No. 858,081. PATENTED JUNE 25, 1907.

W. K. LIGGETT.

MACHINE FOR MAKING WORM AND SPIRAL GEAR.

APPLICATION FILED FEB. 24, 1903.

4 SHEETS—SHEET 1.

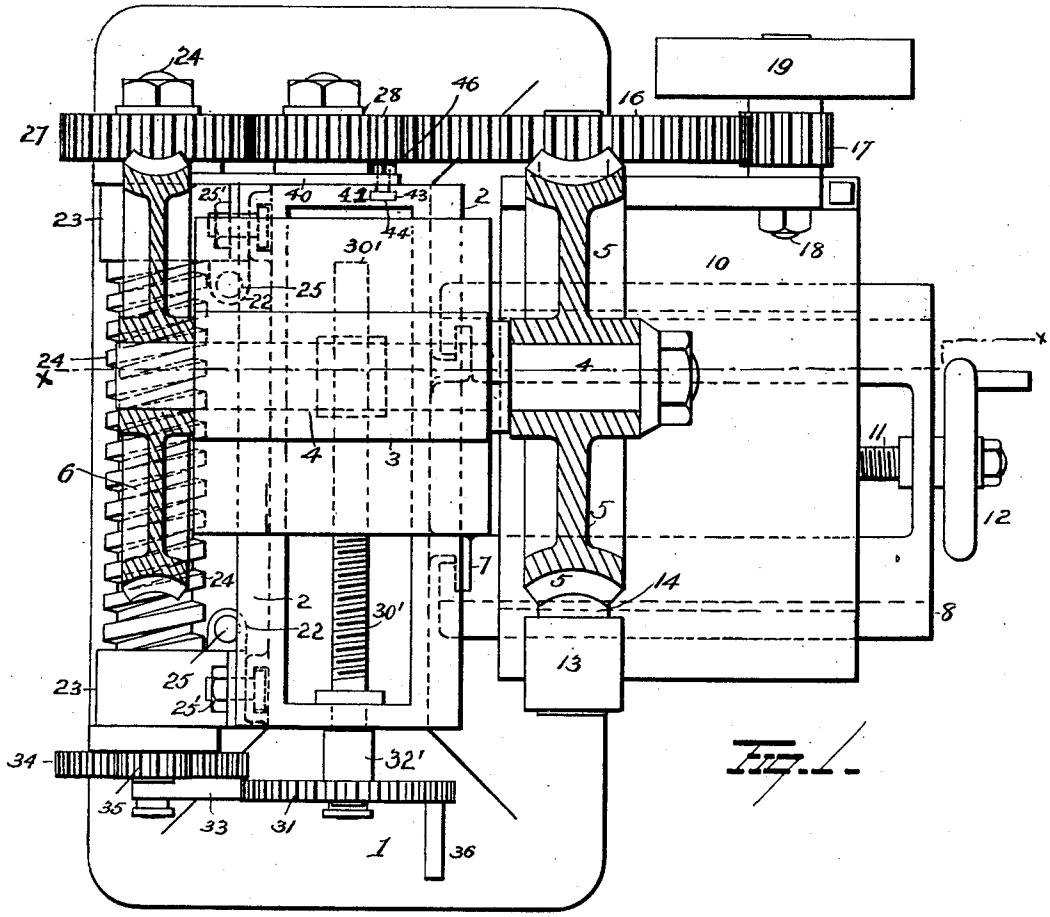


FIG. 1.

FIG. 6.

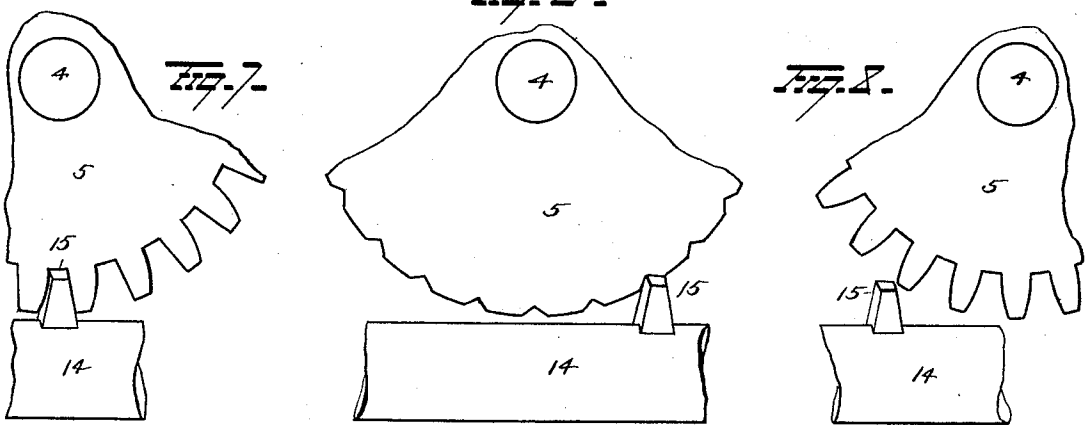


FIG. 7.

FIG. 8.

WITNESSES

E. L. Nottingham

G. F. Downing.

INVENTOR

W. K. Liggett

By H. A. Seymour

Attorney

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4 SHEETS—SHEET 2.

FIG. 2.

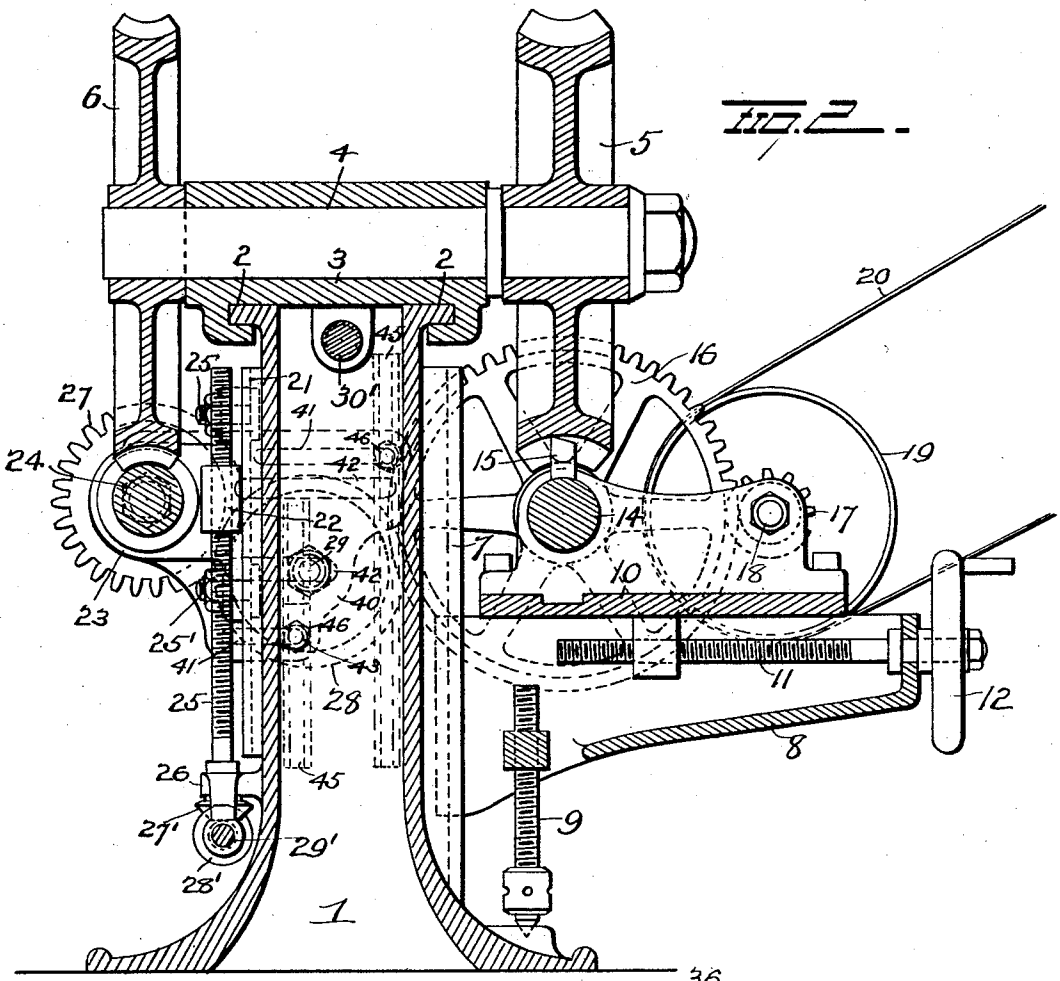
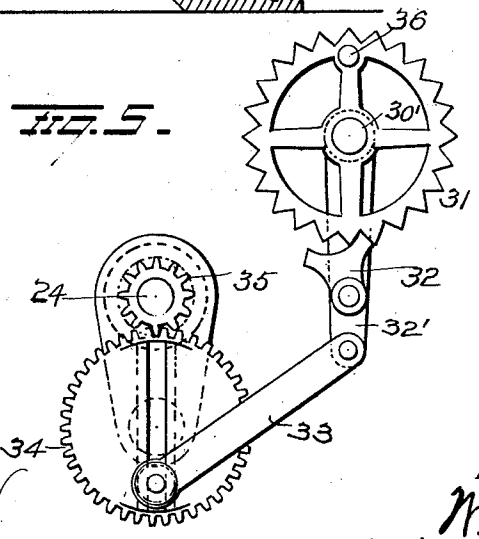


FIG. 5.



WITNESSES

E. J. Nottingham

G. F. Downing.

INVENTOR

W. K. Liggett

By H. A. Seymour

Attorney

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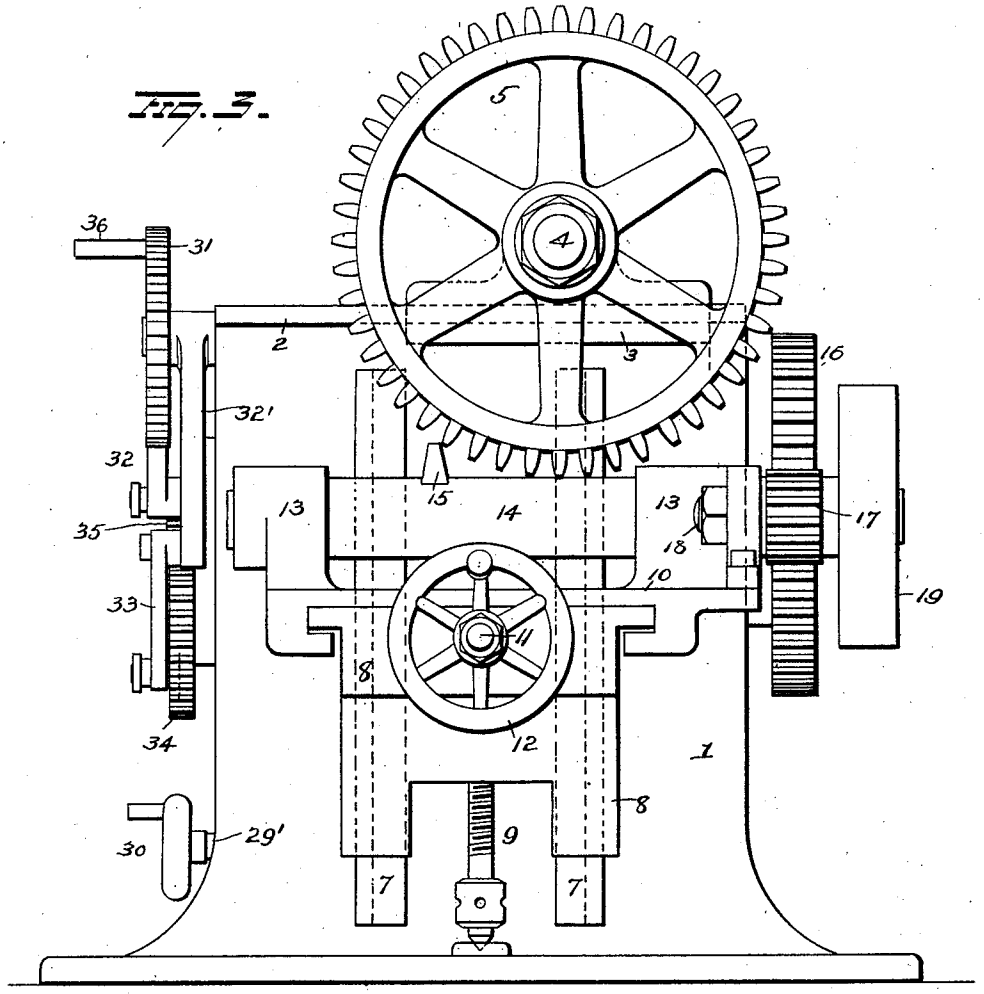
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4 SHEETS—SHEET 3.

Fig. 3.



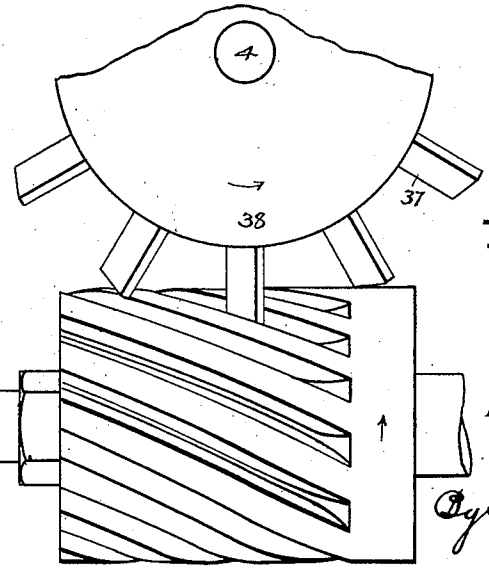


Fig. 9.

WITNESSES

E. L. Nottingham

G. F. Downing.

INVENTOR

W. K. Liggett

By H. A. Seymour

Attorney

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4 SHEETS—SHEET 4.

Fig. 4.

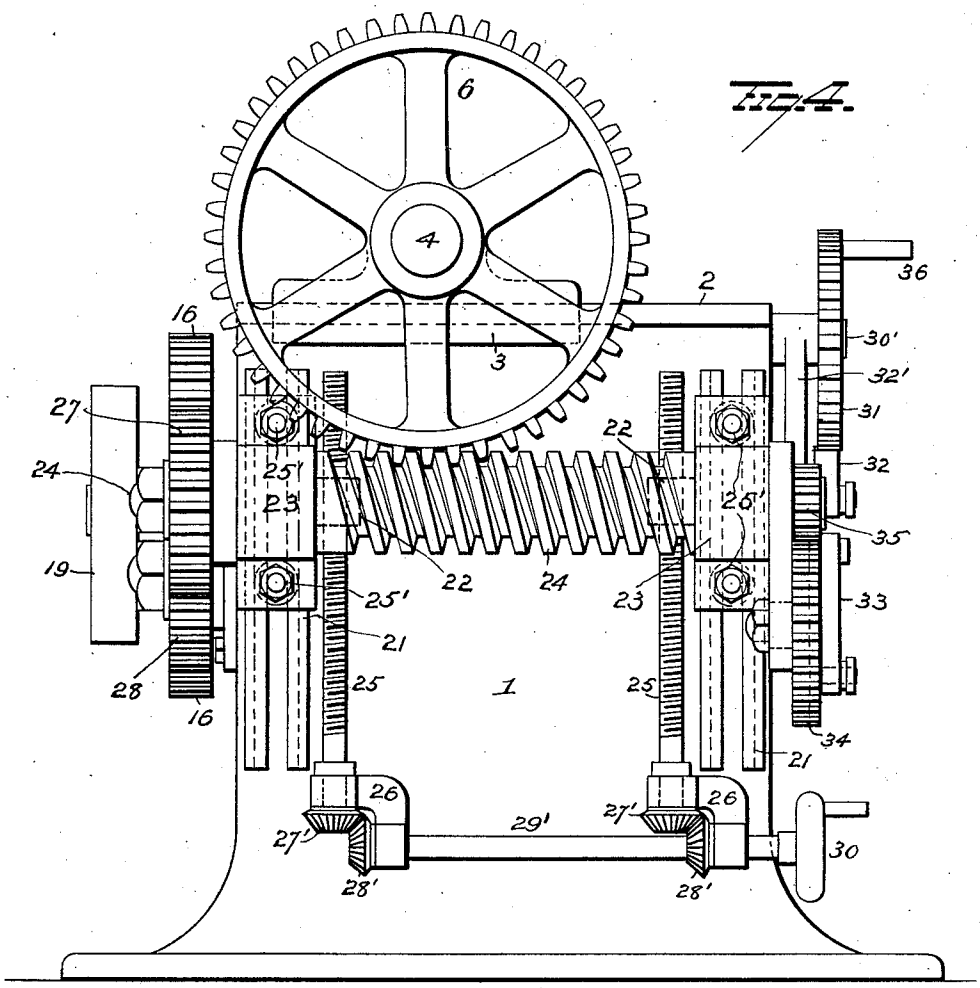
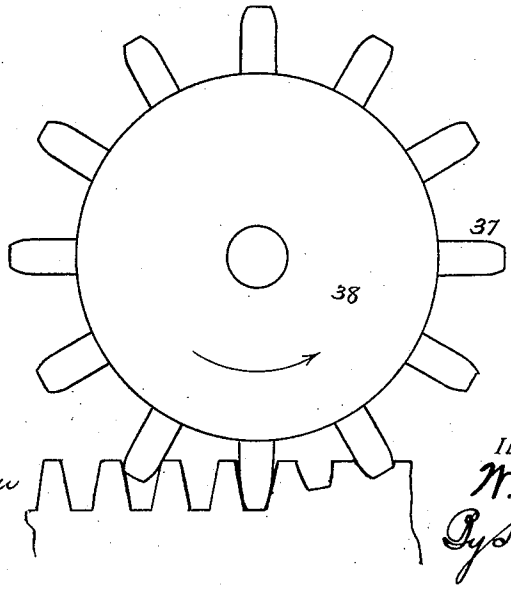


Fig. 10.



WITNESSES

E. Nottingham

G. F. Downing

INVENTOR

W. K. Liggett

By H. A. Seymour

Attorney

UNITED STATES PATENT OFFICE.

WILLIAM K. LIGGETT, OF COLUMBUS, OHIO, ASSIGNOR OF ONE-HALF TO WALDO T. GUY, OF COLUMBUS, OHIO.

MACHINE FOR MAKING WORM AND SPIRAL GEAR.

No. 858,081. Specification of Letters Patent. Patented June 25, 1907.

Application filed February 24, 1903. Serial No. 144,747.

To all whom it may concern:

Be it known that I, WILLIAM K. LIGGETT, of Columbus, in the county of Franklin and State of Ohio, have invented certain new and useful Improvements in Machines for Making Worm and Spiral Gear; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in machines for making worm and spiral or helical gears. Heretofore, such gears have been made by the use of various forms of hobs or milling cutters, in combination with complicated mechanism entailing more or less constant care of an attendant to keep the machine in operation.

The object of my invention is to simplify the construction and operation of machines for cutting helical worms and worm wheels; to avoid the use of complicated and expensive tools and intricate mechanism for operating them, and to construct the machine in such manner that after it shall have been set for cutting a certain blank gear, it will operate to generate the teeth or worms of the gear without attention from the operator until the particular piece shall have been finished.

A further object is to construct the machine in such manner that by its use, a change from one size or class of work to another can be easily accomplished.

With these objects in view, the invention consists in certain novel features of construction and combinations and arrangements of parts as hereinafter set forth and pointed out in the claims.

In the accompanying drawings, Figure 1 is a plan view of a machine embodying my improvements. Fig. 2 is a section on the line x—x of Fig. 1. Fig. 3 is a front elevation. Fig. 4 is a rear elevation. Fig. 5 is a detail view of the ratchet feed. Figs. 6, 7 and 8 are diagrams illustrating the generation of the teeth of a worm wheel. Figs. 9 and 10 are views showing the arrangement for making screws and spiral gears.

1 represents a vertical frame provided at its top with laterally projecting flanges which constitute ways 2 for the accommodation of a horizontally disposed sliding head 3. This head is provided with a bearing for a horizontal shaft 4, the ends of which project beyond the sides of said bearing and head. On one end of the shaft 4, a worm wheel blank 5 is removably secured and to its other end a master worm wheel 6 is secured, the latter being, in every instance of the same pitch diameter as that of the worm wheel to be cut, as illustrated in Fig. 2, or of the same pitch diameter as that of the cutting tool for worms or helical toothed gears.

The vertical frame 1 is provided on one side with guides or ways 7 for the accommodation of a laterally projecting frame 8 and screws 9 are provided for adjusting this table vertically. A platform 10 is mounted upon the adjustable frame 8 and is adapted, by means of a screw 11 swiveled in the outer end of frame 8 and provided with an operating wheel 12, to be adjusted in a direction toward and away from the main frame 1. Bearings 13 are located on the platform 10 and in these bearings, a mandrel 14 is mounted, and provided with a tool or cutter 15, in the case of worm wheels being made, but carrying the blank in the case of worms or helical gears. The mandrel is mounted so as to be at right angles to the axes of the blank 5 and master wheel 6 and hence said mandrel will be made to rotate in a direction at right angles to the direction of rotation of the blank. The tool 15 is secured to the mandrel in such manner that it revolves in a circle, the diameter of which is equal to that of the screw proposed to be used with the worm wheel to be cut, and the cutting edge of said tool should be of the exact shape of a section of the thread on said screw, plus whatever may be required for clearance. A large gear wheel 16 is secured to the mandrel 14 and receives motion from a pinion 17 secured to a short shaft 18 mounted on the platform 10. A pulley 19 is also secured to the short shaft 18 and receives motion, by means of a belt 20 from an electric motor or other convenient source of power.

The main frame 1 is provided on the side opposite to the frame 8, with vertical guides 21 for the accommodation of slides 22 carrying bearings 23 for the ends of a long screw 24 adapted to mesh with the master worm wheel 6. Screws 25 are swiveled at their lower ends in boxes 26 projecting from the

main frame 1 and pass through threaded holes in the slides 22 for moving the worm 24 into mesh with the master wheel 6 or away from said wheel. Clamping bolts 25^1 may be provided for locking the slides 22 in position on the screws 25. Each screw 25 is provided at its lower end with a bevel pinion 27^1 and these receive motion from bevel pinions 28^1 carried by a horizontal shaft 29^1. A hand wheel 30 is secured to the shaft 29^1 for operating it and simultaneously raising or lowering both ends of the worm 24.

A gear 27 is secured to the worm 24 and a gear 28, removably mounted on a stub shaft 29, transmits motion from the gear wheel 16 to the gear 27. The gears 16, 27 and 28 are so proportioned relatively to each other, that the tool carrying mandrel 14 and blank 5 shall rotate at a fixed ratio relatively to each other, said fixed ratio being determined by the number of teeth the proposed worm wheel is to have. Thus while the blank is making one complete revolution, the mandrel 14 will make as many revolutions as the worm wheel is to have teeth. In other words, if it is desired to make a worm wheel having twenty teeth, single pitch, the gears 16, 27 and 28 are so proportioned that the ratio of rotation between the tool holding mandrel 14 and the blank 5 will be 20 to 1. If the worm wheel is to be right handed, an odd number of gears (16, 27 and 28) will be employed, but if it is desired to make a left hand worm wheel, an even number of gears will be employed so as to reverse the direction of rotation of the blank, as will be readily understood.

In order to provide for the use of an odd number of gears between the mandrel 14 and worm 24, or to change the ratio of rotation of the worm or screw 24 and the mandrel 14 by the provision of a larger or smaller gear 28, the adjustable devices now to be described may be employed. An adjustable bracket 40 is mounted on a hub projecting from one of the bearings 23 and provided with slots 41, 41 and slots or grooves 42, 42. Clamping screws 43 pass through the slots 41 and these screws are provided with heads 44 to enter T-shaped guides 45 on the frame, the outer end of each screw being provided with a nut 46. The stub 29 is secured adjustably in one of the slots or grooves 42, and when a left hand worm wheel is to be made, another gear, similar to the gear 28 is mounted on a stub shaft secured in the other slot or groove 42.

A feed screw 30^1 is swiveled in the top of the main frame 1 and engages a threaded projection on the sliding head 3 for the purpose of moving the latter to feed the work 5 relatively to the cutter in the case of worm wheels but the cutter relative to the work in the case of worms and helical toothed gears. The feed screw 30^1 could be operated manually if desired but I prefer to operate it automatically. To accomplish this, a ratchet wheel 31 is secured to the feed screw 30^1, and is engaged by a dog 32 carried by an arm 32^1 loosely hung at its upper end upon a plain portion of said feed screw. To the lower end of the arm 32^1, one end of a rod or pitman 33 is attached and the other end of said rod or pitman is adjustably connected to a gear wheel 34. This gear wheel receives motion from a pinion 35 secured to the worm shaft 24. Thus as the worm shaft 24 rotates and drives the master wheel 6 and blank 5, it also operates the ratchet feed above described and gradually moves the work (blank 5) toward the cutter, in the case of worm wheels but the cutter to the work in the case of worms or helical toothed gears. By providing the ratchet wheel 31 with a handle 36, the feed screw can be operated manually.

In setting up the machine all the bolts are loosened and the worm or screw shaft 24 and mandrel 14 are properly adjusted and the proper gear is placed on end of the worm or screw 24; then a proper intermediate gear is placed on the stud or stub shaft 29 and slid along the key slot 42 until it comes into proper mesh with the gear on the screw, when the operator will secure the stub shaft to the bracket 40. The whole bracket 40 will then be swung up until the intermediate gear meshes also with the driving gear 16, when said bracket will be secured in place by the bolts or screws 43 in the slots 41. The clamping of the bearings supporting the long worm after it has been raised to position is done by the bolts 25^1.

The operation of the machine to make a worm wheel is as follows: The blank 5 is fitted to one end of the shaft 4 and a master wheel 6 of the same pitch diameter as the proposed worm wheel is secured to the other end of said shaft or mandrel 4. The worm screw 24 is then brought up into proper mesh with the master wheel by means of the adjusting screws and clamped firmly in position so that it is parallel with the head 3. Next a tool 15 is provided and secured to the mandrel 14 in such manner that it will revolve in a circle, the diameter of which will be equal to the worm screw proposed to be used with the worm wheel 5, and its edge should be of the exact shape of a section of the thread on said worm screw plus whatever may be required for clearance. The mandrel 14 is then brought to the proper position under the blank 5 so that the center distance from shaft or mandrel 4 to mandrel 14 shall be the same as that of the proposed worm and worm wheel. Next a train of gears 16, 27, 28, will be selected with such a ratio that the blank 5 and the tool holding mandrel 14 shall revolve in exact ratio to each other as the proposed worm wheel is to have teeth, as hereinbefore explained. Next the head 3 will be adjusted so that as the tool revolves,

its point will just touch the edge of the blank 5. The machine is then started, the pawl 32 of the ratchet feed is thrown in and the machine continues to perform its functions until the wheel is finished. At first the cut will be upon one corner of the tool only, as shown in Fig. 6; but as the work advances, the tool will get deeper and deeper into the blank, thus generating the full tooth as shown in Figs. 7 and 8. It will be observed that the master wheel being of the same pitch diameter as the worm wheel to be made, forces any point upon its pitch circumference to travel in an epicycloidal path when operated by the feed alone, since the master wheel 6 rolls upon the screw 24 as a toothed wheel would roll upon a rack. This action takes place whenever the feed moves the head 3 and is not interfered with by the independent rotation of the blank. The cross section of the tooth generated is therefore of the involute form. When the feed has progressed so far that the tooth has ceased cutting, the work will be finished. The feed may then be run back; the finished worm wheel removed; a new blank put in its place, and the machine again started. The machine will cut worm wheels with involute teeth, worm wheels and worms after the Hindley pattern, all sorts of screws and helical toothed gears and spur gears.

In cutting screws or spiral gears, I form a cutter by inserting steel blanks 37 in a disk 38 and mounting the same upon the shaft or mandrel 4 in place of the worm wheel blank 5. I then go through the same operations as that described for cutting a worm wheel. The pieces of steel are then removed one by one, backed off and tempered, and returned to place, thus forming a cutting tool as shown in Figs. 9 and 10. The work to be operated upon is then placed upon the mandrel 14 and this tool on mandrel 3 and the machine, being properly geared and set, operates as shown in Figs. 9 and 10.

In the machine there are two work mandrels, viz. the mandrel 4 on top with a horizontal feed and the mandrel 14 underneath and at right angles to the first, which has a vertical feed and also a horizontal feed at right angles to the feed for the top shaft or mandrel.

In cutting worm wheels or spur gears the work is always placed on the mandrel 4 and the cutting tool on mandrel 14, but in cutting worm screws or helical toothed gears, the cutting tool is placed on mandrel 4 and the blank or work on mandrel 14 as above explained. The tool and work, except in the case of spur gears, always revolve at a fixed ratio with each other. In cutting worm wheels with involute shaped teeth, the work is fed over the tool, but the tool is fed over the work for screws and helical toothed gears. In cutting worm wheels with involute shaped teeth, or screws, or helical toothed gears, the upper slide carrying mandrel 4 is used for the feed. For worm wheels and worms cut after the Hindley type the vertical feed is used. The mandrel with its tool is fed upward into the blank for the worm wheel. The mandrel with its blank is fed upward into the tool for the worm. For spur gears the cutter is fed to the work from the front by means of the sliding table 10 with its screw 11 and hand wheel 12, the gearing 16, 27 and 28 being disconnected and the worm and master wheel used only for indexing.

The master wheel need not be of the same pitch diameter as the work to be cut or the tool used except in those cases when the upper side slide 3 is used. That is, in cutting screws and helical toothed gears and worm gearing with involute shaped teeth (the ordinary form).

In cutting Hindley type of worm wheels and worms the master wheel may be of any diameter more or less or equal to the diameter of the blank or tool so long as the gearing is adjusted to give the required fixed ratio of revoution between the work mandrel and tool mandrel.

An important feature of my machine is the combination of a long driving screw with a master worm wheel of the same pitch diameter with the work or tool secured to the other end of the same mandrel and a feed motion parallel to said screw so that the master wheel while driven by the screw also rolls on it by virtue of the feed, each of these motions being independent of the other at any and every position. This function is always used 1st. in cutting the ordinary form of worm wheels; 2nd. in cutting the ordinary worm screw or helical toothed gear. In cutting the ordinary form or worm wheels the blank is placed upon the same shaft as the master worm wheel and the tool is in the other mandrel.

Various slight changes might be made in the details of construction of my invention without departing from the spirit thereof or limiting its scope and hence I do not wish to limit myself to the precise details herein set forth.

Having fully described my invention what I claim as new and desire to secure by Letters-Patent, is:—

1. In a gear cutting machine, the combination of a blank carrying mandrel, a cutter carrying mandrel, means for feeding the blank carried by the blank carrying mandrel, to the cutter tangentially with relation to said blank, and means for rotating said mandrels at speeds bearing a definite ratio to each other.

2. In a gear cutting machine, the combination of a blank carrying mandrel, a cutter mandrel, a single-toothed cutter carried by the cutter mandrel, means for feeding one of said mandrels in a direction parallel to the

axis of the other mandrel, and means for simultaneously rotating said mandrels at speeds bearing a fixed ratio to each other.

3. In a gear cutting machine, the combination of a blank carrying mandrel, a cutter mandrel, a single cutter carried by the cutter mandrel, means for moving the blank carrying mandrel in a direction to impart a tangential feed of the blank to the cutter, and means for simultaneously rotating said mandrels at speeds bearing a fixed ratio to each other.

4. In a gear cutting machine, the combination of a blank carrying mandrel, a cutter carrying mandrel disposed at right angles to the blank carrying mandrel, a master worm wheel carried by the blank carrying mandrel and having the same pitch diameter as that of the proposed worm wheel to be cut, a worm meshing with said master wheel, means for feeding the blank carrying mandrel in a direction parallel to the axis of the cutter carrying mandrel, and gearing between said cutter mandrel and said worm, for imparting to said mandrels a speed having a fixed ratio to each other.

5. In a gear cutting machine the combination with a rotary mandrel and a cutter substantially such as described carried thereby, of a master worm wheel having the same pitch diameter as the worm wheel to be cut and adapted to transmit motion to the blank, a worm with which the master worm wheel meshes, means for feeding the master wheel and blank laterally, and gearing between the cutter mandrel and said worm, said gearing proportioned to rotate the tool mandrel as many times as there are to be teeth in the worm wheel, while the master wheel and worm wheel blank are making a single revolution.

6. In a gear cutting machine, the combination with two mandrels disposed at right angles to each other, of a cutter substantially such as described carried by one of said mandrels, a master worm wheel carried by the other mandrel, said last mentioned mandrel also adapted to carry a blank, means for imparting lateral feed movement to the mandrel which carries the master wheel and blank, a long worm on which the master wheel rolls and gearing for rotating said worm to rotate the master wheel and blank, and for rotating the tool mandrel.

7. In a gear cutting machine, the combination with a blank carrying mandrel and a tool carrying mandrel disposed at right angles to each other, of a master wheel on the blank carrying mandrel and having a pitch diameter equal to the pitch diameter of the gear to be cut, gearing between said master wheel and the tool carrying mandrel arranged to drive the two mandrels at different speeds having a definite ratio to each other and means for feeding the blank-carrying mandrel in a direction parallel to the axis of the tool carrying mandrel.

8. In a gear cutting machine, the combination of a mandrel, a master wheel secured thereto, a long worm meshing with said master wheel, means for feeding said mandrel laterally and causing the master wheel to roll on the worm, a second mandrel disposed at right angles to the first, a cutter substantially such as described secured to said second mandrel, and gearing for rotating the worm and the two mandrels.

9. In a gear cutting machine, the combination with a blank-carrying mandrel and a mandrel disposed at right angles thereto and carrying a tool substantially such as described, of a master worm wheel secured to the blank carrying mandrel and having a pitch diameter equal to that of the proposed worm wheel, gearing for imparting rotation to said mandrels at a fixed ratio, and means for feeding the blank carrying mandrel in a direction parallel to the axis of the tool carrying mandrel.

10. In a gear cutting machine, the combination with a blank carrying mandrel and a mandrel disposed at right angles thereto and carrying a tool substantially such as described, of a master worm wheel secured to the blank carrying mandrel and having a pitch diameter equal to that of the proposed worm wheel, a worm to mesh with said master wheel, gearing for rotating said mandrels at predetermined speeds, and means for feeding the blank carrying mandrel in direction parallel to the axis of said worm.

11. In a gear cutting machine, the combination with a mandrel, a single-toothed cutter carried thereby and a worm disposed parallel with said mandrel and gearing for rotating said mandrel and worm at predetermined speeds, of a blank carrying mandrel disposed above said tool carrying mandrel and worm and at right angles to both, a master worm wheel of the same pitch diameter as the worm wheel to be cut secured to the blank carrying mandrel and meshing with said worm, and means for feeding the blank carrying mandrel in a direction parallel with the axes of the tool carrying mandrel and worm during the rotation of said mandrels and worm.

12. In a gear cutting machine, the combination with a frame and a sliding head thereon, of a blank carrying mandrel mounted on said sliding head, a master worm wheel secured to said mandrel and having a pitch diameter equal to the pitch diameter of the proposed worm wheel, a worm meshing with said worm wheel, a tool carrying mandrel disposed below and at right angles to the end of the first mentioned mandrel which carries the blank, gearing for rotating said mandrels

at different speeds and means for feeding the sliding head in a direction parallel to said worm and tool carrying mandrel.

13. In a gear cutting machine, the combination with a frame and a sliding head thereon, of a tool carrying mandrel mounted on the frame and disposed parallel with said sliding head, a blank carrying mandrel mounted on said sliding head and adapted at one end to receive a blank to be disposed over the tool carrying mandrel, a master worm wheel on the other end of said blank carrying mandrel, having a pitch diameter equal to that of the proposed worm wheel, and meshing with said mandrels at a predetermined ratio and means for feeding the sliding head in a direction parallel to the axes of the tool carrying mandrel and said worm.

14. In a gear cutting machine, the combination with a mandrel, a tool substantially such as described carried by said mandrel and a blank-carrying mandrel disposed at right angles to the mandrel carrying the tool, of a master worm wheel on the blank-carrying mandrel and having a pitch diameter equal to that of the proposed worm wheel, means for rotating said mandrels at predetermined speeds having a fixed ratio to each other, and means for feeding one of said mandrels in a direction parallel to the axis of the other.

15. In a gear cutting machine, the combination with a main frame, and a sliding head thereon, of a blank-carrying mandrel mounted on said sliding head, a laterally projecting frame attached to the main frame, a platform on said laterally projecting frame, a tool-carrying mandrel mounted on said platform, means for adjusting the laterally projecting frame vertically, means for adjusting the platform toward and away from the main frame, means for rotating said mandrels and means for simultaneously feeding the sliding head in a direction at right angles to the axis of the blank carrying mandrel during the rotation of said mandrels.

16. In a gear cutting machine, the combination with a main frame, and a sliding head thereon, of a blank-carrying mandrel mounted on the sliding head, a master worm wheel secured to said mandrel, a worm to mesh with said master wheel, means for moving said worm vertically into and out of mesh with the master wheel, a tool-carrying mandrel under one end of the blank carrying mandrel, means for adjusting the tool carrying mandrel, gearing for rotating said tool carrying mandrel and said worm at definite ratio of speed, and means for simultaneously feeding the sliding head in a direction parallel to the axes of the tool carrying mandrel and said worm.

17. In a gear cutting machine, the combination of a long driving screw, with a mandrel, a master worm wheel thereon of the same pitch diameter as the work or tool secured to the other end of the same mandrel with the master wheel and a feed device for moving the said mandrel parallel with the long driving screw, whereby the master wheel will be driven by the screw and also roll on the screw by virtue of the action of said feed device, each of said motions of the master wheel being independent of the other at any and every position.

18. In a gear cutting machine, the combination of mandrel bearings disposed at right angles to each other, mandrels mounted in said bearings, means for feeding one of said bearings in a direction at right angles to the axis of the mandrel mounted therein, means for feeding the other bearing in two directions at right angles to each other, a master wheel on one of said mandrels, means for imparting motion to said master wheel, means for imparting motion to the other mandrel, a blank secured to one of said mandrels and a tool carried by one of said mandrels.

In testimony whereof, I have signed this specification in the presence of two subscribing witnesses.

WILLIAM K. LIGGETT.

Witnesses:
W. S. GUY,
C. H. HOUSEMAN.