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J. E. GLEASON.

GEAR GENERATING MACHINE.

APPLICATION FILED JAN. 5, 1907.

Patented Mar. 1, 1910.

11 SHEETS—SHEET 1.

Fig. 1.

Fig. 28.

Witnesses

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11 SHEETS—SHEET 2.

Fig. 2.

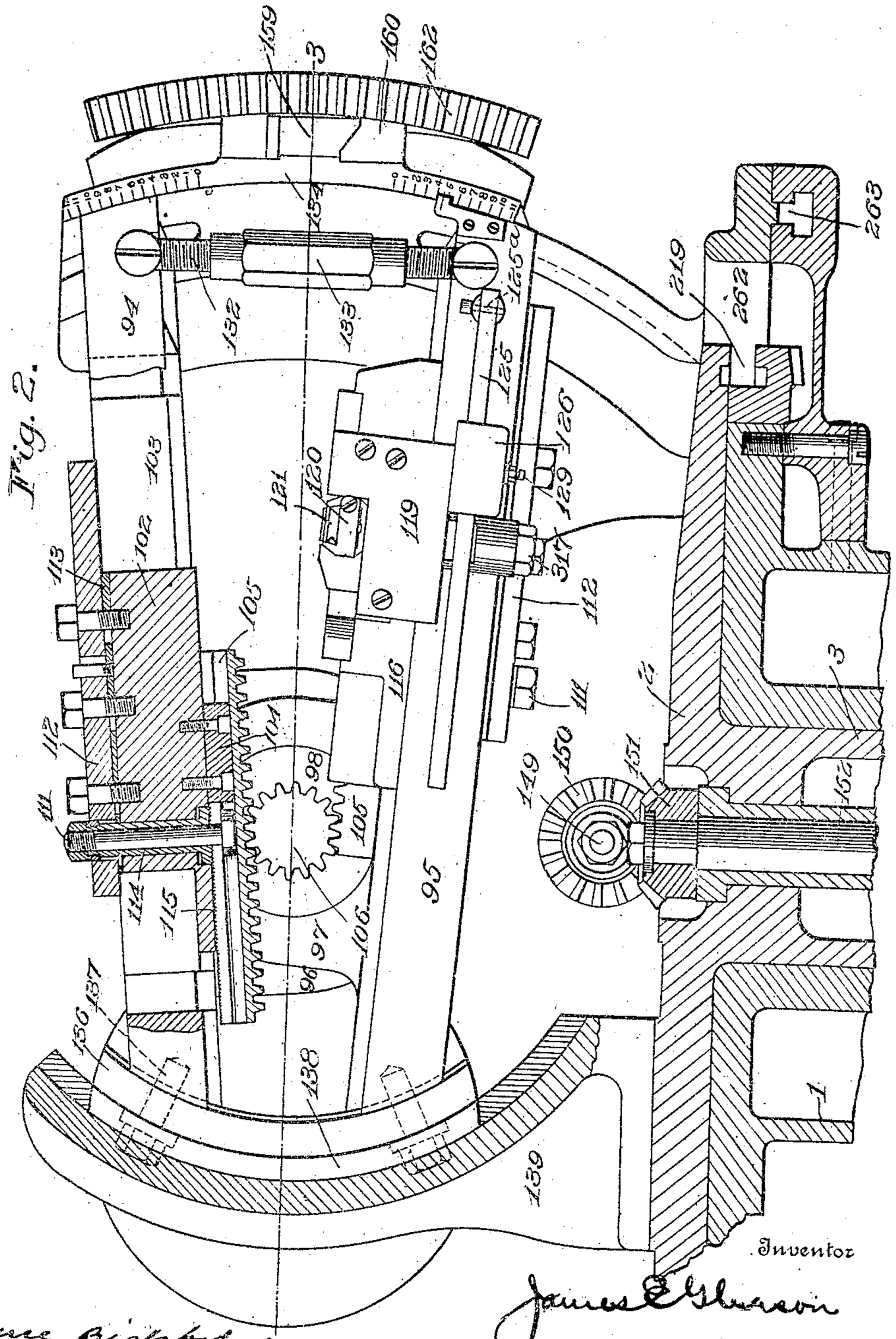

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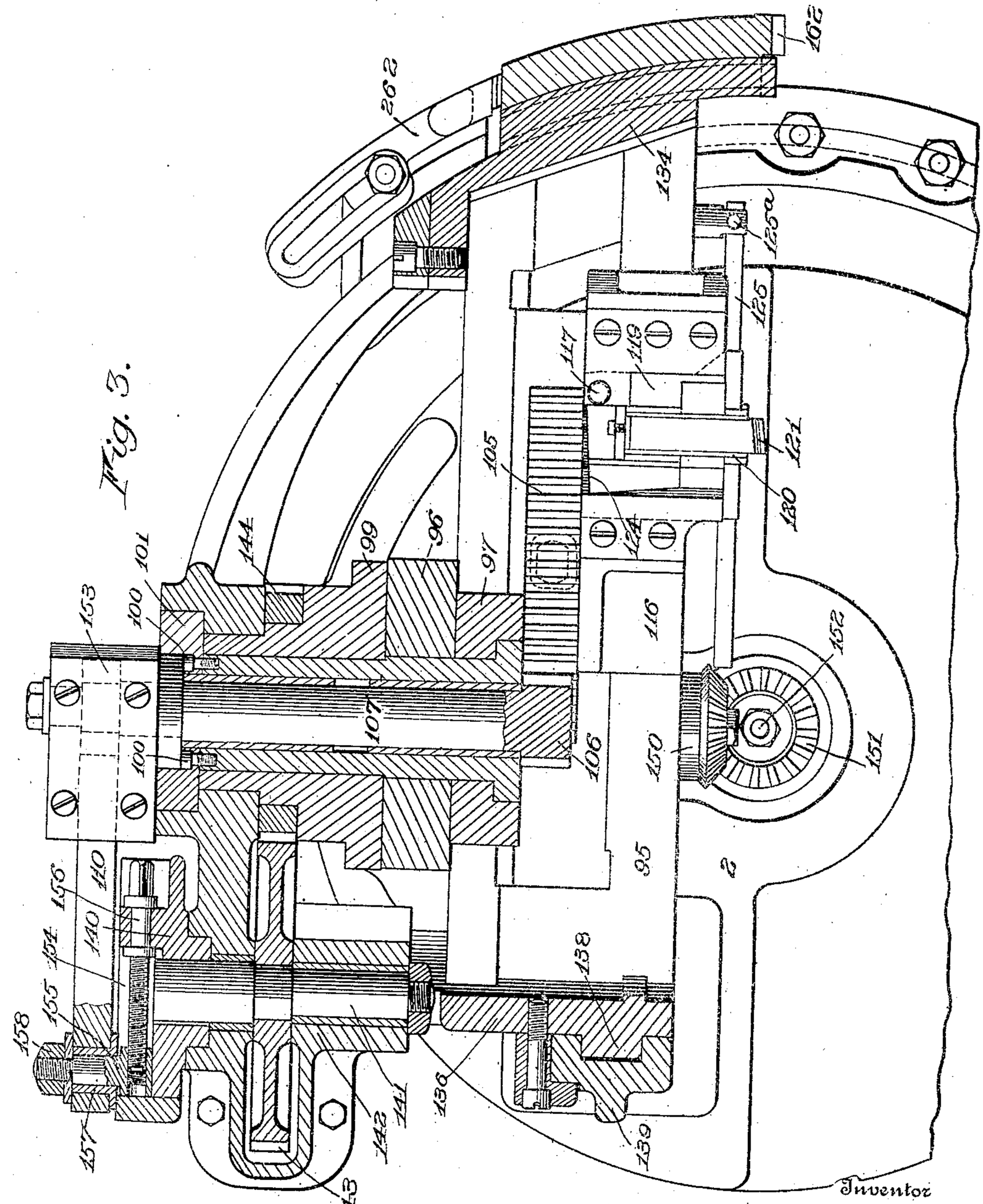
Fig. 3.



Witnesses

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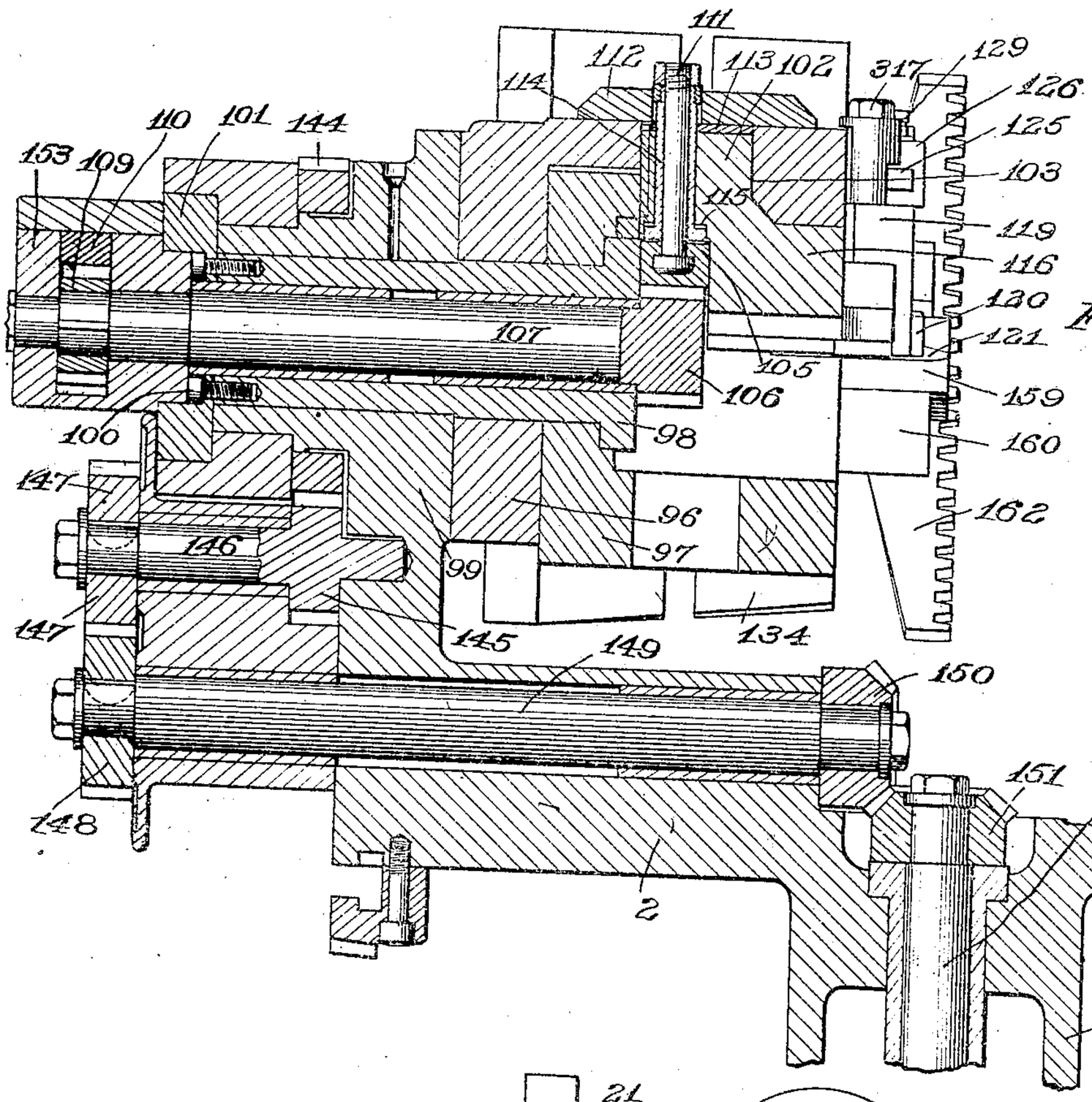

Fig. 4.

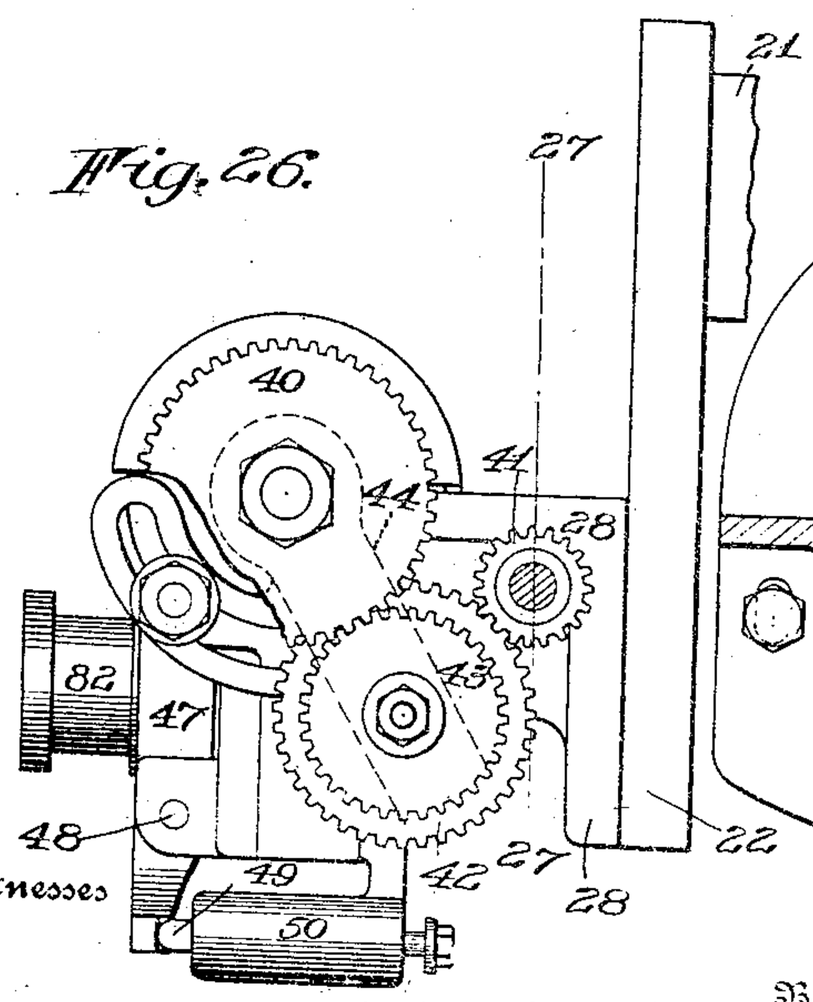

Fig. 26.

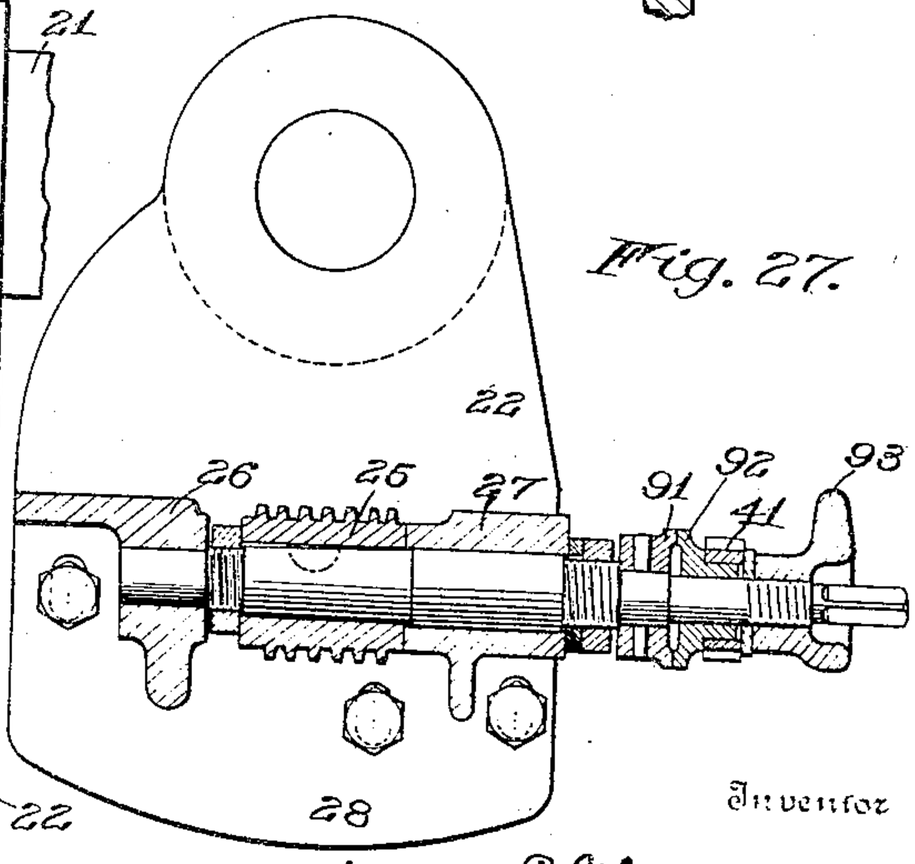

Fig. 27.

Witnesses

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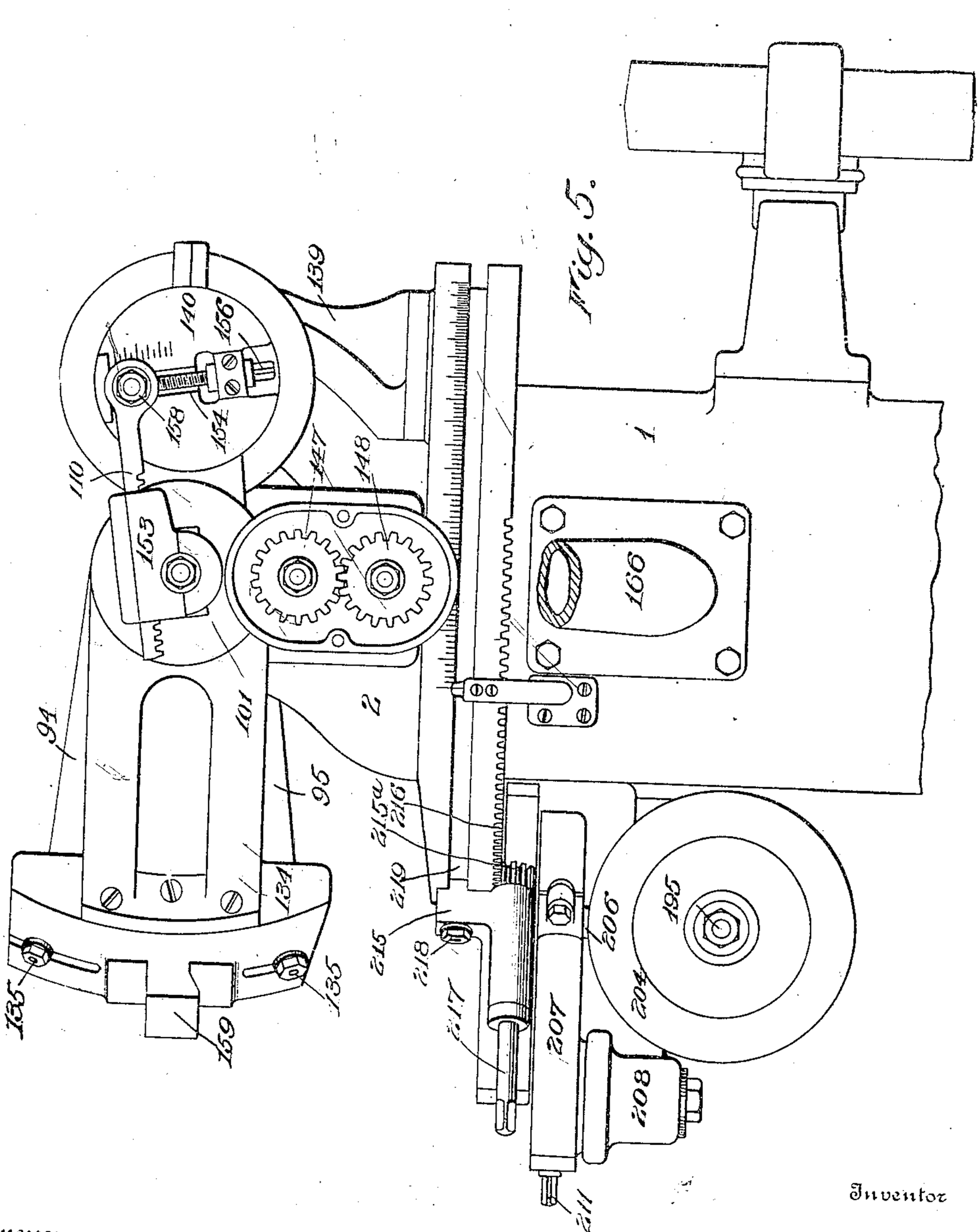
Fig. 5.



Witnesses

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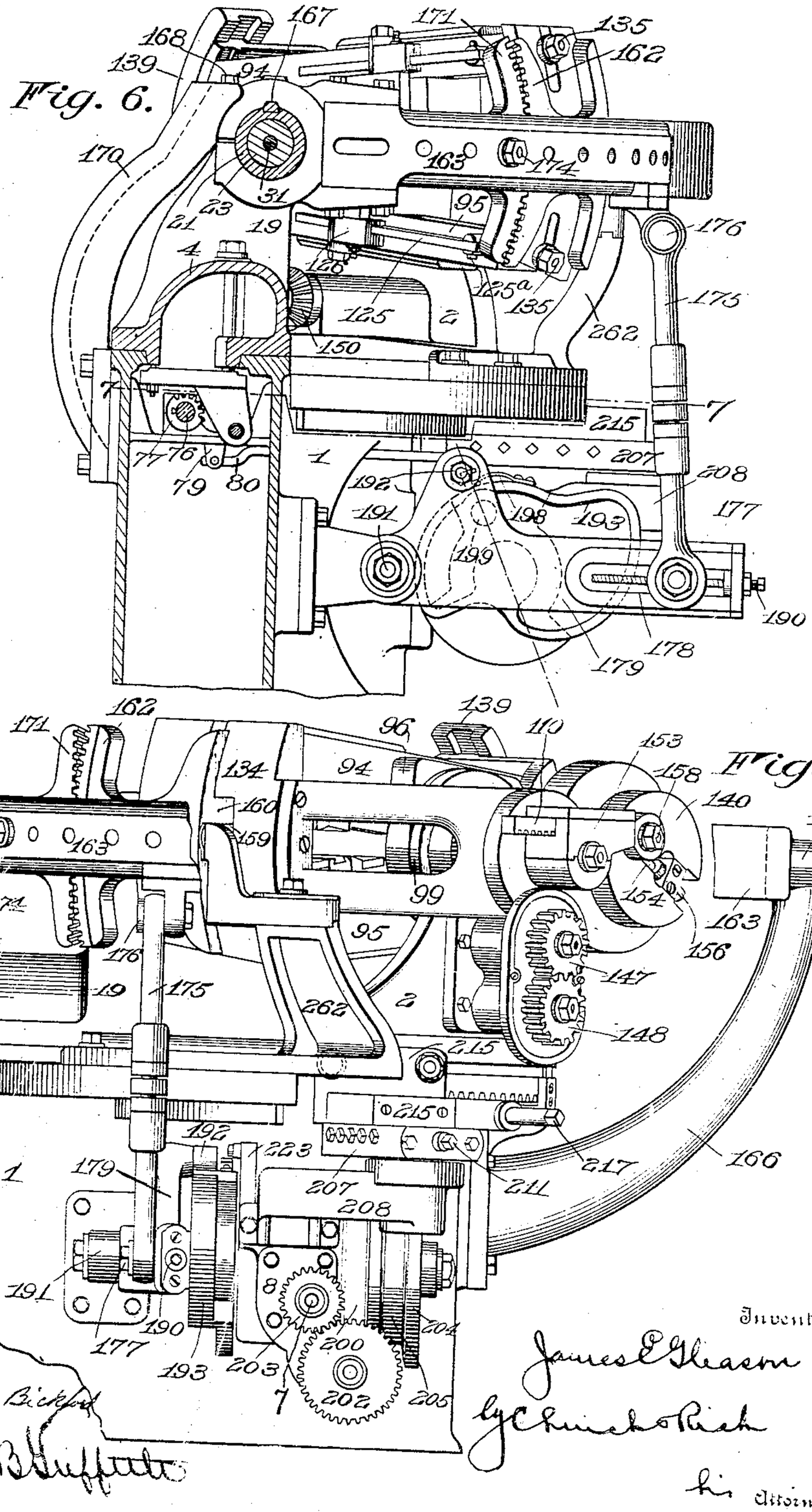
Fig. 6.



Witnesses

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Fig. 7.

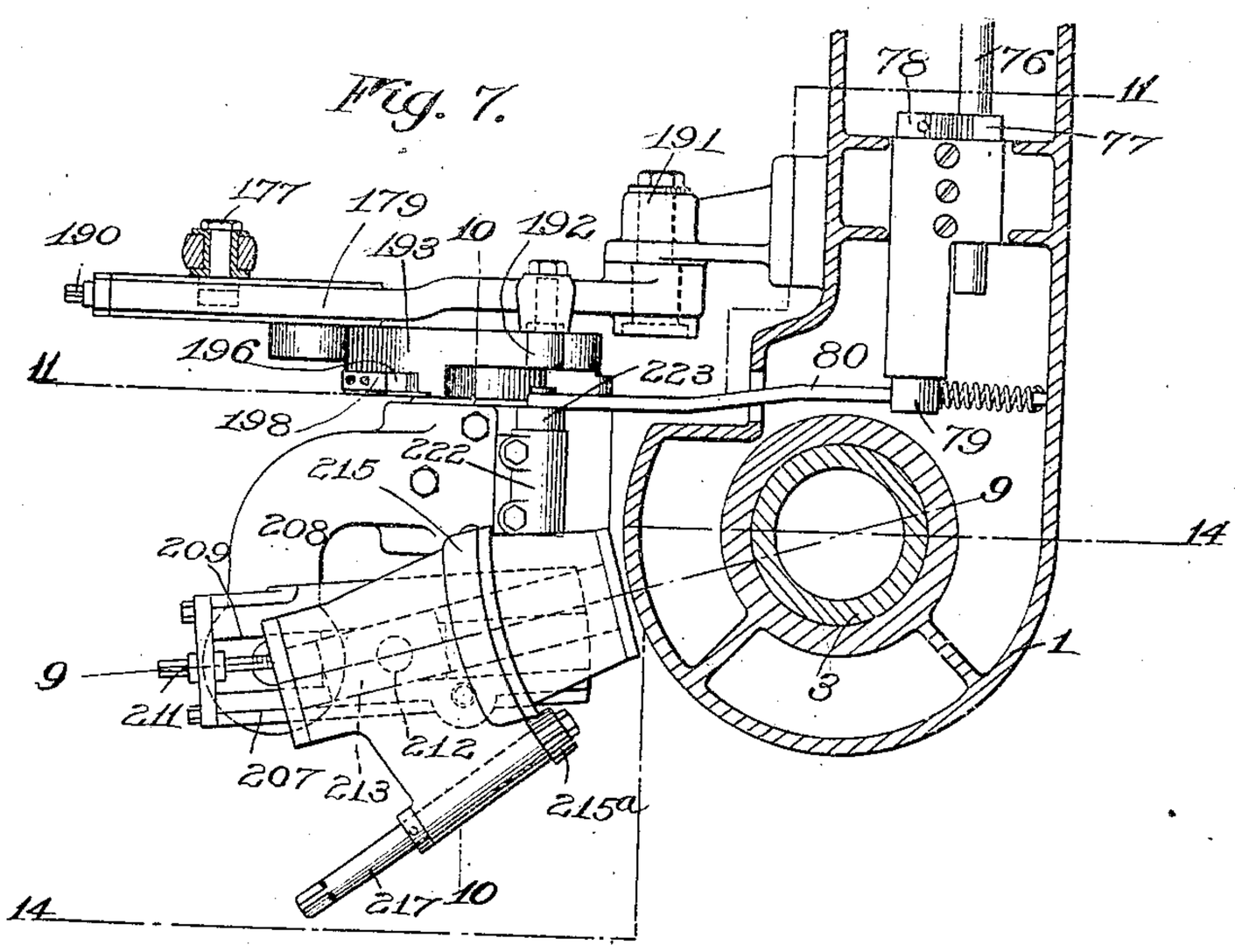


Fig. 9.

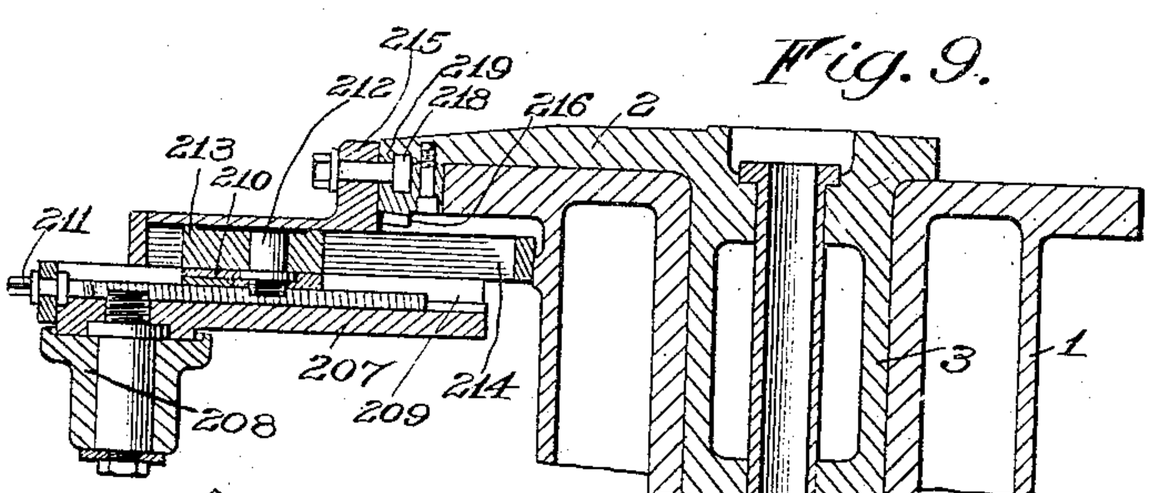
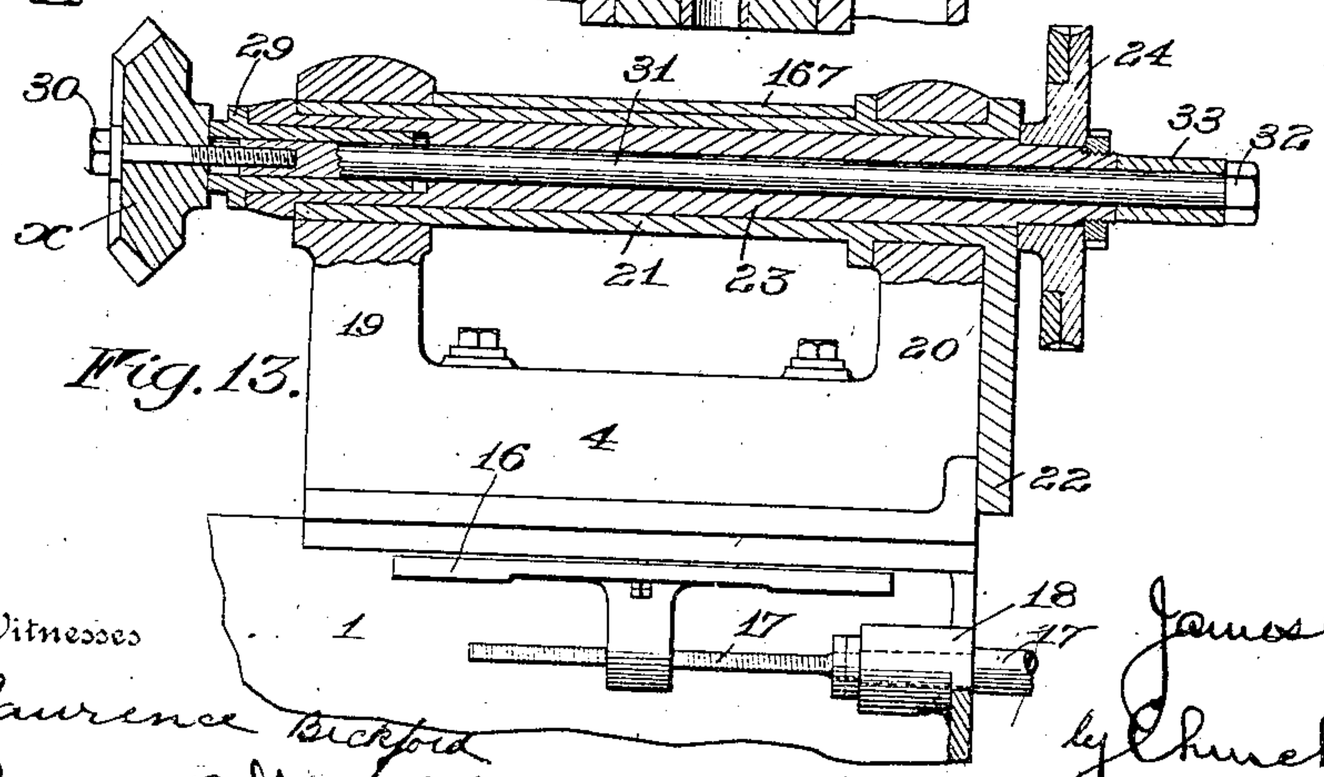


Fig. 13.



Witnesses

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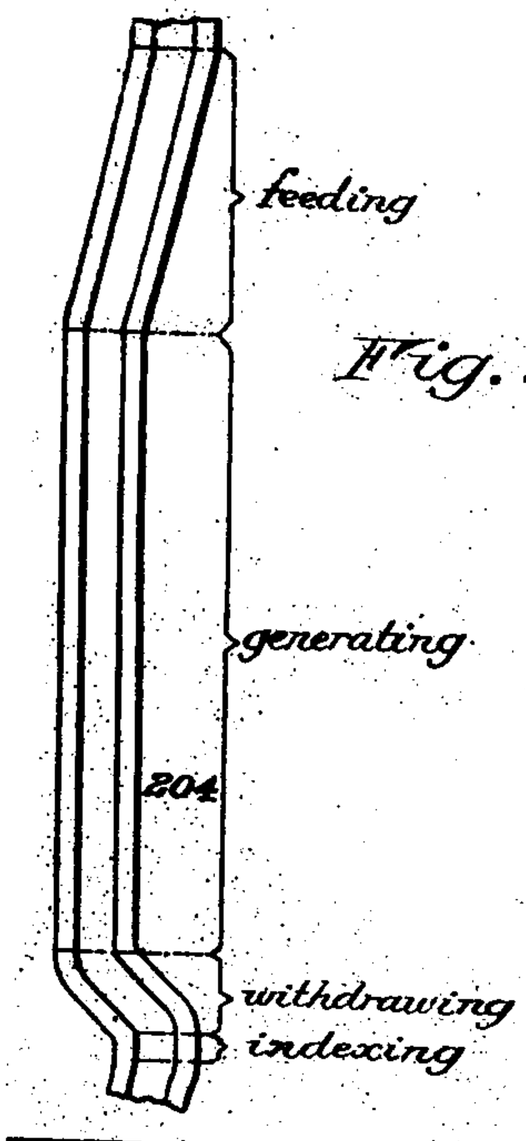


Fig. 29.

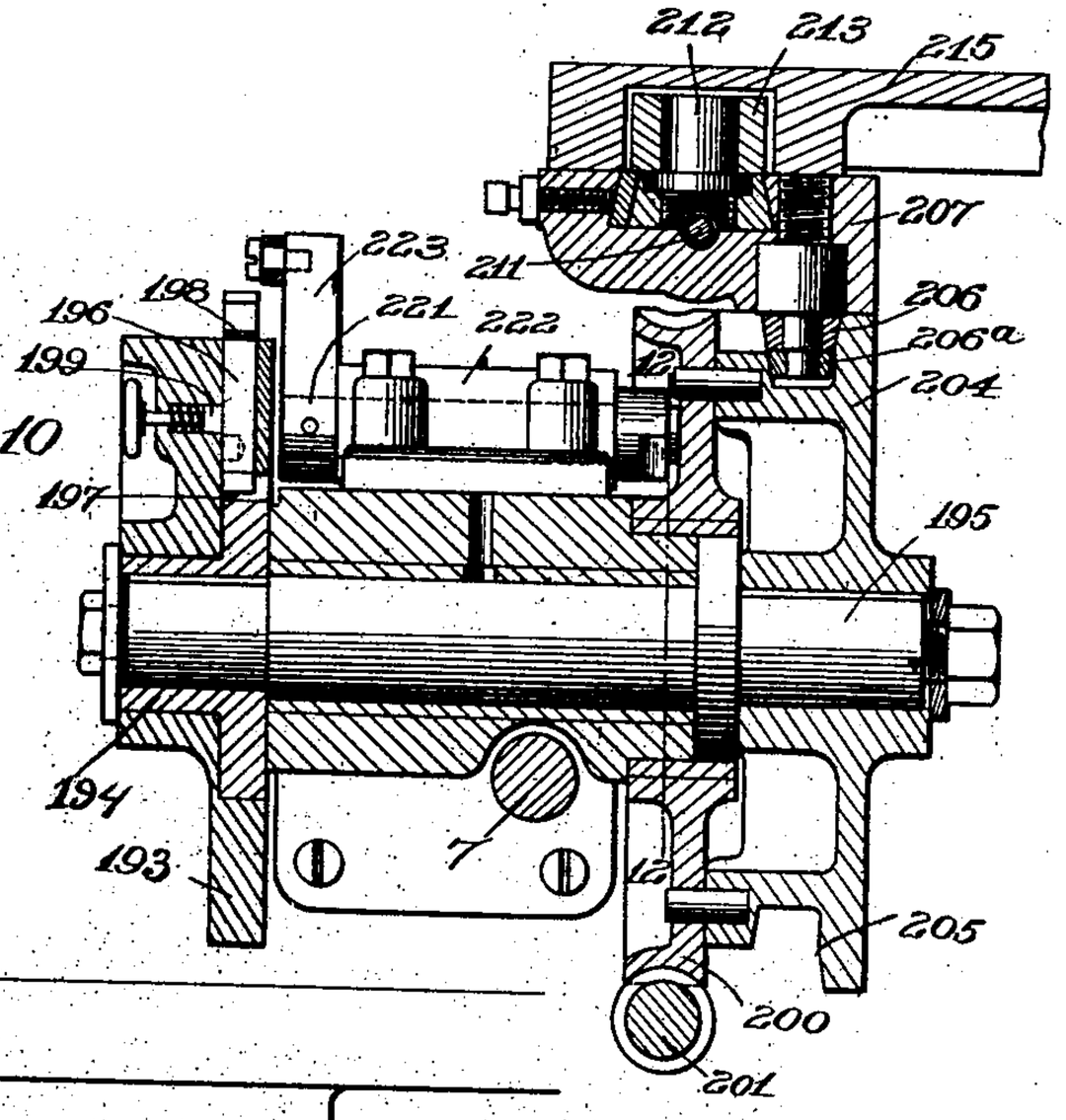
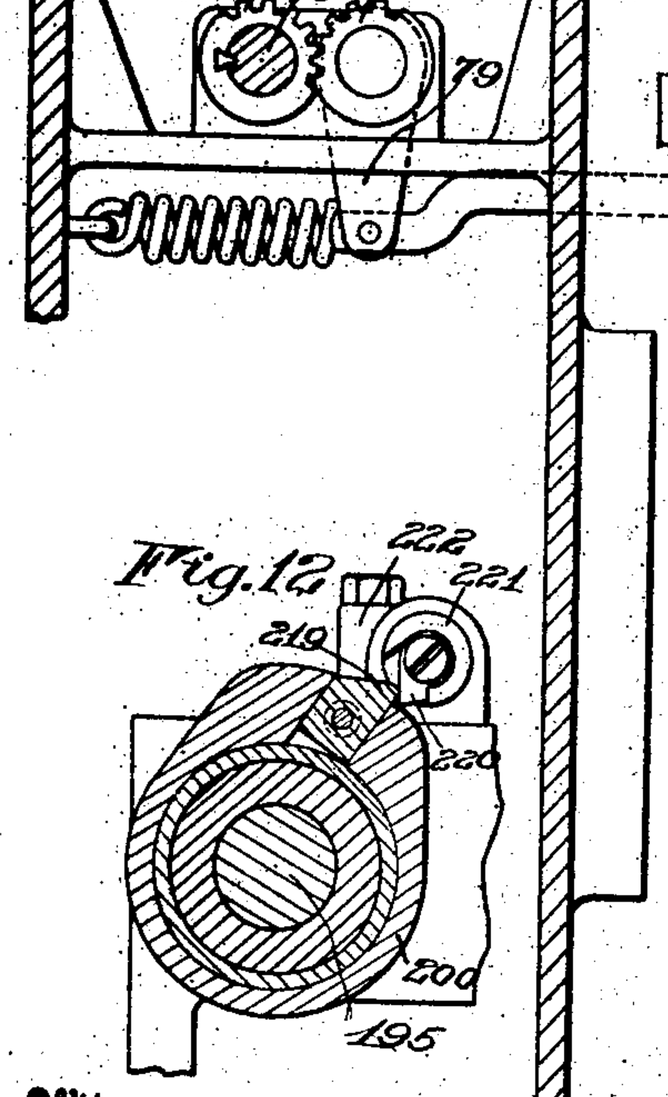


Fig. 10



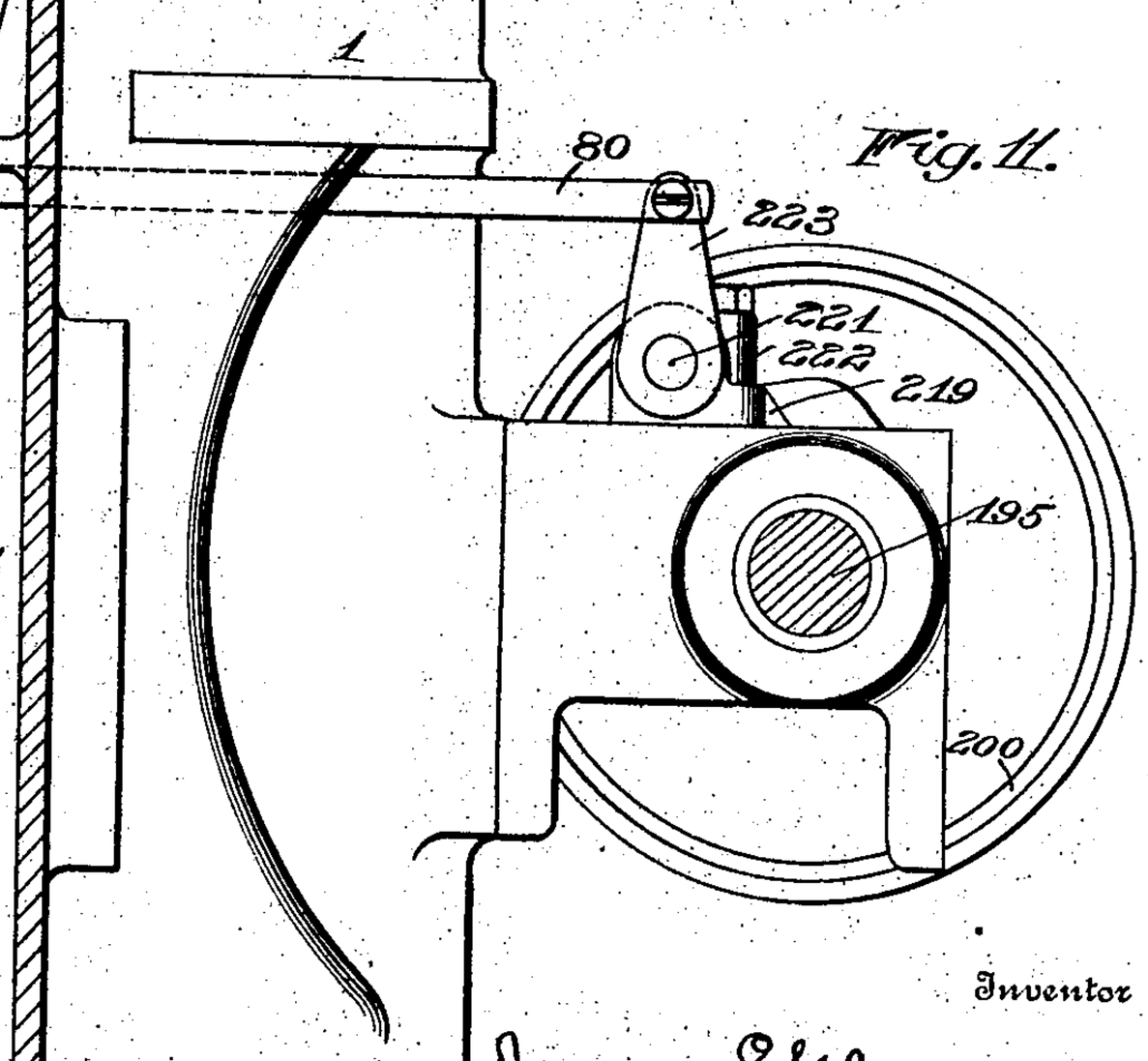


Fig. 11.

Fig. 12.

Witnesses

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Fig. 23.

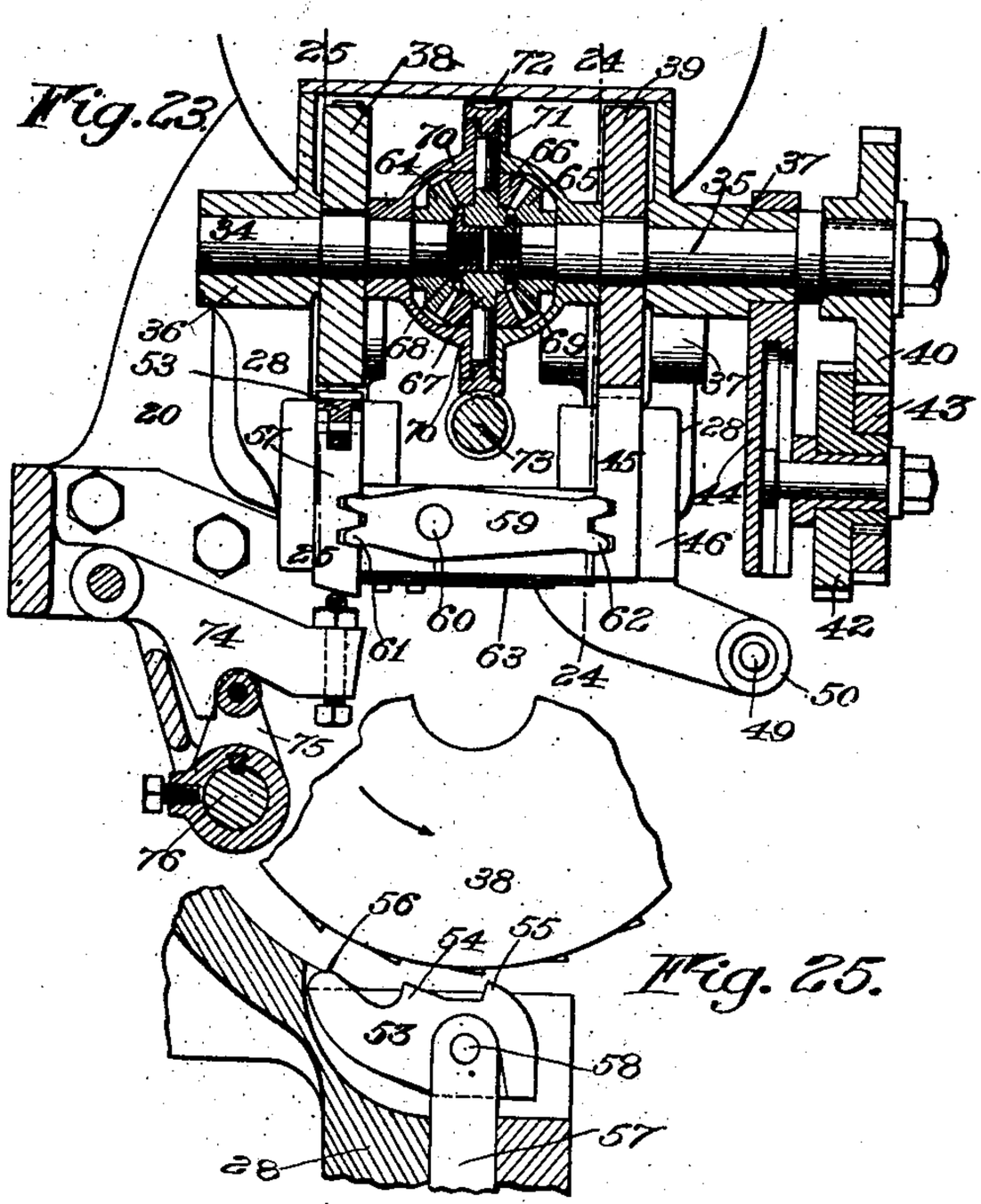

Fig. 24.

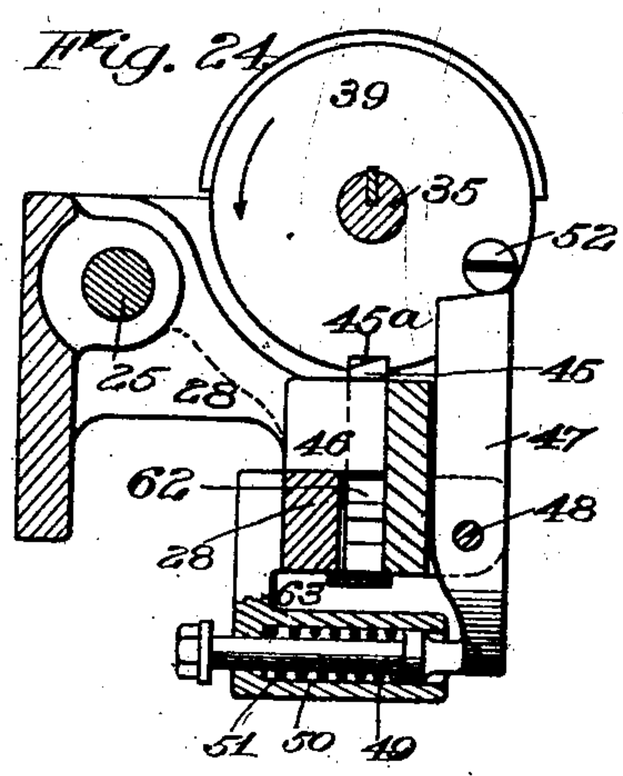

Fig. 25.

Fig. 14.

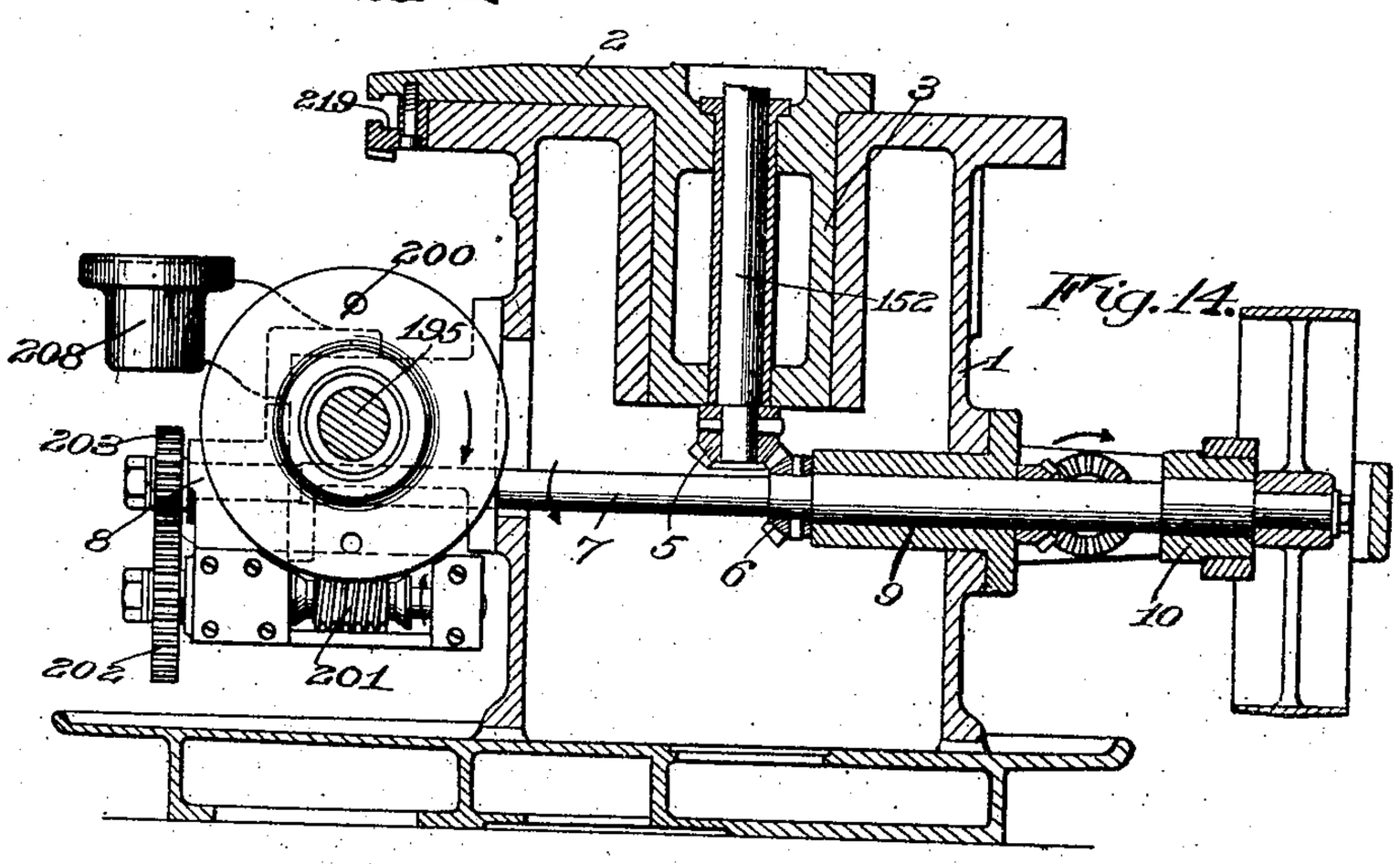

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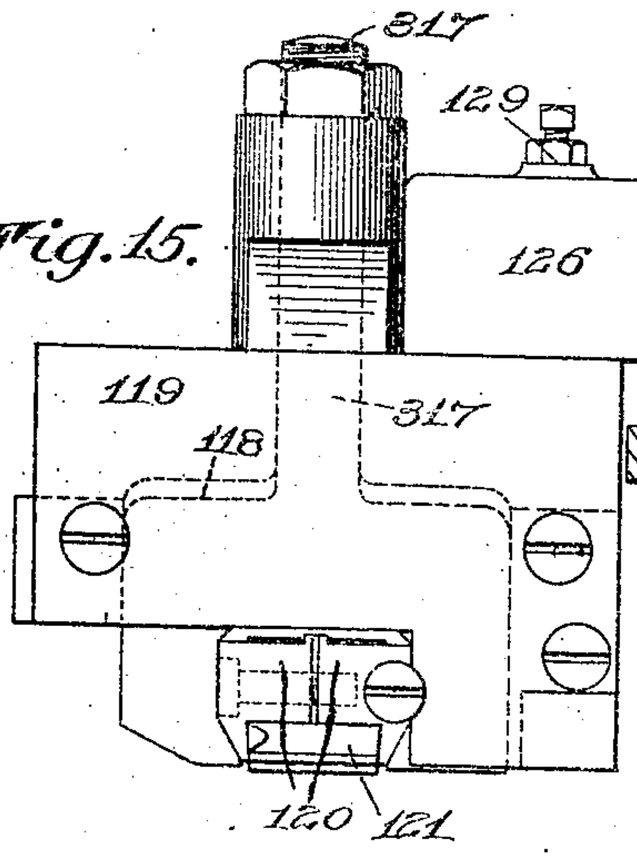
Fig. 15.



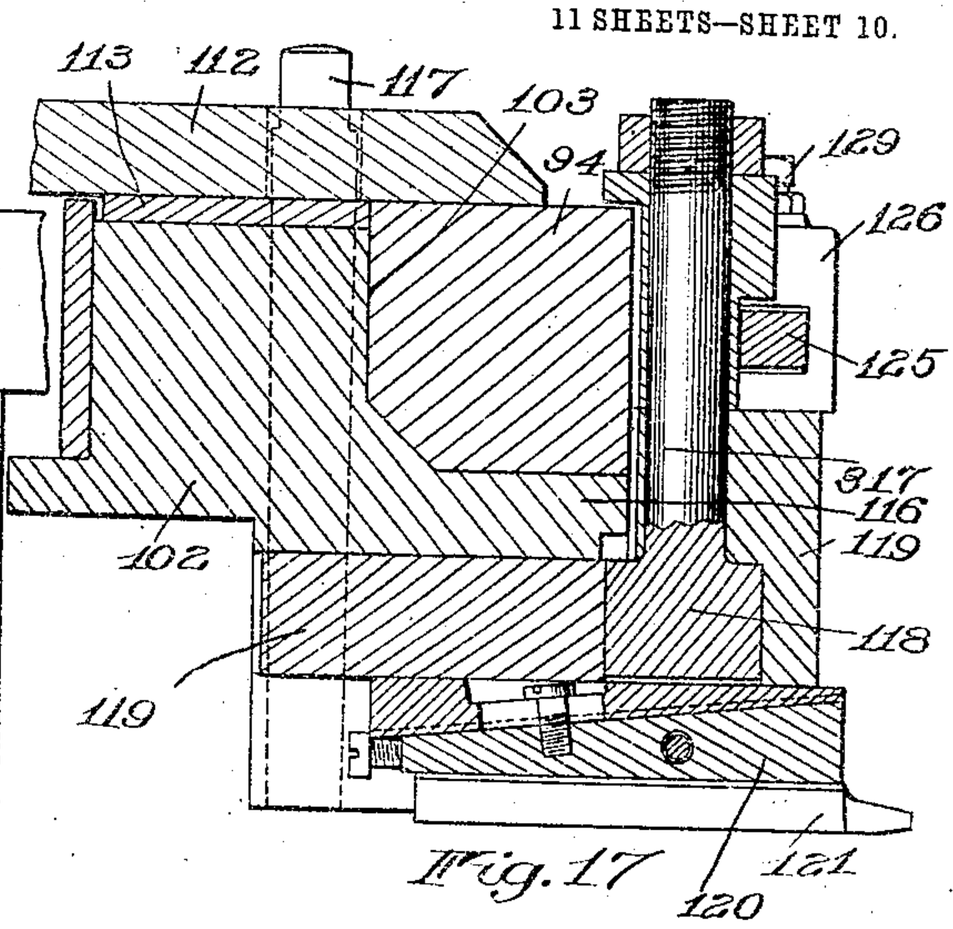


Fig. 17

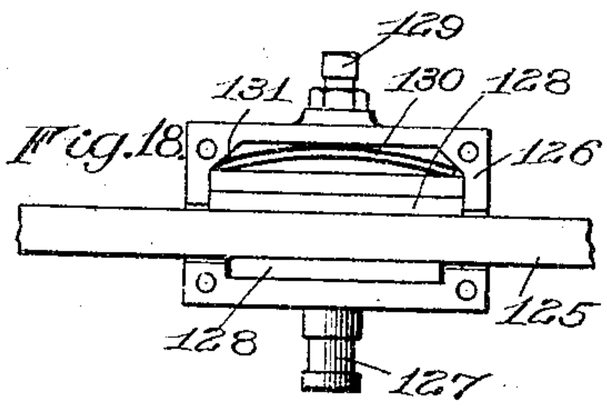


Fig. 18.

Fig. 16.

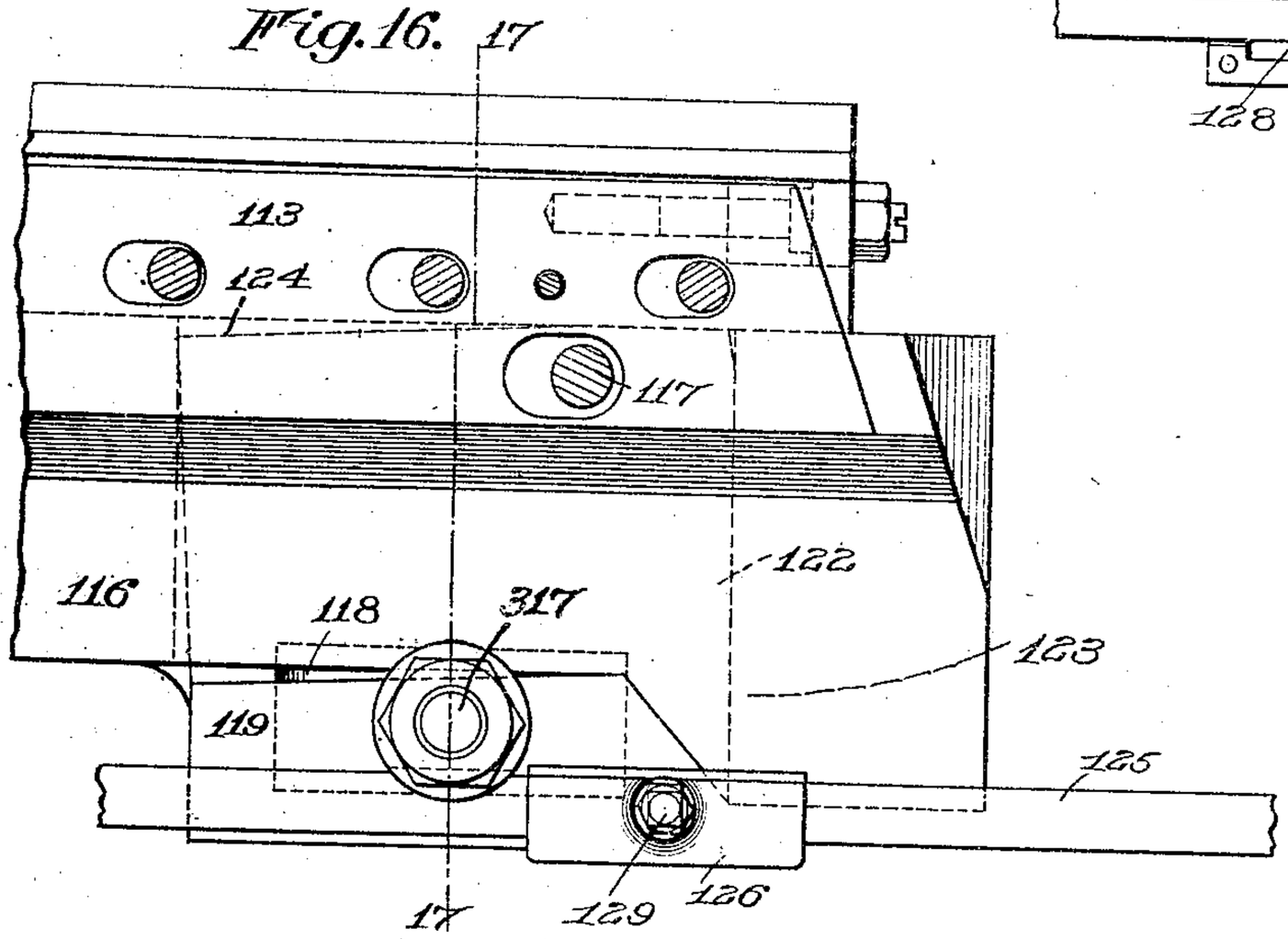


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Fig. 19.

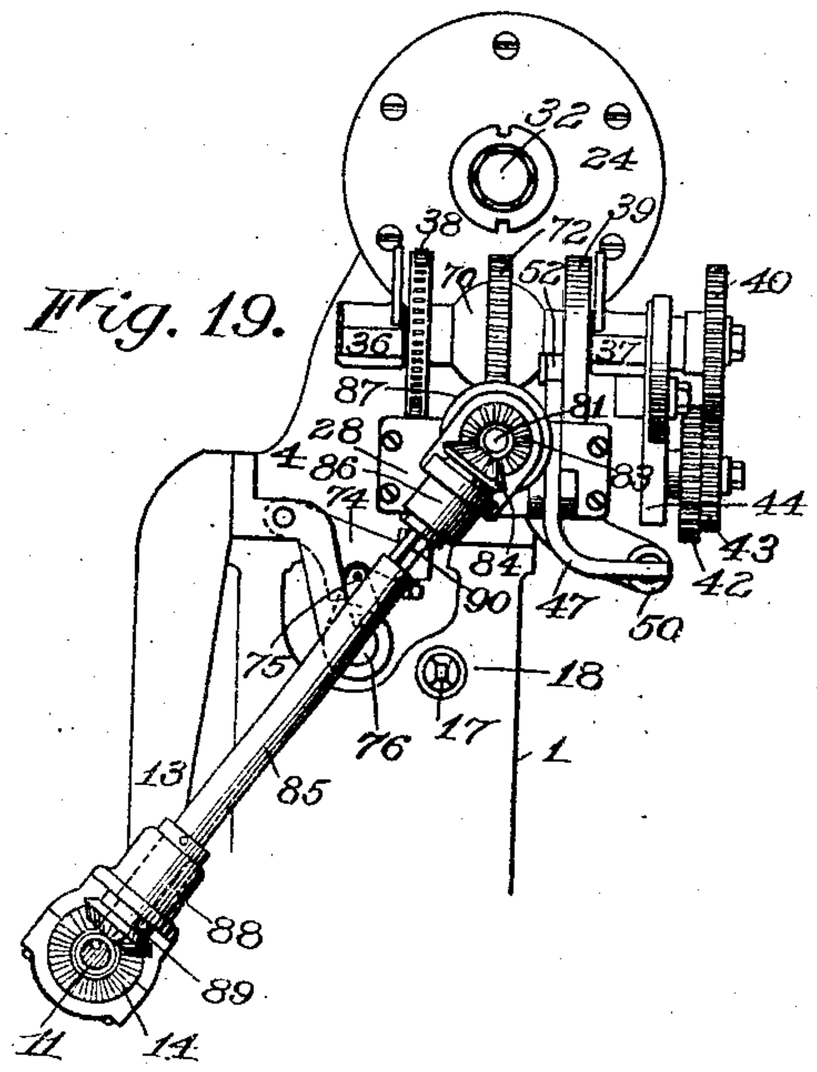


Fig. 22.

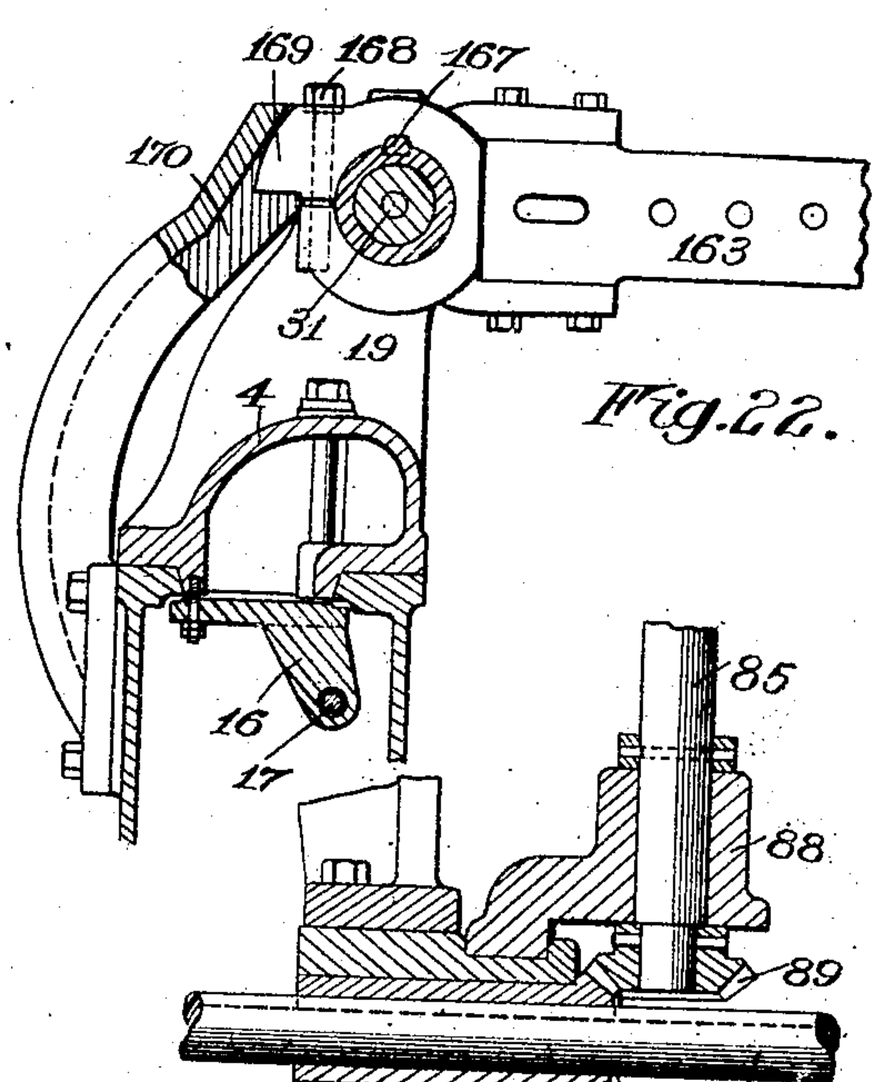
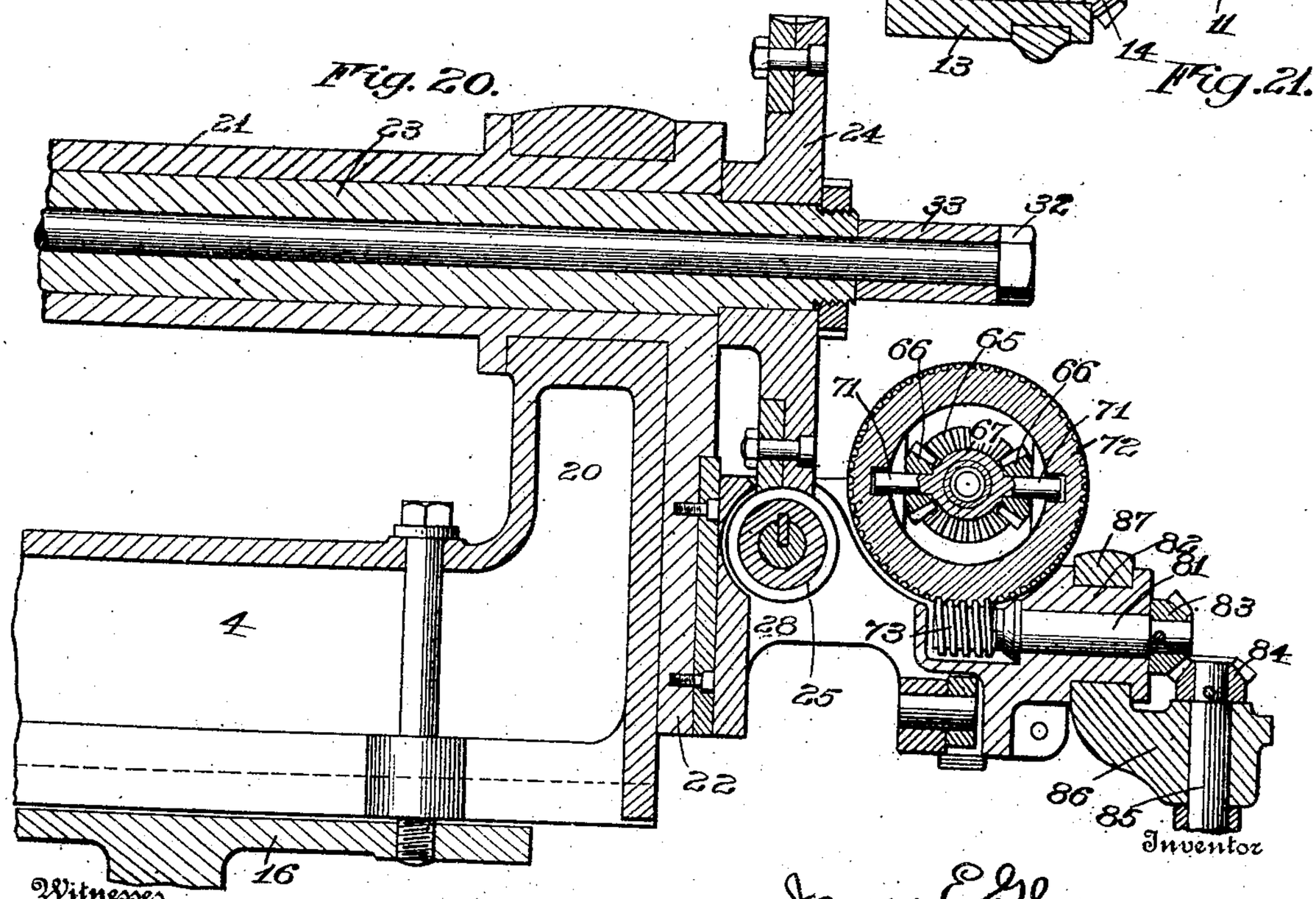


Fig. 21.

Fig. 20.



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UNITED STATES PATENT OFFICE.

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GEAR-GENERATING MACHINE.

950,766. Specification of Letters Patent. Patented Mar. 1, 1910.

Application filed January 5, 1907. Serial No. 351,014.

To all whom it may concern:

Be it known that I, JAMES E. GLEASON, of Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Gear-Generating Machines; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of the specification, and to the reference-numerals marked thereon.

My present invention relates to improvements in machines for generating the curves or working faces of gear teeth on the principles of evolution, and the object of the present invention is to provide a machine which is universally adjustable in order to accommodate bevel gears having pitch cones of varying angles, and wherein interchangeable devices may be readily applied to the machine which correspond to the angle of the pitch cone of the gear, and employing means for simultaneously operating the blank and the tools to generate the curves of the gear teeth thereon on the rolling principle, and furthermore, to provide improved devices for indexing the gear blank and for effecting the various adjustments and movements of the parts to carry the invention into effect, and to these and other ends the invention consists in certain improvements and combinations of parts, all as will be hereinafter more fully explained, the novel features being pointed out in the claims at the end of the specification.

In the drawings: Figure 1 is a plan view of a machine constructed in accordance with my present invention and adapted for generating bevel gears. Fig. 2 is a vertical section on the line 2—2 of Fig. 1 showing the tool guides and their coöperating parts on an enlarged scale. Fig. 3 represents a horizontal section on the line 3—3 of Fig. 2. Fig. 4 represents a vertical section on the line 4—4 of Fig. 1. Fig. 5 is an end elevation of a machine looking from the left in Fig. 1. Fig. 6 represents a vertical section on the line 6—6 of Fig. 1 showing the means for imparting the generating movements to the tool and gear blank. Fig. 7 represents a horizontal section on the line 7—7 of Fig. 6 showing the tool feeding devices. Fig. 8 is a view of the devices for feeding and swinging the tool as viewed from the right of Fig. 7. Fig. 9 represents a vertical section on the line 9—9 of Fig. 7. Fig. 10 represents a section on the line 10—10 of Fig. 7. Fig. 11 represents a section on the line 11—11 of Fig. 7 showing the actuating devices for setting the indexing mechanism into operation. Fig. 12 is a sectional view on the line 12—12 of Fig. 10 showing the cam for operating the indexing actuating devices. Fig. 13 represents a longitudinal section through the gear blank and its arbor, the indexing mechanism being shown detached therefrom. Fig. 14 represents a vertical section through the machine on the line 14—14 of Fig. 7. Fig. 15 is a detail view of one of the tool holders removed from its guide. Fig. 16 is a plan view of one of the tool holders with the top plate removed. Fig. 17 represents a transverse section of the tool holder on the line 17—17 of Fig. 16. Fig. 18 is a detail view of one of the friction devices for automatically swinging the tool clear of the work on the return stroke. Fig. 19 is an end elevation of the machine looking from the right of Fig. 1. Fig. 20 represents a vertical section on the line 20—20 of Fig. 1 showing the indexing devices. Fig. 21 is a sectional view through the gears connecting the indexing devices with their driving shaft. Fig. 22 represents a transverse section of a portion of the machine on the line 22—22 of Fig. 1. Fig. 23 represents a vertical section through a portion of the indexing mechanism on the line 23—23 of Fig. 1. Figs. 24 and 25 represent sections on the lines 24—24 and 25—25 respectively, of Fig. 23 and showing the devices for controlling the operation of the index mechanism. Fig. 26 is a view of the indexing mechanism in side elevation. Fig. 27 represents a section on the line 27—27 of Fig. 26, and Fig. 28 is a sectional view of a portion of the segmental gear supporting arm, and one of the interchangeable gears showing means for securing these parts in coöperative relation, and Fig. 29 represents a layout of the feed cam.

Similar reference numerals in the several figures indicate similar parts.

The object of the present invention is to provide a machine especially adapted for generating the curves or working faces of bevel gears having pitch cones of different angles, and it operates on the principle of a tooth of a crown gear coöperating with a bevel gear having a pitch surface corre-

sponding substantially with that of the gear to be generated, the working faces of the tools in the present instance corresponding to the opposing faces of two adjacent teeth of the crown gear, and operating to cut away the metal of the blank on curves or lines determined according to the movements of the tools while the latter and the pitch surface of the gear blank are moving at the same velocity. The generating movements of the tools and gear blank are controlled and proportioned in the present instance by a pair of coöperating gear members, one of the members being attached to the tool support and being in the form of a crown gear, and the other gear member being operatively connected to the gear blank and having a pitch cone corresponding in angle to that of the gear to be generated, a set of gear members of varying cone angles being adapted to be interchangeably fitted so that the machine may be set to generate gears having pitch cones of various angles.

The present invention provides improved means for mounting these interchangeable gears, and for connecting the tool and gear supports to effect the generating movements thereof, and also to provide improved operating mechanism for the tools whereby the strains during the cutting operations will be so balanced that a smooth and even cut may be obtained and excessive wear and breakage of the machine is avoided.

The present invention also provides improved means for effecting the generating movement of the tool and gear blank, and also embodies an improved indexing mechanism of the type shown and described in my Patent No. 842,455, dated January 29th, 1907.

The generating machine shown in the present instance comprises generally a suitable bed 1, having a turret 2 rotatably supported on the vertical journal 3 toward one end of the machine and adapted to support the operating tools and having horizontal ways extending radially of the axis of the turret on which is adjustably supported a gear carrier 4. The tools are carried by the turret and suitable means are employed for driving these tools at all positions of adjustment of the turret on its axis, a vertical shaft 15^2 being journaled, in the present instance, in the axis of the turret and connected by the bevel gears 5 and 6, to the main driving shaft 7, the latter extending horizontally through the bed of the machine, and is journaled in bearings 8, 9 and 10, the side shaft 11, which serves to operate the indexing device, being mounted in a relatively fixed bearing 12 on the bed and having a key slotted portion resting in a bearing 13 which is carried on the gear support 4 (see Fig. 21), this bearing last described having a pinion 14 rotatably journaled therein and having a key coöperating with the keyed portion of the shaft to provide a driving connection between these parts to permit relative longitudinal movement of the gear support relatively to this side shaft. The gear support is adjustable in the direction of the axis of the gear blank, and it is held firmly in position on its ways by means of a bracket 16 having a threaded portion adapted to coöperate with an adjusting screw 17, the latter being journaled in the bed at 18 and extending a sufficient distance to permit the application of a handle or crank by means of which the screw may be turned to adjust the distance of the gear blank relatively to the operating tools, so that the machine may accommodate gears of various diameters.

The gear blank support is provided with a pair of bearing standards 19 and 20 having a sleeve 21 journaled therein, the latter being provided with a radial arm 22 which serves to support the indexing mechanism, and within the sleeve is fitted a hollow shaft 23 having a worm wheel 24 mounted to turn therewith and coöperate with a worm 25 (see Fig. 20), this worm being mounted in bearings 26 and 27 on the bracket 28, and the latter is fixed to the arm 22 for supporting the indexing mechanism, so that the worm and worm wheel, when operated, serve to rotate the shaft 23 relatively to the sleeve 21, and under normal conditions they provide a positive lock for holding this shaft and sleeve in fixed relation. A tapered center 29 is fitted into the end of the shaft opposite to that carrying the worm wheel, and the threaded bolt 30 passing through the axis of the gear blank, and drawn up by the tightening rod 31, serves to lock the gear blank firmly to the shaft 23, as shown most clearly in Fig. 13, the tightening rod extending preferably through the shaft beyond the worm wheel and provided with a nut or similar portion 32 adapted for the application of a wrench by means of which this tightening rod may be rotated to lock and unlock the gear blank, sleeves or washers 33 of different lengths being interposed between this nut and the adjacent nut of the shaft to permit the insertion of centers of different sizes, the gear blank being locked between this center and the bolt 30, and the tapered center is locked by means of its tapered surfaces firmly to the shaft.

Indexing mechanism.—As will be hereinafter described, the sleeve 21 carrying the indexing mechanism and the shaft 23 swing simultaneously and in locked relation during the generating movements of the gear blank and the tools during the formation of the curves of each gear tooth, and the indexing of the blank is accomplished by rotating the shaft relatively to the sleeve. In the present instance the indexing mechanism is supported on the bracket 28, and the latter is,

as previously stated, bolted to the radial supporting arm 22 on the sleeve 21, and it embodies means tripped automatically to set the indexing devices into operation to bring the next tooth on the blank in operative position relatively to the tools, and to automatically interrupt the operation of these devices without undue shock, and to securely lock the gear blank during the operation of the tools thereon. This mechanism in the present instance comprises, generally, a pair of axially alined shafts 34 and 35 mounted, respectively, in the bearings 36 and 37 carried by the bracket 28, the shaft 34 carrying a notched stop wheel 38 and the shaft 35 carrying a stop wheel 39. The shaft 35 is adapted to be connected by change gears of any well known form such as the gear 40 on the shaft 35, the gear 41 on the shaft carrying the worm 25, and intermediate gears such as 42 and 43 carried on the arm 44 which are adjustable radially of the shaft 35, these gears being of various relative sizes, proportioned according to the number of teeth to be formed on the gear to be generated. The worm 25 is normally locked from rotation by means of a detent 45 mounted to operate vertically in a guide 46 on the bracket 28, and operation of the stop wheel 39 is gradually arrested without shock by means of a latch 47 pivoted at 48 and having an arm thereon arranged to coöperate with a spring-operated plunger 49, the latter being mounted in a casing 50 and provided with a helical spring 51 which normally operates to hold this latch in a position shown in full lines in Fig. 24, and to cooperate with a projection 52 on the stop wheel 39 and thereby lock the latter from retrograde movement, and this projection engages this spring-operated latch a moment before the bolt 45 enters its coöperating notch 45ª in the stop wheel, and the resistance offered by this spring-operated latch serves to offer a yielding resistance to the turning movement of the stop wheel, the latter at this time being disconnected from the driving devices, as will presently appear.

Mounted in coöperative relation with the notched wheel 38 is a detent 53, having a pair of projections 54 and 55 thereon, one in advance of the other, and spaced at a distance not quite equal to the distance between the notches on its coöperating stop wheel, and also having a pair of fingers 56 thereon adapted to engage the stop wheel at each side of the projections thereon, these fingers being arranged in advance of the projections previously described. This latch is pivotally mounted on an operating bolt 57 at a point 58, which is intermediate of the notch engaging projections 54 and 55. The bolt 57 serves to move this detent into coöperative relation with the stop wheel while the latter is operating in the direction indicated by the arrow (Fig. 25), and the rear projection 55 will first engage one of the projections on the stop wheel, and this will cause a tilting movement of the detent about its pivot that will bring the forward projection 54 into engagement with the next adjacent tooth, the fingers 56 engaging the wheel in advance of the projection 54, and in this way rotation of the stop wheel 38 is interrupted gradually, and without undue shock to the parts, and after the indexing movement of the blank has been completed, retraction of the bolt 57 will draw the detent away from the stop wheel, the fingers 56 engaging the wheel, and serving as fulcrums about which the detent pivots while the projection 54 is being disengaged from its coöperating projection or notch on the wheel by the spring 63.

The bolts 45 and 57 are connected for simultaneous movement by a lever or rocker arm 59, the latter being pivoted to a relatively fixed part of the bracket 28 at 60, and having a suitable connection with the two bolts, gear connections 61 and 62 being employed for this purpose in the present instance, and a spring 63 normally operates on the bolt 45 to move the latter into engagement with its coöperating stop 45ª of the stop wheel 39, and through the connection 59 between these bolts the bolt 57 will be normally held in retracted position with its detent disengaged from the stop wheel 38.

The proximate ends of the shafts 34 and 35 are provided with opposed bevel gears 64 and 65, and coöperating with these gears are a set of pinions 66, the latter being mounted on a gear frame or spider 67 having a hub journaled on bearing sleeves 68 and 69 threaded on the proximate ends of the two shafts, and journaled on these two shafts and inclosing the gear mechanism just described, is a casing 70 connected to turn with the gear spider by means of the arms 71 and having a worm wheel 72 arranged on its periphery, a worm 73 coöperating with this worm wheel and serving to impart a continuous rotary movement to the casing during operation of the machine. Normally, the operation of the casing 70 will rotate the gear spider 67, causing the pinions thereon to travel about the axis of the shaft, and in so doing, they will rotate the stop wheel 38 for the reason that the stop wheel 39 is positively locked by the bolt or stop 45 at all times excepting during the indexing operation, and consequently the gear 65 on the corresponding shaft will be stationary and a planetary movement of the pinions, coöperating with the gear 64 on the shaft that is unlocked, will cause rotation of the latter at doubled speed. At the moment the indexing operation commences the shaft 35 is unlocked by reason of the retraction of the bolt 45 from its coöperating notch 45ª in the stop

wheel 39, and by means of the lever connection 59, the bolt 57 will be simultaneously elevated to bring the detent 53 thereon into coöperative relation with the stop wheel 38 to interrupt its operation, and this will reverse the conditions previously prevailing; that is to say, the gear 64 on the shaft 34 will be locked from rotation while the gear 65 on the shaft 35 is unlocked, and the planetary movement of the pinions betwen these gears will cause operation of the shaft 35 to effect the indexing of the gear blank.

The indexing mechanism is preferably set into operation automatically after the tools have completed the generating movement and have been fully retracted from the gear blank, and this is accomplished in the present instance by means of a pivoted arm 74 having its inner end adapted to coöperate with the lower end of the bolt 57 to lift the latter, and this arm is arranged to be operated by means of a crank or cam 75, as shown in Fig. 19, the latter being mounted on an operating shaft 76 and having a keyed connection therewith to insure operation of the cam when this shaft is rotated, and to permit relative longitudinal movement between the cam and the shaft when the gear support is shifted on the bed of the machine. This shaft is suitably mounted in the bed of the machine and provided with a gear 77 coöperating with a similar gear 78 arranged on a pivoted crank 79, the latter being provided with an operating rod 80 which is adapted to be reciprocated by a suitably timed cam, that will be hereinafter described, to automatically control the operation of the indexing mechanism.

The worm 73 for operating the indexing mechanism is mounted on a shaft 81, and the latter in turn is journaled in a bearing 82 forming a part of the bracket 28, and this shaft is provided with a pinion 83 arranged to coöperate with a pinion 84 on a shaft 85, the latter being journaled at one end in a bearing bracket 86 having a bearing portion 87 mounted to swing about the axis of the shaft 81, so that the angular relation of the shafts 81 and 85 may be altered without disturbing the coöperative relation of the gears connecting them. The lower end of the shaft 85 is journaled in a similar bearing bracket 88 which is mounted to swing about the side shaft 11, and the shaft 35 is connected to the pinion 14 on the latter by means of a pinion 89 which is fixed thereto. In order to permit the indexing mechanism to swing about the shaft 23 as an axis during the generating movement, the shaft 85 is composed of two telescopic sections that will permit lengthening and shortening of the shaft and having a key 90 to provide a driving connection between them, and such a connection will maintain an operative driving connection between the side shaft and the indexing mechanism, although the worm shaft 81 alters its position about the shaft 23 as an axis, and such a connection avoids the necessity of employing clutches or other power connecting and disconnecting devices, as would otherwise be necessary. The shaft for the worm 25 is preferably provided with clutch members 91 and 92 for enabling this shaft to be disconnected from the indexing mechanism, and thus enable it to be rotated by means of a crank or other wrench to bring the gear blank, when the latter has been roughed out into register with the operating tools, without the necessity of disturbing the change gears, the threaded handle 93 serving to control the connections between these clutch members.

Operating tools.—The operating tools are supported on the turret, as previously described, and in the present instance a pair of tools is shown which are arranged to operate to simultaneously form both faces of a gear tooth, and the arrangement of these tools in the present embodiment is such that a balance is effected between the two tools to sustain and neutralize the thrust of the tools during the operation as well as during the generating movements, and this is generally preferable as it relieves excessive strains on the parts, and enables the generating movements to be accomplished at the expenditure of less power. The tools employed in the present instance are of a planer type and are mounted to reciprocate on a pair of tool guides 94 and 95, provided with the bearing lugs 96 and 97 respectively, by means of which they are mounted to turn about a common axis 98, the latter in the present instance being formed of a bearing sleeve over which these bearing lugs are fitted, and this sleeve is fitted into a standard 99 which extends upwardly from the turret, the sleeve being locked in position by means of the screws or bolts 100 coöperating with the washer 101. The tool guides are provided with tool holders which are duplicates mounted in reverse arrangement, and a description of one of these tool holders and its tool guide, will suffice for both. Each tool holder embodies a guiding portion 102 formed to fit and reciprocate longitudinally in a guiding slot 103 in the tool guide, and to the under side of this guiding portion is fastened a T-shaped block 104, adapted to fit into a T-shaped slot formed in a rack bar 105, the rack bars of the two tool holders being arranged to cooperate at opposite sides with an actuating pinion 106, mounted on an operating shaft 107, journaled in the bearing sleeve 98 and having an operating pinion 109 on its outer end and provided with a coöperating rack 110. Each rack bar is firmly locked to its corresponding tool holder by means of a headed bolt 111, the latter extending

through the guiding portion of the tool holder, and through the top plate 112 which is bolted to the guiding portion and rests on the upper surface of the tool guide, an adjustable wedge plate 113 being interposed between this top plate and the guiding portion of the tool holder in order to compensate for wear. The rack securing bolt 111 extends through a sleeve 114, the locking nut at the upper end of this bolt engaging the upper end of the sleeve, while its lower end clamps against the rack bar, serrations being preferably provided on these parts at 115 to insure a positive locking action that will prevent shifting of the rack bar after it has been adjusted. These rack bars of the respective tools are so set in relation to the pinion that when the latter is rotated to the limit of its movement in each direction, the tools will be in readiness to perform the cutting operation on the tool moving from opposite sides and in opposite directions.

The guiding portion of each tool holder has a portion 116 extending to the forward face of the tool guide, and in close proximity to the plane of operation of the tools, and it is provided with a tool clamping bolt 317, having a yoked portion 118 extending into a clapper block 119 which is closely fitted to the under side of the guiding portion 102 of the tool holder and the yoked portion of this bolt serves to draw the jaws 120 together and clamp the operating tool 121. A pivot bolt 117 serves as a center about which the clapper block turns, the latter being provided with a shoulder portion 122 adapted to coöperate with an abutment 123 of the tool holder when the latter is operating in one direction to hold the tool in cutting position, and being provided with a beveled portion 124 which permits a pivotal movement of the clapper block that will enable the tool to clear the work on the returning or non-working stroke. In order to avoid dulling of the tool, it is preferable that this pivotal movement of the tool should be accomplished automatically otherwise than by the engagement of the tool with the work, as has been the practice heretofore, and a device for accomplishing this result is shown in Figs. 16 and 18 embodying generally a friction rail 125 attached to each tool guide at 126 and the clapper block 119 has a housing 126 pivotally attached thereto by the pivot 127, this housing being fitted to reciprocate longitudinally on the friction rail as the tool is reciprocated. Within this housing are fitted friction plates 128 adapted to bear on opposite sides of the friction rail 125 and a yielding pressure between these friction plates and the friction rail is produced by means of a set screw 129 operating on a laterally-curved spring 130 having its ends arranged to coöperate with beveled surfaces 131 of the housing, and as these ends are spread against these beveled surfaces by means of the set screw 129, they will be forced against the upper friction plates and will thus compress them against the friction rail. The friction, of course, is present on both the feed and return strokes of the tools, and when the tool holder begins its feeding stroke, this friction device will operate on the clapper block to turn the tool about the pivot bolt 117 and thus bring it into operative position, and after the completion of the feed stroke, and at the beginning of the return stroke, this friction device serves to turn the clapper block in a reverse direction and thus move the tool clear of the work, so that dulling of the tool is thereby prevented.

The tool guides are adjustable, of course, to enable the tools to operate in paths corresponding to the root angle of the gear teeth to be generated, the adjustment, of course, occurring about the common axis so that the tools at all times will work toward the apex of the gear blank, and in order to facilitate the adjustment of these guides and to lock them in adjusted angular relation, a screw 132 is attached to the inner side of each tool guide, and these screws are connected by a turn buckle 133 which serves as a rigid connecting device between the tool guides, and also serves to shift these guides into the desired angular relation. The ends of the tool guides farthest separated are also fitted to a segmental connecting member 134, and they are locked thereto by means of the bolts 135, while the narrow ends of the tool guides are connected by a similar segmental member 136 having bolts 137 for locking the tool guides in fixed relation. The segmental member 136 is provided with a guiding rib 138 arranged to coöperate with a concentrically-formed guide 139 which constitutes a rigid portion of the turret, and the coöperative relation between this guide and the member 136 serves to insure operation of the tools in a given plane.

The tool-operating devices shown in the present instance embody a crank 140 mounted on a shaft 141, and the latter in turn is journaled in bearings 142 formed on a part of the turret, a gear 143 being fixed to this crank shaft and meshing with a ring gear 144 journaled on a portion of the standard 99 as a center, and coöperating with this ring gear is a pinion 145 fixed to a shaft 146, the latter in turn being provided with a pinion 147, which cooperates with a pinion 148 on the horizontal shaft 149, the latter being journaled in the turret and provided with a bevel gear 150 meshing with a coöperating pinion or gear 151 on the vertical shaft 152, the latter being mounted on an axis coincident with the axis of the turret.

The crank 140 connects directly with the

rack 110, the latter being held in coöperative relation with the pinion 109 by means of the housing 153 which is rotatable on the shaft 107, and in order to enable the throw of the tools to be adjusted, the crank is provided with a radial slot 154 to receive the crank pin 155, the latter being shifted in this slot by means of an adjusting screw 156, and this crank pin is attached to the rack 110 by means of the bearing sleeve 157 and the nut 158, continuous rotation of the crank in one direction obviously continuing to turn the rack 107 alternately in reverse directions, and the pinion 106 coöperating with the racks on the respective tool holder in like manner, serving to reciprocate the latter in reverse direction.

Generating mechanism.—The segmental member 134, which is locked to the widened ends of the tool guides, is provided with a rib 159 concentric with the axis of the turret and arranged in a plane parallel to the plane of movement thereof, and this rib is fitted into a correspondingly-grooved portion of the bracket 160, the latter being movable relatively to the tool guides and about the axis of the turret as a center for the purpose of permitting the feeding and retracting movement of the tools without disengaging the change gears, and it is held in operative position by a rest 262 guided in a slot 263 in the bed to permit adjustment of the rest corresponding to that of the turret, suitable means being employed for locking the rest in adjusted position. The bracket 160 is provided with a gear segment 162 which forms a section of a crown gear having the axis of adjustment of the tool guides as a center, and this gear segment of the gear sector is adapted to coöperate with another gear sector having a pitch cone corresponding in angle to the pitch cone of the gear to be generated, and being operatively connected to the gear blank. In the present instance these gear sectors last mentioned are interchangeably fitted to a segmental arm 163, the latter having a groove 164 formed at its inner circumference, and concentric with the axis of rotation of the turret, the ends of this arm being pivoted to turn about the axis of the gear blank; that is to say, one end is supported by a bearing 165 on an arm 166 extending upwardly from the left end of the machine as seen in Fig. 1, and its opposite end is fitted over the sleeve 21 which is concentric with the axis of the gear blank, as shown in Fig. 22, the sleeve 21 having a key or rib 167 adapted to cooperate with a corresponding key seat in the end of this arm and being split to enable it to be compressed and clamped rigidly on this sleeve by means of the bolt 168, a lug 169 on the segmental arm being provided to cooperate with a bracket 170, rigidly secured to the bed of the machine for the purpose of holding this end of the segmental arm against longitudinal movement on the sleeve 21.

From the above description it will be understood that the arm 163 carrying the appropriate gear sector 171 coöperating with the sector 162 forms an operative connection between the gear blank and the operating tools that will serve when the arm 163 is swung on its axis to insure an equal motion of the operating tools in their respective plane of operation, and the pitch surface of the gear blank so that these tools will generate the curve of the teeth according to the true principle, and in each instance the gear sector 171 will have its pitch surface forming a part of the pitch surface of the particular gear to be generated, or approximately so. These interchangeable gear sectors may be fitted to the arm 163 in any desired manner, the tightening means being shown in the present instance wherein each gear sector is provided with a rib 172 adapted to fit the correspondingly formed groove 164 of the segmental arm and having an aperture or slot 173 to receive a locking or clamping bolt 174, the latter passing through apertures or sleeves in the arm 163 and being locked or secured by a nut or other suitable means.

The generating movement is imparted to the arm 163 in the present instance by a pitman 175 pivotally attached at its upper end by a bracket 176 on the segmental arm and having its lower end connected to a crank pin 177, the latter being adjustably mounted in a radial slot 178 formed in a crank 179, an adjusting screw 190 being preferably employed for shifting the position of this pin 177, and thereby varying the travel of the segmental arm, while the crank swings through a fixed angle. This crank is pivoted to the bed at 191 and it is provided with a pin or projection 192 arranged to cooperate with an actuating cam 193, the latter being loosely fitted on a hub 194, and this hub being fixed to an operating shaft 195, the hub and cam being operatively connected, under normal conditions, by means of a bolt 196 fitted to operate radially in a portion of the cam and arranged to coöperate with a recess or notch 197 in the hub, a spring 198 serving to normally hold this pin in operative position to maintain the driving connection between the hub and cam, and a spring-operated detent 199 in the cam serving to hold the bolt 196 retracted, when it is desirable for any purpose to disconnect the generating mechanism from the remainder of the machine. The shaft 195 has a worm wheel 200 fixed thereon, and the worm 201 coöperating with this wheel serves to drive the shaft, the worm being provided with a gear 202, which in turn coöperates with a gear 203 on the main driving shaft

7, the cam 193 rotating continuously with the shaft 195 and having its periphery appropriately laid out so as to swing the arm 179 alternately downwardly, thence upwardly and finally bringing it to rest normally in the position shown in Fig. 6, the parts remaining in this position while the tools are being fed toward and away from the gear blank.

Tool feeding mechanism.—The mechanism for advancing and retracting the tools between the periods when the parts are swinging to generate the curve of the gear teeth, is preferably operated from the shaft 195 also, and this mechanism in the present instance embodies a cam 204 fixed to rotate with the shaft and provided with a cam groove 205 adapted to coöperate with a roller or projection 206 on the lever 207, the latter being pivoted on the bearing bracket 208 arranged on a relatively fixed part of the bed, and provided with a radial groove or slot 209 adapted to receive a cross head 210, an adjusting screw 211 being preferably provided for adjusting the position of the cross head in the slot 209, that is to say, in a direction radially of the axis of movement of the lever, and this cross head is provided with a pivot 212 having a block 213 pivotally mounted thereon, and this block in turn is fitted to operate in a groove 214 formed in a bracket 215 rigidly secured to the turret, the slot 214 extending radially of the axis of the turret. As the cam 204 rotates, it will turn the lever 207 about its axis, and by means of the cross head and the operating block just described, operating in the groove 214, it will serve to swing the carrier through an arc sufficient to feed the tools to the depth of the teeth and to retract them to clear the teeth, indexing of the blank occurring while the tools are retracted. In order to facilitate the adjustment of the tool supports so that the tools will operate in a plane corresponding to the different angles of the gears to be generated, it is preferable to provide a suitable adjusting device, the device shown in the present instance embodying a pinion 215ª arranged to coöperate with a concentric gear segment 216 formed on a part of the turret as shown in Fig. 5, the pinion being provided with a shaft 217 adapted to receive a crank or wrench to enable it to be readily turned after the locking bolts 218 have been loosened, the T-shaped portions or heads of these locking bolts coöperating with the T-shaped slot 219 formed in the periphery of the turret, and serving to lock the bracket 215 in fixed relation to the turret, and as this bracket remains in fixed relation with the lever 207, by reason of its connection therewith through the block 213, it will be obvious that the turret will be shifted while this bracket remains stationary, and after the turret has been brought to the proper position, the parts may be locked together by means of the bolts 218, so that the adjustment is effected without disturbing the adjustment of the tool feeding devices.

The rod 80 which serves to control the indexing mechanism is operated in the present instance by means of a part which turns with the shaft 195, this part embodying a projection 219 fixed in the hub of the worm wheel 200, and arranged to trip the pawl 220, the latter being mounted on a shaft 221 journaled in the bearing 222 and provided with a crank 223 having a pin connecting it to the rod 80, so that once in each revolution of the shaft 195, when the cam 204 is in such a position that the tools are fully retracted from the blank, and the cam 193 will be in a position to support the arm 179 in the central position, as shown in Fig. 6, the rod 80 will be operated to set the indexing mechanism into operation to rotate the blank until the next tool is brought into operative position relative to the tools.

Operation of the machine.—Fig. 29 represents a layout of the feed cam 204 beginning at the point where the tools are fed into the blank to the full depth of the tooth and held in this position while the generating movements are imparted to the tools and the gear blank to form the curves on the teeth thereof on the rolling principle, the retracting movement of the tools succeeding the generating movement, and after the tools have been fully retracted, the indexing devices are set into operation to automatically bring the next tooth into a position to be operated upon by the tools, the cycle of operations above outlined being performed during the formation of each gear tooth. The gear blank x is firmly locked to turn with the shaft 23 by means of the bolt 30 and the tightening member 31 as shown in Fig. 13, and the screw 17 is operated to shift the gear support 4 to bring the gear blank into a position where the apex of its cone is coincident with the vertical axis of the turret. The tools may be brought into proper coöperative relation with the blank after loosening the bolts 218 (see Figs. 5, 8 and 9), and then turning the shaft 217, the pinion 215 coöperating with the rack 216 on the turret serving to rotate the latter, until the tools are brought into the proper plane of rotation, the block 213 coöperating with the bracket 215 serving to hold the latter stationary relatively to the tool feeding devices, and the range of movement of the tools is adjusted by means of the clamping bolt 111 (Fig. 2) which controls the longitudinal adjustment of each rack bar 105, while the throw of the tools may be adjusted by means of the screw 156 (Fig. 3), which serves to shift the position of the crank pin 155 radially of the crank and

thereby vary the travel of the rack 110 which serves to operate the shaft 107 carrying the pinion 106, the latter coöperating with the racks on the tool holder. The travel of the tools and the blank during the generating movements may be varied by operation of the screw 190 (Fig. 6), as this serves to shift the crank pin 177 of the arm 175 radially relatively to the pivot pin 191 of the arm 179. The number of teeth to be formed on the gear may be varied according to the proportions of the change gears 40, 41, 42 and 43 and which are interposed between the worm shaft carrying the worm 25, and the shaft 35, the operation of the latter being controlled by the stop mechanism, and in cases where the blanks have been previously roughed out, the teeth thereon may be brought into register with the tools by loosening the handle 93 (see Fig. 27), and turning the shaft carrying the worm 25, as the latter coöperates directly with the worm wheel 24, and this wheel serves to rotate the gear blank relatively to the sleeve 31 (see Fig. 13.)

The main driving shaft 7 operates continuously, and it drives through the gearing shown, the vertical shaft 152 and the horizontal shaft 149 (Fig. 4), the pinions 147 and 148 between the latter shaft and the intermediate shaft 146, and the pinion 145 on the latter serving to rotate the ring gear 144 (Fig. 3), the latter coöperating with the gear 143 on the crank shaft 141 serves to operate the crank thereon imparting a reciprocating movement to the rack 110, and the latter coöperating with pinion 109 on the shaft 107 (see Fig. 4), causes rotation alternately in opposite directions of the pinion 106, and the latter coöperating with the racks 105 on the respective tool holders (see Fig. 2), causes the latter to be reciprocated simultaneously and in opposite directions on their respective guides, and the angular relation of the paths in which these tools operate, is adjusted by the turn buckle 133 on these guides, and it serves to adjust them about their common axis.

The indexing devices are driven from the side shaft 11, the latter operating the telescoping shaft 85 through the gear and connection shown, and the latter serving to rotate the worm shaft 81 continuously, a continuous motion being thus transmitted to the casing 70, but under normal conditions the parts will occupy the positions shown in Fig. 23, the bolt 45 coöperating with the notch 45[a] in the stop wheel 39 to prevent rotation of the shaft 35, and thus lock the gear blank from rotation, while the bolt 57 will ocupy such a position that the detent 53 thereon will rest clear of the wheel 38, permitting free rotation of the latter. The feed cam 204 and the cam 193 which imparts the generating movements to the tools and gear blank, are driven continuously from the shaft 195, and the latter in turn is operated by the worm wheel 200 thereon cooperating with the worm 201, the latter in turn being connected to the main shaft 7 by means of the gears 202 and 203, (see Figs. 8, 10 and 14).

After the gear blank has been properly located and firmly locked in place, and the adjustments above outlined have been effected, the first step in the cycle of operations is produced by the cam 204, which operating on the projections or rollers 206 and 206[a], will swing the lever 207 about its bearing or center 208, and through the cross head 210 and block 213, this swinging movement of the lever will be transmitted to the bracket 215, which is locked to the turret, the movement being in a direction to feed the tools into the blank to the full depth of the tool. At this point the feeding movement ceases and the cam 193 will be in a position to operate the arm 179 about its center 191, swinging it first upwardly from the central position shown in Fig. 6 until the tools have cleared the tooth on the blank, thence downwardly to a corresponding position, and finally returning it to the central position as shown in Fig. 6, a concentric portion of the cam 193 serving to support the arm in this position at all times except during the generating movement. The segmental arm 163 swings about the axis of the gear blank, as previously stated, and at the same speed therewith, the arm 175 forming a connection between it and the cam-operated arm 179, and through the change gear 171 thereon and the gear sector 162, a corresponding swinging movement is imparted to the tool guides, the latter swinging in a given plane about their common axis 98, and as the pitch surfaces of the gear teeth on the sectors 162 and 171 correspond to the pitch surface of an imaginary crown gear having a center coincident with that of the tool guides, and as the pitch surfaces of the change gear 171 has a pitch cone corresponding to that of the gear to be generated, a uniform speed of movement is imparted between the pitch surface of the gear to be formed and the tools, and as the two operating tools correspond to the opposing faces of two adjacent teeth on the crown gear, these tools will cut away the metal on lines or curves on the principle of a crown gear rolling on the pitch surface of the gear blank, the metal of the blank being removed by the proximate working faces of the tools and the tooth being defined by the metal untouched between these opposite faces of the tools after the feeding and generating movements have been performed.

After the arm 179 has returned to its central position as shown in Fig. 6, that is to say, after the completion of the generating

movement and after the tools have been retracted the projection 219 will engage the pawl 220 on the shaft 221, causing operation of the crank 223 which has a connection with the rod 80, and as the latter is reciprocated, the gears 77 and 78 will serve to impart a rocking movement to the shaft 76 and the latter through the cam or crank 75 thereon, will lift the arm 74 (see Fig. 19), and as the latter is lifted it will engage the bolt 57 as the latter is elevated, and before the detent 53 thereon engages the stop wheel 38, the lever 59 coöperating with the bolt 45, will serve to retract the latter from its cooperating notch 45ª in the stop wheel 39, sufficiently to permit the wall of the notch to engage the bevel in this bolt to throw it downwardly in position to the spring 63. This will release the stop wheel 39 and a moment later will cause the rear projection 55 on the detent 53 to engage one of the projections on the stop wheel 38, the impetus of the latter causing the latch to tilt on its axis 58, carrying the forward projection 54 thereon into engagement with the next adjacent tooth on the stop wheel, and at the same time the fingers 56 will rest in engagement therewith. The operation just described unlocks the shaft 35 and locks the shaft 34, the bevel gear 64 on the latter being held in fixed relation while the pinions 66 coöperating therewith are given a planetary movement from the continuously rotating casing 70, and as the bevel gear 65 on the shaft 35 at this time is free to rotate, these pinions will cause operation of the shaft 35, and through the change gears, movement will be imparted to the worm 25 and its coöperating worm wheel 24. The indexing mechanism, as previously stated, is fixed to an arm 22 on the sleeve 21, the latter being connected by the segmental arm 163 with the work supports, and while the worm wheel 24 and its coöperating worm 25 normally form a lock for retaining the gear blank, rotatable with the shaft 23, and the sleeve 21, in fixed relation during the generating movements, operation of this worm wheel and operating worm will serve to alter the relation between the gear blank and the sleeve 21 which is connected to swing with the tool guides, and in this way the blank is indexed, the teeth on the blank being brought into operative position relatively to the tools after the completion of the cycle of operations thereon. The notch 45ª in the stop wheel 39, when it returns to a position opposite to the bolt 45, will permit the latter to engage therewith under the action of the spring 63, so that operation of the stop wheel will be interrupted at the moment the tooth is properly centered or indexed, and the projection 52 on the stop wheel engaging the spring-pressed lever 47 serves to retard the speed of this stop wheel before the notch therein is engaged by the locking bolt or stop, so that the shock is minimized, and as this locking bolt operates to lock the stop wheel 39, the bolt 57 will be simultaneously retracted by means of the lever 59 connecting these bolts, the bolt 57 drawing the projection 54 of the detent out of engagement with its coöperating projection on the stop wheel 38, the fingers 56 of the detent serving as fulcrums to enable the spring 63 to perform this operation unassisted. This completes the cycle of operations of the index mechanism as the wheel 38 is free to revolve and the stop wheel 39 is locked so that the gear blank is held in fixed relation to the operating tools during feeding and generating movements.

I claim as my invention:

1. In a bevel gear generating machine, the combination with a suitable support for the gear blank, of a pair of tool guides mounted to swing about a common axis and having operating tools thereon adapted to coöperate with the blank to form the teeth thereon, a gear segment carried with the tool guides, devices for effecting the adjustment of the gear segment and the guides to correspond to the pitch cone of the gear to be formed, a bevel gear segment operatively connected to the gear blank to turn therewith and coöperating with the gear segment connected to the tool guides, said bevel gear segment having a pitch cone corresponding to that of the gear to be formed, and suitable means for imparting swinging movements to the blank and tool guides about their respective axes.

2. In a bevel gear generating machine, the combination with a suitable support for rotatably centering a gear blank on its axis, of a pair of tool guides mounted to swing about a common axis, and having tools mounted thereon adapted to coöperate with the gear blank, a bracket connecting said guides for locking them in fixed angular relation, a crown gear segment carried by said bracket, devices for effecting the adjustment of the gear segment and the guides to correspond to the pitch cone of the gear to be formed; an arm operatively connected to the gear blank, a bevel gear segment thereon having a pitch cone corresponding to that of the gear to be generated and coöperating with the crown gear segment, devices for effecting the adjustment of the bevel gear segment on the arm in order to permit it to coöperate with the crown gear segment and means for swinging the gear blank and tool guides on their respective axes.

3. In a machine for generating bevel gears, the combination with a turret mounted on a vertical axis, and a tool guide mounted on a horizontal axis on the turret and carrying an operating tool, of a support for rotatably centering a gear blank, an arm operatively connected to the gear blank and

mounted to swing about the axis of the gear blank and having a portion concentric with the axis of the turret, a gear segment operatively connected to the tool guide, devices for effecting the adjustment of the gear segment and the tool guide to correspond with the pitch cone of the gear to be formed; an interchangeable bevel gear segment attached to the concentric portion of said arm and having a pitch cone corresponding to that of the gear to be generated, devices permitting the positioning of the bevel gear segment on the arm in order to permit the bevel gear segment to correspond with the adjusted position of the gear segment and operating means for swinging said arm on its axis for generating the curves of the gear teeth.

4. In a machine for generating bevel gears, the combination with a turret mounted on a vertical axis, and a tool guide mounted on a horizontal axis on the turret and carrying an operating tool, of a support for rotatably centering a gear blank, an arm operatively connected to the gear blank and mounted to swing about the axis of the gear blank and having a portion concentric with the axis of the turret, a gear segment operatively connected to the tool guide, devices for effecting the adjustment of the gear segment and the tool guide to correspond with the pitch cone of the gear to be formed; means for interchangeably securing bevel gear segments on the concentric portion of said arm having pitch cones corresponding to those of the gears to be generated and devices permitting the positioning of the bevel gear segment on the arm in order to permit the bevel gear segment to coöperate with the gear segment.

5. In a machine for generating bevel gears, the combination with a turret mounted on a vertical axis, a tool guide mounted on a horizontal axis on the turret, and a suitable support for rotatably centering a gear blank on its axis, of an arm operatively connected to the gear blank and mounted to swing about the axis of the latter, a portion of said arm being formed concentrically with the axis of the turret, a gear segment operatively connected to the tool guide, devices for effecting the adjustment of the gear segment and the tool guide to correspond with the pitch cone of the gear to be formed a bevel gear coöperating therewith having a pitch cone corresponding to that of the gear to be generated, and a coöperating rib and groove on the said arm and bevel gear segment for interchangeably locking them.

6. In a machine for generating bevel gears, the combination with a turret adjustable on a vertical axis, a tool guide mounted thereon on a horizontal axis, and a suitable support for centering a gear blank on its axis, of an arm operatively connected to the gear blank and mounted to swing about the axis thereof, a portion of said arm being provided with a groove concentric with the axis of the turret, a bevel gear segment having a pitch cone corresponding with that of the gear to be generated and having a rib adapted to coöperate with the groove of said arm, means for detachably securing said bevel gear segment to said arm, a gear segment operatively connected to the tool guide and coöperating with the bevel gear segment on said arm, and devices for effecting the adjustment of the gear segment and the tool guide to correspond with the pitch cone of the gear to be formed.

7. In a machine for generating bevel gears, the combination with a suitable support for rotatably centering a gear blank on its axis, a rotatable turret adjustable about an axis at right angles to the axis of the rotary support to accommodate gears having pitch cones of different angles, and a tool guide pivotally mounted on the turret, of a gear segment operatively connected to the tool guide to move with said guide about the pivot of the latter, and a beveled gear segment connected to the blank support to turn with the latter, meshing with the gear segment and having a pitch cone corresponding with that of the gear to be generated.

8. In a machine for generating bevel gears, the combination with a suitable support for rotatably centering a gear blank on its axis, a rotatable turret adjustable to accommodate gears having pitch cones of different angles, and a tool guide pivotally mounted on the turret and carrying an operating tool, of an arm operatively connected to the gear blank and mounted to swing about the axis thereof, devices arranged between the said arm and the tool guide for insuring equal speed of movement between the tool and the pitch surface of the gear blank during the generating movements, means for periodically feeding and retracting the tool relatively to the blank, and means for effecting the generating movements of the tool and gear blank embodying a pivoted operating arm, a rotary cam coöperating with said arm to hold the latter in a central position during the feeding and retracting movements of the tool and to periodically swing it to each side of the central position and return it thereto, and an operative connection between the cam-operated arm and the arm connected to the gear blank.

9. In a machine for generating bevel gears, the combination with a bed, a pivoted tool guide thereon carrying an operating tool, mechanism for operating the tool, a suitable support for rotatably centering a gear blank on its axis, and coöperating gears arranged between the tool guide and gear blank for insuring equal speed of movement of the tool and the pitch surface of the gear blank, of a bracket fixed to the bed having a cam-

operating shaft journaled therein, a cam on said shaft having an operative connection with the tool guide and the gear blank for swinging them on their respective axes, and a device for locking and unlocking the cam and its operating shaft controlled by the tool operating mechanism.

10. In a machine for generating bevel gears, the combination with a bed, a tool guide pivoted thereon carrying the operating tool, a suitable support for rotatably centering a gear blank on its axis, an arm arranged to turn with the gear blank and operative connections between the same arm and the tool guide for swinging the latter and the gear blank on their respective axes to generate the curves of the gear teeth, of means for effecting the generating movements of the tool and gear blank embodying an arm pivoted on the bed and having an operative connection with the arm first mentioned, a bracket fixed to the bed, a cam shaft journaled therein, and a suitable cam on said shaft coöperating with said arm to hold it normally in a central position, to periodically swing it alternately in opposite directions from the central position and return it to the latter position.

11. In a machine for generating bevel gears, the combination with a bed, a turret pivoted on a vertical axis thereon, a tool guide mounted on a horizontal axis on the turret, a suitable support for rotatably centering a gear blank on its axis, an arm mounted to swing with the gear blank and about the axis of the latter, and devices operatively connecting the said arm and the tool guide at different angular positions of the turret about its axis for insuring uniform swinging movement of the gear blank and tool guide on their respective axes, of means for feeding the tools and imparting generating movements to the latter and the gear blank embodying a bracket secured to the bed, a cam shaft journaled therein and having feed and generating cams thereon, and devices operated by said cams and connected respectively to the turret and said arm.

12. In a bevel gear forming machine, the combination with a bed, a suitable support for the gear blank, and a turret pivoted on the bed and angularly adjustable to accommodate gears having pitch cones of different angles, a tool guide mounted to turn on the turret and carrying an operating tool, and a rack on the bed concentric with the axis of the turret, of an operating cam mounted on a relatively fixed part of the bed, turret operating devices coöperating therewith, and a device connecting said devices and the turret embodying a bracket having a pinion thereon coöperating with the rack on the bed for turning the turret thereon, and devices coöperating with the turret for locking the said bracket in fixed relation thereto.

13. In a bevel gear forming machine, the combination with a bed, a suitable support for the gear blank, and a turret pivoted on the bed and angularly adjustable to accommodate gears having pitch cones of different angles, a tool guide on the turret for the operating tool and a rack on the bed concentric with the axis of the turret, of means for feeding and retracting the tool relatively to the gear blank embodying a main operating shaft journaled in the bed, a bracket fixed at one side of the bed, a cam shaft journaled in said bracket and operatively connected to the main shaft, a cam on the cam shaft, an arm pivoted on said bracket and having a projection coöperating with said cam, a bracket having means for locking it to the turret and operatively connected to said pivoted arm, and means carried by said bracket for adjusting the turret relatively thereto.

14. In a gear cutting machine, the combination with a suitable tool guide, and a support for rotatably centering a gear blank in coöperative relation with the tool, of indexing mechanism embodying a pair of stop wheels, one of the latter being operatively connected to the gear blank and the other notched and normally freely revoluble, a continuously operating driving device normally acting on the stop wheels, a stop for locking the wheel connected to the gear blank during the cutting operation of the tool, a stop for the other stop wheel, and means for moving the last mentioned stop into engagement with its stop wheel and the other out of engagement with its stop wheel after each cutting operation of the tool.

15. In a gear cutting machine, the combination with a suitable tool guide, and a support for rotatably centering a gear blank in coöperative relation with the tool, of indexing mechanism embodying a pair of stop wheels, one of the latter being operatively connected to the gear blank and the other notched and normally freely revoluble, a continuously operating driving device normally acting on the stop wheels, a stop for locking the wheel connected to the gear blank during the cutting operation of the tool, a reciprocatory bolt, a detent pivoted thereon in the plane of rotation of the freely revoluble stop wheel having projections thereon arranged to cooperate with the notches thereon, and fulcrums on the detent in advance of the projections, a device for simultaneously engaging said detent and disengaging the stop relatively to their respective stop wheels, and vice versa, and a spring normally acting to withdraw said detent and engage said stop relatively to their respective stop wheels.

16. In a machine for generating bevel

gears, the combination with a suitable support for rotatably centering a gear blank, of a turret adjustable to accommodate gears having different pitch cones, a pair of pivoted tool guides having reciprocatory tool holders thereon, means for locking said guides in fixed angular relation, coöperating guiding portions concentric with the pivot of the tool guides and arranged between the latter and the turret for insuring operation of the tools in a given plane, and devices for imparting generating movements to the tool guides and the gear blank on their respective axes.

17. In a machine of the class described, the combination with a suitable work support, of a pivoted tool guide having a tool holder mounted to reciprocate thereon, a driving shaft mounted coincident with the axis of the tool guide, a pinion on said shaft, a rack on the tool holder coöperating with said pinion, and means for rotating said shaft alternately in opposite directions, comprising a crank, a second rack connected to the crank and a pinion with which this last mentioned rack meshes, connected to the driving shaft.

18. In a machine of the class described, the combination with a suitable work support, of a pivoted tool guide having a tool holder mounted to reciprocate thereon, a shaft mounted coincident with the axis of said guide, means for rotating said shaft alternately in opposite directions, a pinion on said shaft, a rack having a T-slot therein, a sleeve carried by the tool holder having one end arranged to coöperate with the rack, and a bolt fitting said sleeve having a nut at one end coöperating with an end of the sleeve and having a head at the other end coöperating with the slot in said rack.

19. In a machine of the class described, the combination with a suitable work support, of a tool guide having a tool holder mounted to reciprocate thereon, a shaft having pinions thereon, a rack carried by the tool holder and coöperating with one of said pinions, a crank having a crank-pin adjustable radially thereof, and a second rack bar connected to said crank-pin and coöperating with a second pinion for said shaft for rotating the latter alternately in reverse directions.

20. In a machine for generating bevel gears, the combination with a suitable support for rotatably centering a gear blank on its axis, of a pivoted tool guide having a tool holder adapted to position a tool relatively to the gear blank, a tool operating shaft mounted coincident with the axis of the tool guide and operatively connected to the tool holder thereon, a pinion on said shaft, a crank shaft mounted parallel to the axis of the tool guide and provided with a crank, a rack connected to the crank-pin of said crank and coöperating with the pinion on the tool operating shaft, a gear on said crank shaft, a coöperating driving gear mounted on an axis coincident with that of the tool operating shaft, and means for driving the last mentioned gear.

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Witnesses:
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