other side of said point of support two points of power application; a bucket; two cables attached to said arm for applying power thereto; and means for directing said cables respectively to opposite sides of the axis of rotation of said crane.

8. In an excavator, the combination of a linkwork bucket-arm; a pivoted crane for supporting said bucket-arm; pivot connections between said arm and said crane; and cables trained from the cable-operating mechanism onto the turn-table, sluing-circle or similar crane-swinging device, one of said cables onto each side of the axis of rotation of said crane for rotating said crane; and said cables thence leading to and being connected with said bucket-arm for operating said arm.

9. In an excavator, the combination of a pivoted crane; a bucket-arm comprising a set of members movable relatively to each other, one of said members constituting an oscillating lever which is supported intermediate of its extremities upon said crane, and a second of said members being pivoted to said lever and being located at or near the extremity of the bucket-arm opposite to the excavator-bucket; a pair of cables for operating said arm and applying power thereto on the same side of the point of support thereof; and guides for said cables whereby the latter are trained from said arm to points on said crane lying on opposite sides of the axis of rotation thereof.

10. In an excavator, the combination of a crane pivoted between its extremities, a linkwork bucket-arm supported upon the forward extremity of said crane, guide-sheaves at the rear extremity of said crane, two cables having points of power application upon the same side of the point of support of said arm for operating the same, said cables extending from said points of application to said sheaves, means for connecting said cables to said arm, other means for guiding said cables from said sheaves to points on opposite sides of the axis of rotation of said crane, and other means for preventing said cables from running along the guides provided therefor upon the crane and its adjuncts.

11. In an excavator, the combination with the bucket-arm and means for operating said arm, of a crane, a turret, and a crane-pivot substantially inclosed within said turret and rigidly attached to said crane, said pivot having a bearing in said turret, and having a horizontally-extending part for receiving the application of power on opposite sides of the axis of rotation of said pivot, for rotating said pivot.

12. In an excavator, the combination with the bucket-arm and cables attached to said arm for operating the same, of a crane, a turret and a crane-pivot substantially inclosed within said turret and rigidly attached at its upper extremity to said crane, said pivot having bearings at its upper and lower extremities, and having between said bearings a horizontally-extending part, guides on said horizontal part on opposite sides of the axis of said pivot, and means for training said cables to said guides, one cable to each side of said axis.

13. In an excavator, the combination of a crane, a linkwork bucket-arm consisting of a plurality of members at least three of which are articulately joined together and one of which is pivoted to said crane, and a locking device for rigidly fixing said bucket-arm relatively to said crane.

14. In an excavator, the combination of a crane, a bucket-arm comprising a pair of members one of which is pivotally supported upon said crane, said members being connected at one end to the excavator-bucket, and at the other joined by a transverse link, and means for rigidly fixing said pivotally-supported member relatively to the crane upon which it is supported.

15. In an excavator, the combination of a crane, a linkwork bucket-arm one of the members whereof is pivoted to said crane, a brake, one part of which is attached to said pivoted member, and another part of which is attached to said crane, and means for setting said brake, thereby preventing the relative motion of the said parts thereof.

16. In an excavator, the combination of a linkwork bucket-arm having one of its members pivotally supported, and having a second of its members movable in a direction transverse to the axis of rotation of said bucket-arm; and means having points of attachment on or near said second member for fixing said second member with reference to its motion transversely to said axis of rotation of said arm.

17. In an excavator, the combination of a linkwork bucket-arm; a pivoted crane for supporting said bucket-arm; pivot connections between said arm and said crane, and means for fixing said arm relatively to said crane at any position of said arm.

18. In an excavator, the combination of a crane, a linkwork bucket-arm, one of the members whereof is pivoted to said crane, a drum rigidly secured to said pivoted member, a

brake-band encircling said drum, and a lever for operating said brake-band, said lever having its fulcrum fixed relatively to said crane.

19. In an excavator, a linkwork bucket-arm comprising an oscillating lever pivotally supported between its extremities, a transverse link at the upper extremity of said lever, a bucket-handle pivoted to said transverse link, a bucket connected with the lower extremities of said lever and said handle, a drum revoluble upon an axis identical with the axis of rotation of said lever, a locking-cable attached to and encircling said drum, the extremities of said cable being attached to said handle at points thereon lying on different sides of said drum, and means for preventing the rotation of said drum about the axis thereof.

20. In an excavator, the combination of excavating parts, driving mechanism, cables for transmitting power to said excavating parts from said driving mechanism, a crane, a hollow crane-pivot secured to said crane, a turret for supporting said pivot and controlling mechanism for operating said excavator from a point on said crane, said controlling mechanism comprising three shafts coinciding with the axis of the crane-pivot and extending through said crane-pivot, two of said shafts being hollow and said shafts lying one within the other, controlling-levers located on said crane, connections between said levers and the upper extremities of said shafts for operating said shafts, and connections between the lower extremities of said shafts and the driving mechanism, said last-mentioned connections comprising collars which permit the rotation of said shafts independently of said driving mechanism.

21. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members, one of which is pivotally supported, said members being connected at one end with the excavator-bucket and at the other joined by a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link, a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof as lies said transverse member, a pivoted crane for supporting said member; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables, so that said cables shall be trained respectively to opposite sides of the axis of said crane; and driving mechanism for operating said cables.

22. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members, one of which is pivotally supported, said members being connected at one end with the excavator-bucket and at the other joined by a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link, a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof as lies said transverse member; a pivoted crane for supporting said member; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables, so that said cables shall be trained respectively to opposite sides of the axis of said crane; means for operating said cables; and other means for fixing said bucket-arm relatively to its supporting-pivot.

23. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members, one of which is pivotally supported, said members being connected at one end with the excavator-bucket and at the other joined by a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link; a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof as lies said transverse member, a pivoted crane for supporting said member; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables, so that said cables shall be trained respectively to opposite sides of the axis of said crane; means for operating said cables; and other means for locking the parts of said bucket-arm relatively to each other.

24. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members, one of which is pivotally supported, said members having connections at one end with the excavator-bucket and at the other having connections to a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link; a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof as lies said transverse link, a pivoted crane for supporting said arm; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables, so that said cables shall be trained respectively to opposite sides of the axis of said crane; means for operating

said cables; and other means for adjusting said oscillating lever longitudinally on its supporting-pivot.

25. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members one of which is pivotally supported, said members having connections at one end to the excavator-bucket, and at the other having connections to a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link; a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof, as lies said transverse link; a pivoted crane for supporting said member; a turret for supporting said crane; means for adjusting said crane upon the said turret in the direction of the length of said crane; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables so that said cables shall be trained respectively to opposite sides of the axis of said crane, and driving mechanism for operating said cables.

26. In an excavator, the combination of a linkwork bucket-arm comprising a pair of longitudinal members, one of which is pivotally supported, said members being connected at one end with the excavator-bucket and at the other joined by a transverse link; a hoisting-cable connected with said transverse link, and exerting its power in a line other than that of the line through the pivots of said transverse link, a retracting-cable attached to the second longitudinal member; a guide for said retracting-cable located upon said first-mentioned longitudinal member at a point thereon lying upon the same side of the pivotal point of support thereof as lies said transverse member; a pivoted crane for supporting said member; a horizontally-extending part fixed relatively to said crane, said part having near its periphery means for guiding said cables, so that said cables shall be trained respectively to opposite sides of the axis of said crane; and means for adjusting said oscillating lever relatively to its supporting-pivot, and in the direction of the length of said lever.

27. In an excavator, the combination of a pivoted crane, a structure for supporting said crane, a linkwork bucket-arm pivotally supported on said crane, two cables for operating said arm, said cables being attached to said arm and being trained respectively to points on said crane on opposite sides of the axis thereof, driving mechanism on said supporting structure for operating said cables; devices upon said supporting structure for controlling said driving mechanism, operating parts located upon said crane, and connections between said controlling devices on said supporting structure and said operating parts on said crane, whereby the operation of said cables may be controlled from said crane.

28. A machine for excavating, lifting, and the like, said machine having a cable-swung crane supporting a linkwork arm, the configuration whereof is controllably varied by means of the cables whereby the crane is swung.

29. An excavator or lifting-machine having a pivoted cable-swung crane, and an arm thereon composed of members movable relatively to each other, two of the principal members of said arm being pivotally connected together, and said arm being connected to and operated by the cables whereby the crane is swung.

30. An excavator having a linkwork arm pivoted to a crane, said crane being pivoted and having a turn-table, sluing-circle or similar device adapted to receive and be rotated by means of cables, in combination with cables for rotating said crane, said cables also having connections to the linkwork arm whereby the configuration thereof is controllably varied.

31. In an excavator, derrick or similar machine, the combination of a pivoted crane having attached thereto a part adapted to receive and be swung by the crane-swinging cables, a linked arm on said crane; and crane-swinging cables as aforesaid, attached to different members of said arm for operating the same and extending to and having engagement with the part on said crane adapted to receive and be swung by said crane-swinging cables.

32. In an excavator, or similar machine, the combination of a pivoted crane rotated by a turn-table, sluing-circle or the like, a linked arm supported on the crane, two cables connected to said arm for operating the same, said cables leading from said arm to said turn-table, thereby tending to rotate the crane as described.

33. In an excavator or similar machine, the combination of a pivoted crane having a part for swinging the same, a linkwork supported between its extremities on said crane, said linkwork constituting the bucket-arm, cables for operating said linkwork, and means for leading said cables to and into engagement with the crane-swinging part.

34. In an excavator, or similar machine, a swinging crane pivotally supporting an arm whose parts are movable relatively to each other, two arm-operating cables attached to the arm on the side of its pivot opposite to the load-carrying extremity thereof, and means for leading said cables from the arm to the sluing-circle, turn-table or other part whereby the crane is swung, said cables thereby effecting the operation of the arm and the swinging of the crane.

35. In an excavator or lifting-machine, the combination of a pivoted cable-swung crane, a pair of cables, and a linkwork arm supported on said crane, said cables having con-

nections with said arm whereby the configuration of the latter is controllably varied and said cables leading from said arm to the turn-table, or other device whereby the crane is swung.

36. In an excavator, derrick, or similar machine, an arm composed of relatively movable members one of which constitutes a thrust-segment pivotally connected to two adjacent members of said arm; a pivoted crane for supporting said arm, said crane having a swinging device adapted to be operated by cables; and a pair of cables connected to said arm for controllaby varying the configuration thereof, one of said cables being connected to said thrust-segment, and both of said cables leading from said arm onto the crane-swinging device.

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