(No Model.) 3 Sheets—Sheet 1.

E. J. O'CONNOR.

GEAR CUTTING MACHINE.

No. 563,301. Patented July 7, 1896.

Fig. 1

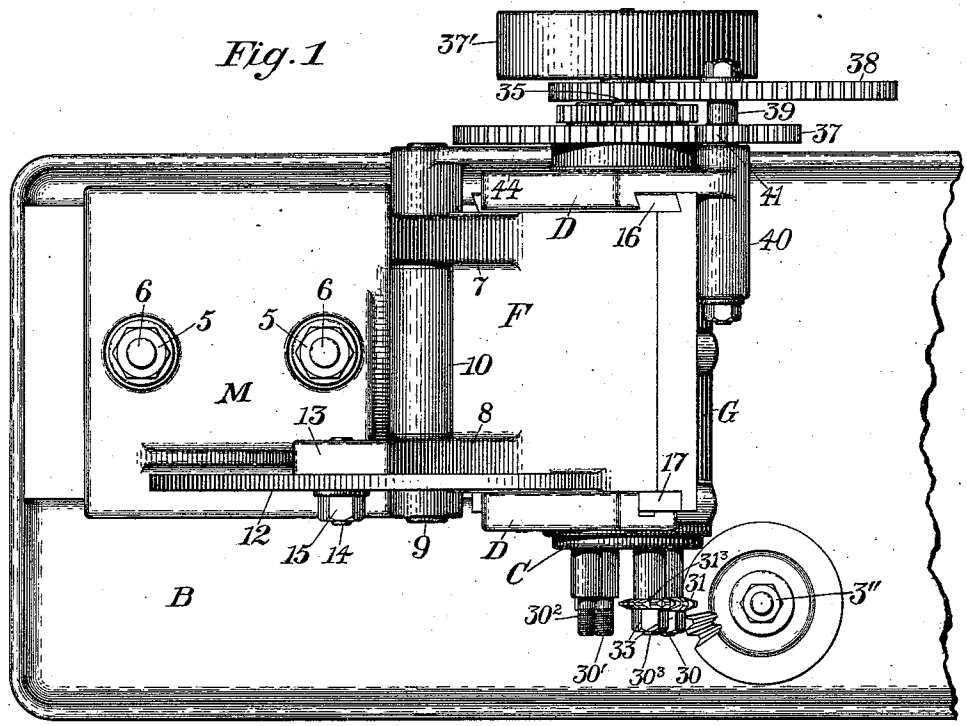
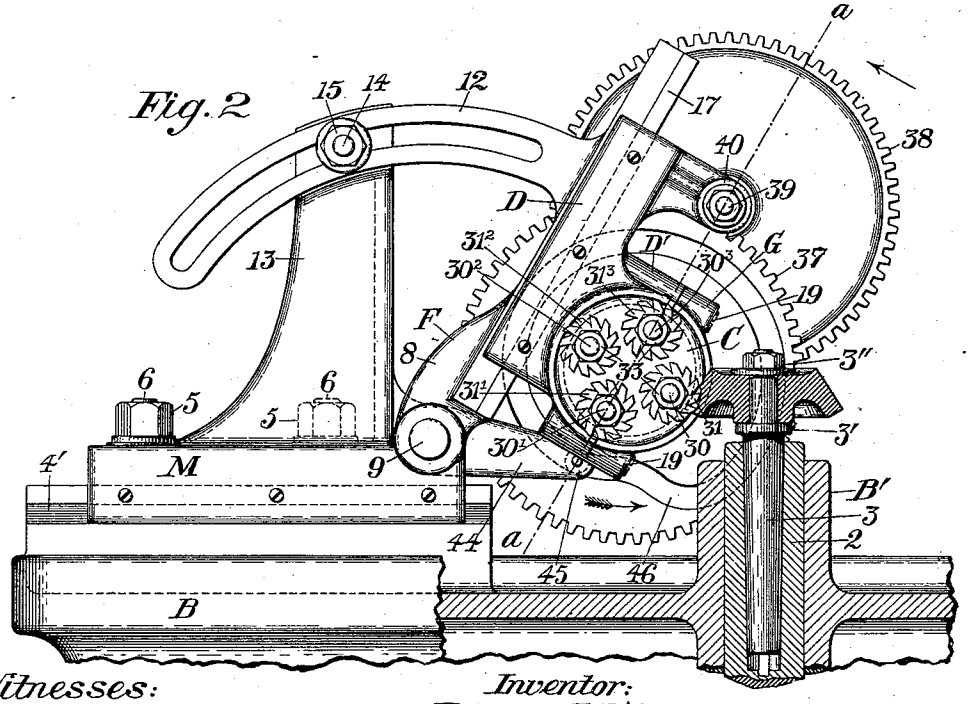


Fig. 2



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F. H. Richards

(No Model.) 3 Sheets—Sheet 2.

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Fig. 4

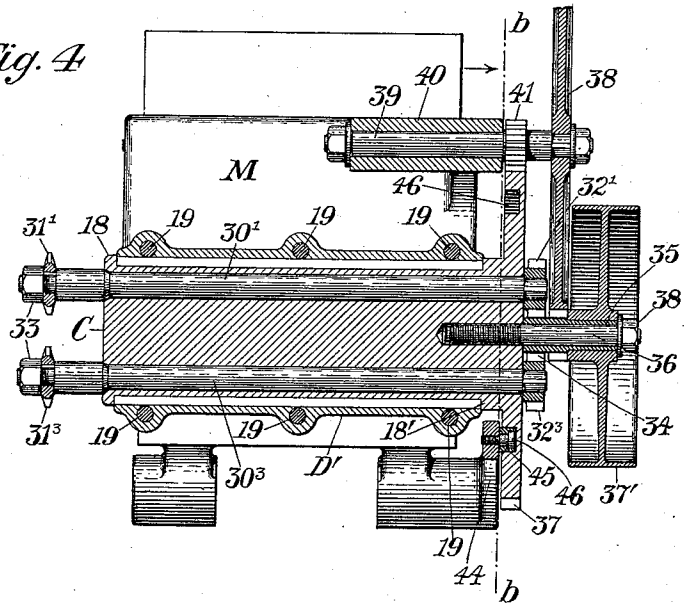
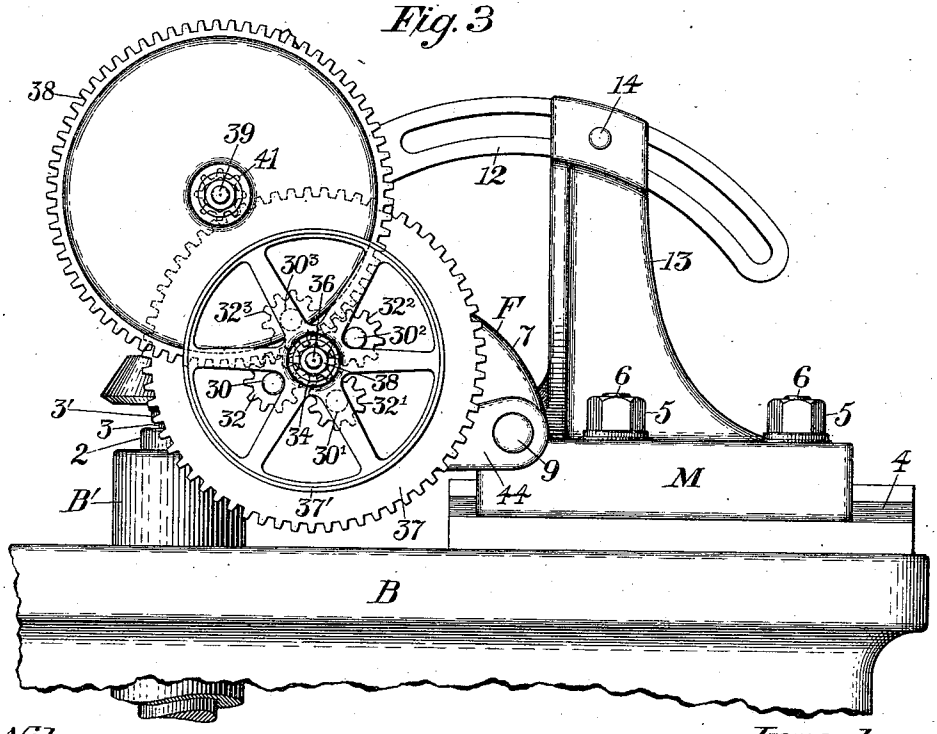


Fig. 3



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(No Model.) 3 Sheets—Sheet 3.

E. J. O'CONNOR.

GEAR CUTTING MACHINE.

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Fig. 6

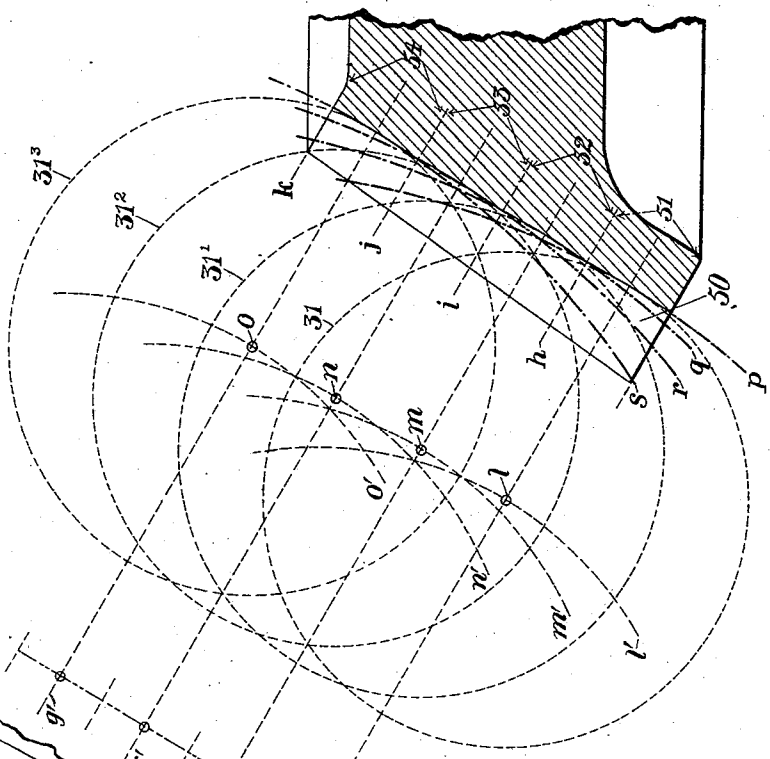


Fig. 7

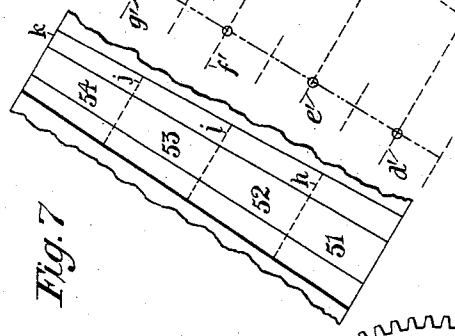


Fig. 5

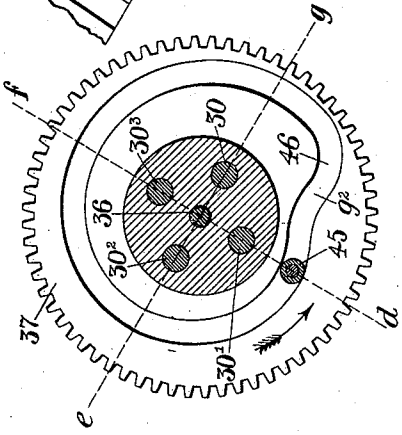


Fig. 11

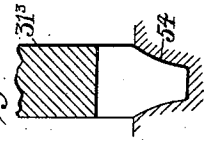


Fig. 10

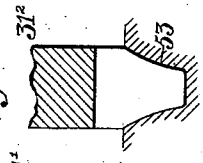


Fig. 9

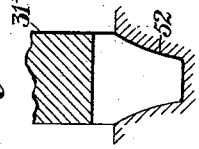
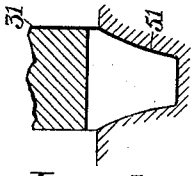


Fig. 8



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UNITED STATES PATENT OFFICE.

EDWARD J. O'CONNOR, OF HARTFORD, CONNECTICUT.

GEAR-CUTTING MACHINE.

SPECIFICATION forming part of Letters Patent No. 563,301, dated July 7, 1896.

Application filed July 15, 1893. Renewed November 4, 1895. Serial No. 567,953. (No model.)

To all whom it may concern:

Be it known that I, EDWARD J. O'CONNOR, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Gear-Cutting Machines, of which the following is a specification.

This invention relates to that class of gear-cutting machines which are intended for cutting bevel spur-wheels, the object being to furnish a machine by which the tapering tooth-space of a bevel-gear may be cut by a series of cutters operating in succession, and each adapted, respectively, for cutting one portion of the length of the tooth-space.

In the drawings accompanying and forming a part of this specification, Figure 1 is a plan view of a portion of an ordinary gear-cutting machine furnished with my present improvements. Fig. 2 is a side elevation, partially in section, of the machine as seen from below in Fig. 1. Fig. 3 is a side elevation of the machine as seen from above in Fig. 1. Fig. 4 is a sectional view on line *a a* of Fig. 2. Fig. 5 is a detail view, partially in section, on the line *b b* of Fig. 4, for illustrating the construction in the preferred form thereof, of certain operative features of the mechanism. Fig. 6 is a diagrammatic view illustrating the process of cutting a bevel spur-wheel by means of my improved gear-cutting machine. Fig. 7 is a plan view of a portion of a finished gear as cut by my improved machine, showing the degree of variation in the width of the tooth-space, the spaces thereof between transverse dotted lines thereon showing the successive portions acted upon and finished by the successive cutters. Figs. 8, 9, 10, and 11 are cross-sectional details of successive portions of the gear, as on lines *d'*, *e'*, *f'*, and *g'*, showing the relative positions of four successive cutters in these four successive stages of the operation in cutting a tooth-space, the said views showing the cutter-teeth at the meridian of their cutting-paths of movement, or at the center of their effective strokes.

Similar characters designate like parts in all the figures.

For the purpose of illustrating the application of my present improvements to the cutting of a bevel spur-wheel, I have shown these improvements applied to a gear-cutting machine of an ordinary and well-known type, which machine is only partially shown in the drawings.

The bed or principal framework (designated in a general way by B) is shown provided with a bearing B', in which is fitted in the usual manner the spindle 2, whose lower end is usually extended downward into a second bearing (not herein shown) and intermediate of its length is ordinarily provided with means for revolving and indexing the same. Said spindle 2 is shown (see Fig. 2) provided with a removable arbor 3, to whose upper end the gear-blank is fixed by means of the collar or shoulder 3' of said arbor and the washer and nut 3''. Other well-known means, however, may be substituted for carrying the gear-blank, or for fixing the same upon its supporting-arbor. The framework B is also shown furnished with suitable guideways 4 4', on which is mounted a sliding frame M, whose edges engage the guideways 4 4', and which is, or may be, clamped in place longitudinally of said guideways by means of the nuts and bolts 5 and 6 after a well-known manner. This framework is adjustably mounted, as described, upon the framework B to carry the cutter mechanism to and from the main spindle 2 of the machine, for adjusting the machine to cut gears of different diameters.

The operative details of the cutter mechanism are mounted upon a swing-frame, which is designated in a general way by F, and which is shown pivotally supported by means of the ears or arms 7 and 8 upon a pivot-shaft 9, that is journaled in the central bearing 10 of the aforesaid sliding frame M. For adjusting the inclination, as shown in Fig. 2, of the swing-frame F, this is shown furnished with the usual slotted quadrant-arm 12, which is clamped to one side of the slide-frame post 13, by means of the bolt 14 and nut 15, after the manner well illustrated in the drawings.

Mounted upon the forward side of the swing-frame, at the right-hand in Figs. 1 and 2, is the slide D, of the cutter mechanism, which slide is gibbed to the guideways 16 and

17, formed on the opposite edges, respectively, of the swing-frame F, and is constructed for receiving the revoluble carrier C.

The slide D, movably supported by the swinging frame F, has a projection D′ at its lower right-hand side, as clearly shown in Fig. 2, which is bored in the direction of the width of the bed to form a journal-bearing to receive and support the revoluble carrier C. This journal-bearing, in the preferred form, as shown in the drawings, will be made in two parts, the projection D′, which has a semicircular bore, forming one-half of the journal-bearing, and a cap G, which is correspondingly bored, forming the other half of said journal-bearing. This construction permits the ready insertion of the revoluble carrier C, which will preferably be flanged at its ends, as shown at 18 18′, to prevent longitudinal displacement. This cap, after the carrier C is in place in the half journal-bearing of the swinging frame F, is secured to the slide by means of suitable lag-screws 19, as best shown in Figs. 2 and 4.

The several cutter-carrying spindles, which may be two or more in number, as circumstances may require, and of which four are shown in the present instance, being herein designated by 30, 30′, 30^2, and 30^3, respectively, are journaled in bearings formed in the carrier C, being provided at one end with the cutters 31, 31′, 31^2, and 31^3, respectively, and at the opposite end with gears, whereby the spindles may be rotated. Said cutters are substantially duplicates, except in size of cutting-teeth, as will be hereinafter described, and are shown similarly mounted upon their respective spindles, being clamped thereon by means of the usual nuts 33 after the ordinary manner of mounting gear-cutters. The driving-gears of said spindles 30, 30′, 30^2, and 30^3, are designated by the characters 32, 32′, 32^2, and 32^3, respectively.

As a means for imparting rotary movement to said spindle-gears, and thereby to the spindles and gear-cutters, the driving-pinion 34 is formed upon or secured to one end of a tubular shaft 35, which shaft is shown revolubly mounted upon a stud or shaft 36, fixed centrally in one end of the revoluble carrier C, as most clearly illustrated in Fig. 4 of the drawings. To the outer end of said tubular shaft 35 is fixed a suitable driving-pulley, as 37′, and said tubular shaft is shown held in place longitudinally upon the stud 36 by means of the nut 38, screwed upon the end of said stud. The fixed shaft 36 being axially coincident with the carrier C, the driving-pinion 34, mounted on said shaft, properly meshes with all of said spindle-gears, and the position of the same is not affected by the rotary movement of said spindle-carrier.

The revoluble movement or "feed" of the cutters is effected by means of devices for imparting a rotary movement to the carrier C, these devices consisting, in the preferred form thereof herein shown, of gearing intermediate to the driving-shaft 35 and the gear 37, shown carried on the rearward end of said spindle-carrier. Said intermediate gearing consists of the relatively large driven gear 38, which is fixed on the outer end of a feed-shaft 39, that is journaled in the bearing 40 of the slide D, and which has a driving-pinion 41, meshing with said carrier-gear 37. By constructing the described intermediate gearing of suitable proportions therefor, any desired rate of rotative feed movement may be obtained, with the limits required in practice.

As a means for obtaining the required rectilinear feed movement of the slide D on the swing-frame F, this frame is shown furnished with an arm 44, carrying a pin or cam-roller 45, which fits and runs in the cam-groove 46, formed on the inner side of the carrier-gear 37. The proper shape of said cam-groove for ordinary requirements is illustrated in Fig. 5, it consisting in a spiral groove extending from the point or quarter-line d around and outwardly from the axis of the carrier C (in the direction opposite to the arrow) to the succeeding quarter-lines e, f, and g, the first and last of these four points representing the beginning and end of the working stroke of the cutter mechanism. The direction of movement of the cam and gear is, of course, indicated by the arrow in Fig. 5, and said quarter-lines d, e, f, and g in this figure correspond with the division-lines d', e', f', and g' shown in the diagrammatic view, Fig. 6. On the rotary movement of the carrier and its cam, the cam roll or pin 47, by engaging in the cam-groove, operates to impart a sliding movement to the entire cutter mechanism in parallelism to the plane of the groove being cut in the gear-blank, according as the cam-groove, at its point of engagement with said roller, approaches or recedes from its axis of rotation. That portion of the cam-groove designated by g^2 causes a return movement of the slide together with its cutting mechanism, bringing the same back to its normal inoperative position.

In the diagrammatic view, Fig. 6, the length of the gear-tooth 50 is shown divided by transverse dotted lines h, i, j, and k into four equal longitudinal portions or divisions, the spaces between which lines are designated by 51, 52, 53, and 54, and whose center lines d', e', f', and g', also designated as "position lines," have already been referred to in connection with the quarter-lines d, e, f, and g. The spaces 51, 52, 53, and 54 between the lines h, i, j, and k indicate the length of effective straight cut of each of the successive cutters, respectively, in their successive paths of movement. The circular lines 31, 31′, 31^2, and 31^3 indicate, respectively, the four successive cutters, which are designated by similar characters in Figs. 1, 2, and 4, the axes of the cutters being here indicated by the small circles l, m, n, and o, respectively. The path of movement of each cutter-axis is indicated by the dotted radial lines l', m', n', and o', respec-

tively, which lines are a resultant of the longitudinal movement of the slide and of the rotary movement of the cutter-carrier on the slide, said longitudinal and rotary movements being simultaneous. The cutter-circles 31, 31′, 31^2, and 31^3 indicate the positions of the cutters when these are at mid-stroke or central with relation to the portions 51, 52, 53, and 54 of the tooth, which portions are successively finished by the successive actions of the successive cutters, and the cutting-path of each successive cutter is designated by the heavy dot-and-dash lines *p*, *q*, *r*, and *s*, respectively.

The operation of the cutters upon the gear-blank is as follows: The first cutter 31 approaches the gear-blank on the axial path *l*′, cuts away the metal of the gear-blank to the heavy dot-and-dash line *p*, and finishes that portion at the base of the tooth to nearly a straight surface 51, which lies between the end of the tooth and the dotted line 8. The second cutter 31′, which will, in practice, be somewhat smaller than the first one, approaches the gear-blank on the second axial path *m*′ and cuts away a succeeding portion of the gear-blank, as indicated by the second dot-and-dash line *q*. In like manner the succeeding cutters 31^2 and 31^3, which are of gradually-reduced sizes, approach the gear-blank and on the succeeding axial paths *n*′ and *o*′, respectively, and cut away the gear-blank, as indicated by the third and fourth dot-and-dash lines *r* and *s*, respectively.

The cutter-teeth of successive cutters, as more clearly illustrated in detail in Figs. 8, 9, 10, and 11, are of gradually-reduced width, in the order shown in said figures, which is the order in which each cutter acts upon the gear-blank in cutting a tooth-space, to form teeth, and each cutter is of a width corresponding, respectively, to the width of the portions 51, 52, 53, and 54, respectively, of the tooth-space, which it acts upon to effect a finished cut, the length of which portions represents the entire length of finished cutting travel of the successive cutters. According to this process, carried out by means of a series of cutters of successive sizes, varying in degree to the successive portions of the cut to be made by said cutters, these being carried and operated substantially as described, the successive portions 51, 52, 53, and 54 of the length of the gear-tooth are each formed by a cutter especially shaped therefor, and the relation of each succeeding cut to the preceding one is such that the surfaces merge one into the other tangentially in regular and gradual manner, producing substantially the same result as if the gear were cut by a planing-tool operating upon lines radiating from the common center or focus of the gear-tooth.

By means of my present invention and the mechanism herein described for automatically bringing a series of cutters of gradually-varying sizes to the work successively in their respective orders, I am enabled to produce a finished bevel-gear of high quality with rapidity and cheapness.

I do not desire to limit myself to the exact construction of means for obtaining the required feed movement of the cutters carried by the revoluble carrier C longitudinally with relation to the tooth being formed, as herein described, as many devices could be used to accomplish this result without departure from my invention.

Having thus described my invention, I claim—

1. In a gear-cutting machine, the combination with the work-carrying spindle, of the revoluble cutter-spindle carrier and its spindles, a series of similar cutters of successive sizes on said spindles and adapted, respectively, for cutting successive portions of the length of the bevel gear-tooth, and means for rotating said spindle and carriers, and bringing the successive cutters successively to the work to be operated upon, substantially as described.

2. In a gear-cutting machine, the combination with the work-carrying spindle, and with the revoluble spindle-carrier and spindles, of a series of similar cutters of successive sizes supported by said spindles upon independent axes radially disposed and equidistant with relation to a common center, and means for rotating said cutters in unison and bringing them independently and successively to the work upon the work-spindle, substantially as described.

3. In a gear-cutting machine, the combination with the work-carrying spindle, of a revoluble cutter-carrier capable of transverse movement, a series of independent cutters of successive sizes revolubly supported by said cutter-carrier with their axes concentric to the axis of said carrier, and means for independently rotating said cutters and for simultaneously rotating and imparting a transverse movement to said carrier, substantially as described.

4. In a gear-cutting machine, the combination with the bed and with the work-holding spindle revolubly supported thereon, of a sliding frame capable of adjustment to and from the work-carrying spindle, a swinging frame intermediate to said sliding frame and spindle, a revoluble cutter-carrier adjustably supported by said swinging frame, a series of cutters of successive sizes revolubly supported by said cutter-carrier with their axes concentric with the axis of the carrier, and mechanism for rotating the said cutters and for rotating and transversely moving the cutter-carrier with relation to the work, substantially as and for the purpose described.

5. In a gear-cutting machine, the combination with a series of cutter-carrying spindles, of the cutter-spindle carrier mechanism for imparting to said carrier two independent movements, one a rotary movement upon its own axis, and the other a rectilinear feed movement transversely of its axis, sub-

stantially as and for the purpose herein described.

6. In a gear-cutting machine, the combination with work-carrying spindle, of a series of cutters mechanism for imparting to said cutters three distinct movements, one a rotary movement upon their independent axes, another a rotary movement around a common axis, and the other a rectilinear feed movement transversely of the common axis to bring said cutters to the work, substantially as described.

7. In a gear-cutting machine, the combination with the work-carrying spindle, of a series of cutter-carrying spindles revolubly supported in a cutter-spindle carrier and concentrically disposed with relation to a common center, and means for rotating said spindles upon their independent axes, and simultaneously imparting a circular movement to said spindles concentric to the common axis and a rectilinear feed movement thereto transversely of the common axis, substantially as and for the purpose described.

8. In a gear-cutting machine, the combination of a series of revoluble cutters of different successive sizes, substantially as described, a cutter-carrier mechanism for imparting to said cutter-carrier two independent movements, one a rotary movement upon its own axis, and the other a rectilinear feed movement transversely to its axis, and means for imparting said movements to said carrier, substantially as described.

9. In a gear-cutting machine, the combination with a work-carrying spindle, of a series of independent revoluble cutters of successive sizes, mechanism for imparting to each of said cutters three distinct but simultaneous movements, one a rotary movement upon its independent axis, another a circular feed movement concentric to the common center of the series of cutters, and the other a rectilinear feed movement transversely of said common center and toward the work-carrying spindle, substantially as and for the purpose described.

10. In a gear-cutting machine, the combination with a series of cutter-carrying spindles, and with the cutters secured thereto, of the cutter-spindle carrier revolubly supported upon a carrier-slide, movably supported upon a frame, and means substantially as described, for imparting a rotary movement to said cutter-spindle carrier and simultaneously imparting a rectilinear feed movement to the carrier-slide in lines transversely of the axis of the carrier, substantially as and for the purpose set forth.

11. In a gear-cutting machine, the combination with the work-carrying spindle, of a series of cutters revolubly supported upon independent axes around a common center, a revoluble cutter-carrier therefor supported in a slide capable of reciprocation at various angles of inclination with relation to the work upon the work-carrying spindle, and means for rotating said cutters and cutter-carrier at varying speeds and for reciprocating said slide, and means for varying the inclination of reciprocation of said slide and cutters with relation to the work, substantially as and for the purpose described.

12. In a gear-cutting machine, the combination with the main frame, or bed, and with the work-carrying spindle, of a sliding frame, a swinging frame pivotally and adjustably secured to said sliding frame, a cutter-carrier-supporting slide movably supported upon said swinging frame, a revoluble cutter-spindle carrier journaled in said slide carrying a series of independently revoluble cutter-spindles, driving-gears therefor, and a cam to reciprocate the slide with relation to the swinging frame, substantially as and for the purpose described.

13. In a gear-cutting machine, the combination with the bed and with the sliding frame, of a pivoted frame adjustably secured to said sliding frame, and a cutter-carrier-supporting slide movably connected with said swinging frame, substantially as and for the purpose set forth.

14. In a gear-cutting machine, the combination with the bed and its work-carrying spindle, of the pivoted frame and its sliding support adapted for various adjustments with relation to the work-holding spindle, and a series of rotating cutters of successive sizes capable of rotating upon their independent axes, of circular movement concentric to a common center and of longitudinal movement with relation to the swinging frame and work being operated upon, and means substantially as described, for imparting said movements to the cutters, all substantially as and for the purpose set forth.

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