(No Model.) 2 Sheets—Sheet 1.

H. C. WARREN.

MACHINE FOR GENERATING GEAR TEETH.

No. 605,982. Patented June 21, 1898.

Fig. 1.

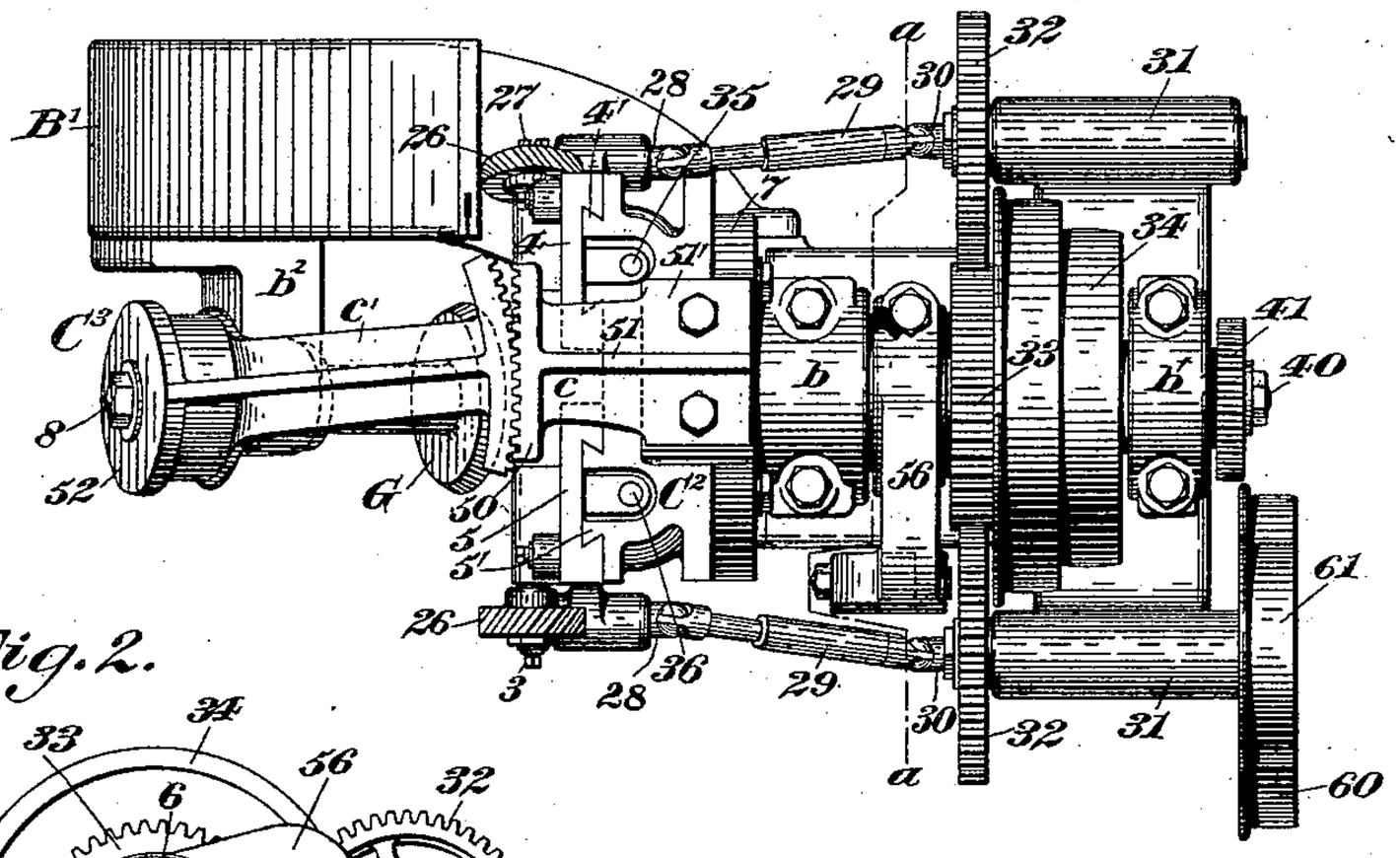


Fig. 2.

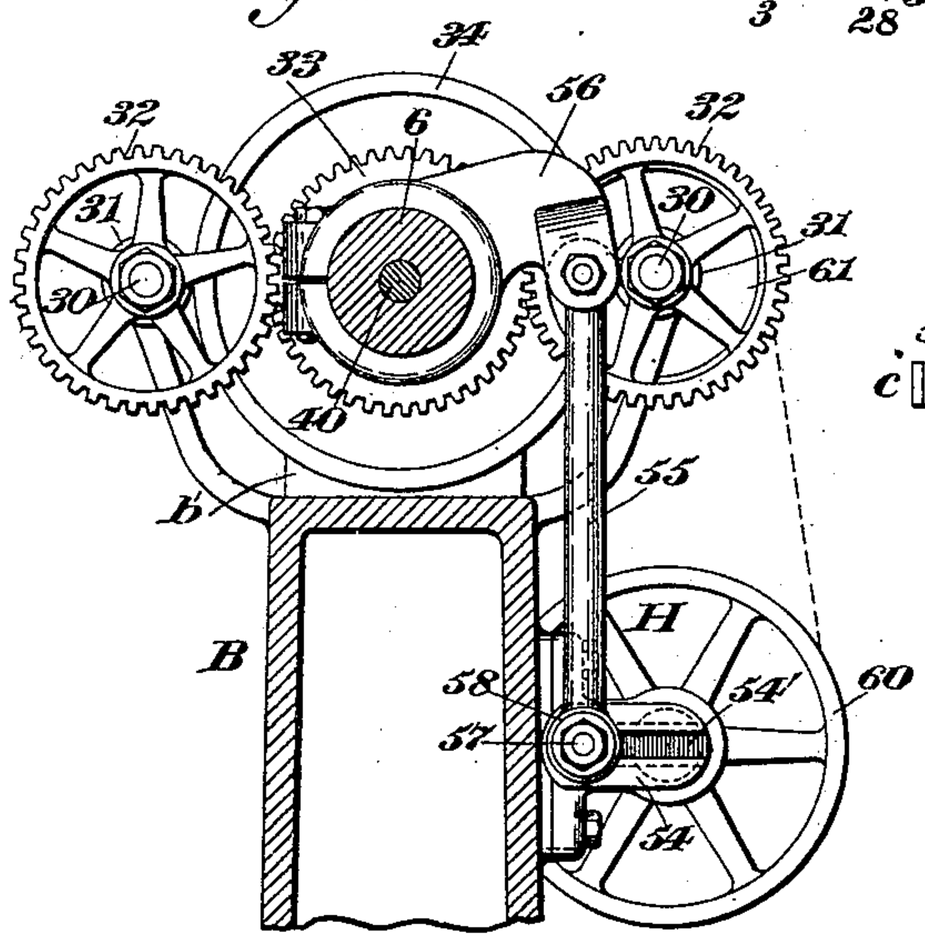
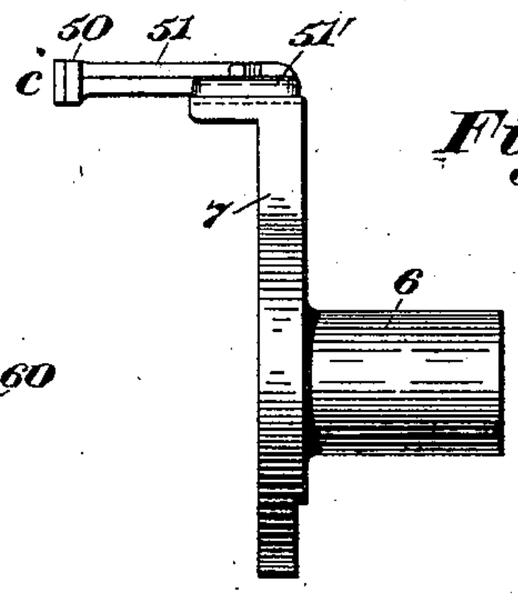


Fig. 3.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 5.

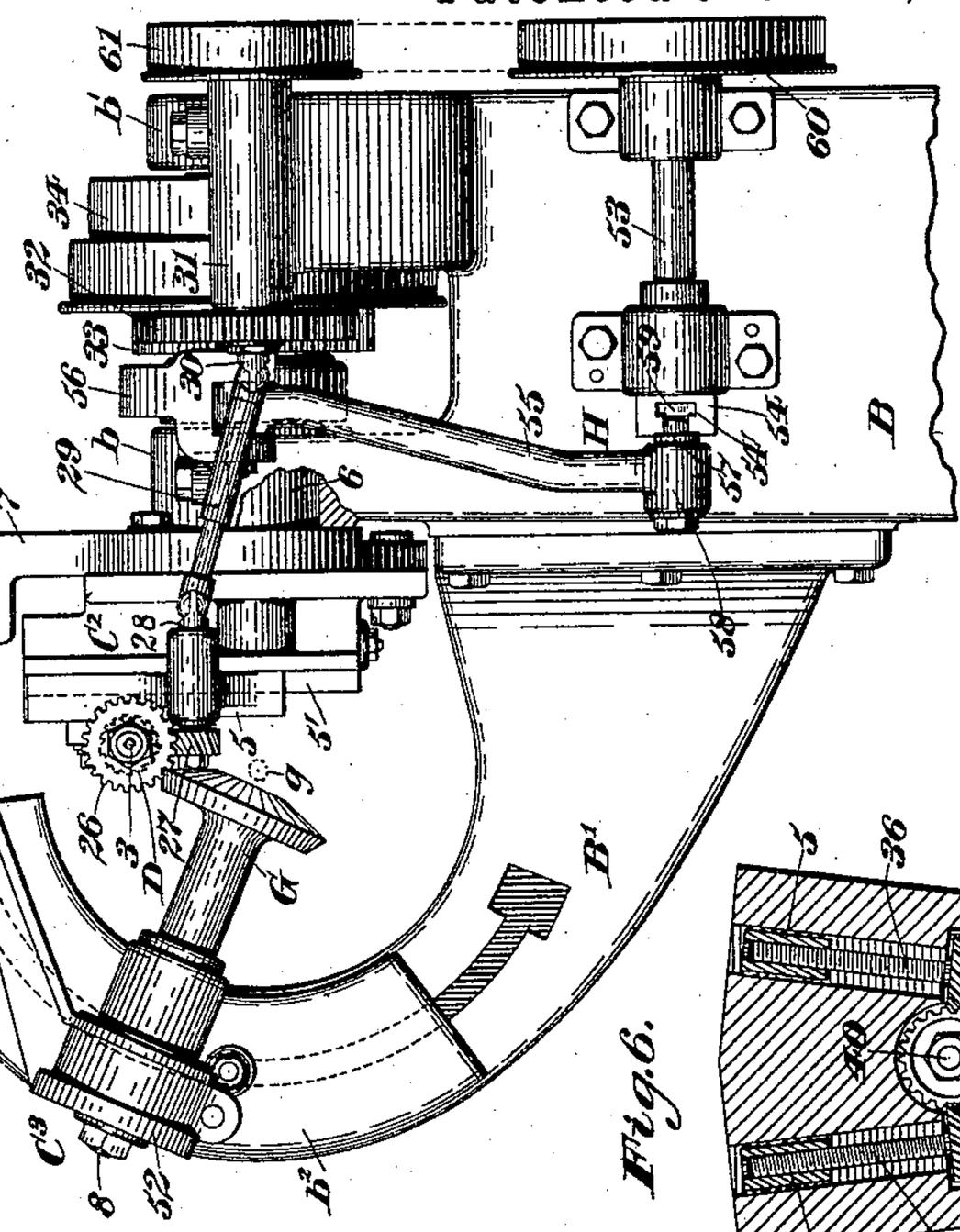


Fig. 6.

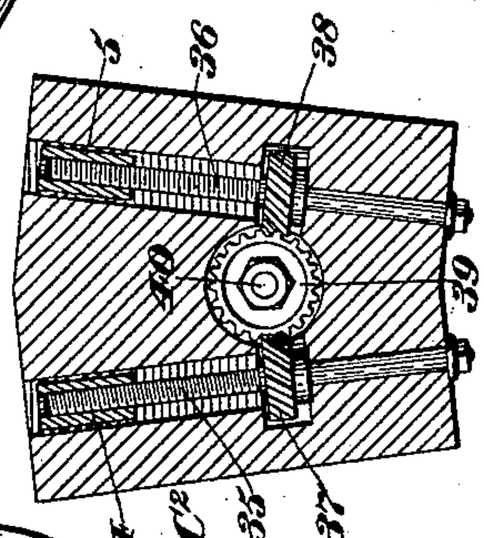
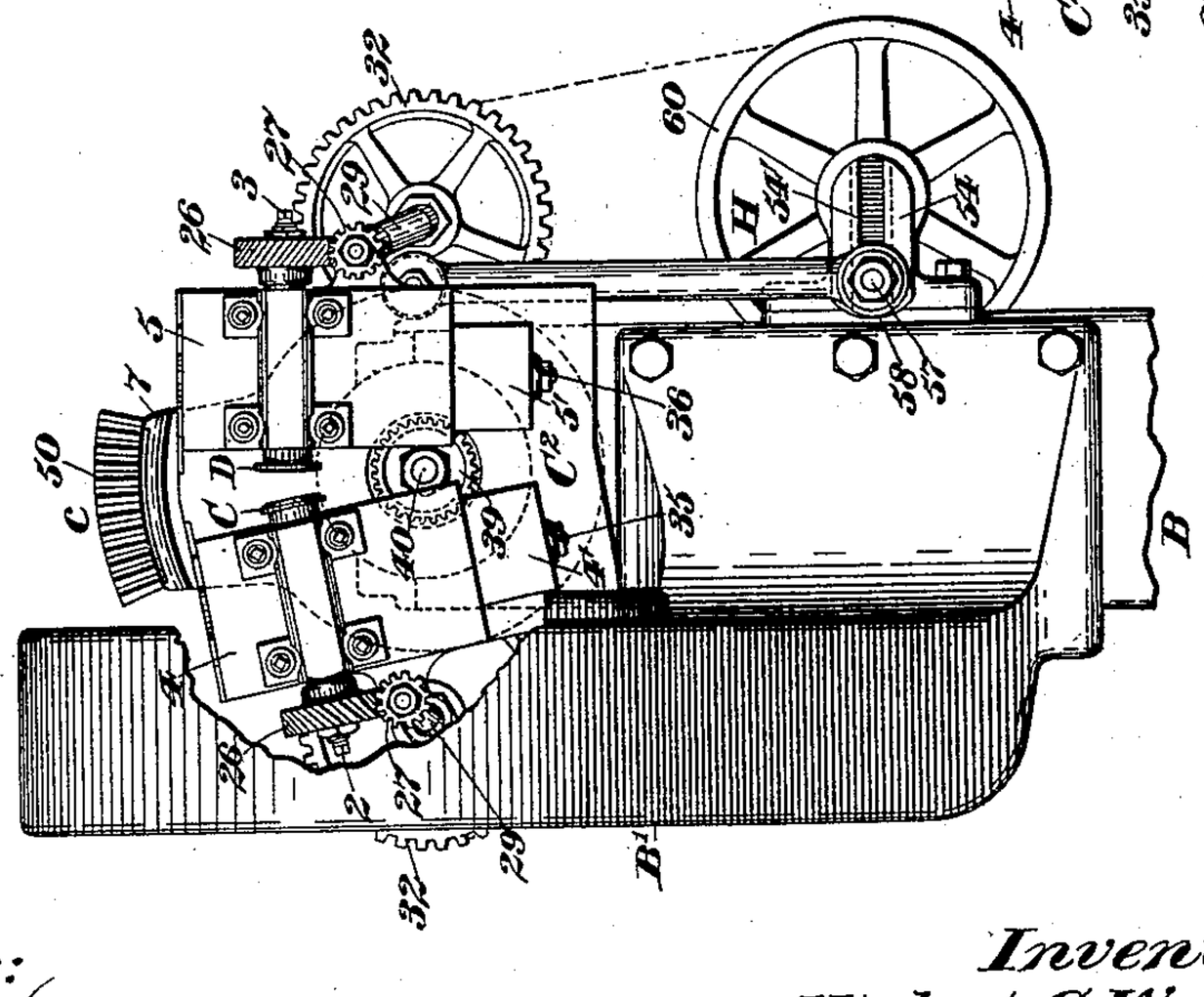


Fig. 4.



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UNITED STATES PATENT OFFICE.

HERBERT C. WARREN, OF HARTFORD, CONNECTICUT.

MACHINE FOR GENERATING GEAR-TEETH.

SPECIFICATION forming part of Letters Patent No. 605,982, dated June 21, 1898.

Application filed June 28, 1897. Serial No. 642,612. (No model.)

To all whom it may concern:

Be it known that I, HERBERT C. WARREN, a citizen of the United States, residing in Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Machines for Generating Gear-Teeth, of which the following is a specification.

This invention appertains to a machine for generating gear-teeth; and it relates more particularly to a machine of that class shown and described in my prior patent, No. 547,571, and also in my contemporaneously-pending application, Serial No. 612,894, to which reference may be had, and which machine embodies an oscillatory or rotary reciprocatory gear-blank carrier, an oscillatory cutter-carrier, a rotary cutter carried by the cutter-carrier, and means for actuating the two carriers in synchronism.

The object of my present invention is to provide in a machine of the class specified improved and simplified means for effecting comparative movements of a predetermined ratio between the cutter-carrier and gear-blank carrier and to so construct and organize the parts thereof that the ratio of movement between said carriers cannot be changed by carelessness of workmen in adjusting the parts of the machine or by the jarring of the machine, but, on the contrary, can only be changed by the removal and replacement of the parts which directly effect the change of ratio.

To this end my improved machine for generating gear-teeth comprises two carriers supported for oscillatory movements, with their axes in oblique disposition relatively to each other, an actuating-connector between and directly connecting the two carriers and embodying two oscillatory members operatively connected together, and means for actuating one carrier and through the connector the other carrier.

In the drawings accompanying and forming part of this specification, Figure 1 is a plan view of a portion of a machine for generating gear-teeth embodying my present invention. Fig. 2 is a vertical cross-section taken in the line *a a*, Fig. 1, looking toward the right hand in said figure. Fig. 3 is a side view of the main portion of the cutter-carrier detached. Fig. 4 is a front elevation of the machine as seen from the left in Fig. 1, the blank-carrier and a portion of the framework being removed. Fig. 5 is a side elevation, partially in section, of a portion of the machine as seen from the right hand in Fig. 4; and Fig. 6 is a vertical cross-section of the cutter-slide carrier, showing portions of the cutter-slides and the feed-wheel and feed-screws in connection therewith.

Similar characters designate like parts in all the figures of the drawings.

Briefly stated, my improved apparatus for generating gear-teeth preferably embodies an oscillatory cutter-carrier, an oscillatory gear-blank carrier, a connector between and directly connecting the two carriers, a rotary cutter carried by the cutter-carrier, means for rotating said cutter, and means for imparting an oscillatory movement to one of the carriers to thereby effect, through the medium of the actuating-connector between the two carriers, an oscillatory movement of the other carrier.

The term "oscillatory movement" as herein applied to the cutter-carrier and gear-blank carrier is used to avoid prolixity and signifies any curvilinear or rotary reciprocatory movement of said carriers.

The apparatus illustrated in the accompanying drawings is especially designed for generating the teeth of bevel-gears.

In generating teeth of bevel-gears, owing to the fact that the spaces between the teeth are of gradually-reduced width toward their geometrical apexes, it is not only desirable, but it is conducive to theoretical correctness, to form only one face of each tooth at one time and to employ a cutter which is very thin and adapted for freely passing through the narrowest part of the tooth-space. Therefore for this purpose and also for the purpose of facilitating the operation by generating a complete circuit or the entire complement of teeth at each complete rotation of the gear-blank and obviate the necessity of repetition of the operation to form opposite faces of successive teeth I have shown in the drawings two rotary cutters set side by side in position for cutting the opposite faces of adjacent teeth, one cutter acting upon and generating one face of one tooth and the other cutter si-

multaneously acting upon and generating the opposite face of the next adjacent tooth.

It is desired to state in the above connection that while it is preferable to employ two rotary cutters so disposed as to generate opposite faces of adjacent teeth simultaneously it will be understood that I do not wish to limit myself to the employment of a plurality of cutters, as a single cutter might be practically employed to generate adjacent faces of each tooth-space, especially if generating the teeth of spur-gears or gears in which the teeth are of uniform width from end to end, which may be accomplished by setting the gear-blank, hereinafter described, with its axis in alinement with the axis of oscillation of the cutter-carrier.

The framework of the machine, which may be of any suitable general construction for supporting and carrying the several fixed and movable details of the several mechanisms and parts, is shown comprising a main body portion or cutter-mechanism frame (designated in a general way by B) having two uprights or brackets b and b', adapted for supporting the cutter-carrier, and also having at one end thereof an outwardly and upwardly extending curved segment or arm B', adapted for supporting a gear-blank carrier.

The cutter-carrier (designated in a general way by C^2) and the gear-blank carrier (designated in a general way by C^3) are shown supported for oscillatory movements about axes located in the same vertical planes, but in intersecting lines, the cutter-carrier being supported with its axis in a horizontal plane in bearings on the uprights b and b' of the framework and the gear-blank carrier being supported with its axis in an oblique plane in a suitable bearing on a bracket or slide b^2, adjustably secured to the blank-carrier-supporting segment B', preferably by means of bolts extending through said slide and through a curved guideway formed through said segment.

The term "cutter-carrier" in the broader sense thereof, as employed in certain claims, signifies any suitable form of device embodying means for supporting the cutter and for facilitating an oscillatory and a reciprocatory movement of the cutter in relatively-intersecting planes.

As in the machine described in the patent and application hereinbefore referred to, the cutter-carrier and the gear-blank carrier have their axes of oscillation in relatively oblique lines which intersect at a common center, which common center is indicated by a circle, (designated by g, Fig. 5 of the drawings.) The gear-blank, which is designated in a general way by G, will, when seated in position to be operated upon by the cutter, have the apex of its face-angles coincident with the common center g. The cutter-carrier in the organization of mechanism shown in the accompanying drawings comprises three members, one of which is in the nature of a cutter-slide carrier (designated in a general way by C^2) supported for oscillatory movement about a horizontal axis and the others of which are shown as two cutter-slides 4 and 5, respectively, and supported on the cutter-slide carrier for reciprocatory movements in planes intersecting the oscillatory path of the carrier member and in planes radial to a common center.

The cutters, which are herein shown as circular milling-cutters and designated by C and D, respectively, are supported side by side with their adjacent faces in oblique planes radial to the common center g, said cutters being supported at the inner ends of arbors 2 and 3, journaled in suitable bearings upon the cutter-slides 4 and 5, respectively, with their axes at right angles substantially to the peripheral plane of said cutters.

The cutter-slides 4 and 5 are supported for reciprocatory movement in guideways 4' and 5' on the slide-carrier C^2 and are located one at each side of the axis of oscillatory movement of said carrier. This carrier C^2 in the form shown most clearly in Figs. 3 and 5 of the drawings comprises a head 7 and a tubular stem or journal 6, rotatably supported in bearings on the uprights b and b'.

The gear-blank carrier C^3, which may be similar in a general way to the gear-blank carrier described in the patent hereinbefore referred to, is shown in Fig. 5, comprising an arbor or spindle 8, journaled for rotation in an elongated bearing on the carrier-supporting slide b^2, with its axis located in a plane intersecting the axial line of the cutter-carrier. In practice the blank-carrier will be furnished with a chuck at that end thereof adjacent to the cutters C and D for holding the gear-blank, and some suitable means will be provided—such, for instance, as is described in my prior patent—for adjusting the blank-holding member or chuck of the blank-carrier longitudinally of its axis.

As a convenient means for rotating the cutter-arbors 2 and 3 each arbor is shown furnished at the outer end thereof with a spiral gear 26, which meshes with a small spiral gear 27, fixed to the end of a short shaft 28, journaled in a bearing on the cutter-slide at the outer side thereof, and which shaft is operatively connected by a universal telescopic connector 29 to a shaft 30, journaled in a bearing 31 on the framework of the machine, preferably in horizontal alinement with the axis of oscillation of the cutter-carrier, and which shaft is provided with a spur-wheel 32, which meshes with a similar spur-wheel 33, fixed to the hub of a driving-pulley 34, which driving-pulley is preferably rotatably mounted upon the journal or tubular stem 6 of the cutter-carrier and which pulley 34 may be driven from any suitable source of power in the usual manner.

In practice feed mechanism will be provided for imparting a slow working stroke to the cutter-slide in a plane intersecting the

oscillatory path of movement of said slide and for effecting a relatively rapid return movement of said slide. This feed mechanism in the preferred form thereof (shown most clearly in Figs. 5 and 6 of the drawings) embodies two feed-screws 35 and 36, journaled in the cutter-slide-carrier head 7, one at each side the axis of oscillatory movement of said carrier, and having screw-threaded bearings in the two slides 4 and 5, respectively, (see Fig. 6,) and two spiral gear-wheels 37 and 38, fixed to the feed-screws 35 and 36 and meshing, respectively, with opposite sides of a spiral feed-wheel 39, fixed to a shaft 40, which shaft is journaled in and extends through the tubular extension 6 of the cutter-carrier, with its axis coincident with the axis of said carrier, said shaft 40 being shown furnished at the outer end thereof with a pinion 41, which in practice will be rotated through the medium of any suitable reversing driving mechanism, such as described in my prior application herein referred to.

In practice the feed mechanism above described will be constructed, organized, and timed to impart an intermittent or step-by-step movement to the cutter-slide, and it is preferable to impart an effective movement to the cutters during and throughout each alternate oscillatory movement of the carrier. To accomplish this, it is simply necessary to oscillate the carrier and rotate the feed-wheel 39 at coinciding velocities. This will cause the spiral gear-wheels 37 and 38, fixed to the feed-screws 35 and 36, to move with the feed-wheel 39 in an orbital path about the axis of said feed-wheel without rotation on their own axes and without effecting a feed or radial movement of the cutter-slides when the cutter-carrier has an oscillatory movement in a direction corresponding to the direction of rotation of the feed-wheel. When said cutter-carrier has an oscillatory movement in a direction opposite to the direction of rotation of the feed-wheel, said spiral wheels 37 and 38 will have a rotative movement about their own axes in addition to an orbital movement about the shaft of the feed-wheel and will through the medium of the feed-screws impart a feed movement to the cutter-slides.

From the foregoing it will be understood that the feed-wheel 39 is during the cutting operation of the cutters rotated constantly in one direction and that the spiral feed-wheels 37 and 38 are only rotated to impart feed movements to the cutter-slides during the oscillatory movement of the cutter-carrier in a direction opposite to the direction of rotation of the feed-wheel and will therefore only impart feed movements to the cutter-slides at and throughout each alternate oscillatory stroke of the cutter-carrier.

As a convenient means for imparting oscillatory or rotary reciprocatory movements to the cutter-carrier and blank-carrier simultaneously, and also for maintaining a predetermined ratio of velocity between said carriers, I have provided an actuating-connector between and directly connecting the two carriers and adapted, when one carrier is oscillated, for effecting an oscillatory movement of the other carrier simultaneously, and I have provided in connection with one of said carriers a carrier-oscillating device embodying means whereby the range of oscillatory movement of said carrier may be arbitrarily modified, all of which will be hereinafter described.

The actuating-connector between the two oscillatory carriers comprises in the preferred form thereof shown in the drawings two oscillatory members (designated, respectively, by c and c') secured to the two carriers C^2 and C^3, respectively, and so connected together at their adjacent ends that an oscillatory movement of one carrier and the member secured thereto will impart an oscillatory movement in the same direction to the other member and its carrier.

To facilitate a change in the ratio of movements and velocities of the two carriers C^2 and C^3, as is necessary when generating the teeth of gears of different pitch and tooth-face angles, and at the same time enable any unskilled mechanic to make this change without liability of error, the oscillatory members of the actuating-connector between the gear-blank carrier and cutter-carrier are preferably in the nature of intermeshing bevel-gear segments, one of which, as c, is removably secured to the cutter-carrier and the other of which, as c', is removably secured to the gear-blank carrier, the apex of the tooth-face angles of the bevel-gear segments c and c' being coincident with the common center g or the point of intersection of the axial lines of the two carriers C^2 and C^3.

In the form shown in the accompanying drawings the gear-segment or connecting member c is shown comprising a curved toothed segment 50, concentric to the axis of oscillatory movement of the cutter-carrier C^2, and a web or arm 51, having a flange 51′, bolted to the flanged upper end of the head 7 of the cutter-carrier C^2. The other gear-segment or connecting member c' is similar in a general way to the member c, the only difference being that the web thereof is shown having at the outer end a split sleeve or hub 52, which surrounds and is clamped to the outer end of the gear-blank carrier C^3.

From the foregoing description it will be seen that the members c and c' of the actuating-connector between the cutter-carrier C^2 and gear-blank carrier C^3 will operate when one carrier is oscillated in the same manner as two intermeshing bevel-gears would operate if one of said gears were fixed to the shaft of the cutter-carrier and the other of said bevel-gears were fixed to the shaft of the gear-blank carrier. This forms a simple and convenient means for effecting the simultaneous oscillatory movement of the two carriers when one carrier is oscillated and

prevents the possibility of the ratio of movement being changed except by removing the two gear-segments *c* and *c'* and replacing them by other segments of different pitch, which is a matter of considerable importance in machines of this class.

When it is desired to change the ratio of movements between the cutter-carrier and the gear-blank carrier, as is necessary when different kinds of bevel-gears are to be cut, the two bevel-gear segments *c* and *c'* will be removed and another set substituted to conform to the change in angular relation between the axes of the two carriers C^2 and C^3, and for this purpose a series of sets of bevel-gear segments will in practice be furnished with each machine of the class herein described, each set being of a form adapted for effecting the requisite ratio of movement to generate a particular kind of gear, so that when it is desired to change the ratio of movements between the two carriers C^2 and C^3, as required when generating the teeth of a particular form of gear, it will be simply necessary for the operator to remove the gear-segments of the machine and replace them by another set which is constructed to secure the ratio of movement requisite for generating the teeth of this particular form of gear. These different sets of gears may in practice be numbered to correspond to the number of the different bevel-gears whose teeth are to be generated as a convenience in selecting the proper gear-segments.

As a convenient means for actuating one of the carriers to effect an oscillatory movement of the other carrier I have provided a carrier-oscillating device, which is designated in a general way by H and which in the accompanying drawings is shown in operative connection with the cutter-carrier C^2. This carrier-oscillating device embodies means whereby the range of oscillatory movement of the carrier may be arbitrarily varied as desired. The carrier-oscillating device H in the preferred form thereof (shown most clearly in Figs. 2 to 5, inclusive, of the drawings) comprises a crank-shaft 53, journaled in suitable bearings on the framework and having a crank-arm 54 at one end thereof, in which is formed a longitudinal slideway 54', a pitman 55, pivotally connected at its upper end to a laterally-projecting arm 56 on the stem or hub 6 of the cutter-carrier, and means for pivotally and adjustably securing the pitman at its lower end to the crank-arm 54 of the crank-shaft 53, and which adjusting means preferably consists of a stud 57, preferably extending through a sleeve 58 in the lower end of the pitman and having at one end thereof a head or slide-block 59, which fits the slideway of the crank-arm and is furnished with a nut at the opposite end, by means of which the same may be tightly clamped in position.

For the purpose of rotating the crank-shaft to impart oscillatory movements to the cutter-carrier said crank-shaft is shown furnished at the outer end thereof with a pulley 60, which is belted to a pulley 61, fixed to the end of the cutter-rotating shaft 30.

When it is desired to increase or decrease the range of movement of the cutter-slide, it is simply necessary to adjust the lower end of the pitman so that the pivotal point thereof is a greater or less distance from the axis of the crank-arm 54.

Having described my invention, I claim—

1. In a machine for generating gear-teeth, two carriers supported for oscillatory movements, in combination with an actuating-connector between said carriers and comprising two members in direct operative engagement with each other and fixedly secured one to each carrier, and means for actuating one carrier, and, through the connector, the other carrier.

2. In a machine for generating gear-teeth, two oscillatory carriers having their axes of oscillation in intersecting lines, in combination with two intermeshing gear-segments fixed one to each carrier, and means for actuating one of said carriers.

3. In a machine for generating gear-teeth, two oscillatory carriers having relatively oblique axes of oscillation, in combination with two intermeshing gear-segments fixed one to each carrier, and means for actuating one of said carriers.

4. In a machine for generating gear-teeth, the combination, with two oscillatory carriers having relatively oblique axes located in the same plane, of two intermeshing gear-segments fixed one to each carrier, and means for actuating one of said carriers.

5. In a machine for generating gear-teeth, the combination, with two oscillatory carriers having their axes of oscillation in intersecting lines, of two bevel-gear segments connected one to each carrier with the apex of their angles coincident with the point of intersection of the axial lines of the two carriers, and means for actuating one of said carriers.

6. The combination, with an oscillatory cutter-carrier and an oscillatory gear-blank carrier, of two intermeshing bevel-gear segments connected one to each carrier, and a carrier-actuating device in operative connection with one of said carriers and embodying means for changing the range of movement of said carrier.

7. In a machine for generating gear-teeth, the combination, with a cutter-carrier supported for oscillatory movement, of a gear-blank carrier supported for oscillatory movement with its axis oblique to the axis of movement of the cutter-carrier; means for effecting a change in the angular relation of the axis of the two carriers; two removable gear-segments carried one by each carrier with their teeth in intermeshing relation; and actuating means in connection with one carrier.

8. In a machine for generating gear-teeth,

the combination, with two oscillatory carriers having their axes of movement in intersecting lines, of an actuating-connector between, and directly connecting, the two carriers and embodying two coöperative oscillatory members one of which is fixed to each carrier; means in connection with one carrier for adjusting the same with its axis at different angles relatively to the other carrier; and an actuating device in connection with one carrier and embodying means for changing the range of movement of said carrier.

9. In a machine for generating gear-teeth, the combination, with a cutter-slide carrier supported for oscillatory movement, of a cutter-slide mounted on said carrier for reciprocatory movements in a path intersecting the path of oscillatory movement thereof; a rotary cutter supported on the cutter-slide; means for rotating the said cutter; a gear-blank carrier with its axis oblique to the axis of movement of the cutter-slide carrier; means for changing the angle of the gear-blank-carrier axis relatively to the angle of the cutter-slide-carrier axis; two intermeshing gears carried one by the cutter-slide carrier and the other by the gear-blank carrier; and means for actuating one carrier to impart synchronous oscillatory movements to both carriers.

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