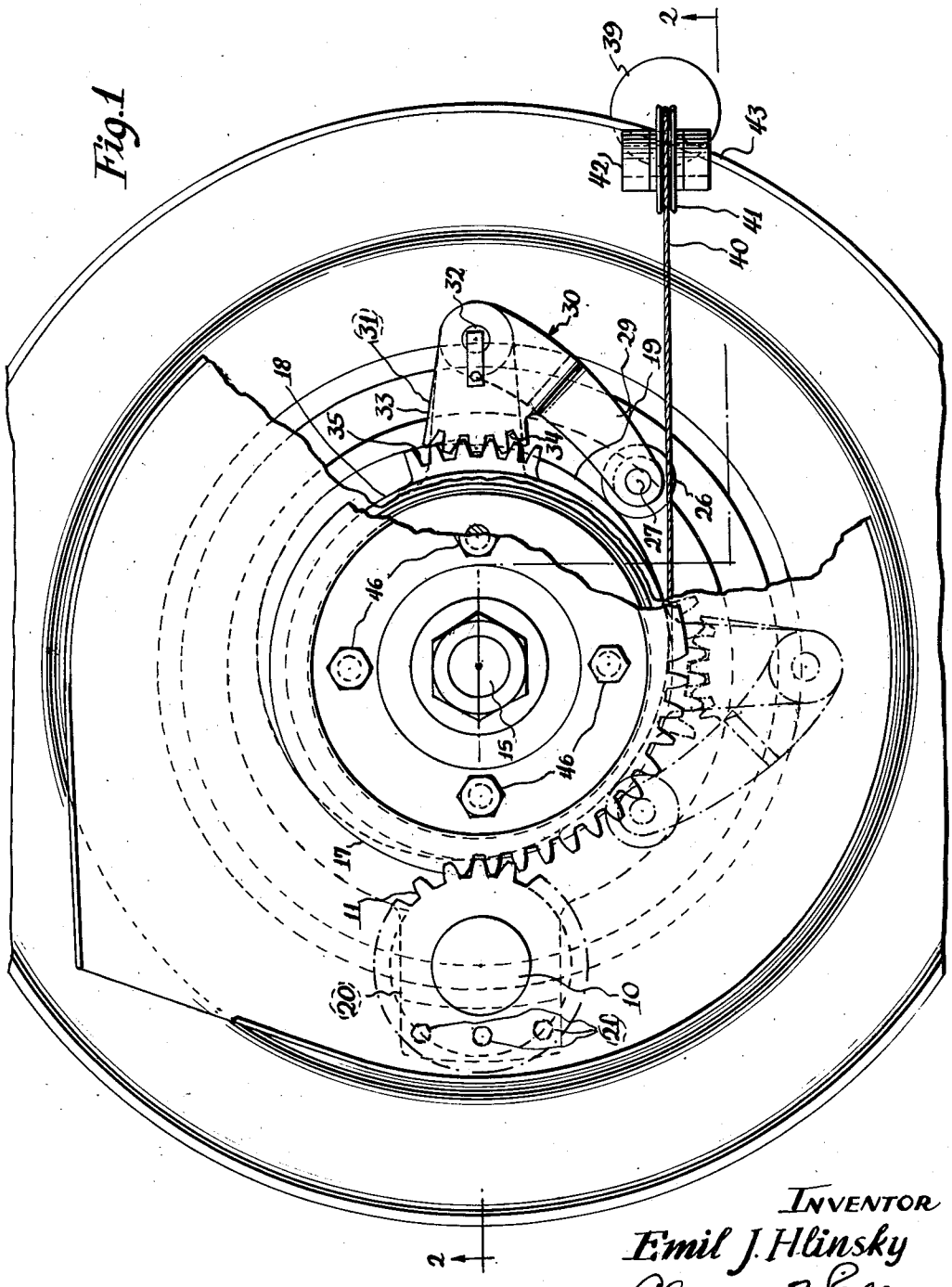
July 8, 1952 E. J. HLINSKY 2,602,374

APPARATUS FOR PRODUCING VARYING SPEED GEARING

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Fig. 1



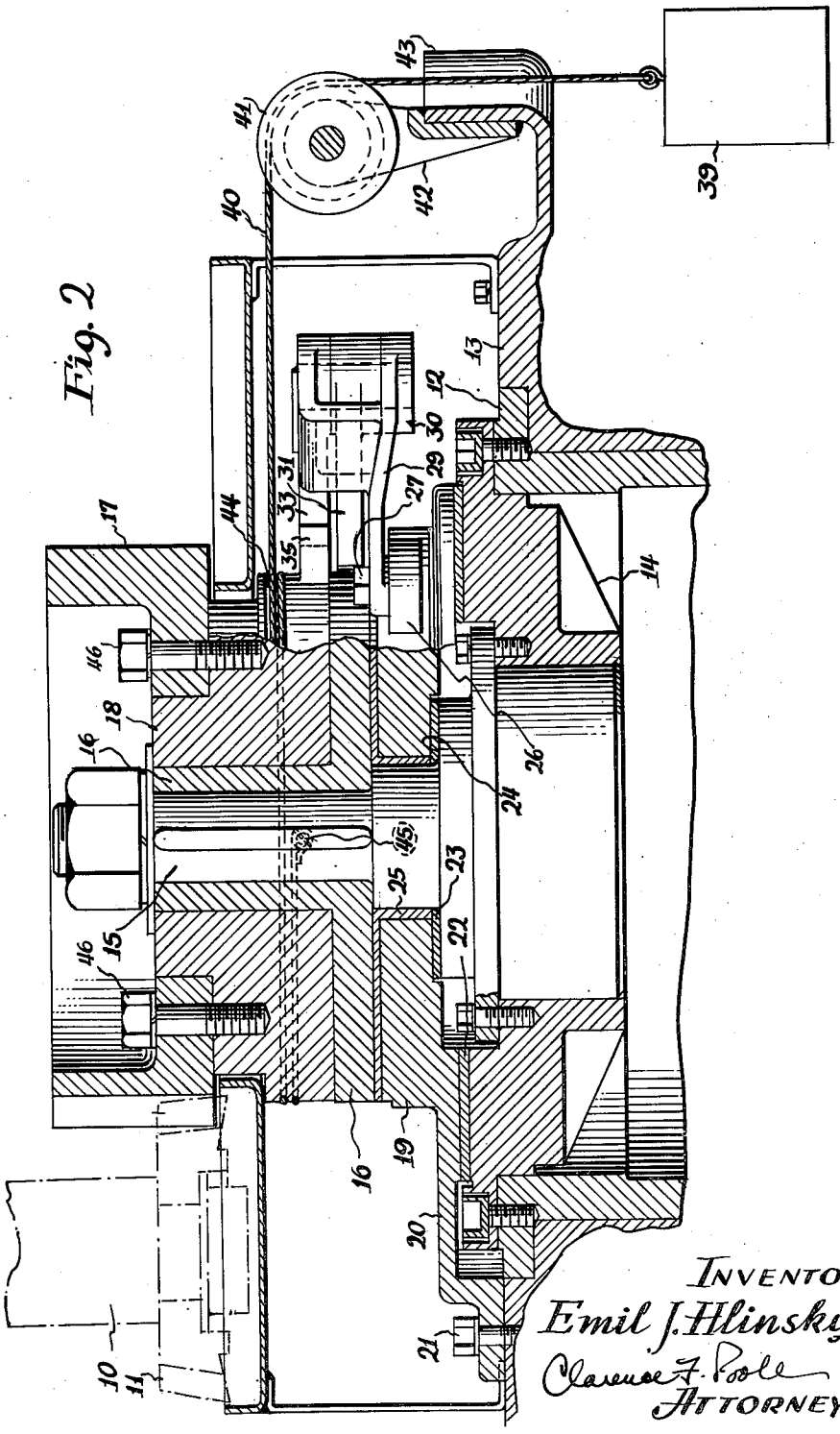
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Fig. 2



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Fig. 3

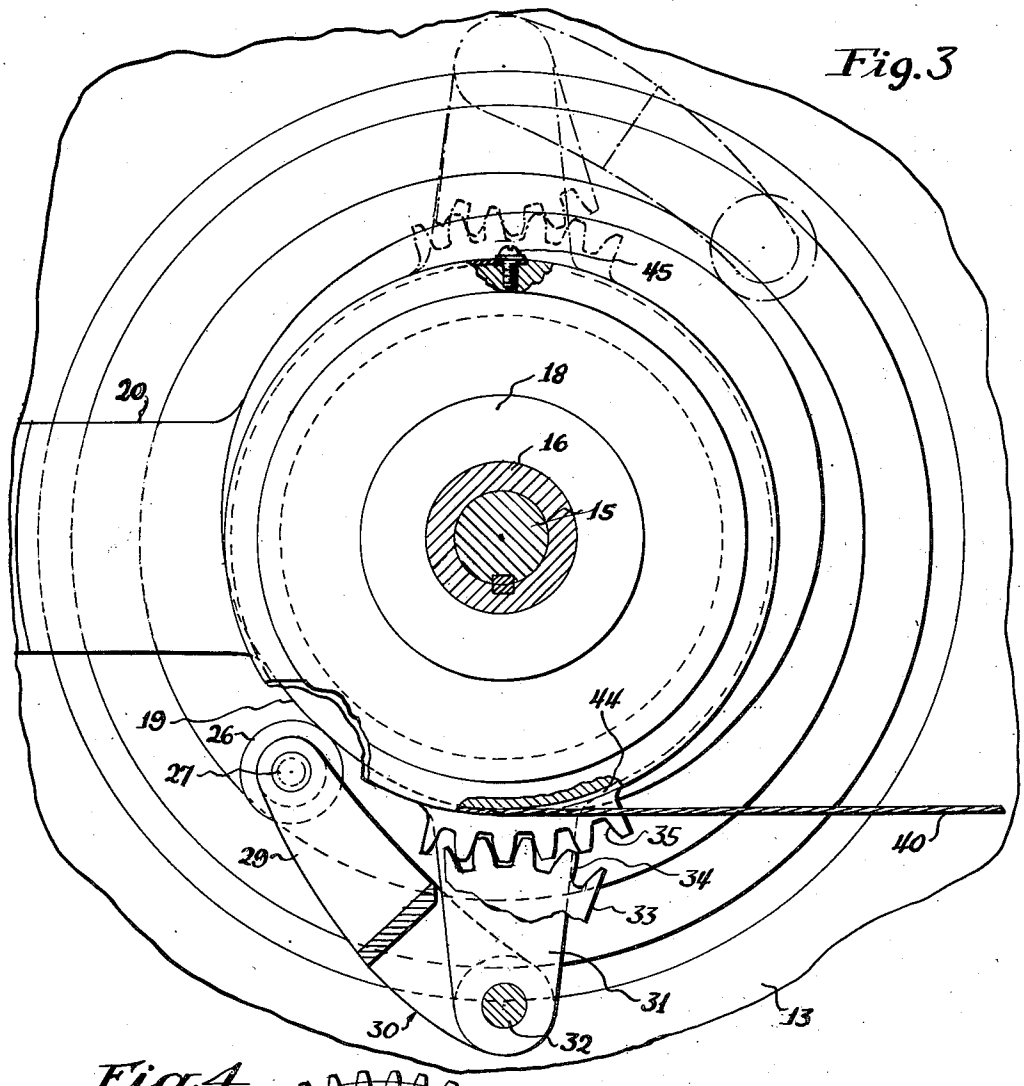
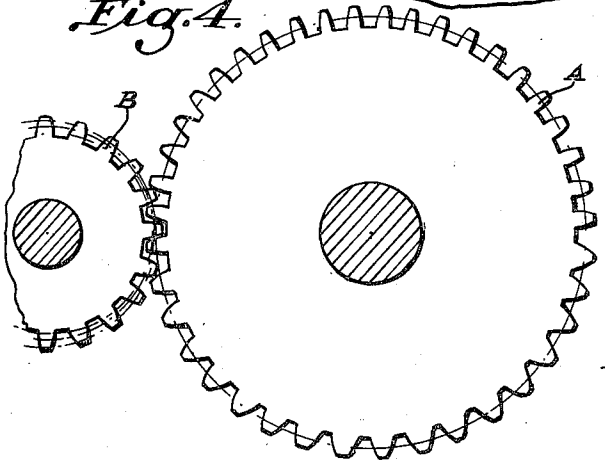


Fig. 4.



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2,602,374

APPARATUS FOR PRODUCING VARYING SPEED GEARING

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Application November 22, 1946, Serial No. 711,745

10 Claims. (Cl. 90—7)

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This invention relates to methods and apparatus for producing varying speed gearing.

An application Serial No. 702,724, filed by William W. Sloane on October 11, 1946, now Patent No. 2,585,971, issued February 19, 1952, and entitled Improvements in Gearing, 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.

The principal object of my invention is to provide a novel, simple and efficient method for generating varying speed gearing of the types disclosed in the aforementioned application with a pinion-shaped cutter.

A more specific object of my invention is to provide a new and novel method and device for adapting a gear shaper to produce varying speed gears of the foregoing types with a pinion-shaped cutter, in a continuous operation.

In carrying out my invention I mount a pinion-shaped cutter having the same number of teeth and of the same tooth form as the pinion which will drive the varying speed gear, on the cutter spindle of a gear shaper. I also mount a gear blank on the work spindle of the gear shaper for relative movement with respect thereto, and rotatably turn the gear blank on the work spindle during the cutting operation at a varying speed as the pinion turns at a constant speed, so the gear and cutter will turn during cutting at the same varying speed ratio at which the finished gear and pinion are to operate.

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 fragmentary plan view of a gear shaper with certain parts broken away, and showing a pinion-shaped cutter in the operation of cutting a varying speed gear in accordance with my invention;

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Figure 2 is a fragmentary sectional view taken substantially along line 2—2 of Figure 1;

Figure 3 is a fragmentary horizontal sectional view taken through the gear blank and showing certain details of my invention not shown in Figure 1; and

Figure 4 is a view showing one form of varying speed gear which may be produced by the method and apparatus of my invention.

In the drawings I have shown the cutter, work blank, and apron of a gear shaper, which may be of the Fellows type and may include a cutter spindle 10 having a cutter 11 mounted thereon for reciprocating movement in a vertical plane and for turning movement in a horizontal plane during the shaping or generating operation, in the manner usual with gear shapers of the generating type. Said cutter may be a standard form of pinion-shaped cutter and should have the same number of teeth with the same tooth profile as the pinion which will drive the finished gear. I have also shown in Figure 4 a finished varying speed gear A made from a circular gear blank in accordance with my invention and mounted for rotation about its center and shown as being driven from a standard involute pinion B which is also mounted for rotation about its center.

A work spindle 12 is shown as being mounted in an apron 13 of the gear shaper for pivotal movement with respect thereto in the usual manner. Said work spindle is rotatably turned from a lower index wheel (not shown) which may be a worm wheel, and said work spindle and apron may yield horizontally during the upward or return movement of the cutter 11, to enable the cutter to clear the work during its return travel. An adapter 14 is secured to said work spindle for rotation therewith. Said adapter in turn has an arbor 15 mounted therein and extending upwardly therefrom, which is adapted to have a work table 16 keyed thereto. Said work table in turn is adapted to have a gear blank 17 mounted thereon for relative movement with respect thereto during cutting on a work mandrel 18, it being understood that in the conjugate generating of constant speed gearing the cutter and gear blank turn at the same speed ratio at which the finished gear and pinion are to operate; that is, for a 2:1 ratio the gear blank will rotate at half the speed of the cutter.

A means is provided for turning the gear blank 17 at a speed which varies with respect to the speed of the work table 16, so that the cutter and gear blank will rotate at the same varying

speed ratio at which the finished gear and pinion are to operate. Said varying speed drive means includes a stationary cam 19 mounted on the arbor 15 beneath the work table 16. Said cam has an arm 20 extending outwardly and downwardly therefrom and abutting the top of the apron 13 and secured thereto by cap screws 21, 21. An annular thrust bearing plate 22 is interposed between the bottom of said cam and the top of the adapter 14, while an annular thrust bearing plate 23 is interposed between a shoulder 24 of the arbor 15 and an under portion of the cam 19. A flanged bearing member 25 is also interposed between the center of said cam and said arbor and between the bottom of the work table 16 and the top of said cam, to permit free rotation of said adapter, arbor, and work table with respect to said cam. Said cam is so shaped as to cause relative movement of the gear blank 17 with respect to the work table 16 during the operation of generating the varying speed gear, so as to move said gear blank at the required varying speed during the cutting operation, as will hereinafter more clearly appear as this specification proceeds.

The cam 19 is engaged by a roller 26 journaled on a pivotal pin 27, secured to and depending from the outer end of a lever arm 29 of a bell crank 30. Said bell crank has a bifurcated control portion and the furcations thereof extend along the upper and lower sides of a bracket 31. Said bracket projects outwardly from the work table 16 and said bell crank is pivotally connected thereto by means of a pivotal pin 32. An arm 33 of said bell crank extends inwardly from said pivotal pin along the upper side of said bracket and has gear teeth 34 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 35 herein shown as extending outwardly from and as being formed integrally with the mandrel 18. The distance from the contact point of the roller 26 on the end of the arm 29 with the cam 19 to the pivotal axis of the bell crank 30 is herein shown as being twice the distance from the pivotal axis of said cam to the pitch circle of the teeth 34 on the end of the arm 33. Also, the angular ratio between the teeth 34 on the arm 33 of the bell crank 30 and the teeth 35 on the mandrel 18 is herein shown as being a 2:1 ratio, giving a final angular ratio from the roller 26 to the center of the gear blank of 2:1. It should be understood, however, that various other ratios may be used if desired.

A means is provided to take up backlash between the teeth 34 and 35 and to yieldably hold the roller 26 in engagement with the face of the cam 19. Said means is herein shown as being a weight 39 depending from the free end of a flexible cable 40. Said cable is trained over a sheave 41 mounted on a bracket 42 secured to and extending upwardly from an outer upright lip 43 of the apron 13, and extends inwardly from said sheave and is wrapped around a spiral groove 44, formed in the outer periphery of the mandrel 18. A machine screw 45 threaded in said mandrel is provided to secure the inner end of said cable to said mandrel. Said weight thus exerts a tension on said flexible cable sufficient to take up backlash between the gear teeth 34 and 35 and to yieldably hold the roller 26 in engagement with the face of the cam 19, so said roller will follow said cam and move said bell crank and said mandrel relatively to said work table, as said cam varies from the form of a true circle.

The form of the cam 19 may be determined by the movement or displacement of the roller 26 on the end of the lever arm 29 of the bell crank 30 necessary to move the gear blank 17 with respect to the work table 16 at the required varying speed, so the varying speed ratio between said gear blank and the cutter 11 will be the same as the varying speed ratio at which the finished gear and pinion are to rotate. As for example, when it is desired to cut a varying speed gear like the gear shown in Figure 4 of the drawings, the form of the cam 19 may be determined from the speed ratio curve of the finished gear and pinion like the illustrative form of speed ratio curve shown in Figure 5 of the drawings of said aforementioned Sloane application. The cam 19, herein shown, has been calculated from such a speed ratio curve and the gear being cut from the blank 17 will be like the gear shown in Figure 1 of said application. The points on the curve of the cam may be determined by measuring the area of the curve from its starting point to the pinion position being considered. When this area is multiplied by a suitable constant determined by the scale of the ordinate and abscissa of the curve, the angular positions of the lever arm 29 of said bell crank will be obtained for each pinion position. When these angular positions are translated to linear dimensions the true displacement of said lever arm may be determined for each pinion position, in a manner well known to those skilled in the art, so not herein shown or described. It is, of course, readily apparent that various forms of cams calculated from various other desired speed ratio curves will produce other forms of varying speed gears than are described herein, to meet various desired requirements.

In the illustrative form of my invention just described, the varying speed gear and pinion rotate about axes concentric with their centers. When, however, it is desired to have a greater variation in speed than may be obtained from a concentric gear and pinion, the cutter 11 may be mounted eccentrically of its center on the cutter spindle 10 with the same degree of eccentricity that the finished pinion driving the finished varying speed gear will have, as has been described in the aforementioned Sloane application. The cutter will turn at a constant speed and its tooth profiles will be the same as the tooth profiles of the eccentric pinion which will drive the finished gear. The shape of the cam which will cause the gear blank to turn at the correct varying speed may be obtained from the desired speed ratio curve of the gear and pinion, as previously described. The cutter and gear blank may then be turned at the same varying speed ratio during the cutting operation at which it is desired that the finished gear and pinion rotate, with the result that a varying speed gear of a form similar to that shown in Figure 6 of said aforementioned Sloane application may be attained. Where the cutter is mounted eccentrically of its center, the gear blank will be of an irregular form, while the gear blank will have a circular outer periphery where the cutter rotates concentrically of its center.

In generating the varying speed gear from the gear blank 17, the apron of the gear shaper may be swung outwardly away from the cutter spindle and the cam 19 may first be secured to the apron

of the gear shaper, coaxial with the arbor 15, by the cap screws 21, 21. The work table 16 and the mandrel 18 may then be placed on said arbor, with the teeth 34 meshed with the teeth 35. The roller 26 on the end of the lever arm 29 of the bell crank 30 may also be engaged with the surface of said cam. Backlash between the teeth 34 and 35 may be taken up and said roller may be held in engagement with said cam, by means of the hanging weight 39 on the end of the cable 40, wrapped around said mandrel and trained over the sheave 41. The gear blank 17 which will be circular when generating the form of varying speed gear shown in Figure 4 of the drawings, may then be secured to said mandrel as by cap screws 46, 46. The cutter 11 being secured to the end of the cutter spindle 10, the apron 13 may then be swung back in place. The shaper may then be started in operation to feed said cutter radially to the proper tooth depth. The shaper may then be operated to turn the cutter and gear blank with respect to each other during reciprocable movement of said cutter in the direction of its axis to effect cutting of the teeth of the gear, it being understood that, as herein shown, the cutter travels vertically, making a cut in the gear blank as it moves in one direction, and that the gear blank and apron of the machine yieldably move away from the cutter during its return strokes, and return into a cutting position as the cutter is ready to make its cutting stroke. At the same time the cutter is turning about the axis of the spindle 10, and the gear blank 17 is turning with the arbor 15, said gear blank is also moved relatively to said arbor about the axis of said arbor by the cam 19 and bell crank 30 in the hereinbefore described manner, so the gear blank and cutter will turn at the same varying speed ratio at which the finished gear and pinion are to operate. When the gear blank has made one complete revolution, a varying speed gear will be completed which when driven from a pinion having the same number of teeth as the cutter, will rotate at the same varying speed ratio at which the cutter and gear blank rotated during the cutting operation.

It should here be understood, however, that where extreme accuracy of the tooth profile is desired, a rough cut may first be taken which will extend for one full revolution of the gear blank and a finish cut may then be taken for a second revolution of the gear blank, either with a separate finish cutter or by moving the cutter into slightly deeper mesh with the gear for the finish cut than for the rough cut.

While I have herein shown and described one form in which my invention may be embodied, it will be understood that the construction thereof and the arrangement of the various parts may be altered without departing from the spirit and scope thereof. 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. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, and an operative connection between

said work table and said mandrel for turning said mandrel and gear blank with said work table at speeds which vary with respect to the speed of said work table, to cause said gear blank and cutter to turn during the cutting operation at the same varying speed ratio at which the finished gear and pinion will operate.

2. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam, a rocking arm pivotally mounted on said work table and having operative engagement with said cam, and means actuated by said rocking arm for moving said mandrel relative to said work table while being rotatably driven thereby, to cause said gear blank and cutter to turn during the cutting operation at the same varying speed ratio at which the finished gear and pinion will operate.

3. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam, a bell crank pivotally mounted on said work table, one lever arm of said bell crank having operative engagement with said cam and the other lever arm of said bell crank having operative connection with said mandrel, and means for holding said one lever arm of said bell crank in engagement with said cam, to cause said bell crank to move said mandrel relative to said work table during rotation thereof, to cause said gear blank and cutter to turn during the cutting operation at the same varying speed ratio at which the finished gear and pinion will operate.

4. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam, a bell crank pivotally mounted on said work table, one lever arm of said bell crank having operative engagement with said cam, means for holding said one lever arm in engagement with said cam, the other lever arm of said bell crank having gear teeth cut integrally therewith, the center of the pitch circle of which gear teeth is coaxial with the pivotal axis of said bell crank, said gear teeth meshing with a gear sector on said mandrel, the center of the pitch circle of which is coaxial with the pivotal axis of said mandrel, for moving said mandrel relative to said work table and for rotatably moving said mandrel with said work table upon rotation thereof, to cause said gear blank and cutter to turn during the cutting operation at the same varying speed ratio at which the finished gear and pinion will operate.

5. A device for adapting a gear shaper having

a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam mounted coaxially with said work spindle, a rocking arm pivotally mounted on said work table, means for engaging said rocking arm with said cam, and means operated by said rocking arm during rotation thereof with said work table for moving said mandrel and said gear blank relative to said work table while rotatably moving said mandrel and gear blank with said work table, to cause said gear blank and said cutter to rotate at the same varying speed ratio during the cutting operation at which the finished gear and pinion will operate.

6. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam mounted coaxially with said work spindle, a bell crank rotatable with said work table and pivotally mounted thereon, one lever arm of said bell crank being adapted to engage said cam and the other lever arm of said bell crank having operative connection with said mandrel for moving said mandrel relative to said work table, and means for holding said one lever arm of said bell crank in engagement with said cam, to cause said cam to move said bell crank and said gear blank during rotation of said work table at speeds which vary with respect to the speed of rotation of said work table and cause said gear blank and cutter to turn during cutting at the same varying speed ratio at which the finished gear and pinion will operate.

7. A device for adapting a gear shaper having a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation to generate a varying speed gear in a continuous operation including a work table mounted on the work spindle of the shaper for rotation therewith, a mandrel mounted on said work table for relative movement with respect thereto and adapted to have a gear blank mounted thereon, a stationary cam mounted coaxially with said work spindle, a bell crank rotatable with said work table and pivotally mounted thereon, rider means on one lever arm of said bell crank for engaging said cam, means for holding said rider means in engagement with said cam, the other lever arm of said bell crank having gear teeth cut integrally therewith, the center of the pitch circle of which is coaxial with the pivotal axis of said bell crank, said gear teeth meshing with a gear sector on said mandrel, for moving said mandrel with said work table during rotation thereof and at the same time moving said mandrel and gear blank relative to said work table, to cause said gear blank and cutter to turn during cutting at the same varying speed ratio at which the finished gear and pinion will operate.

8. In a gear shaper for producing a varying speed gear, a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation, a rotating work spindle, a support for a gear blank mounted for relative rotative movement with respect to said work spindle, a cam, a cam follower mounted for rotation with said work spindle and having an operative engagement with said cam, and means actuated by the movement of said cam follower in following the contour of said cam for advancing or retarding the rate of said movement of said gear blank relative to said work spindle in accordance with the relative speed ratio at which the finished gear and pinion will operate.

9. In a gear shaper for producing a varying speed gear, a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting operation, a work spindle adapted for rotation during reciprocating movement of said cutter, a support for a gear blank adapted to rotate relatively with respect to said work spindle, a stationary cam, a cam follower mounted for rotation with said work spindle, said cam follower having an arm in operative engagement with the contour of said cam, and a second arm having an operative connection with said gear blank support, and means for holding the first named arm of said cam follower in engagement with the contour surface of said cam to advance or retard the rate of feed movement of said gear blank with respect to said work spindle in accordance with the relative speed ratio at which the finished gear and pinion will operate.

10. In a gear shaper for producing a varying speed gear, a pinion-shaped cutter rotatably driven at a constant speed during its reciprocating cutting movement, a rotating work spindle, a support for a gear blank mounted for relative rotative movement with respect to said work spindle, a stationary cam, a bell crank mounted for rotation with said work spindle and also mounted for pivotal movement with respect to said work spindle, one lever arm of said bell crank having operative engagement with said cam, means for holding said one lever arm in engagement with said cam, the other lever arm of said bell crank having gear teeth cut integrally therewith, the center of the pitch circle of said gear teeth lying on the pivotal axis of said bell crank, said gear teeth meshing with a gear sector on said gear blank support, the center of the pitch circle of said gear sector lying in the pivotal axis of said gear blank support, for advancing or retarding the rate of feed movement of said gear blank with respect to said work spindle in accordance with the relative speed ratio at which the finished gear and pinion will operate.

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