

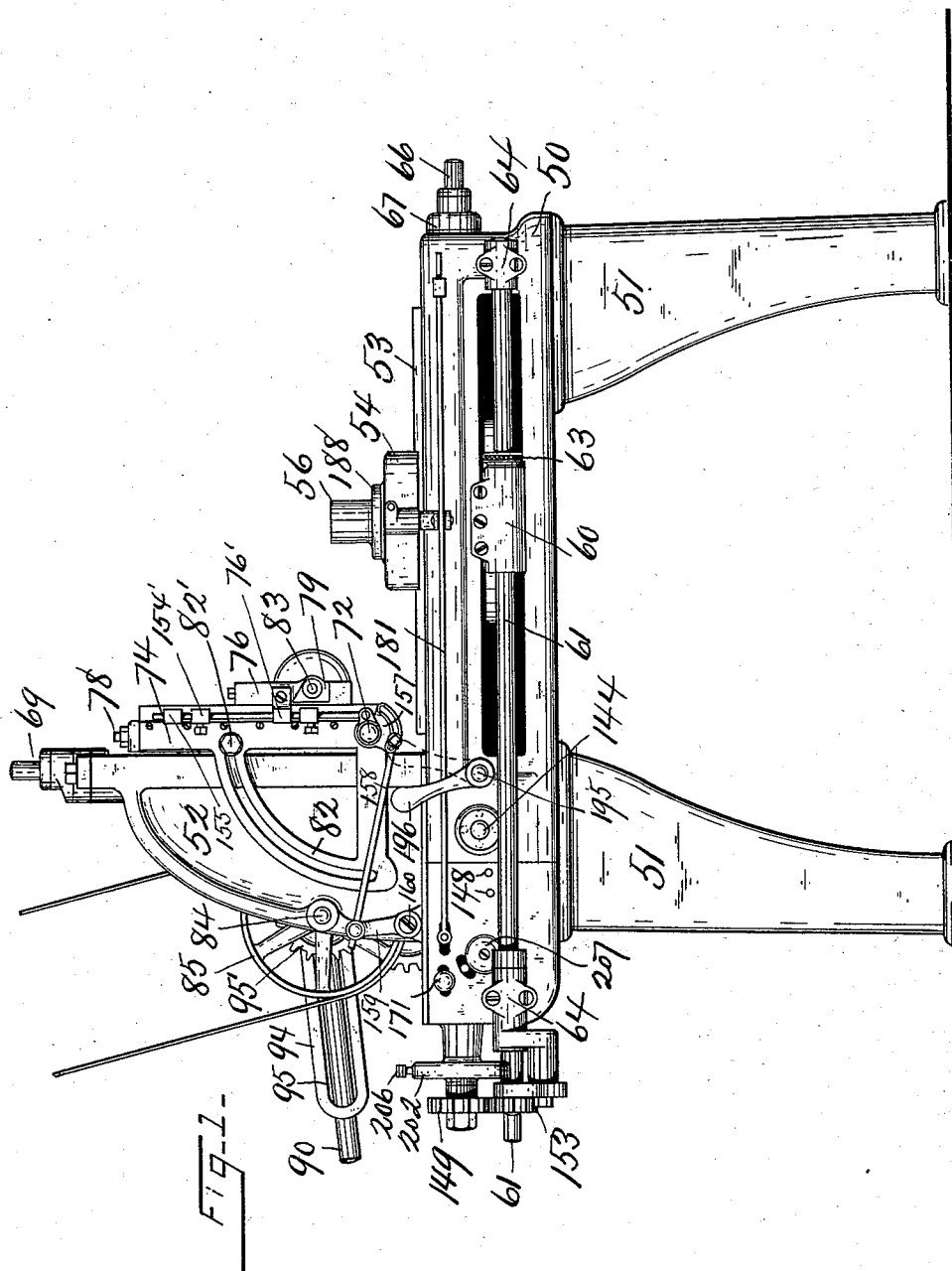
(No Model.)

10 Sheets—Sheet 1.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



Witnesses  
*August L. Luther.*  
*Allan Terry.*

Inventor  
*Lucius E. Whiton.*  
By Attorney  
*Frank H. Allen.*

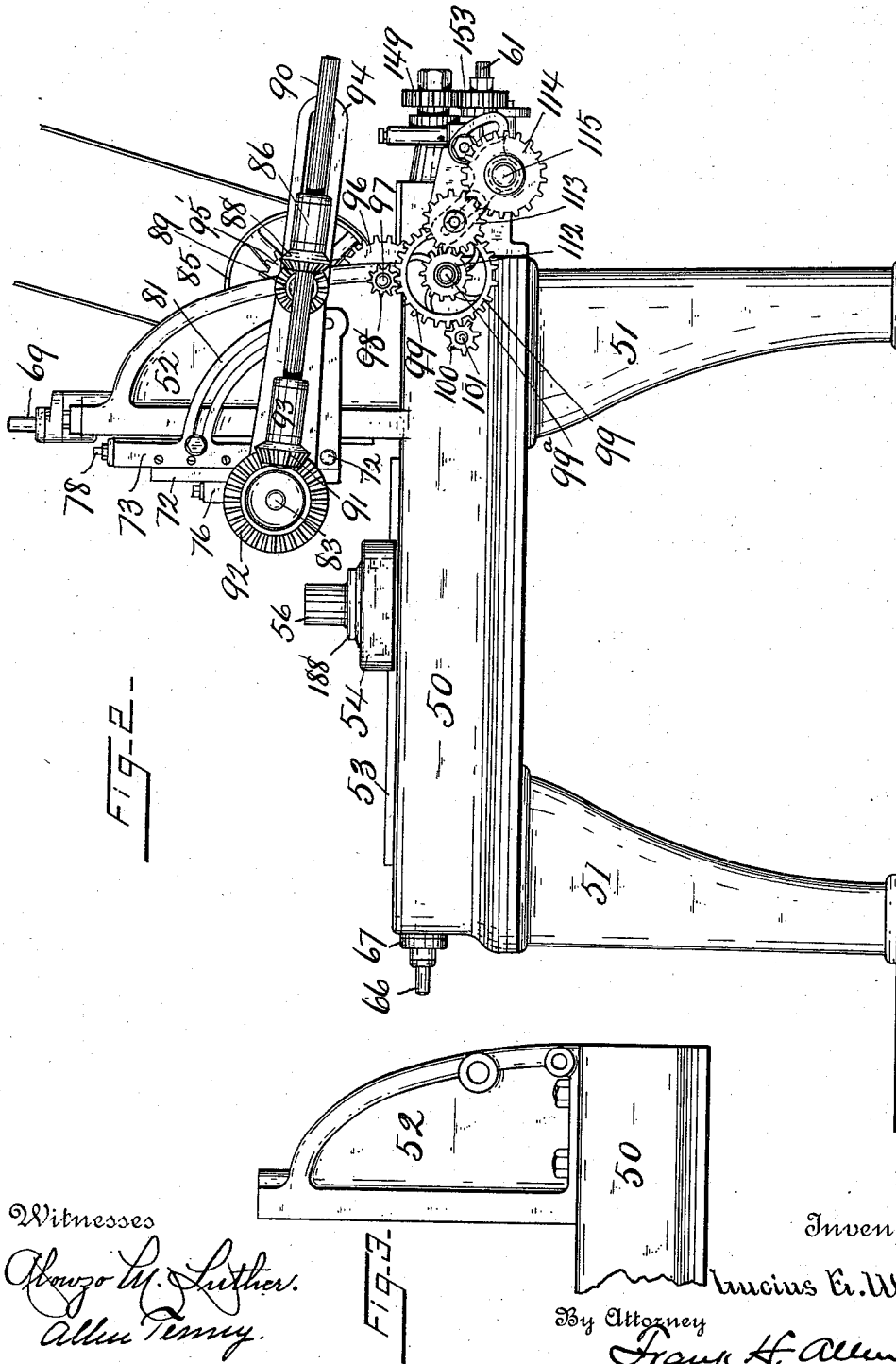
(No Model.)

10 Sheets—Sheet 2.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



Witnesses  
*George W. Luther.*  
*Allen Tenny.*

Inventor  
*Lucius E. Whiton*  
By Attorney  
*Frank H. Allen*

(No Model.)

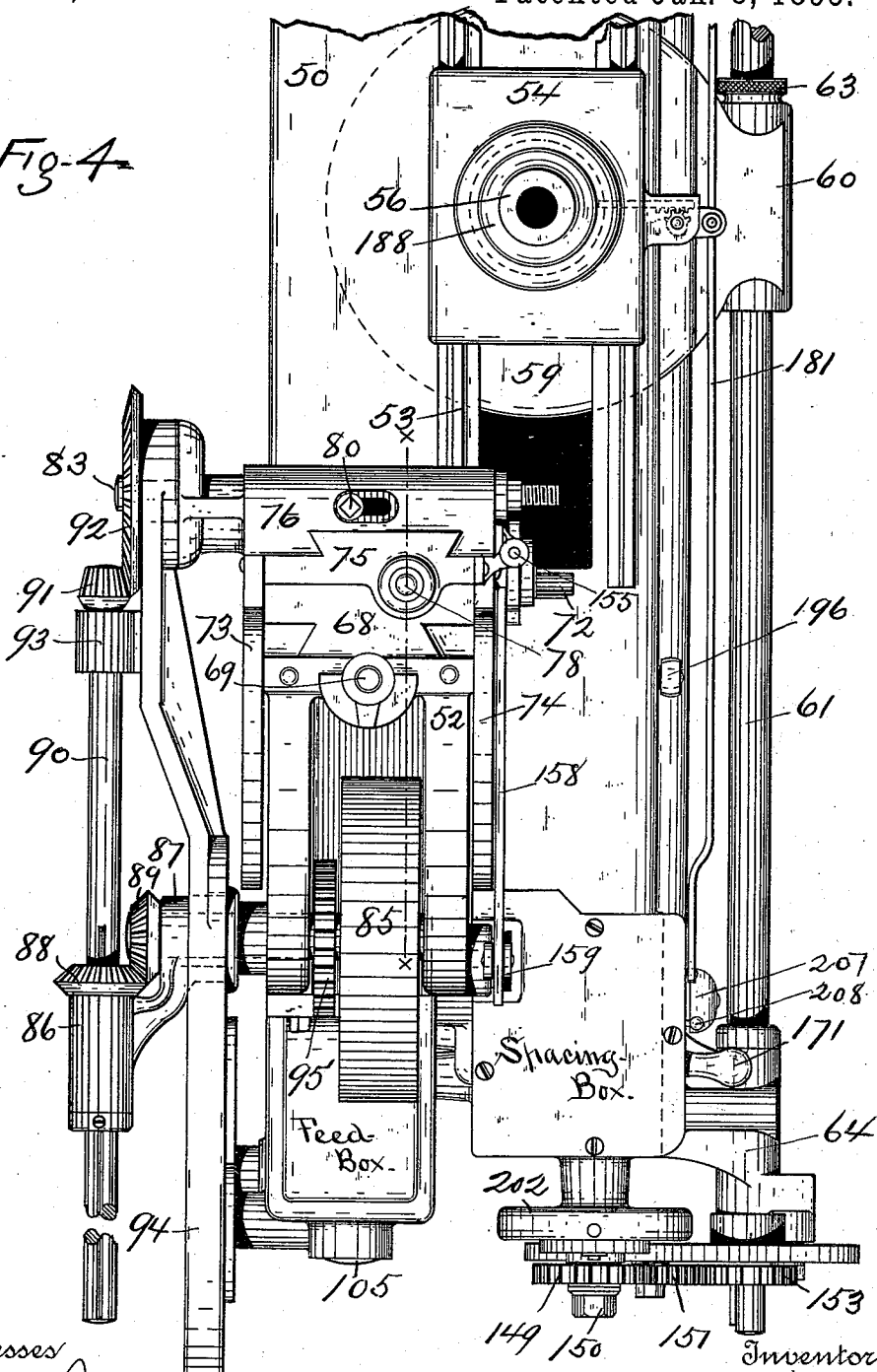
10 Sheets—Sheet 3.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.

Fig. 4



Witnesses

Alvanzo M. Luther.  
Allen Tenny.

Inventor.

Lucius E. Whiton.

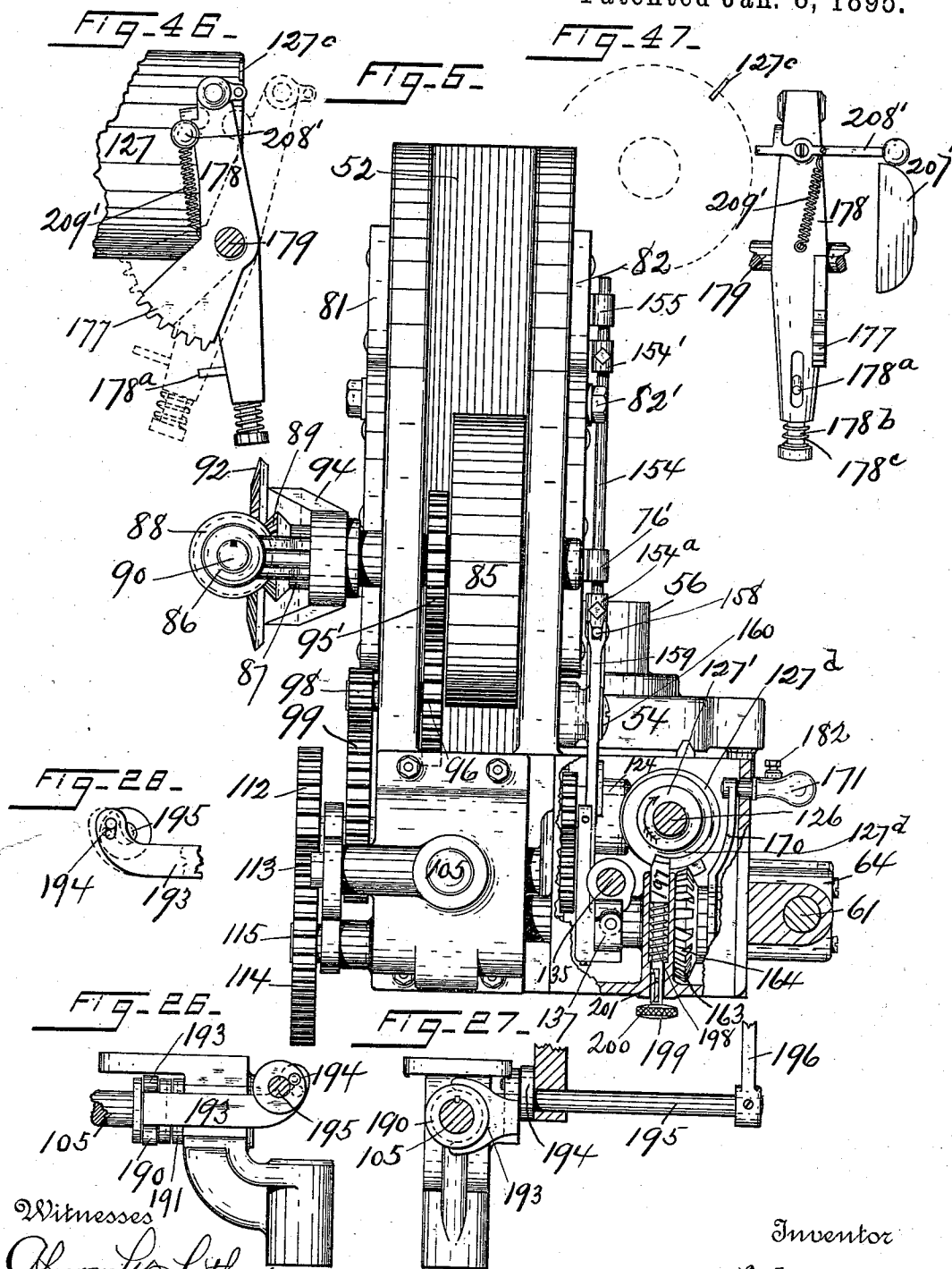
By Attorneys

Frank H. Allen.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



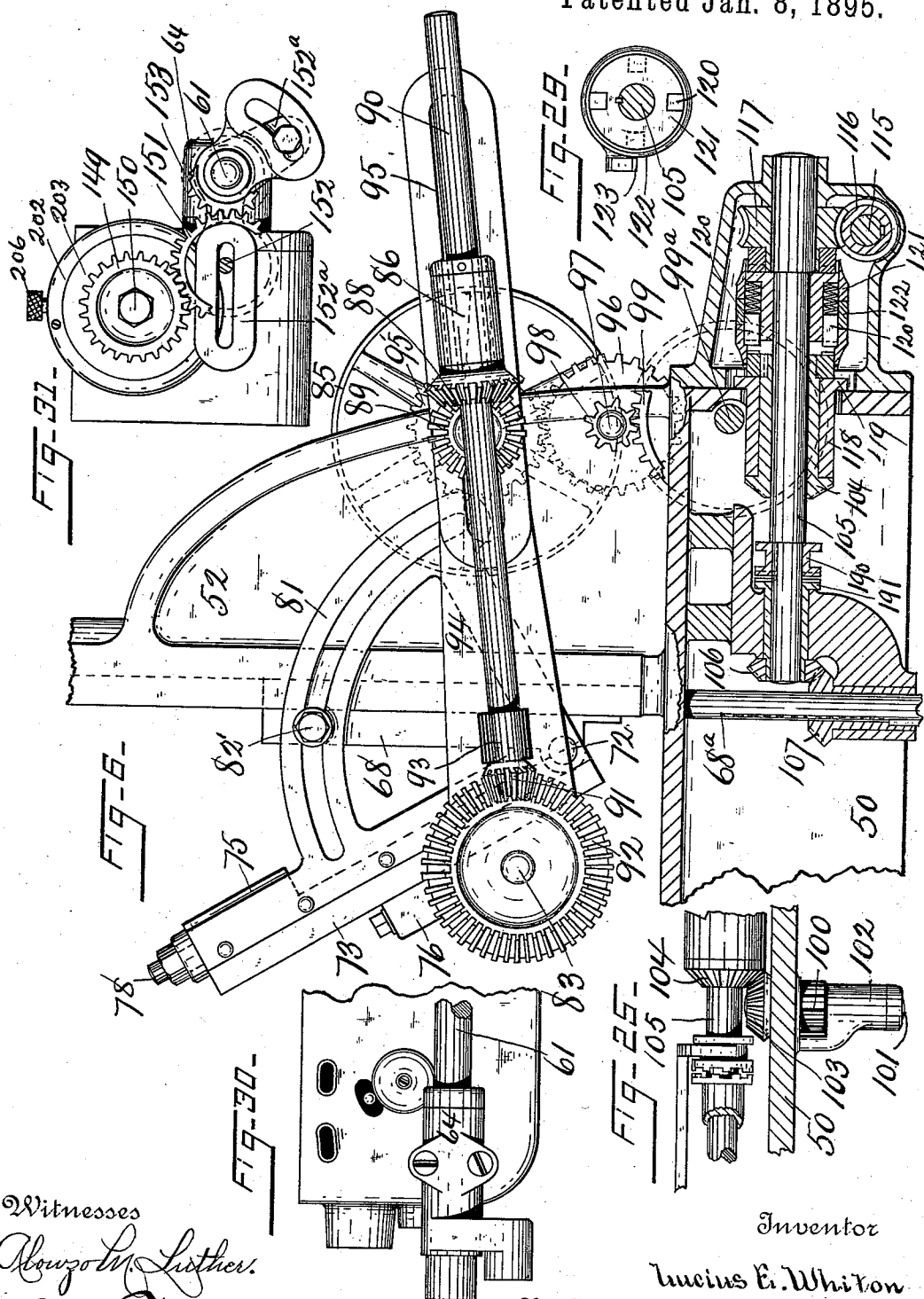
Witnesses  
Hugo L. Luther.  
Allen Lemmy.

Inventor  
Lucius E. Whiton.  
By Attorney  
Frank H. Allen

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



Witnesses  
Houzo L. Luther.  
Allen Tenny.

Inventor

Lucius E. Whiton

By Attorney

Francis H. Allen.

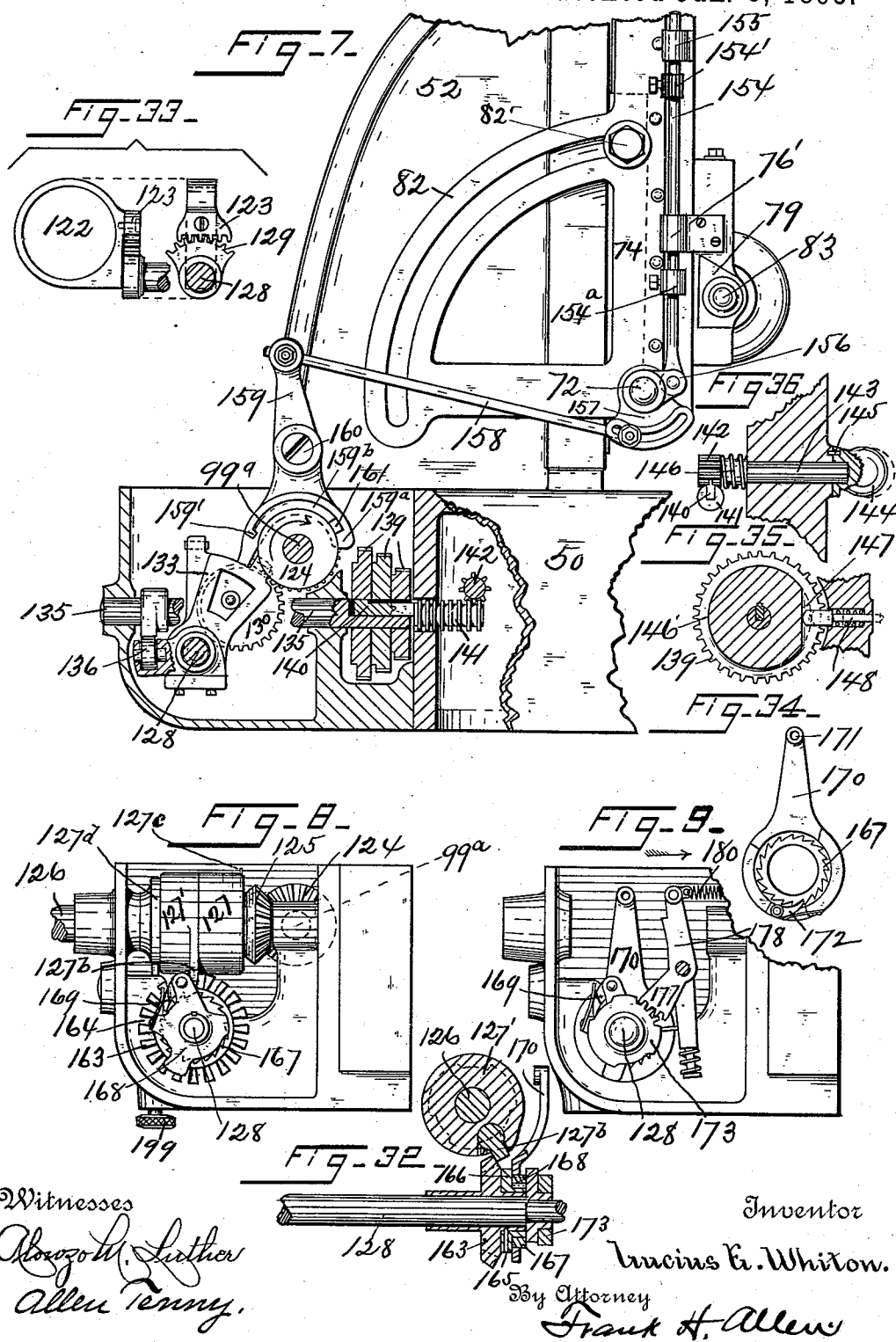
(No Model.)

10 Sheets—Sheet 6.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



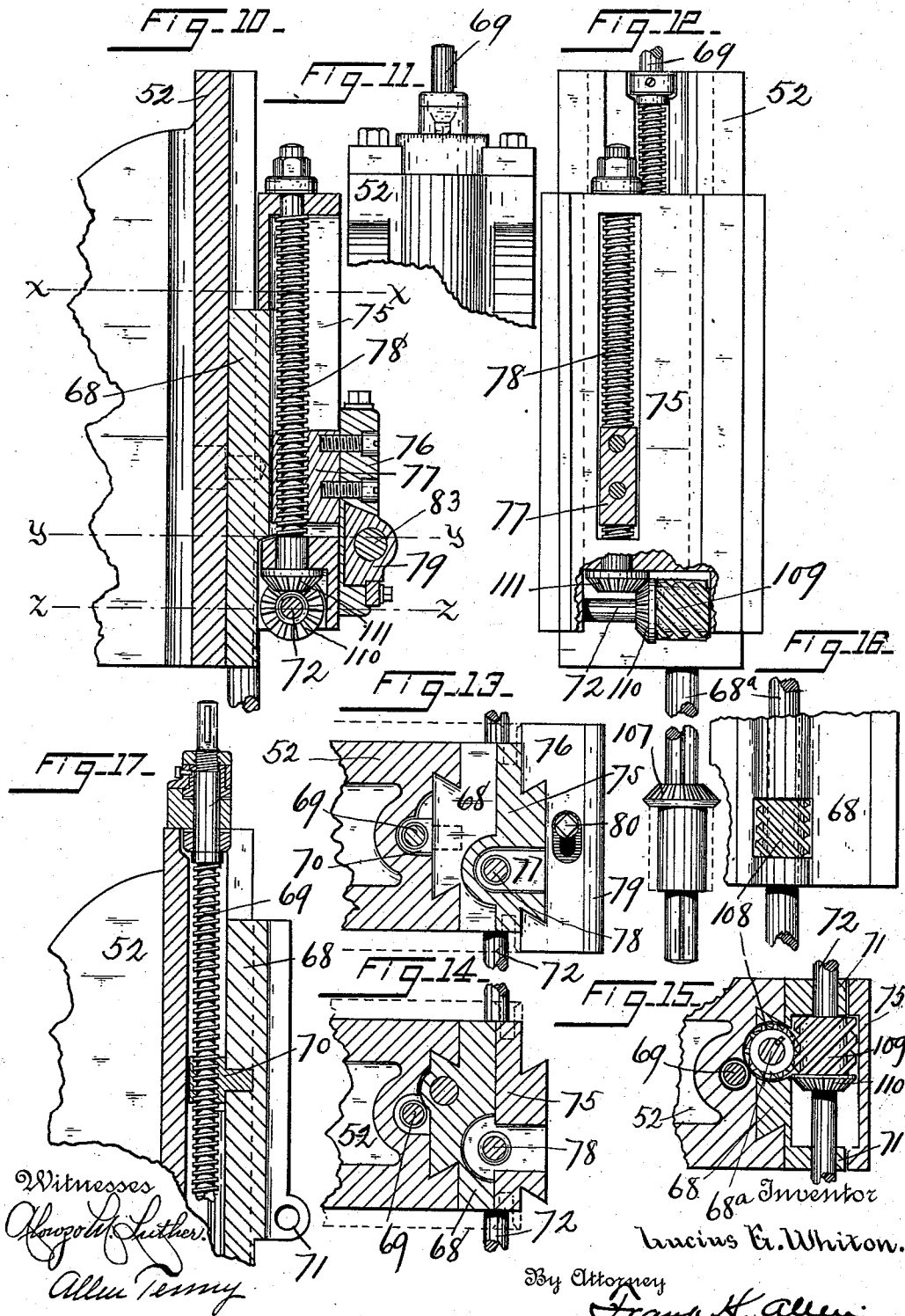
(No Model.)

10 Sheets—Sheet 7.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



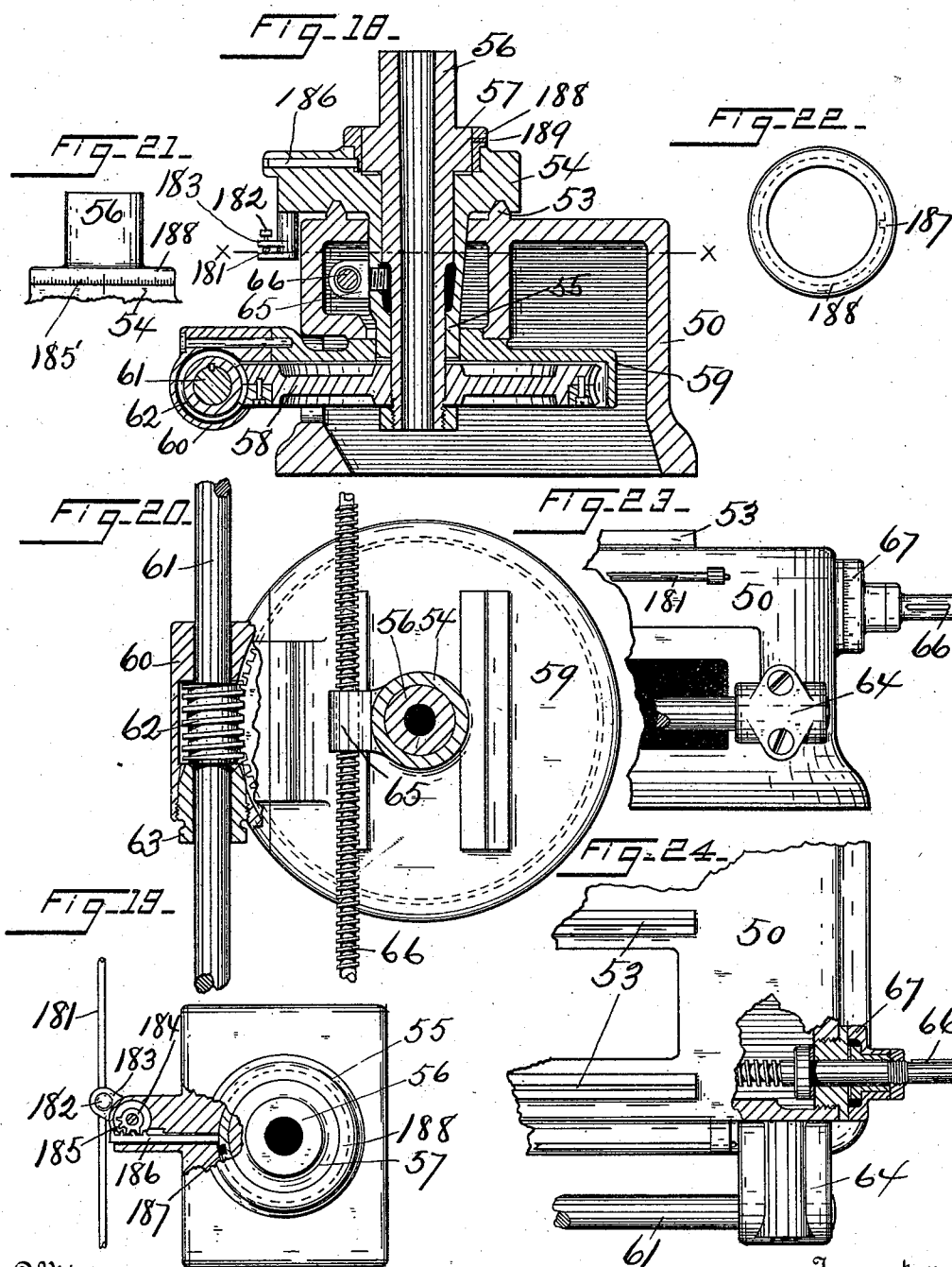
(No Model.)

10 Sheets—Sheet 8.

L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



Witnesses  
*Horatio M. Luther.*  
*Allen Tenny.*

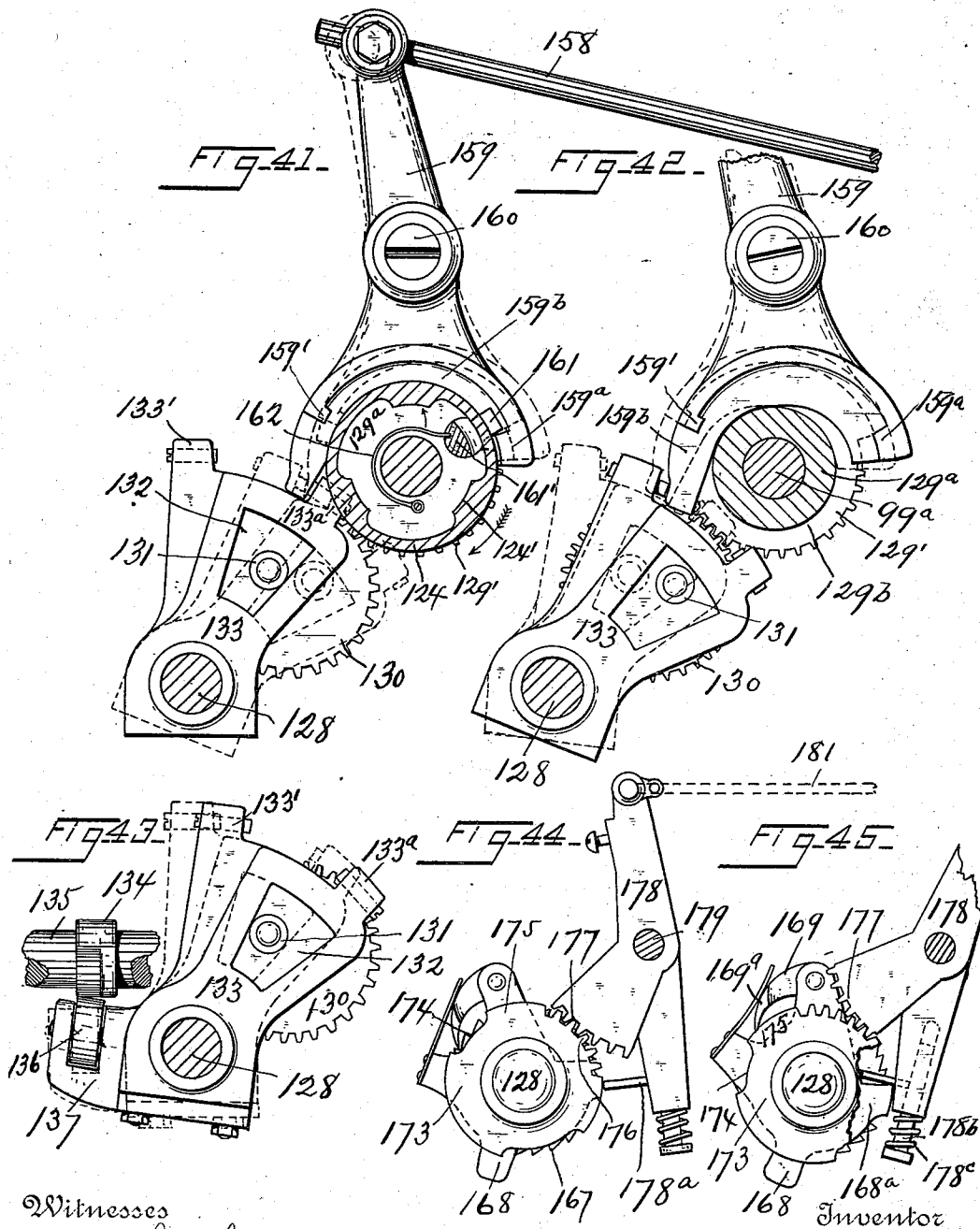
Inventor  
*Lucius E. Whiton.*  
By Attorney  
*Frank H. Allen*



L. E. WHITON.  
GEAR CUTTING MACHINE.

No. 532,127.

Patented Jan. 8, 1895.



Witnesses

*Oliver D. Luther.*  
*Allen Tenny.*

L. E. Whiton.

By Attorney

*Frank H. Allen.*

# UNITED STATES PATENT OFFICE.

LUCIUS E. WHITON, OF NEW LONDON, CONNECTICUT.

## GEAR-CUTTING MACHINE.

SPECIFICATION forming part of Letters Patent No. 532,127, dated January 8, 1895.

Application filed February 28, 1894. Serial No. 501,864. (No model.)

*To all whom it may concern:*

Be it known that I, LUCIUS E. WHITON, a citizen of the United States, residing in the city and county of New London and State of Connecticut, have invented certain new and useful Improvements in Gear-Cutting Machinery, which improvements are fully set forth and described in the following specification, reference being had to the accompanying sheets of drawings.

My immediate object is to produce a gear cutter which will be entirely automatic, whose various movements shall be so timed, relatively to each other, that the greatest possible economy of time shall result and which will cut, with equal facility, spur or bevel gears, yet, notwithstanding the variety and range of work performed, the mechanisms employed are not complex.

A particularly valuable feature of my gear cutting machine should be noted in the fact that its various movements not only follow each other, automatically, in practical and proper sequence but that each of said movements is controlled, and dependent upon, the completion of the next preceding movement so that the failure of either of the several elementary mechanisms to work properly will serve to prevent the starting and operation of all the succeeding mechanisms, thus avoiding all chance of mutilated blanks or otherwise spoiled work.

A further important object of my invention is to provide a machine in which the several mechanisms are all positively driven, thus eliminating the danger of imperfect action resulting from the use of frictional devices, and avoiding the constant waste of power entailed by such devices as well as the necessity of careful and frequent adjustment.

To explain my invention most clearly I have provided the annexed drawings, in which—

Figure 1 is a front side elevation of a gear cutting machine embodying my invention and Fig. 2 is a rear side elevation of the same. In these views the head 52 (upon which are mounted the carriages that support the cutter-shaft) is an integral part of the machine-bed but in Fig. 3 said head is shown as cast separately and bolted to the bed. Fig. 4 is a plan view of said gear cutter and Fig. 5 an end elevation of the same with the machine-

legs removed. This figure also shows broken away the casing of what I term a "spacing box," which box contains the mechanism that controls and actuates the spacing of the gear teeth. Fig. 6 is a rear side elevation of the head that supports the cutter shaft carriages and also illustrates in section a portion of the bed and of an extension of said bed which I term the "feed box," in which box is located the mechanism that controls the traversing movements of the cutter. Fig. 7 is a front side elevation of said head and has also a sectional view of the spacing box, illustrating particularly the mechanism by means of which the downward feed of the cutter shaft is arrested and the return feed set in operation. Figs. 8 and 9 are views taken within said spacing box and described in detail hereinafter. Fig. 10 is a vertical, sectional, view of the head 52 taken on line  $x-x$  of Fig. 4, disclosing the feed-screw which moves the carriages that support the cutter shaft. Fig. 11 is an elevation of the upper portion of the head 52, as viewed from the left hand end of Fig. 1, showing the projecting end of a screw-shaft that may be rotated (by means of a suitable wrench) to raise or lower the initial carriage of the train of carriages that support the cutter shaft, and Fig. 12 is an elevation of the head 52 as viewed from the right hand side of Fig. 1, showing mounted thereon said initial carriage and also the next of the train. Figs. 13, 14 and 15 are, respectively, cross-sectional views on lines  $x-x$ ,  $y-y$  and  $z-z$  of Fig. 10 (the carriage 76 being removed in Fig. 14), and Fig. 16 is an elevation of a portion of the rear (inner) side of carriage 68 illustrating the manner in which said carriage is chambered to receive and support a spiral gear 108 mounted upon a vertical shaft that controls the cutter-feed. Fig. 17 is a view of a portion of head 52 similar to that shown in Fig. 10, illustrating a screw (for hand use) by means of which the initial carriage and its various supports may be raised or lowered independently of the automatic feeding devices. Fig. 18 is a cross-sectional view of the machine bed having mounted thereon the revoluble spindle that supports the gear-blank during the operation of cutting and also illustrating worm-gear and shaft connections for revolving said blank-support-

ing spindle. Fig. 19 is a detached plan view of said revolving spindle and of the carriage upon which it is mounted. Fig. 20 is a plan view of the revolving blank support, its worm and worm-shaft and also of a screw-shaft by means of which said blank support may be adjusted upon the machine bed within the limits of its ways. Fig. 21 is a side elevation of the upper portion of the hollow blank-supporting spindle and Fig. 22 is a plan of a ring secured to said spindle for a purpose hereinafter explained. Fig. 23 shows a portion of the right hand end of the machine bed of Fig. 1, and Fig. 24 is a plan of substantially the same parts. Fig. 25 shows a cross section of a portion of the rear side of the machine bed having connected therewith certain elements of the mechanism that drives the cutter-shaft. Figs. 26 and 27 are side and end views of a clutch shifting mechanism that may be operated by hand to stop the cutter-feed shaft and Fig. 28 is a detached view of an eccentric and an arm operating therewith forming parts of said clutch-shifting mechanism. Fig. 29 is an end view of the clutch section (121) that controls the cutter-feeding devices and also shows an encircling ring that is used to shunt said clutch section into and out of operative engagement with its companion section. Fig. 30 is an enlarged view of the front face of the "spacing box" which is, in effect, an extension of the bed 50, and Fig. 31 is a similar view of the rear face of said "spacing box." Fig. 32 is a view of a cross-shaft 128 located in the "spacing box" and having mounted thereon certain devices for releasing at stated times the mechanism that partially revolves the blank supporting spindle to "space" for the next tooth. Fig. 33 illustrates, by end and edge views, the clutch-operating ring referred to in Fig. 29 and also a rocking segment used to shunt said ring. Fig. 34 is a detached view of the pawl 170 and ratchet 167 of Fig. 9. Fig. 35 shows, detached, one of the gears (139) and a telltale which extends outward, through the wall of bed 50 to indicate the positions of the said gears relatively to the spline that locks them to the cam shaft. Fig. 36 illustrates certain mechanism provided to shift said spline in its seat to lock either of the gears to the cam shaft. Figs. 37 and 38 are face and sectional views of a graduated disk or index used in connection with the blank spacing mechanism, and Fig. 39 is a plan view of the clamping device of the said index. Fig. 40 shows, detached from their bearings and other supports, several of the most important shafts and their connections. Figs. 41, 42 and 43 illustrate a certain escapement that "times" and controls the cutter-feeding mechanism, and Figs. 44 and 45 illustrate certain mechanism for automatically stopping the machine upon the completion of a gear. Figs. 46 and 47 show side and front elevations of the upper end of the lever-arm 178 showing the bell-hammer 208 pivoted thereto.

In the drawings 50 indicates the bed of my

gear cutting machine, 51 its supporting legs and 52 an upwardly extending head located at one end of bed 50 and, preferably, formed integral therewith as in Fig. 2, although it may be cast separately and bolted to the bed, as in Fig. 3. The upper portion of bed 50 is formed with parallel ways 53 upon which is mounted to slide a carriage 54 (shown on a larger scale in Figs. 18 and 19); said carriage having a downwardly extending shell 55 which is bored to receive a hollow spindle 56. Said spindle is held against endwise movement in one direction by an annular enlargement 57 seated in the counter-bored carriage 54 and in the opposite (upward) direction by a worm gear 58 whose hub abuts the lower end of the shell 55. Gear 58 is secured to and rotates with the spindle 56. Secured to the lower end of said shell is a shield 59 having a lateral extension 60 that is bored to receive a shaft 61 and counterbored to provide a chamber in which is located a worm 62 that meshes with gear 58 and, under certain conditions, is brought into service to partially rotate the worm gear.

63 denotes a thimble or bushing screwed into the otherwise open end of the extension 60 forming an abutment for one end of worm 62 which latter is splined upon shaft 61 and is free to slide thereon. Shaft 61 is located at what I consider the front side of the machine, being the side at which the operative naturally stands and is journaled in bearings 64 bolted to bed 50.

Referring now particularly to Figs. 18 and 20, it will be seen that the shell 55 has screwed to it a threaded bracket 65 within which is mounted a screw 66 journaled in the machine bed 50 having one end projecting beyond said bed as in Figs. 1, 2, 23 and 24. This projecting end is shaped to receive a wrench or, if preferred, may be provided with a hand wheel by means of which the screw 66 may be rotated to move the connected shell 55, carriage 54 and the blank-supporting spindle 56, along the ways 53. Screw 66 as here shown has no connection with the various automatic mechanisms of my machine but, *per contra*, is operated only by hand whenever it may be necessary to vary the position of the spindle 56, relatively to the cutter, to accommodate gear-blanks of greater or lesser diameter. The exposed end of screw 66 has secured to it a collar 67 that is graduated, as shown in Fig. 23, so that partial revolutions of said screw may be accurately made to vary the depth of the teeth of the gears, by slightly moving the blank toward or away from the cutter.

Referring now to Figs. 1, 2, 4, 5, 6, and 10 to 17 it will be seen that the face of the head 52 is formed with dove-tail ways in which a carriage 68 may slide and I also provide in connection with said carriage a screw 69 that is journaled in head 52 and engages a threaded bracket 70 extending laterally from carriage 68 as best seen in Figs. 13 and 17. The

lower front portion of carriage 68 is formed with perforated ears 71 in which is journaled a short shaft 72 whose ends project like trunnions and support frames 73 and 74 that are bolted, or otherwise secured to the sides of a plate 75, which latter is thus hinged to carriage 68 and adapted to be swung on the shaft 72 to vary the inclination of plate 75 relatively to the head 52 and bed 50, as seen in Fig. 6. The exposed face of plate 75 is formed with ways upon which a carriage 76 is fitted to slide, said carriage being provided with a threaded extension 77 that is engaged and controlled by a screw-shaft 78 journaled in the plate 75 at top and bottom of the latter. The carriage 76 is formed with transverse ways in which is fitted a carriage 79 that may thus be adjusted, a limited distance, in a direction at a right angle to the movement of its supporting carriage 76. This transverse carriage may be firmly clamped, after adjustment, by means of a set screw 80 that projects outward through a slot in carriage 76. (See Fig. 13.) The hinged frames 73 and 74 are each formed with slotted arc-shaped extensions 81—82 that pass rearward alongside the carriage 68 and head 52, when the plate 75 and its attachments are swung to a vertical position, as in Fig. 7. By means of screws 82', located in the slots of extensions 81—82 and tapped into carriage 68, the plate 75 may be firmly clamped at any inclination within the limits of the arc-shaped slots.

Journaled in the transversely adjustable carriage 79 is a shaft 83 one of whose ends projects sufficiently to receive a suitable mill or cutter for use in cutting the gear teeth. This projecting end is shown most clearly in Fig. 4 but it is thought unnecessary to show a cutter attached thereto. Said cutter, when secured upon shaft 83, should register perfectly with the center of the mandrel opening in the spindle 56 and should there be any variation it may be quickly corrected by easing back the set screw 80 and sliding the carriage 79 in its ways until the desired adjustment is attained.

I will now proceed to describe the mechanism which revolves the shaft 83 and the cutter mounted thereon. In the rear portion of the side walls of head 52 is journaled a shaft 84 which constitutes the prime mover of my machine and which bears a pulley 85 that may be driven from any convenient counter-shaft. Upon the rear end of shaft 84 is a bracket arm drilled to provide two journal bearings 86 and 87 that are at a right angle to each other. One of said bearings 86 supports a bevel gear 88 and the companion bearing 87 is mounted upon the projecting end of shaft 84, just inside a bevel gear 89 that may thus mesh with the gear 88 and drive the latter when the shaft 84 is in revolution. Within the bevel gear 88 is a shaft 90 that is splined to slide longitudinally therein and which bears upon one end a small bevel gear 91 that meshes with a larger gear 92 secured to the

end of the cutter-shaft 83 in such manner that, when the initial shaft 84 is started, rotary motion is imparted to the cutter shaft, as will be best understood by reference to Fig. 4 of the drawings. The end of shaft 90 nearest gear 91 is supported in a journal bearing 93 secured to an arm 94 whose adjacent end is swiveled on the movable carriage 76. The other end of said arm 94 extends parallel with shaft 90 and is slotted, as at 95, to straddle the shaft 84. This manner of supporting said arm permits free endwise movement and also holds it and the shaft 90 parallel.

Whenever it is necessary to vary the inclination of the plate 75 to cut bevel or miter gears, the splined shaft 90 and its supporting arm 94 readily adjust themselves to such changes as also to all changes of position of cutter carriage 76, yet the several gears of the train always remain in mesh.

I will now describe the mechanism employed to feed the cutter and its supports downward by a slow and regular movement to cut a tooth, and then upward by a "quick return" movement to its point of starting, calling particular attention to Figs. 2, 4, 5 and 6. Fixed upon the initial shaft 84, between the side walls of head 52, is a gear 95' that meshes with and drives a like gear 96 on a shaft 97 that is also journaled in said side walls. Upon the projecting end of shaft 97, at the rear side of the machine, is a small spur gear 98 that meshes with and drives a larger gear 99 which, in turn, drives a small gear 100 on a short shaft 101 journaled in the rear wall of bed 50 and in a bracket 102 secured to said bed. (See Fig. 25) This short shaft bears upon its inner end, inside the machine bed, a bevel gear 103 that drives a similar gear 104 mounted loosely on a shaft 105, that is parallel with the machine bed and extends to a point beneath the carriage 68 on head 52, where it terminates in a loosely mounted miter gear 106 that meshes with a similar gear 107 splined on a vertical shaft 68<sup>a</sup>. The gear 106 is, ordinarily, connected with shaft 105 by a clutch 190 illustrated in Fig. 40 and described hereinafter.

Whenever the gear 106 is set in revolution, motion is imparted to the shaft 68<sup>a</sup> which is journaled in the lower end of carriage 68 and bears a spiral gear 108 (see Fig. 16) that meshes with and drives a corresponding gear 109 mounted upon the shaft 72 already described.

While I have shown and described spiral gearing for transmitting motion from the shaft 68<sup>a</sup> to the hinge-shaft 72 I do not wish to be confined to the use of such spiral gears as miter gears could be successfully substituted therefor.

Upon the shaft 72 is a miter gear 110 that meshes with a like gear 111 on the screw-shaft 78, also hereinbefore described, and it will now be understood that when rotary motion is given to the splined shaft 68<sup>a</sup> a correspond-

ing motion will be imparted, through the described train of gearing to said screw-shaft 78 which will at once cause the carriage 76 and the connected cutter-shaft carriage to travel upward or downward according to the direction of rotation of said shaft 68<sup>a</sup> and it will also be understood that by reason of the location of the miter gear 110 on the shaft 72 (which forms the pintle of the hinged plates 73 and 74) the gears 110 and 111 will remain in operative engagement whether the cutter and its supports are in the vertical position of Figs. 1, 2 and 7 or inclined, as in Fig. 6, to cut bevel gears. The shaft 78 is here shown cut as a single thread of ordinary pitch but, when a quick return movement is to be desired, said screw-shaft may be cut with a double or treble thread and of increased pitch.

In order to control both the upward and downward movements of the cutter, to obtain the most satisfactory and economical results it is desirable that the downward, or cutting, movement shall be very slow but that the upward, or return, movement shall be very rapid and these results I am able to attain by providing two separate driving mechanisms for the shaft 105 of which the described bevel gears 103—104 constitute the quick return driving mechanism. The slower, or feed, movement is imparted to said shaft 105 by a train of gearing best seen in Figs. 2, 6 and 40. The shaft of gear 99 (indicated by 99<sup>a</sup>) bears also a small gear 112 in mesh with a gear 113 that is adjustably mounted and serves as an intermediate between the said gear 112 and a gear 114 on a short shaft 115 journaled in the "feed box" secured to the bed 50. Secured upon said shaft 115 is a worm 116 that engages and drives, at a very slow rate, a worm gear 117 loosely mounted on the shaft 105. Through the train of gearing 112, 113 and 114 the said worm gear 117 is caused to revolve in a direction opposite to that of the "quick return" gear 104. The latter named gear (104) is formed with a long hub which revolves in a shell 118 that is fixed in the bed 50. The confronting ends of gear 104 and worm gear 117 are provided with notches or depressions that may be engaged by corresponding projections 120 at the ends of a sliding clutch-collar 121 that is splined to shaft 105. I prefer to provide several depressions in the shell and worm gear and but two projections 120 at each end of the clutch collar and I also by preference form the said projections as spring-pressed bolts, as clearly seen in Fig. 6 of the drawings so that, when the clutch-collar is shunted on shaft 105 to interlock with either of the loose clutch sections, if the projections and notches fail to register, the projecting bolts may be forced back for an instant and ride around until they coincide with their respective notches when the springs will force them ahead into said notches. By thus providing a splined sliding clutch section adapted to lock with the worm gear 117 at one end or with the bevel-

gear 104 at the opposite end I am able to lock either of said gears to shaft 105 and thus rotate said shaft in opposite directions and at different speeds. To thus slide the clutch section 121 I have provided thereon a ring section 122 (see Figs. 6, 29, 33 and 40) which has secured to one side a short rack 123 that is parallel with the desired movement of the clutch section 121.

In order to carry into effect one of the essential principles of my complete machine (namely the dependence of each movement upon the completion of the last preceding movement) it is necessary that the sliding clutch-section 121 be given three distinct steps or movements; that is to say, first, a movement in one direction to lock with and be revolved by the worm gear 117 to produce the slow feed for the cutter; second, a movement in the opposite direction to lock with the bevel gear 104 to set shaft 105 in operation in the opposite direction at increased speed, and, third, a limited return movement which shall leave said clutch section in a neutral position between said gears so that shaft 105 and the cutter feed shall be at rest during the time required to partially revolve the blank that is being cut, preliminary to cutting the next tooth. To thus control the sliding clutch section, and to produce these three described movements, I have provided novel mechanism which will be best understood if reference is made to Figs. 5, 7, 8, 32, 33, 40, 41, 42 and 43.

In Figs. 7, 8 and 40 will be seen the shaft 99<sup>a</sup>, extending nearly across the machine and terminating with a miter gear 124 that meshes with and drives alike gear 125 mounted loosely upon a shaft 126, said gear 125 having an enlarged extension 127 that forms the loose half part of a clutch whose companion part 127' is fixed on the shaft 126. The clutch section 127 is kept in constant revolution but the companion section and its shaft 126 are only moved at such times as the clutch sections may be locked together.

128 indicates a rock-shaft journaled within the "spacing box" and having at one end a gear segment 129 that meshes with the described rack 123 on the clutch ring 122 (see Fig. 33), in such manner that the rocking of shaft 128 will serve to slide said collar and its connected clutch section; the length and direction of movement of said clutch, being determined by the movements of shaft 128.

The miter gear 124 has an extended hub 124<sup>a</sup> which constitutes the driving half of an intermittently acting clutch similar to 127 and 127' on shaft 126 previously referred to. Shaft 99<sup>a</sup> has also loosely mounted thereon a gear 129' which meshes with and at certain times drives a similar gear 130 hung at a point midway the shafts 99<sup>a</sup> and 128 and this last named gear bears upon one face a roll 131 which is eccentric to said gear and lies within an opening 132 in a plate 133 secured to shaft 128. Whenever gear 130 is caused

to rotate, the roll 131 engages one wall of the opening 132 thus rocking shaft 128 and moving the feeding clutch 121 into engagement with the "quick return" gear 104. In Fig. 42 the plate 133 is shown in full lines thus moved, the eccentric roll having passed around out of contact with the wall of opening 132. Continued movement of said roll at the proper time brings it into contact with the opposite wall of the opening which is of such width that said roll moves the plate back to the position shown in full lines in Fig. 43 rocking shaft 128 sufficiently to move the feed clutch into its neutral position.

The third step, necessary to rock the shaft 128 into the position shown in full lines in Fig. 41 and thus throw into clutch the slow feed movement of the cutter, is not brought into action until the blank-spacing mechanism has completed its work, but as this third step relates particularly to the feed mechanism just set forth it is thought best to describe it here. Said third step is obtained through a cam 134 on a shaft 135 that is parallel with shaft 126 but in a lower plane. (See Figs. 5 and 40.) This cam 134 engages at the proper time a roll 136 hung in a radial arm 137 fixed on shaft 128 and forces said arm downward sufficiently far to rock the shaft 128 and slide the clutch section 121 into operative engagement with the worm gear 117 thus starting the slow feed mechanism of the cutter.

Figs. 7 and 40 best illustrate the manner of driving the cam shaft 135. Shaft 126, which has already been referred to, bears upon its inner end one or more gears 138 of different diameters that mesh with like gears 139 on the cam shaft 135. Gears 138 are fixed on their shaft but the gears 139 are loosely mounted and are only connected with their shaft 135 by a sliding spline 140 whose exposed portion is formed as a continuation of shaft 135 and cut with annular grooves to form a rack 141 that may be engaged by a pinion 142 on a short shaft or stud 143 arranged to both slide and revolve in the wall of bed 50. The outer end of shaft 143 is provided with an operating handle or knob 144 by means of which said shaft may be partially rotated to slide the spline-rack 140 and so lock either of the gears 139 to the cam-shaft 135 the other gears on said shaft meanwhile running idly. To lock the shaft 143 after adjustment I have provided in the base of knob 144 a pin 145 that may enter one of several holes in bed 50 and to retain said pin in the holes I have placed a spring 146 on shaft 143 between said bed and the spur gear 142, as in Fig. 36. When it is necessary to slide the spline 140 the knob 144 is first grasped and drawn outward to release the pin 145. Shaft 143 is then rotated to move the spline, the holes for pin 145 serving to show when the proper adjustment has been reached. When knob 144 is released the spring 146 draws shaft 143 inward and the pin 145 then locks the shaft against accidental displacement.

The gears 138—139 are of such relative sizes that the speed of the cam-shaft 135 may be varied by bringing into use the different gears and, thus, the time allowed for the revolution of shaft 126, and its connected mechanism, for shifting the gear blank to space for the next tooth, may be correspondingly varied, as more fully set forth hereinafter. This is desirable for the reason that, in some instances, it is necessary to allow more time for the blank-spacing mechanism to act before starting again the cutter-feeding devices.

It will be seen by reference to Figs. 7 and 35 that the gears 139 are each turned down to provide a hub or boss 146' that is flattened at one side; as at 147, said flattened portion being so located relatively to the spline 140 that when the spline-seats in all of the gears 139 are brought into coincidence with the spline this flattened portion faces the front wall of bed 50 and I have located in said bed spring-pressed bolts 148 whose inner ends are flattened to enter between the gears 139 and ride upon the circumferential edges of the hubs 146 and whose outer ends project slightly through bed 50, as seen in Fig. 1, to serve as indicators to show when gears 139 are in proper position to allow the spline to be moved by the knob 144, as above described.

Upon the end of shaft 126 that projects through the "spacing box" is a gear 149 that is mounted upon said shaft and clamped in place by a nut 150. This gear 149 meshes with a gear 151 mounted on a stud 152 that is adjustably secured to an arm 152'. (See Fig. 31.) Gear 151 meshes with a gear 153 on the end of the spacing shaft 61 and, by suitable changes in the train of gearing, the speed of shaft 61 relatively to its driver 126, may be varied at will. Shaft 61 I have already described as located at the front side of the machine (see Figs. 1, 4, 18 and 20) and as having a worm 62 that meshes with a worm-gear 58 controlling the rotary motion of the spindle 56 and of a gear blank held therein. Whenever the train of gearing 149, 151 and 153 is set in motion shaft 61 is correspondingly moved. Worm 62, being splined on said shaft, then partially rotates the worm gear 58 and thus moves the gear blank around a suitable distance to receive the next cut. The revolution of shaft 61 is necessarily very slight as it is desired ordinarily to feed the gear blank around only a distance equal to one tooth.

I have now described in a general way the several shafts and connecting mechanism for revolving the cutter shaft, for feeding said cutter shaft and returning it to its starting point, for adjusting the blank supporting carriage on its ways and for revolving said blank supports.

I will now explain in detail various clutches and escapements which control the starting and stopping of the said shafts and which, as a rule, are dependent for their action upon

the completion of some important preceding movement.

If reference is made to Figs. 1, 4, 5 and 7 it will be seen that the cutter shaft carriage 76 has secured to one side a bracket 76' that is adapted to slide on a rod 154 loosely fitted at its upper end in a stand 155 secured to the plate 74 and is connected at its lower end with a crank-arm 156 hung on the projecting end of the hinge pintle 72. Said arm 156 is also formed with a plate 157 having an arc-shaped slot in which is adjustably clamped one end of a rod 158 whose other end is connected with the upper end of a lever 159, that is fulcrumed on a stud or screw 160 projecting from the head 52. Rod 154 has adjustably mounted thereon two collars 154'—154<sup>a</sup>, which in practice are so adjusted on rod 154 that they will be engaged by bracket 76' just as the cutter-shaft carriage is about to complete its movement in either direction. Continued movement of said carriage then serves to slide rod 154 in the direction of the moving carriage. The lower end of the lever 159 is shaped substantially like the fork of an anchor escapement, the arms of which terminate with inwardly projecting ends 159'—159<sup>a</sup> and immediately in the rear of said fork is a plate 159<sup>b</sup> that projects downward from the arm 159 a considerable distance, as seen in Figs. 7, 41 and 42. The escapement fork is here illustrated as a curved rib formed upon the face of the plate 159<sup>b</sup> and integral therewith.

In Fig. 42 it will be seen that plate 159<sup>b</sup> lies in an annular groove 129<sup>b</sup> and that its longer end lies between two projecting ends 133' and 133<sup>a</sup> of the plate 133. When the lever-arm 159 is rocked in either direction this projecting end of the plate 159<sup>b</sup> acts by engagement with one of the projections 133'—133<sup>a</sup> to rock the shaft 128 a sufficient distance to disengage the clutch points 120 from the worm-gear 117, or quick return gear 104 as the case may be, and thus stop the cutter-shaft carriage. The movement of plate 159 serves also to release the clutch mechanism of gear 129 permitting it to make a partial revolution thus setting in motion gear 130 and, by means of eccentric rod 131 to continue the rocking motion of shaft 128 begun by plate 159<sup>b</sup> as above described.

Fig. 40 shows clearly the shaft 99<sup>a</sup> having fixed thereon the miter gear 124 and also the loosely mounted gear 129' before described. Gear 129' has a hub 129<sup>a</sup> that extends toward and abuts the hub of the miter gear 124 and is formed with the annular groove 129<sup>b</sup>. When my machine is assembled the plate 159<sup>b</sup> of lever 159 lies in said groove 129<sup>b</sup> (see Fig. 42) and the escapement points 159' and 159<sup>a</sup> overlap the hub 129<sup>a</sup> and are adapted to engage alternately (when lever 159 is rocked) a latch 161 that projects radially from said hub 129<sup>a</sup>. The confronting ends of hubs 129<sup>a</sup> and 124 are peculiarly formed to provide a clutch that may be brought into use whenever it is desired to lock together said hubs to set in motion the

gear 129' and the gear 130. Fig. 41 illustrates most effectually the construction of said clutch. The hub 124 is recessed in such manner that one or more inward projections 124' are provided, the inner edges of said projections being concentric with the hub. In Fig. 41 the recessed rim of hub 124 that bears the said inward projections is shown in section and immediately in its rear is seen the end of the hub 129<sup>a</sup> which has pivoted therein near one edge the radial latch 161 above referred to. The body portion of said latch is substantially circular and is seated in a corresponding recess in the end of hub 129<sup>a</sup> the radial arm of said latch projecting outward beyond the circumference of the hub. The circumferential opening or slot through which the latch end projects is enlarged in one direction so that the projecting end of the latch may at times be rocked and folded down nearly to said circumference. The inner half of the circular body of latch 161 is formed with a projection 161' that extends into the recessed rim of the hub 124. When the latch is in its normal position, as in Fig. 41, the outer edge of the projection 161' allows the projections 124' of the constantly revolving hub 124 to pass freely by, but whenever the latch is permitted to rock in its seat the heel of the projection 161' is swung outward into the path of one of said projections 124' and the two hubs 124—129<sup>a</sup> are immediately locked together and the gear 129' is caused to revolve. A spring 162, on the end of hub 129<sup>a</sup>, seeks constantly to rock the latch 161 into position for such engagement. The clutch section 124 travels constantly in the direction indicated by the arrow in Fig. 41.

When the escapement lever 159 is rocked on its fulcrum its projecting points 159' and 159<sup>a</sup> are swung alternately into the path traversed by the projecting end of latch 161 and serve as stops to check said latch as well as the hub 129<sup>a</sup> to which it is secured. The sudden stopping of the latch also serves to swing its end outward, against the force of its spring 162, thus throwing the heel of projection 161' out of locking engagement with the projections 124' of the constantly revolving hub 124, when hub 129<sup>a</sup> and its gear 129' stop.

While the feed clutch 121 on shaft 105 is in engagement with the worm gear 117 the cutter carriage 76 moves slowly downward until the bracket 76' engages the collar 154<sup>a</sup> and forces the rod 154 downward, when the escapement lever 159 is rocked from the position shown in Fig. 41 to that of Fig. 42, releasing latch 161 from the point 159<sup>a</sup>. Spring 162 then rocks said latch in its circular bearing bringing the heel of its projection 161' into the path of the revolving points 124' one of which immediately locks with said heel and starts the hub 129<sup>a</sup> and its gear 129'. Simultaneously the gear 130 is revolved and the cam-roll 131 forces plate 133 over into the position in full lines in Fig. 42. This movement of plate 133 rocks shaft 128, and the segment

129 on its other end slides clutch 121, on shaft 105, into engagement with the quick return gear 104 and starts the cutter-shaft carriage 76 upward at a rapid rate. So soon as the bracket 76' of said carriage reaches the collar 154' the rod 154 is moved upward and the escapement lever is rocked to release the end of latch 161 from the point 159' of said escapement. The latch is then rocked by its spring and locks with one of the points 124' and gear 129' is again started forward but is immediately checked by the anchor-point 159<sup>a</sup>. This limited movement, instead of rocking plate 133 and shaft 128 sufficiently to slide clutch 121 back into engagement with the worm-gear 117, serves to bring said clutch back only halfway, to a point where the bolts 120 are out of engagement with their respective notches at both ends of the clutch when, for a time, the cutter-shaft carriage 76 is at rest, and, during this time of rest, the spacing mechanism is set in motion, as I shall now explain.

Reference to Figs. 7, 8, 9, 32, 44 and 45 will help to explain several disks, pawls, shields, &c., mounted upon the rock-shaft 128. I have referred already to clutch-disks 127 and 127' on shaft 126, the former (127) being loose on said shaft and constantly revolving while the latter (127') is fixed on said shaft and only revolves when clutched to the section 127. Section 127' is provided with a rock-latch 127<sup>b</sup> of the same form as the latch 161 described in detail above and the companion section 127 has one or more inward projections identical in form and action with the projections 124' and adapted to lock with said latch 127<sup>b</sup>. Upon shaft 128, nearly in vertical alignment with shaft 126, is a disk 163 whose rim is provided with notches 164 of such size and depth that the projecting end of latch 127<sup>b</sup> may pass therethrough at such times as the disk 163 is revolved to bring the spaces or notches 164 into the circular path of said latch. At other times the solid portions of the disk 163, between said notches, serve as stops that check the latch 127<sup>b</sup> and, by rocking the latter in its circular seat, disengage the two disks 127—127' and thus stop the latter and its shaft 126, as well as the connected blank-spacing mechanism and cam-shaft 135. The moving and timing of the notched disk 163, to thus control the spacing mechanism, forms one of the essential and novel features of my invention. Said notched disk is loosely mounted on shaft 128 and is formed with an extended hub on which is fastened, by a set screw 165, a disk 166 which also has a hub on which is mounted a ratchet disk 167, whose teeth equal in number the notches of disk 163. Said notched disk and ratchet are here shown as separate pieces, because more easily adjusted into proper relation if so constructed, but operate as one piece only and may be so constructed if desirable. Next to said ratchet disk is a plate 168 that is secured to shaft 128 and bears a spring pressed pawl 169 adapted to

coact with said ratchet teeth. When the pawl-plate 168 is rocked in one direction its pawl 169 partially rotates the ratchet-disk and also the connected notched-disk 163 to bring one of the notches 164 into coincidence with the latch 127<sup>b</sup> to release said latch or, *per contra*, to move said disk 163 properly to check said latch.

170 indicates a plate that is loosely mounted on the ratchet-disk 167 and has an upwardly extending arm to which is attached an operating handle 171 that extends outward through the wall of bed 50 as best seen in Figs. 4 and 5. Hung in the lower side of this plate 170 is a spring pressed pawl 172 that also engages the teeth of the ratchet 167. By grasping handle 171 of this pawl-plate 170, and slightly rocking the same, the ratchet 167 and the connected notched disk 163 may be rocked independently of the pawl 169 which latter is intended to be operated automatically by the rocking of the shaft 128.

Upon the hub of the pawl-plate 168 is a rocker-plate or shield 173 (see Figs. 9, 44 and 45) whose rim is, in the main, circular but is cut away as at 174, adjacent to the pawl 169. The end of said pawl has a laterally extending portion 169<sup>a</sup> which overlaps the said shield 173. When the shield is in its normal position, that is to say, while a gear is being cut, the pawl and shield occupy the relative positions shown in Fig. 44, when the pawl 169 is free to engage the teeth of the ratchet disk 167, but whenever shield 173 is rocked as shown in Fig. 45 (which occurs just before the finishing of a gear) the circular edge 175 of said shield prevents the pawl from engaging with said ratchet. A portion of the edge of shield 173 is cut with gear teeth 176 that mesh with teeth 177 on a lever 178 hung on a stud 179. The upper end of said lever is connected with a spring 180 (see Fig. 9) that seeks constantly to draw said upper end in the direction indicated by the arrow in said figure. The upper end of said lever is also connected with a rod 181 that extends along the front of the machine (see Figs. 1, 4, 18 and 19) and has adjustably connected therewith, by set screw 182, a crank-arm 183 secured to a shaft 184. This shaft bears a gear segment 185 that meshes with a rack 186 mounted in the carriage 54 and whose end serves as a bolt that may enter a notch 187 in a ring 188 clamped upon the enlargement 57 of the hollow spindle 56, by a set-screw 189. (See Fig. 18.)

When a gear-blank has been spaced to receive its last cut, notch 187 is brought into coincidence with the end of bolt 186, but said bolt is kept from shooting forward into the notch by a stud 178<sup>a</sup> projecting laterally from the lower arm of the lever 178, which stud abuts, for the time, a projection 168<sup>a</sup> on the pawl-plate 168. Stud 178<sup>a</sup> is attached to a bolt 178<sup>b</sup> whose lower end is headed and bears a spring 178<sup>c</sup> that seeks constantly to

draw the bolt and stud 178<sup>a</sup> downward, but which may yield slightly, as will be understood from the drawings.

In order to attract the attention of the operator to the completion of a gear, I have provided an alarm that acts when the last tooth of the gear has been cut and upon the commencement of the final quick return movement of the cutter carriage. This alarm consists of a bell 207 fixed to the spacing box (see Fig. 1) and rung by a hammer 208 attached to the upper end of lever 178 within the spacing box. Said hammer is pivoted to the lever 178 as shown in Fig. 46, and projects through a slot in the spacing box, as seen in Fig. 1. Referring now to Fig. 8, the enlarged hub 127 of miter gear 125 bears a small projection 127<sup>c</sup>. The rocking of shaft 128 to slide clutch 121 also serves to rock the pawl-plate 168 backward when the projection 168<sup>a</sup> passes below the end of stud 178<sup>a</sup> and spring 180 immediately rocks lever 178 into the position of Fig. 45 and causes the bolt 186 to shoot forward into notch 187. When lever 178 is thus swung into the position of Fig. 45 by the completion of the cutting of a gear, as described, the shorter end of the hammer 208 is moved into the path of the projection 127<sup>c</sup> and said hammer is lifted by said projection at each revolution of hub 127. As said projection passes out of contact with the hammer the latter is caused to strike the bell by means of a spiral spring 209' shown in Fig. 46. The rocking of lever 178 also serves to partially rotate the shield 173, bringing its projecting portion 175 beneath the end of pawl 169, thus preventing the operative engagement of said pawl with the ratchet disk 167. Meanwhile the cutter carriage, has been carried to its highest position by the quick return mechanism, and the bracket 76' engages the collar 154' to rock the escapement lever 159 and, through its connections, rock the shaft 128 to slide clutch 121 into its intermediate position, when the cutter carriage stops. Ordinarily when shaft 128 is thus rocked to bring clutch 121 into its intermediate position, pawl 169 engages the ratchet disk to rock the notched disk 163 and so set in operation the spacing shaft 61, but it will be remembered that the shield 173 has now been rocked to throw said pawl out of engagement with the ratchet disk and, consequently, the pawl rides idly on the raised portion 175 of the shield, and the several operations of the machine are practically at a standstill. The operator then swings lever 178 into the position of Fig. 44 thus moving the bell-hammer out of the path of the projection 127<sup>b</sup> thus stopping the alarm. After a new blank has been substituted for the cut one the handle 171 of the pawl plate 170 is grasped and rocked to the left hand (as viewed from the front side of the machine) thus causing its pawl 172 to partially rock the shaft 128 and bring one of the spaces 164 coincident with latch 127<sup>b</sup>. This movement of

the disk 163 releases the latch 127<sup>b</sup> which, by reason of its spring, is rocked in its circular seat and at once locks with the constantly revolving clutch section 127 and begins to rotate with the latter, thus starting the shaft 126 which through the gearing 149—151 and 153, starts the spacing shaft 61 and partially rotates the blank-support to take up all backlash and bring the blank into position to cut its first tooth. So soon as the shaft 126 is thus started, motion is also imparted through the gears 138—139 to the cam shaft 135 and as said shaft revolves, the cam 134 engages roll 136 and rocks shaft 128 and plate 133 into the position shown in Fig. 41. Two important results are attained by thus rocking shaft 128. First, the notched disk 163 is rocked with said shaft and brings one of the teeth or partitions (between the notches 164) into the path of the latch 127<sup>b</sup> resulting in stopping said latch and throwing it out of locking engagement with the constantly revolving section 127, when shaft 126, and the connected blank-spacing mechanism, as well as the cam-shaft 135, stop, and second, the rocking of shaft 128 by cam 134 also serves, through the segment 129, to slide the clutch 121 into lock with the worm-gear 117 and thus start the slow feed movement of the cutter carriage.

It will thus be seen that, upon the completion of each important step or operation, certain mechanism controlling the next succeeding important step, is released and started into action and that if, for any reason whatsoever, any one of the important mechanisms fail to act all succeeding operations will be held in check and will not be allowed to operate. It will be seen also that the various mechanisms are all driven positively by means which consume power only while in action, thus preventing any drag upon the machine, and all undue wear of the parts.

While my described gear cutting machine is particularly designed to work automatically, provision is made so that the cutter carriage may be fed by hand if desired, thus making my machine more valuable for general machine shop use.

By referring to Figs. 26, 27, 28 and 40, it will be seen that I have provided on shaft 105 a splined clutch section 190 that may co-act with a companion clutch section 191 on the end of the hub of the loosely mounted miter gear 107. Section 190 is formed with an annular groove in which lies the forked end of an arm 193 which is movable in a direction parallel with shaft 105. The other end of said arm 193 is connected by a crank 194 with a rock-shaft 195 extending toward and through the front wall of the machine bed and having secured to it, outside said bed, an operating handle 196 by means of which the shaft 195 may be rocked to throw the clutch section 190 into or out of engagement with the companion section 191, as will be understood by the drawings. When the said clutch sections are disengaged, as in Fig. 40, the automatic

feed mechanisms for the cutter-carriage, both slow and "quick return," become inoperative and in order to move said cutter-carriage I extend the hinge pintle or shaft 72 (see Fig. 4) so that an ordinary crank, or hand wheel, may be fixed on said extension with which to rotate said pintle by hand and thus feed the cutter carriage upward or downward, as may be desired.

My machine is also adapted for "hobbing" worm gears and this without requiring any changes in the described construction. When the machine is to be so utilized a hobbing cutter, identical in pitch and size with the worm or screw, which is to be used with the worm-gear, is secured on the cutter shaft 83. The worm-gear blank is then mounted on a mandrel that is held in spindle 56. The automatic feed mechanism for moving the cutter-carriage is then thrown out of use by disengaging the clutch 190—191, leaving the hobbing cutter free to revolve continuously in a single horizontal plane. It now becomes necessary to start the shaft 61, which serves as the spacing shaft for ordinary gears and to cause said shaft to revolve continuously instead of intermittently. Having thrown out of service for the time, the cutter carriage feeding mechanisms and the devices which form the connecting link between said mechanisms and the shaft 126, it is only necessary to rock the lever 170 and through its pawl 172, rock the disk 163 until one of the notches of the latter is made to register with the latch 127<sup>b</sup>. Said latch, being thus released, immediately locks with the clutch section 127 and shaft 126 begins to revolve. Through the train of gearing 149—151—153 the shaft 61 is simultaneously started and inasmuch as the devices that ordinarily control the notched disk 163 are thrown out of service the latch 127<sup>b</sup> will continue to revolve, passing without hinderance through the coincident notch of said disk 163. Thus the hobbing cutter and the worm-gear blank are revolved continuously, the cutter gradually cutting its way into the blank.

In order to thus utilize my machine for "hobbing" it is, of course, necessary that the blank and cutter shall be driven at the same relative speeds that the finished gear and its coacting worm will have when put to use and this I am able to accomplish by suitably changing one or all of the gears 149—151 and 153. In order to produce this result conveniently, I prefer to so organize the machine that the speed of the constantly revolving element 127 coincides with that of the cutter shaft, which result is accomplished by making the ratio of the gearing connecting this element (127) and the driving shaft 84 equal to that connecting said shaft 84 to the cutter shaft.

Fig. 5 illustrates a bolt 197 that is fitted to slide vertically in the "spacing box" and is forced upward by a spring 198, as clearly shown. The exposed end of said bolt is pro-

vided with a knob or head 199 and its upper end engages the end wall of a spiral cam groove 127<sup>a</sup> cut on the clutch section 127'. When the clutch section 127' is set in motion, the said cam gradually forces bolt 197 outward until a complete revolution of the cam has been made, when the bolt snaps from the highest to the lowest point of the cam and then serves as a lock to prevent backward rotation of the clutch section 127'. The end of latch 127<sup>b</sup>, resting against the notched disk 163, serves at the same time to prevent said section from revolving in the opposite direction. By thus locking the section 127' against rotary movement in either direction all tendency to work loose or become displaced is forestalled and prevented. It should be noted that the bolt end 197 is beveled at one side in such manner that if the clutch section 127' should fail to make a complete revolution or, if the shock resulting from the sudden impact of latch 127<sup>b</sup> against the notched disk should cause section 127' to recoil slightly, the point of bolt 197 will enter and be forced home by spring 198.

When my machine is to be used for "hobbing," as above explained, it is desirable that bolt 197 be withdrawn so that it may not act as a drag on the then constantly revolving clutch section 127'. So I have slotted the said bolt longitudinally as at 200 and have cut a short lateral notch at the upper end of said slot. Through the slot thus provided I have passed a pin 201 that is seated in the wall of the spacing box. When it is desired to withdraw bolt 197 from operative engagement with the cam 127<sup>c</sup> it may be quickly and effectually done by drawing the bolt downward and turning it a partial revolution, causing the said lateral notch to pass over the pin 201.

When my machine is to be used for "hobbing" worm-gears the gear 98 should bear the same ratio to gear 99 as the bevel gear 91 does to gear 92.

Figs. 37, 38, 39 and 40 illustrate a graduated coupling, which connects shaft 126 with gear 149 or, more properly with the collar on which said gear is mounted. Fig. 38 explains most clearly the construction and arrangement of the various parts of said coupling. Keyed upon shaft 126 is a disk 202 whose face is cupped to receive a circular plate 203 whose entire periphery is finely serrated as at 204 and whose exposed face is graduated to correspond to said serration. Said plate is here shown as formed with three hundred and sixty serrations but the number is not material. Dove-tailed in the outer edge of disk 202 is a plate 205 arranged to interlock with a screw 206 that is tapped into the edge of said disk 202 as clearly seen in Fig. 38. The inner end of plate 205 is curved and serrated to conform to the serrated periphery of the graduated plate 203. By partially unscrewing the screw 206 the plate 205 may be moved in its ways to release its serrations from those of the plate 203, when the latter named plate may be re-

volved within disk 202. The projecting portion of shaft 126 is reduced in diameter and has mounted thereon a collar 207 provided with an annular flange 208 over which is fitted a rabbeted ring 209 that is secured to the graduated plate 203 by screws 210 and serves to clamp the flanged collar 207 firmly to the graduated plate. Collar 207 is turned down, as at 211, and splined to receive the initial gear 149 of the train that transmits motion from shaft 126 to the spacing shaft 61.

It is frequently found desirable, in fact necessary, to adjust the spacing shaft 61 without disturbing its driving shaft 126 as, for example, in making two or more cuts through a single tooth to provide greater clear space or in cutting bevel gears which, to be correct, should have both the teeth and intervening spaces converging to the apex of the pitch cone and this can be accomplished only by "setting over" the blank slightly after a single cut has been made and making a second cut which, instead of being parallel with the first cut, will lead toward said apex and thus produce teeth and spaces that are gradually narrower as they approach said apex. The described graduated coupling makes it both possible and easy to thus adjust shaft 61 independently of the shaft 126, it being only necessary to unscrew the screw 206 and withdraw the serrated plate 205 from the edge of the graduated plate 203 when said plate as well as the collar 211, the train of gearing 149, 151, 153 and shaft 61 may be rotated without disturbing shaft 126 and its disk 202. By utilizing the graduated plate 203 a succession of fine adjustments may be accurately made if desired. After such adjustment has been made the screw 206 is screwed home to force the sliding plate 205 into locking engagement with the serrated edge of plate 203. The coupling thus provided is then as strong and effectual, for the purpose in hand, as if the gear 149 was secured immediately to the shaft 126.

Should it be desired to disconnect the described coupling, so that the shaft 61 may be freely revolved, the screws 210 may be unscrewed, when the flanged disk 207, to which the gear 149 is secured, may revolve freely in the ring 209. It will thus be understood that either a very fine adjustment of the coupling sections may be attained (by means of screw 206 and plate 205) or that said coupling sections may be entirely disengaged by releasing screws 210.

I have referred briefly to the notched ring 188 that is located on the blank-supporting spindle 56 and whose notch may coast with bolt 186 under certain conditions. This ring is adjustable in its seat and is intended to register with the bolt 186 when the blank has been spaced for the last tooth. For greater convenience and accuracy in setting the ring 188 I have graduated its circumferential edge as at 185' and have provided a zero mark on

the carriage 54 over the bolt 186. In cutting ordinary gears it is only necessary to start with the bolt 188 coincident with the notch of ring 188. When, however, it is desired to cut gear-segments the ring 188 should be so set that the notch will be brought into coincidence with the bolt when the last tooth of the required segment shall have been spaced off.

Referring to the described mechanism for rocking shaft 128, shown and described as gear 130, eccentric roll 131 and rock shaft arm 133, I wish it understood that while this is my preferred form, owing to its adaptation to the shape and location of the parts, yet any equivalent rocking device set in motion by means of the described intermittent clutch, is within my invention. Referring also to the described construction of intermittent clutches mounted on shafts 99<sup>a</sup> and 126, I wish to state that any equivalent positively driving intermittent clutch suited to the requirements as set forth in the foregoing specification, falls within my invention as applied to automatic gear cutting machines; the construction shown being my preferred form of such clutch.

I wish also to define my use of the terms "intermittently," "intermissions," &c., in describing and claiming the movements of the cutter-carriage of my improved machine, as referring to intentionally designed and prolonged periods of rest, during which other movements of various parts of the machine occur, as herein described, in contradistinction to the momentary periods of rest common to the cutter-carriages of other gear cutting machines at the point of reversal, which are incidental only, and due to the disengagement of the feeding clutch while passing the neutral point between the clutch drivers. In the machines of this class, already well known, the cutter-carriages may properly be said to reciprocate rather than to move intermittently.

Having described my invention, and the manner in which it is operated, I claim as new and wish to secure by Letters Patent—

1. In a gear cutting machine, the combination of a blank-holder, automatic mechanism for revolving said holder intermittently, a cutter carriage mounted to slide as set forth, and automatic mechanism for moving said cutter carriage intermittently, all substantially as specified.

2. In a gear cutting machine, the combination with a suitable frame, of a sliding cutter carriage, automatic mechanism for sliding said carriage intermittently, a revoluble blank-holder and mechanism for revolving said blank-holder during the intermissions in the movement of said cutter-carriage.

3. In a gear cutting machine, the combination with a suitable frame, of a sliding cutter carriage, automatic mechanism for sliding said carriage intermittently, a revoluble blank-holder, and positively driving mechanism for

revolving said blank-holder during the intermissions in the movement of said cutter carriage.

4. In combination, a blank holder, mechanism for revolving the same intermittently, a cutter carriage mounted to slide as set forth, and positively acting mechanism, driving the said blank revolving mechanism and cutter carriage, and timed to start the latter only upon the completion of the intermittent movements of the blank holder, all substantially as specified.

5. In combination with a revoluble blank holder, mounted to travel on ways, mechanism for revolving said holder intermittently, a cutter carriage, mounted to travel in a direction parallel with the axis of the gear blank, and hinged to swing at an angle to said axis, mechanism for moving said cutter carriage intermittently, positive clutch mechanism for actuating said cutter carriage and driving mechanism, and means for automatically stopping the cutter carriage while the blank holder is being revolved, all substantially as specified.

6. In an automatic gear cutting machine, wherein the various movements are actuated by a single driving shaft, the combination of a blank holder, means for revolving said holder intermittently, positive clutch mechanism for controlling such revolution of the blank holder, means for starting said clutch mechanism into action, a cutter shaft and mechanism intermediate said driving shaft and cutter shaft for revolving the latter.

7. In combination with a revoluble blank holder, mounted to travel on ways, mechanism for revolving said holder intermittently, a cutter carriage mounted to travel in a direction parallel with the axis of the gear blank, and also inclinable at an angle to said axis, a cutter shaft journaled in said carriage, and fixed driving shaft, and mechanism, substantially as set forth, intermediate said driving shaft and cutter shaft for revolving the latter.

8. In a gear cutting machine, the combination with a suitable frame-work having a revoluble blank holder and a sliding cutter-spindle-carriage thereon, of a driving shaft mounted in fixed journal bearings upon said frame, splined shaft (90) pivotally attached to said cutter spindle and said driving shaft, gears (88) (89) connecting said driving shaft and said splined shaft, and gears (91) and (92) connecting said splined shaft and said cutter spindle, substantially as described.

9. In a gear cutting machine, the combination with a suitable frame or bed, having revoluble blank holder and a sliding cutter spindle carriage thereon, of a driving shaft mounted in fixed journal bearings upon said frame, splined shaft (90) pivotally attached to said cutter spindle and said driving shaft, gears 88—89 connecting said driving shaft and said splined shaft, and gears 91—92 connecting said splined shaft and said cutter spindle, and the arm 94 adapted to support

the journal bearings of said splined shaft to keep them in alignment, substantially as described.

10. In combination, a cutter shaft journaled in a carriage, mounted to slide on ways, and also hinged to be swung at an angle with said ways, gear 92 fixed on said shaft, driving shaft 84 having secured thereon a bevel gear 89, and shaft 90, having fixed on one end a bevel gear 91 meshing with said cutter-shaft gear 92, and having splined on its other end a bevel gear 88; the shaft 90 being journaled, adjacent to its gear 91, in a stand secured to an arm 94 that is swiveled on the cutter shaft at one end, and arranged to straddle a slide on the driving shaft 84, all substantially as and for the purpose specified.

11. In a gear cutting machine in combination with a blank holder, adjustably mounted on ways, and means for revolving said holder intermittently, and a cutter shaft journaled in a carriage, mounted to slide in a direction parallel with the axis of the blank, and hinged to be adjusted at an angle to said axis as set forth, mechanism substantially as specified for revolving said cutter-shaft continuously, and also for feeding the cutter shaft carriage intermittently, for the purpose specified.

12. In a gear cutting machine the combination with a suitable frame, of a revoluble blank holder, an inclinable cutter carriage support, a cutter carriage mounted to slide thereon, a feeding shaft forming the pivot of said carriage support, a feeding screw mounted in said carriage support, and gears connecting said pivot shaft and feeding screw, substantially as described.

13. In a gear cutting machine, the combination with a suitable frame having mounted thereon a revoluble blank holder, and a sliding cutter carriage, of an initial reversible feeding shaft mounted in fixed journal bearings on said frame, a feeding screw for said cutter carriage and gearing connecting said initial reversible feeding shaft and feeding screw, substantially as described.

14. In a gear cutting machine, the combination with a suitable frame, having mounted thereon a revoluble blank holder, an inclinable cutter-carriage-support with a cutter carriage mounted to slide thereon, a feeding screw mounted in said cutter carriage support, and gears connecting said feeding screw with a shaft forming the pivot of said inclinable cutter-carriage-support, of an initial reversible feeding shaft mounted in fixed journal bearings, and gearing connecting said initial reversible feeding shaft with the pivotal shaft of said inclinable cutter carriage support, substantially as described.

15. In a gear cutting machine, the combination of a blank holder, means for revolving the said holder intermittently, a cutter carriage and shaft mounted to travel on ways, means for removing said cutter carriage consisting of a shaft with oppositely moving clutch drivers thereon, and a sliding clutch

upon said feed shaft, and automatic mechanism for moving said clutch from one of said drivers, to the companion driver, and for returning said clutch by two movements, the first of which stops the clutch midway said drivers and provides a period of rest for the cutter feeding mechanism, all substantially as specified.

16. In combination with a blank holder, and mechanism for revolving the same intermittently, a cutter-shaft-carriage mounted to slide in a direction parallel with the axis of the gear blank, mechanism for moving said cutter shaft carriage, consisting of a shaft with oppositely moving clutch drivers thereon, a sliding clutch upon the said feed shaft, a rack 123 attached to said clutch, a gear segment 129 in mesh with said rack, and means substantially as specified for rocking said segment.

17. In combination with a blank holder, mounted adjustably on ways, mechanism for revolving said holder intermittently, a sliding cutter-shaft-carriage, means substantially as described for moving said cutter shaft carriage intermittently and clutch mechanism as 190, 191 forming an element of said cutter-carriage moving mechanism whereby the latter may be disconnected, all substantially as specified.

18. In combination with a blank holder, and mechanism for revolving the same intermittently, a cutter-shaft-carriage mounted to slide in a direction parallel with the axis of the gear blank, a rod 154, mounted to slide at one side of said carriage and provided with adjustable collars 154', 154<sup>a</sup> a bracket 76' secured to the cutter carriage, adapted to engage said collars to slide shaft 154, mechanism for moving said cutter-shaft-carriage intermittently, and mechanism connecting the rod 154 and the cutter carriage actuating mechanism, substantially as described.

19. In a gear cutting machine, clutch-sliding mechanism, consisting of a constantly revolving shaft 99<sup>a</sup>, an intermittent clutch as 124<sup>a</sup>—129<sup>a</sup>, intermittently acting mechanism as eccentric 130, rock shaft arm 133 having the relatively wide opening 132, rock-shaft 128, and mechanism substantially as set forth connecting said rock shaft and said sliding clutch so organized that said eccentric will cause said clutch to slide farther in one direction than in the opposite direction, in combination with a cam 134 connected with the blank revolving mechanism and adapted to continue the shorter movement of said sliding clutch before said blank revolving mechanism stops, substantially as described.

20. In a gear cutting machine, the combination of a sliding cutter-carriage, having a stop bracket 76' secured thereto, a stop rod 154 mounted to slide in a direction parallel with said cutter carriage, and provided with adjustable stop collars 154'—154<sup>a</sup>, a lever 159 connected to rod 154, rock-shaft arm 133 hav-

ing projections 133'—133<sup>a</sup>, rock-shaft 128, sliding clutch 121, and mechanism connecting said clutch and said rock shaft 128 so organized that contact of said stop bracket 76' with said stop collars will move said clutch 121, substantially as and for the purpose described.

21. In a gear cutting machine, the combination of a sliding cutter carriage having a stop bracket 76' secured thereto, a stop rod 154 mounted to slide in a direction parallel to said cutter carriage and provided with adjustable stop collars as set forth, a constantly revolving shaft 99<sup>a</sup> provided with an intermittent clutch substantially as described and an escapement lever 159 coacting with said clutch, all so organized that contact of said stop bracket 76' with said stop collars will release said intermittent clutch, substantially as described.

22. Blank revolving mechanism consisting of a constantly revolving element as 127 and shaft 126, upon which said element is loosely mounted, and revoluble blank-holder mechanism, as set forth, connecting said shaft 126 and blank-holder, and positively engaging clutch mechanism for locking together the said element 127 and the shaft 126.

23. In a gear cutting machine, blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft, 126, a revoluble blank holder and mechanism connecting said shaft and said blank-holder, in combination with mechanism for controlling the engagement of said driving element 127 and the intermittently revolving shaft 126, all substantially as described.

24. In a gear cutting machine, a blank revolving mechanism consisting of a constantly revolving driving element 127, a positively driven intermittently revolving shaft 126, clutch hub 127' mounted on said shaft and provided with a latch 127<sup>b</sup>, rock shaft 128, having mounted thereon pawl plate 168, provided with pawl 169, and notched disk 163 provided with ratchet 167; all combined and operating substantially as described.

25. In a gear cutting machine, blank revolving mechanism consisting of a constantly revolving driving element 127, a positively driven intermittently revolving shaft 126, clutch-hub 127' mounted on said shaft and provided with a latch 127<sup>b</sup>, rock-shaft 128 having mounted thereon pawl-plate 168, with its pawl 169, and notched disk 163 provided with ratchet 167, and mechanism for rocking shaft 128 to cause the pawl to move the notched disk; all being combined substantially as specified.

26. In a gear cutting machine, blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft 126, clutch hub 127', mounted on said shaft and provided with latch 127<sup>b</sup>, notched disk 163

mounted on shaft 128 and provided with ratchet 167, and a hand lever 170 with its pawl 172 mounted to coact with said ratchet and notched disk; all combined and operating substantially as described.

27. In a gear cutting machine, blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft 126, means for connecting said shaft and said driver, and gears 138 mounted on shaft 126, in combination with shaft 135 provided with gears 139, and mechanism substantially as described for controlling the connection between shaft 126 and its driver.

28. In an automatic gear cutter wherein the various movements are actuated by a single driving shaft, the combination of a blank holder and means for revolving the same intermittently, a cutter carriage mounted to travel in a direction parallel with the axis of the gear blank, mechanism for moving said cutter carriage intermittently, and means consisting of gears 138, 139, in the train of mechanism, whereby the initial revolution of the blank revolving mechanism may be varied for the purpose specified.

29. In an automatic gear cutting machine, the combination of a blank holder, and means for revolving the same intermittently, a cutter carriage mounted to travel in a direction parallel with the axis of the gear blank, mechanism for moving said cutter carriage intermittently, means consisting of gears 138—139 in the train of mechanism whereby the initial revolutions of the blank revolving mechanism may be varied, and an indicator or telltale consisting of spring pressed pins 148 adapted to engage with said gears 139, substantially as described.

30. Blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft 126, provided with an index coupling substantially as set forth, a revoluble blank holder and mechanism connecting said coupling and blank holder, all combined substantially as described.

31. Blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft 126, provided with a clamp coupling consisting of a driving element 202 mounted upon said shaft 126, a driven element 207, means as ring 209 for clamping said elements, a revoluble blank holder and mechanism connecting said driven element and blank holder, all combined substantially as described.

32. Blank revolving mechanism consisting of a constantly revolving driving element as 127, a positively driven intermittently revolving shaft 126, hub 127', mounted on said shaft provided with latch 127<sup>b</sup> and spiral cam seat 127<sup>c</sup>, in combination with a suitable stop, as notched disk 163, for said latch and a spring-pressed bolt 197 adapted to securely lock said

shaft 126 when not in revolution, substantially as described.

33. In a gear cutting machine, in combination, a blank holder, and mechanism for revolving the same intermittently, a graduated notched collar, concentric with and adjustably secured to said blank-holder, and a spring actuated bolt seated in the blank-holder support and adapted to engage said notch upon the completion of a predetermined series of movements of said blank holder in the manner and for the purpose specified.

34. In a gear cutting machine, in combination, a blank-holder and mechanism for revolving the same intermittently, a notched collar adjustably secured to said blank-holder, a spring actuated bolt seated in the blank-holder support and an alarm consisting of a bell and hammer and operating mechanism substantially as herein described, whereby said bell is rung upon the entrance of said bolt into said notch.

35. In a gear cutting machine in combination, a blank holder and mechanism for revolving the same intermittently, a notched collar adjustably secured to said blank holder, a spring actuated bolt seated in the blank holder support, a spring actuated lever 178 provided with sliding bolt 178<sup>b</sup> having projection 178<sup>a</sup>, in combination with rock shaft 128, and a pawl-plate 168 having projection 168<sup>a</sup>, mounted on said shaft, so organized that said projection 178<sup>a</sup> on bolt 178<sup>b</sup> and projection 168<sup>a</sup> of pawl plate 168, will prevent movement of lever 178 until the suitable rocking of shaft 128, substantially as described.

36. In an automatic gear cutting machine, in combination, a blank holder and mechanism for revolving the same intermittently, a notched collar adjustably secured to said blank holder, a spring actuated bolt seated in the blank holder support, mechanism connecting said bolt with a spring actuated lever 178 provided with gear segment 177, a coacting toothed ratchet guard 173, with high portion 175, mounted on shaft 128, a pawl and pawl-plate mounted on said shaft, so organized as to render the pawl inoperative whenever said lever 178 is suitably moved; substantially as herein described.

37. In a gear cutting machine, in combination, a driving shaft 84, a cutter shaft 83, a revoluble blank holder, blank revolving mechanism consisting of a constantly revolving element as 127 and shaft 126 upon which said element 127 is loosely mounted, clutch mechanism for locking together said element 127 and shaft 126, gearing connecting said driving shaft and said element 127 of such ratio that the element 127 will revolve at the same speed as said cutter shaft, and gearing connecting said shaft 126 and said blank holder.

LUCIUS E. WHITON.

Witnesses:

FRANK H. ALLEN,  
ALONZO M. LUTHER.