This invention relates to machine tools such as lathes in which work of approximately circular cross section is produced. In some types of turned work a slightly smaller diameter on certain diameters is desired. As an illustration of such work, pistons for automobile engines are preferably of less diameter along the axis of the wrist pin than at right angles thereto. This difference in diameter is very slight, however, being commonly only a few thousandths of an inch. The skirt of such an engine piston is also preferably slightly tapered. Such work must be produced commercially at very high speed and it has been found that the usual relieving devices as hereofore known are unsatisfactory for such high speed work on account of the weight and inertia of the reciprocated parts.

It is the general object of my invention to provide apparatus by which slightly non-circular work may be turned in a lathe or other similar machine tool at high speed and with predetermined eccentricity or other irregularity of diameter. More specifically, I provide means by which slight predetermined variations in diameter or radius are obtained as a result of the rotary motion of a cutting tool about an axis transverse to the axis of the work. My invention further relates to arrangements and combinations of parts which will be herein-after described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawings, in which:

Fig. 1 is a plan view of portions of a lathe embodying my improvements;

Fig. 2 is a sectional front elevation, taken along the line 2—2 in Fig. 1;

Fig. 3 is a sectional side elevation, taken along the line 3—3 in Fig. 1;

Fig. 4 is an enlarged side elevation of the cutting tool used in my improved apparatus;

Fig. 5 is an end view of the cutting tool, looking in the direction of the arrow 5 in Fig. 4;

Figs. 6 to 11 are diagrammatic views illustrating the operation of the invention, and

Fig. 12 is a diagrammatic plan view to be described.

Referring to the drawings, I have shown portions of an automatic lathe including a head stock 20 (Fig. 1), a tailstock 21, a chuck 22, a tail center 23 and a piece of work W supported between the chuck 22 and tail center 23.

A tool carriage 25 is slidable lengthwise of the lathe on supporting portions of the frame F of the lathe and may be moved longitudinally of the lathe by the usual feed screw 21. A table 30 is slidable transversely of the carriage 25 and guide ways 31 and may be secured in any adjusted position in said guide ways.

A stand 33 is slidable longitudinally of the machine in guide ways 34 (Fig. 3) on the upper surface of the table 30 and may be clamped in any adjusted position by bolts 35 (Fig. 1). The upper surface of the table 30 is preferably inclined at a slight angle as indicated in Fig. 3.

A tool slide 40 is slidable in guide ways 41 (Fig. 1) on the stand 33 and is provided with a roll 42 engaging one side of a templet bar 43. The opposite edge of the bar 43 engages a bearing surface in a portion 44 of the stand 33, and a cap plate 45 (Fig. 3) holds the templet bar in firm contact with the portion 44.

The end of the bar 43 is secured to any convenient fixed portion of the machine, by which connection the bar is held from longitudinal movement. The roll 42 is pressed against the templet bar 43 by one or more springs 47 (Fig. 3) mounted in pockets 48 in the stand 33 and engaging a projecting portion 49 of the slide 40.

The roll 42 is thus held in firm contact against one edge of the templet bar 43, and any variation in the width of the bar will cause a corresponding movement of the tool slide 40 toward or from the work W.

By varying the shape of the templet bar, the diameter of the work may be increased or decreased as desired by the turning operation thereon proceeds. If the sides of the templet bar are both straight but at a slight angle, uniformly tapered work will be produced.

A rotary cutter 50 is mounted in a tool spindle 51 (Fig. 3) rotatable in anti-friction thrust bearings 54 and 55 in the tool slide 40. Preferably the axis of the spindle 51 intersects the axis of the work W. Suitable provision such as a cup washer 56 and coil spring 57 may be provided to exclude dirt at the end of the tool spindle adjacent the work.

A worm gear 60 is secured to the spindle 51 and is driven by a worm 61 mounted on a sleeve 62 supported in roller thrust bearings in the tool slide 40. A driving shaft 63 is slidable in the sleeve 62 but is keyed to provide a driving connection therewith. The driving shaft 63 is connected through universal joints 64 and 65 and a connecting shaft 66 to a countershaft 67 driven
by gears 58 from the work spindle on which the chuck 22 is mounted.

The cutter 59 is thus rotated in timed relation to the rotation of the work W and this driving relation is maintained during the longitudinal feed of the cutter relative to the work. If it is desired to produce work having shorter and longer diameters at right angles to each other, the work and cutter are rotated in such speed relation that the cutter rotates through one tooth space for each half revolution of the work W.

The cutter 59 resembles an end mill, with teeth 70 each formed with a transverse cutting end surface. These cutting surfaces may be in a plane transverse to the axis of the cutter but are preferably very slightly crowned for purposes of clearance. This crowning of the cutting edges is indicated in exaggerated form for the purposes of clearance in Fig. 12.

Having described the mechanical construction of my improved apparatus, the method of operation thereof to produce non-circular work will now be described.

The slight variations in diameter are produced as a result of the gradual upward movement of the cutting teeth, by which movements each cutting edge very slightly approaches the axis of the work W and thereby similarly recedes therefrom.

The operation of successive cutting edges or teeth is shown diagrammatically in Figs. 6 to 11 of the drawings. It is assumed that the work W rotates in the direction of the arrow a and that the cutter 59 rotates in the direction of the arrow b so that the tool-engaging portion of the work moves downward while each work-engaging tooth of the cutter moves upward.

The relative positions of the tool and cutter are shown on a greatly enlarged scale in the diagrammatic views for the sake of clearness. If these views were actually drawn to scale, the variations in diameter would be too small to be detected.

The stop of a cut of tooth No. 1 is substantially below the center of the work, as indicated in Fig. 6, and with the tooth in this position the resultant diameter of the work is obviously a maximum.

As the work and cutter rotate in the direction of the arrows a and b respectively, tooth No. 2 moves upward to the position shown in Fig. 7, where the edge of the cutting tooth is at the shortest distance from the axis of the work. During this upward movement of the tooth, the work has rotated about one quarter of a revolution and the diameter of the turned portion of the work has been gradually reduced, as indicated in Fig. 7.

As tooth No. 1 thereafter continues its upward movement, the tooth moves further away from the axis of the work, thus gradually increasing the diameter of the work until said tooth reaches the position indicated in Fig. 8, where this tooth clears the work, thus ending its cut.

By this time, however, tooth No. 2 has reached the position formedly occupied by tooth No. 1 (Fig. 6), with the work at substantially 180° from the starting position. Tooth No. 2 then moves upward during about a quarter of a revolution of the work, from the position shown in Fig. 9 to the position shown in Fig. 10, and continues its upward movement during the next quarter of a revolution to the position shown in Fig. 11. A full revolution of the work is thus completed, during which a desired amount of stock has been removed and the work has been given the non-circular section indicated in Fig. 11.

Attention is again called to the fact that, however, that the difference between the longest and shortest diameters is extremely slight and can hardly be detected except by calipering instruments.

As the tool slide 40 occupies a fixed position during the described angular advance of the cutting teeth, and as the movements of both the work and the cutter are rotary and continuous, the parts may be rotated at any desired speed and the speed is not limited by the weight or inertia of the parts, as in the usual relieving devices.

If the end faces of the cutter teeth are in a plane perpendicular to the axis of the work W, there is a tendency for the tooth opposite the cutting tooth to drag on the turned surface of the work, which may dull the cutter or mar the turned surface. To avoid this effect, the end of the cutter may be slightly crowned and the axis of the cutter may be placed at a very angle to the axis of the work, as indicated in exaggerated form in Fig. 12.

If tapered or other formed shape of the finished work is desired, a templet bar 43 of a corresponding outline is provided. If straight work is to be produced, the bar 43 will be replaced by a block holding the tool slide 40 in fixed relation to the stand 33.

By varying the speed ratio between the cutter and the work spindle, any desired number of longer or shorter diameters or radii may be produced, and the work may be given any desired number of high spots and depressions.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but will in all respects reserve the right to make any changes which may appear to be desirable to the art.
stantially intersecting said axis, and means to rotate said tool slowly and in timed relation to the rotation of the work, the rotary speed of the work being substantially greater than the rotary speed of the tool.

5. Apparatus for producing non-circular work comprising means to support and rotate a piece of work, a tool having end cutting teeth, a tool spindle having its axis substantially perpendicular to the axis of the work and substantially intersecting said axis, and speed-reducing driving connections between the work-rotating means and the cutting tool, said connections including a worm gear on said spindle, a worm meshing therewith, a driving shaft slidable in said worm, a countershaft geared to said work-rotating means, and a universal connection between said countershaft and said driving shaft.

10. Apparatus for producing non-circular work comprising means to support and rotate a piece of work, a tool having a plurality of end cutting teeth, a tool spindle having its axis substantially perpendicular to the axis of the work and substantially intersecting said axis, means to effect relative lengthwise travel between the work and tool, means to rotate said spindle and tool at a rotary speed not greater than the speed of the work and to thereby cause each cutting tooth to move slightly toward and from the axis of the work during each revolution of the work, and additional means to move said cutting tool bodily toward or away from the work during said relative lengthwise travel of the tool and work and in predetermined relation to said relative lengthwise travel.

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