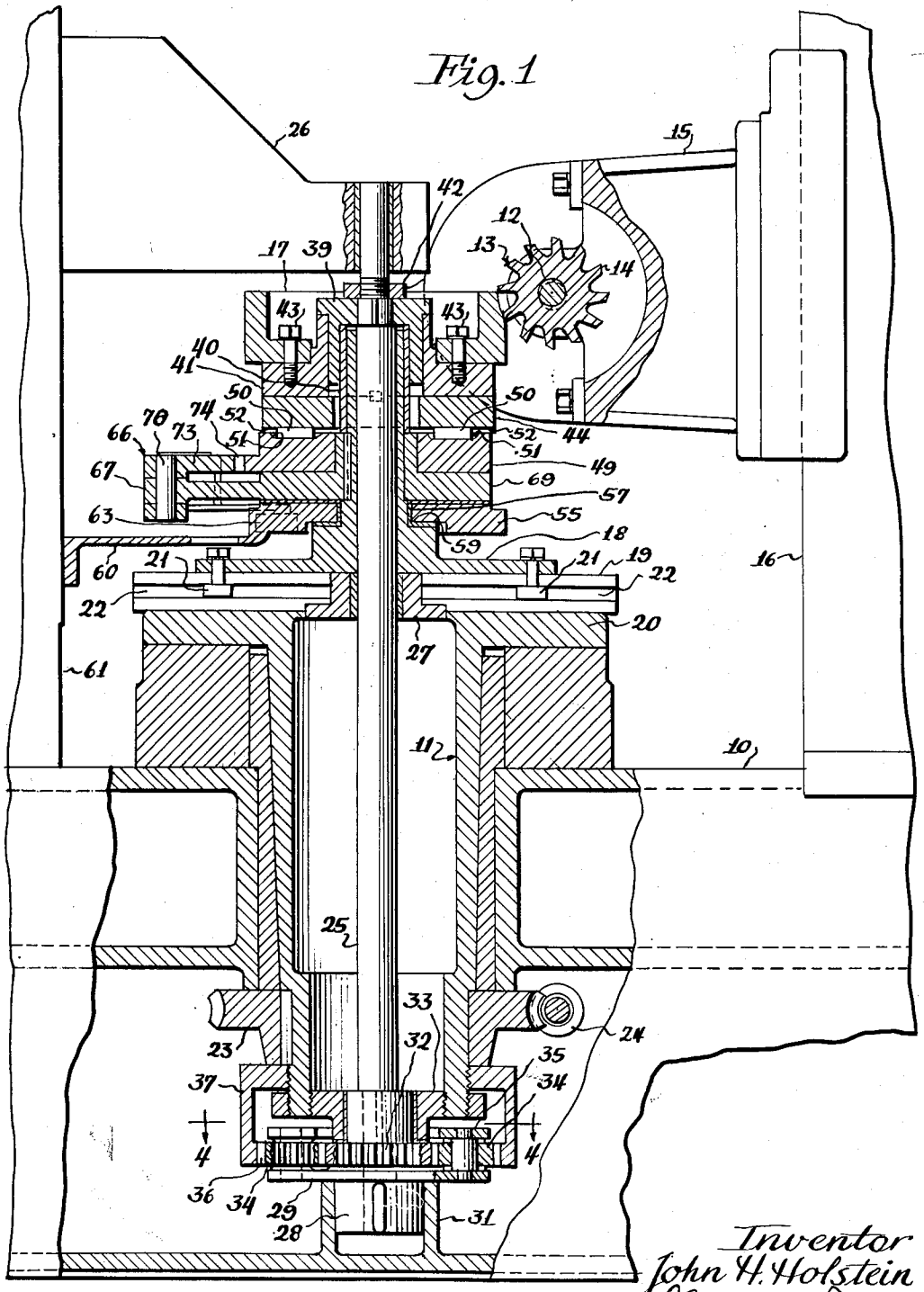
Nov. 4, 1952 J. H. HOLSTEIN 2,616,336

APPARATUS FOR PRODUCING VARYING SPEED GEARING

Filed March 11, 1947 4 Sheets-Sheet 1

Fig. 1



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APPARATUS FOR PRODUCING VARYING SPEED GEARING

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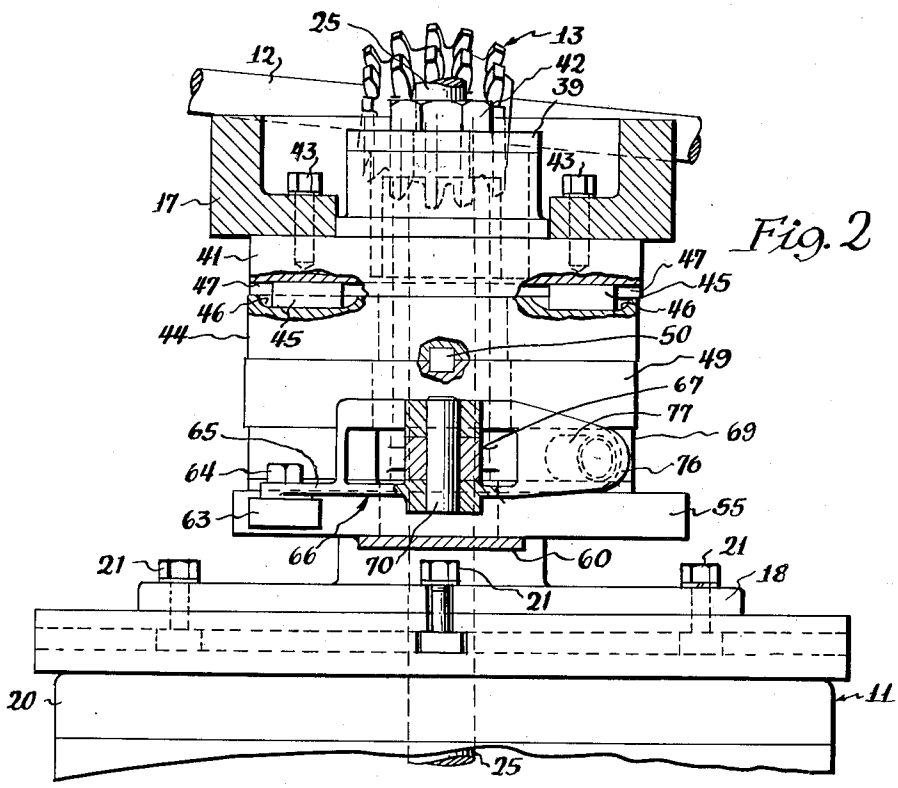


Fig. 2

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APPARATUS FOR PRODUCING VARYING SPEED GEARING

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Fig. 3

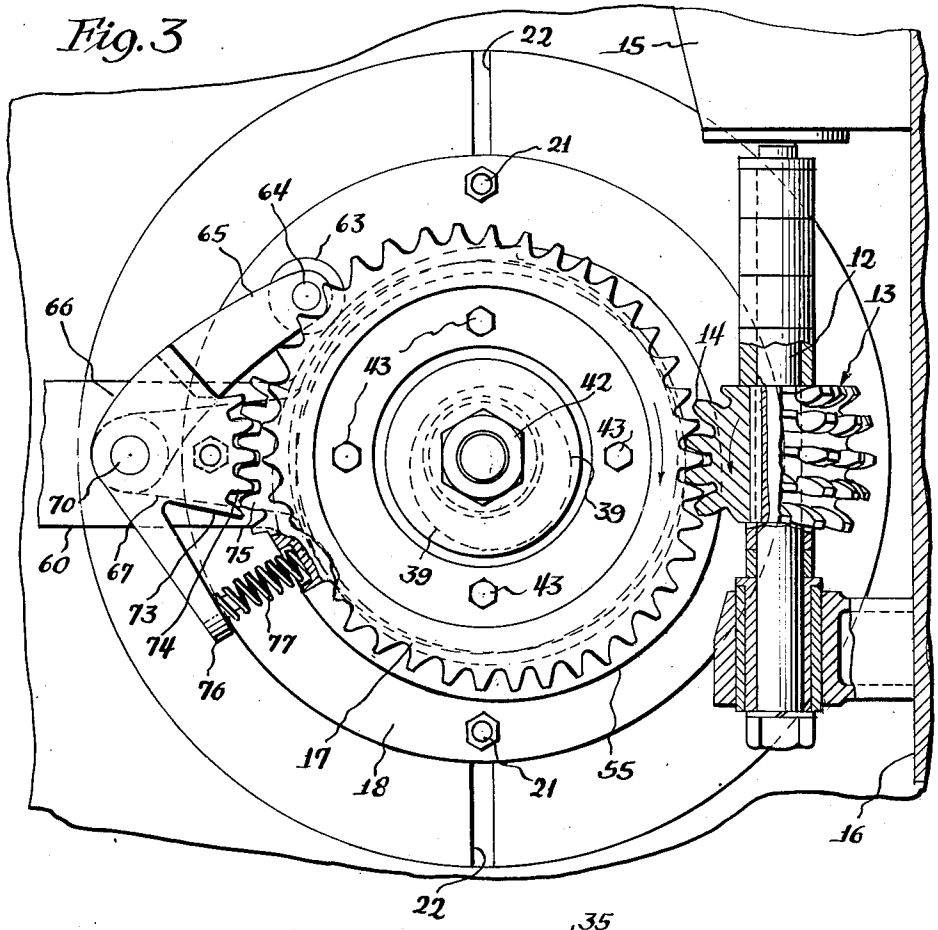
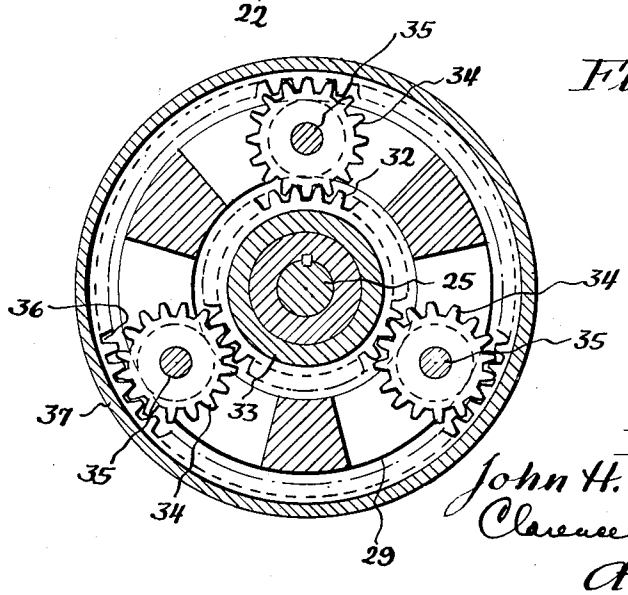


Fig. 4



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APPARATUS FOR PRODUCING VARYING SPEED GEARING

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Fig. 5

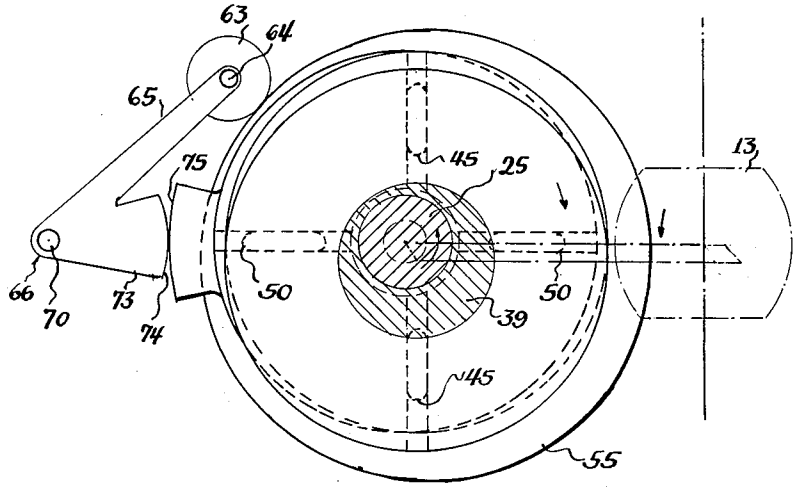
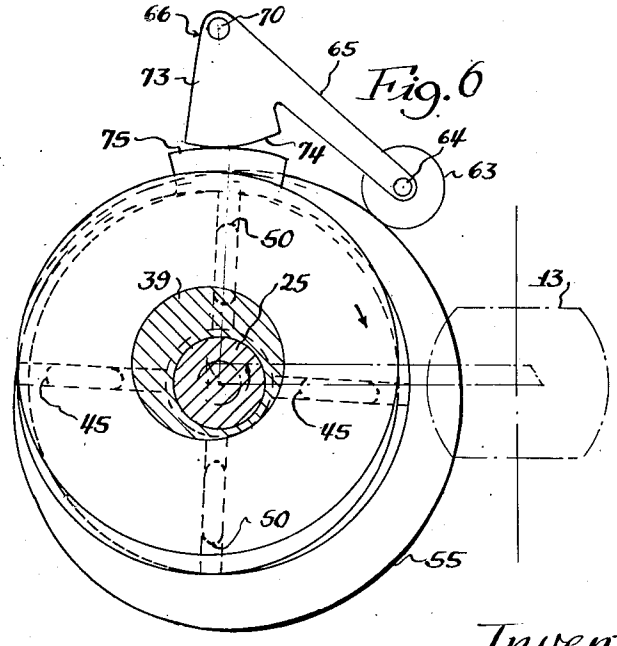


Fig. 6



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Patented Nov. 4, 1952 2,616,336

UNITED STATES PATENT OFFICE

2,616,336

APPARATUS FOR PRODUCING VARYING SPEED GEARING

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Application March 11, 1947, Serial No. 733,839

5 Claims. (Cl. 90—4)

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This invention relates to improvements in apparatus for producing varying speed gearing.

An application Serial No. 702,724, filed by William W. Sloane on October 11, 1946, and entitled Improvements in Gearings, discloses a new and novel form of varying speed gearing in which the speed variations are attained by modifying the gear teeth so the pinion teeth may contact the gear teeth along contact lines which cross the common center line of the gear and pinion at varying points with respect to the tips and roots of the teeth of the gear and pinion. With this form of varying speed gearing, varying speed sets of gearing may be produced with round gear and pinion blanks and a concentric pinion having a standard tooth form, and with a round pinion blank having a standard tooth form and mounted eccentrically of its center and an irregularly shaped gear blank, as may clearly be understood with reference to the aforementioned Sloane application.

A more specific object of my invention is to provide a new and novel device for adapting a hobbing machine to generate varying speed gears of the foregoing types in a continuous operation.

In carrying out my invention I mount a barrel-shaped hob on the hob spindle of a gear hobber the cross contours of the teeth of which are identical to a segment of the pinion which is to drive the finished gear. I also mount a gear blank on the work spindle of the hobber for relative movement with respect thereto, and where the varying speed gear is to be driven by a pinion mounted eccentrically of its center I mount the gear blank on an eccentric having the same eccentricity as the pinion which will drive the finished gear and rotate the eccentric in one direction at a constant speed corresponding to the speed of the eccentric pinion which will drive the finished gear, and rotate the gear blank in an opposite direction at a varying speed corresponding to the speed of rotation of the finished gear, so the speed ratios between the eccentric and gear blank will be the same as the varying speed ratios at which the finished gear and pinion are to operate.

An application Serial No. 711,745, filed November 22, 1946, by Emil J. Hlinsky, relates to a method and apparatus for producing varying speed gears of the type disclosed in the aforementioned Sloane application. The apparatus of my present invention differs from that disclosed in the foregoing Hlinsky application, however, in that in the Hlinsky application the cutter rotates about an axis eccentric of its center when

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generating a varying speed gear of a type which is adapted to be driven by an eccentric pinion. In my present invention the cutter always rotates about an axis concentric with its center and when a gear of a type which is adapted to be driven by an eccentric pinion is being generated, the gear blank moves translatively with respect to its cutter as said gear blank rotates during cutting so that said gear blank and the periphery of said cutter will maintain the same relative positions with respect to each other during cutting as are maintained by the finished gear running with its eccentric pinion.

These and other objects of my invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings wherein:

Figure 1 is a transverse sectional view taken through the work spindle of a gear hobbing machine having mechanism for adapting the machine to cut a varying speed gear in accordance with my invention embodied therein;

Figure 2 is a fragmentary view of the work spindle looking towards the hob and showing the gear blank in transverse section, and showing certain of the parts for supporting the gear blank on the work spindle and for driving the gear blank from the work spindle, broken away and in section;

Figure 3 is an enlarged plan view looking down on the work spindle of the gear hobbing machine, showing the completed varying speed gear on the work spindle and showing certain parts of the hob and support for the hob spindle broken away and in section;

Figure 4 is a sectional view taken substantially along line 4—4 of Figure 1;

Figure 5 is a diagrammatic view showing the position of the gear blank with respect to its eccentric when the eccentric is in one extreme position; and

Figure 6 is a diagrammatic view showing the position of the gear blank with respect to its eccentric, when the eccentric is in an opposite extreme position from that shown in Figure 5.

In the drawings I have shown a part of a main platform and housing 10, a vertical work spindle 11, and a hob spindle 12 of a gear hobbing machine. Said gear hobbing machine may be of any well known form and is no part of my present invention so is only herein shown insofar as is necessary to make my present invention readily understandable.

The hob spindle 12 has a hob 13 mounted thereon. Said hob is of a substantially barrel-

shaped form having teeth 14 cut on a helix with the cross contours of said teeth identical to a segment of the pinion which is to drive the finished gear, as shown in Figure 3, to more accurately generate the varying speed gear and assure that the hob will not cut off the tips of the teeth of the gear where the contour of the gear blank is irregular. Said hob spindle is shown as being set at an angle to the gear blank that corresponds to the helix angle of the hob at its pitch line and is mounted adjacent its ends on a head frame 15 guided in a vertical guide standard 16, adjustably movable along the platform 10, towards and from the work spindle 11. Said frame is vertically movable along said guide standard for feeding said hob across the face of a gear blank 17 during the cutting operation, in a manner usual with gear generating machines of the hobbing type.

The work spindle 11 is rotatably mounted in the housing and platform 10 of the hobbing machine and forms a support for the gear blank 17 on an arbor 18. Said arbor is detachably secured to a work table 19 on the top of a flanged portion 20 of said work spindle, as by bolts 21, the heads of which are mounted in diametrically extending T-slots 22, 22 formed in said work table and herein shown as extending at right angles with respect to each other. An index gear 23, herein shown as being a worm gear, is keyed on said work spindle adjacent its lower end (see Figure 1). Said worm gear is driven from an index worm 24 at a speed synchronized with the speed of rotation of the hob 13 in a manner well known to those skilled in the art and no part of my present invention, so not herein shown or described.

A vertical shaft 25 mounted for rotation with respect to the spindle 11 is herein shown as being journaled within said work spindle, coaxial with the axis of rotation thereof, and as projecting upwardly therefrom above the gear blank 17 and arbor 18. Said shaft is journaled adjacent its upper end in a bracket 26, which may be vertically adjusted along a standard 61, to permit insertion of the gear blank 17 thereon and removal of the finished gear therefrom. Said shaft is journaled intermediate its ends in a flanged collar 27 mounted adjacent the upper end of said work spindle and is journaled adjacent its lower end in a depending hub 28 of a cage 29 of a planetary geared reduction device. Said hub is keyed within a cylindrical boss 31 projecting upwardly from the base of the hobbing machine. A sun gear 32 of said planetary geared reduction device is keyed on said shaft, for driving said shaft from said work spindle. The hub of said sun gear is journaled in a flanged collar 33, herein shown as being threaded within the lower end of said work spindle and as depending therefrom. Said sun gear meshes with a plurality of planetary pinions 34, 34 on vertical shafts 35, 35 mounted at their opposite ends in the cage 29. Said pinions mesh with and are rotatably driven from an internal gear 36 extending inwardly from a drum 37, herein shown as being threaded on and rotatably driven from said work spindle 11.

Said planetary is herein shown as being arranged to step up the speed of rotation of the vertical shaft 25 and drive said shaft from the work spindle 11 at twice the speed of rotation of said work spindle in a direction opposite to the direction of rotation of said work spindle. The speed ratio between said shaft and the gear blank 17 should be the same as the speed ratio of the finished gear and pinion. As for example, where the average speed reduction between the finished gear and pinion is a 2:1 reduction, the shaft 25 will rotate at twice the speed of the work spindle 11 and in a direction opposite to the direction of rotation of said work spindle; where the average reduction between the pinion and gear is a 3:1 reduction, the shaft 25 will have to rotate at three times the speed of rotation of said work spindle; and where there is no speed reduction said shaft will rotate at the speed of rotation of said work spindle.

An eccentric 39 is keyed adjacent the upper end of the shaft 25 just beneath the bracket 26. Said eccentric is of a cylindrical formation with a closed top except for an opening to receive the shaft 25, and its walls extend downwardly along a bearing 40 mounted on the arbor 18. A work supporting mandrel 41 is mounted on said eccentric for rotatable movement with respect thereto and is abutted by a shouldered upper portion thereof. The inside of the top of said eccentric abuts a shouldered portion of said shaft and said eccentric is held in position on said shaft by means of a nut 42 abutting the top of the closed portion of said eccentric.

Where the finished gear is to be driven by an eccentric pinion, the eccentricity of the eccentric 39 is the same as the eccentricity of the pinion which will drive the finished gear so that the position of the gear blank 17 will be varied with respect to the hob 13 in a manner identical to the operation of the finished gear with its eccentric driving pinion. The mandrel 41 has the gear blank 17 detachably mounted thereon as by cap screws 43, 43. The mandrel 41 is slidably supported on the top surface of a spacing plate 44 and is guided for diametral movement with respect to said plate by means of two aligned feather keys 45, 45 mounted on the top surface of said spacing plate 44 on opposite sides of the axis of rotation thereof in keyways 46, 46. Said keyways are formed in the top surface of said spacing plate and are intersected at their longitudinal center by a common diametral line intersecting the center of the shaft 25. Said feather keys slidably engage keyways 47, 47 formed in the bottom of said arbor, to rotatably drive said arbor, but to permit movement of said arbor across the face of said spacing plate in one direction. Said spacing plate in turn rests on and is driven from a driving plate 49 driven from the arbor 18 at a varying speed in a manner which will hereinafter more clearly appear as this specification proceeds. Said spacing plate is driven from said driving plate by means of feather keys 50, 50 on opposite sides of the center of rotation of the shaft 25 and disposed at right angles to the feather keys 45, 45. Said feather keys are mounted in keyways 51, 51 cut in the top surface of the plate 49 and intersected at their longitudinal center by a common diametral line intersecting the center of rotation of the shaft 25. Said keys slidably engage keyways 52, 52 formed in the bottom of the spacing plate 44. Rotatable movement of the eccentric 39 will thus rectilinearly move the work mandrel 41 and the gear blank 17 with respect to the cutting tool or hob 13 to change the position of the center of said gear blank with respect to said hob in the same manner the center of the eccentric pinion which is to drive the finished gear will move with respect to the finished gear, while the gear blank is rotatably driven at a varying speed about the vertical shaft 25 in a direction

opposite to the direction of rotation of said shaft.

The means for turning the driving plate 49 and the gear blank 17 at a speed which varies in the same manner the speed of the finished gear will vary when driven by an eccentric pinion, includes a stationary cam 55 mounted on the arbor 18 on a flanged bearing 57 which abuts a lower shouldered portion 59 of said arbor. Said cam has an arm 60 extending therefrom which is secured to the upright standard 61 of the hobbing machine, to hold said cam from rotation. The shape of said cam is such as to cause relative movement of the gear blank 17 with respect to the adapter plate 44 so as to move said gear blank at the varying speed during cutting required to produce the desired varying speed gear, as will hereinafter more clearly appear as this specification proceeds.

The cam 55 is engaged by a roller 63 journaled on a pivotal pin 64 secured to and depending from the outer end of a lever arm 65 of a bell crank 66. Said bell crank has a bifurcated central portion, the furcations of which extend along the upper and lower sides of a bracket 67 extending outwardly from and formed integrally with a driving member 69 keyed on the arbor 18 and rotatably driven thereby. A pivotal pin 70 extending through the furcations of said central portion of said lever arm and said bracket pivotally connects said bell crank thereto. An arm 73 of said bell crank extends inwardly from said pivotal pin along the upper side of said bracket and has gear teeth 74 cut integrally with the inner side thereof. The center of the pitch circle of said gear teeth is herein shown as being coaxial with the pivotal axis of said bell crank. Said gear teeth mesh with gear teeth 75 herein shown as extending outwardly from and as being formed integrally with the driving plate 49 for rotatably driving said plate and the mandrel 41 and gear blank 17 at a varying speed upon rotation of said arbor 18 and driving member 69. The distance from the contact point of the roller 63 to the pivotal axis of the bell crank 66 is herein shown as being twice the distance from the pivotal axis of said bell crank to the pitch circle of the teeth 74. Also the angular ratio between the teeth 74 on the arm 73 of the bell crank 66 and teeth 75 on the plate 49 is herein shown as being a 2:1 ratio giving a final angular ratio from the roller 63 to the center of the gear blank of 2:1. It should be understood, however, that this ratio is not a determining factor and has been picked for convenience, and that various other ratios may be used if desired.

The bell crank 66 also has an arm 76 extending from its pivotal axis in a direction opposite from the arm 65 but towards the driving member 69. Said arm is engaged by a spring 77 interposed between the end of said arm and the driving member 69, for holding the roller 63 in engagement with the surface of the cam 55.

The form of the cam 55 may be determined by the movement or displacement of the roller 63 on the end of the lever arm 65 of the bell crank 66 necessary to move the gear blank 17 with respect to the shaft 25 at the desired varying speed so the varying speed ratio between said gear blank and said shaft will be the same as the varying speed ratio at which the finished gear and pinion are to operate. The form of said cam may be determined graphically and mathematically from a speed ratio curve of the finished gear and pinion in a manner well known to those skilled in the art, which is no part of my present invention so is not herein shown or described.

In the illustrative form of my invention just described the varying speed gear and pinion rotate about axes eccentric of their centers. When, however, it is not desired or necessary to have as great a variation in speed as may be obtained from an eccentric gear and pinion, the mandrel 41 and gear blank 17 may be mounted to rotate about an axis concentric with the centers of said mandrel and gear blank. Said gear blank may then be rotatably driven about its center at a varying speed which will give the same varying speed ratio as will be obtained when the finished gear is rotatably driven by its pinion. The shape of the cam which will give the required varying speed of the gear may be determined graphically and mathematically from the desired speed ratio curve of the gear and pinion in the manner mentioned before and not herein shown or described since it is no part of my invention. The hob 13 may then be driven at a constant speed of rotation and fed across the face of said gear blank in the direction of the axis of rotation of said gear, to effect cutting.

In generating the varying speed gear shown in Figure 3 from the gear blank 17, and assuming that said gear blank is mounted on the mandrel 41 on the eccentric 39 and the hob 13 is mounted on the hob spindle 12, the cutting head 15 may then be moved downwardly along its guides formed in the guide frame 16 to a position in close proximity to the top portion of the face of said gear blank. The machine may then be started to rotatably drive the gear blank in one direction and the eccentric 39 in an opposite direction at a speed which may be twice the speed of rotation of the work spindle 11, to generate the gear illustrated herein. At the same time, the hob 13 is driven at a constant speed of rotation which is synchronized with the speed of rotation of said work spindle 11. When said hob and gear blank are both rotating, feeding movement of said cutting head 15 and hob 13 in the direction of the axis of said gear blank may then be started, to commence generating the teeth of the gear by said hob while said gear blank is rotating about the eccentric 39 at a varying speed and said eccentric is rotating in a direction opposite to the direction of rotation of said gear blank at a constant speed corresponding to the speed of the pinion which will drive the finished gear. Feeding movement of the hob in the direction of the axis of the gear blank is continued as said hob and gear blank rotate with respect to each other until the teeth of the gear have been completely generated across the entire face of said gear blank, it being understood that the feeding and generating operations are done in the manner usual in generating standard tooth forms for constant speed gears on gear hobbing machines.

It may be seen from the foregoing that a new and improved method has been provided for cutting varying speed gears on a gear hobbing machine and that this method is particularly adapted to cut varying speed gears of the type which are driven from an eccentric pinion. It may further be seen that this method makes it possible to generate a varying speed gear of the type driven from an eccentric pinion with a gear hobbing machine by transferring the eccentricity of the pinion to the gear by mounting the gear on an eccentric and by driving the eccentric and gear in the same relative directions with respect to each other as the directions at which the finished gear and pinion will rotate and at the

same varying speed ratios at which the finished gear and pinion will operate.

It may still further be seen that by this method of generating a varying speed gear, a gear may be generated having the desired tooth contour, which may vary for the several teeth of the gear, and that it is possible to generate a gear having a varying tooth contour for the several teeth of the gear by generating the teeth with a hob of a barrel-shaped formation wherein the cross contours of the teeth of the hob are identical to the teeth of a segment of the pinion which is to drive the finished gear.

It should here be understood that while I have herein shown and described my method of generating varying speed gears as being adapted to generate varying speed gears from a gear hobbing machine, that such gears can also be generated from a gear shaper using a concentric pinion type cutter, and using the speed varying and position changing mechanism illustrated herein, without departing from the scope of my invention. Furthermore, I do not wish to be construed as limiting my invention to the specific embodiment illustrated, excepting as it may be limited in the appended claims.

I claim as my invention:

1. In a machine for generating varying speed gearing, a work spindle mounted for rotation at constant speed, a work support for a gear blank adapted to be driven by said work spindle, a rotating cutter having cutting teeth with a cross section in a plane perpendicular to the axis of rotation of said gear blank over the portion coming in contact with said gear blank consisting of a series of teeth of identical cross section essentially of involute form, said cross section being a reproduction of a portion of a conjugate matching pinion adapted to run with a finished varying speed gear generated from said gear blank, means for imparting translative movement to said work support and said gear blank in accordance with the varying pitch radius of said finished gear, a cam, a cam follower mounted for rotation with said work spindle and having an operative engagement with said cam, means actuated by the movement of said cam follower in following the contour of said cam for imparting relative rotation between said work spindle and said work support and said gear blank in accordance with the desired velocities of said finished varying speed gear.

2. In a machine for generating varying speed gearing, a work spindle mounted for rotation at constant speed, a work support for a gear blank adapted to be driven by said work spindle, a rotating cutter having cutting teeth with a cross section in a plane perpendicular to the axis of rotation of said gear blank over the portion coming in contact with said gear blank consisting of a series of teeth of identical cross section essentially of involute form, said cross section being a reproduction of a portion of a conjugate matching pinion adapted to run with a finished varying speed gear generated from said gear blank, means for imparting translative movement to said work suport and said gear blank in accordance with the varying pitch radius of said finished gear, a cam, a cam follower mounted for rotation with said work spindle and having an operative engagement with said cam, means actuated by the movement of said cam follower in following the contour of said cam for imparting relative rotation between said work spindle and said work support and said gear blank in accordance with the desired angular velocities of said finished varying speed gear, and coupling means between said work support and said work spindle for affording such translative movement of said gear blank during rotation thereof on said work support.

3. In a machine for generating varying speed gearing, a work spindle mounted for rotation at constant speed, a work support for a gear blank adapted to be driven by said work spindle, a rotating cutter having cutting teeth with a cross section in a plane perpendicular to the axis of rotation of said gear blank over the portion coming in contact with said gear blank consisting of a series of teeth of identical cross section essentially of involute form, said cross section being a reproduction of a portion of a conjugate matching pinion adapted to run with a finished varying speed gear generated from said gear blank, a cam, a cam follower mounted for rotation with said work spindle and having an operative engagement with said cam, means actuated by the movement of said cam follower in following the contour of said cam for imparting relative rotation between said work spindle and said work support and said gear blank in accordance with the desired angular velocities of said finished varying speed gear.

4. In a machine for generating varying speed gearing, a work spindle mounted for rotation at constant speed, a work support for a gear blank adapted to be driven by said work spindle, a rotating cutter having cutting teeth with a cross section in a plane perpendicular to the axis of rotation of said gear blank over the portion coming in contact with said gear blank consisting of a series of teeth of identical cross section essentially of involute form, said cross section being a reproduction of a portion of a conjugate matching pinion adapted to run with a finished varying speed gear generated from said gear blank, an eccentric driven from said work spindle for imparting translative movement to said work support and said gear blank to maintain the same relative positions between said gear blank and cutter during generation of said varying speed gear as are maintained between the finished varying speed gear and an eccentrically mounted pinion conjugate therewith, coupling means between said work support and said work spindle for affording such translative movement of said gear blank during rotation thereof on said work support.

5. In a machine for generating varying speed gearing, a work spindle mounted for rotation at constant speed, a work support for a gear blank adapted to be driven by said work spindle, a rotating cutter having cutting teeth with a cross section in a plane perpendicular to the axis of rotation of said gear blank over the portion coming in contact with said gear blank consisting of a series of teeth of identical cross section essentially of involute form, said cross section being a reproduction of a portion of a conjugate matching pinion adapted to run with a finished varying speed gear generated from said gear blank, an eccentric driven from said work spindle for imparting translative movement of said work support and said gear blank to maintain the same relative positions between said gear blank and cutter during generation of said varying speed gear as are maintained between the finished varying speed gear and an eccentrically mounted pinion conjugate therewith, a cam, a cam follower mounted for rotation with said work spindle and having an operative engagement with

said cam, means actuated by the movement of said cam follower in following the contour of said cam for imparting relative rotation between said work spindle and said work support and said gear blank in accordance with the desired angular velocities of said finished varying speed gear.

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