Jan. 15, 1935. R. F. KNIGHT 1,987,832

ABRADING MACHINE

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Fig. 1.

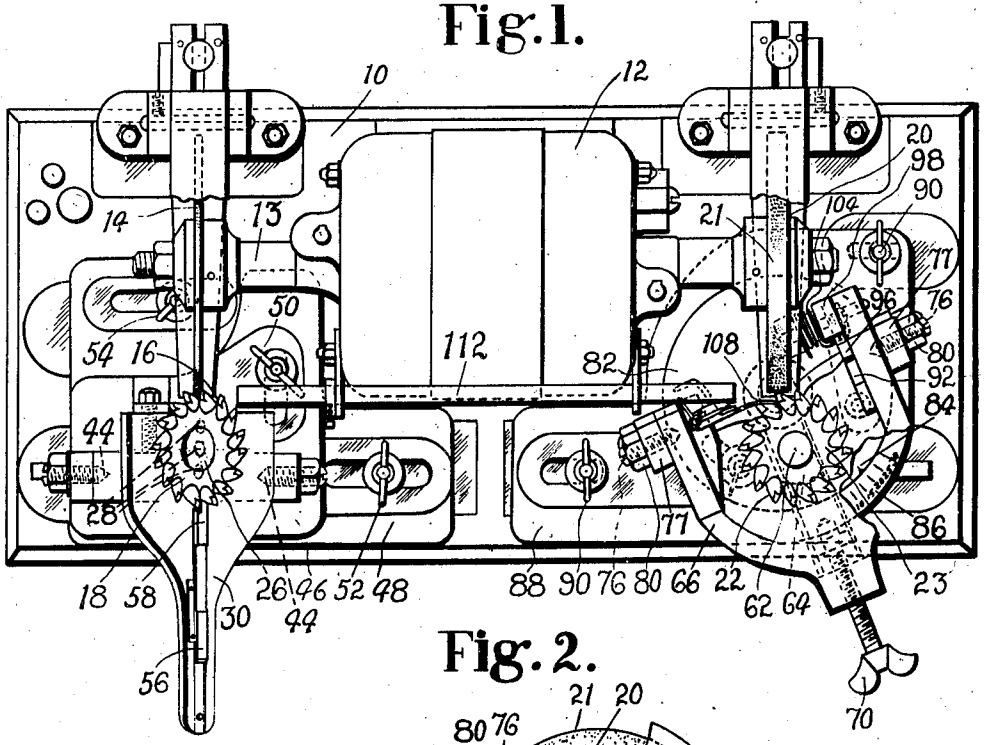


Fig. 2.

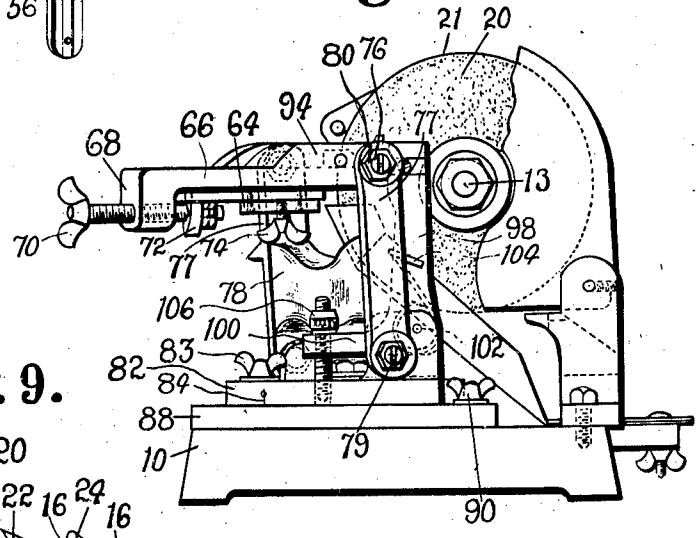
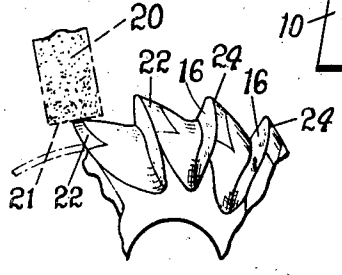


Fig. 9.



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Fig. 3.

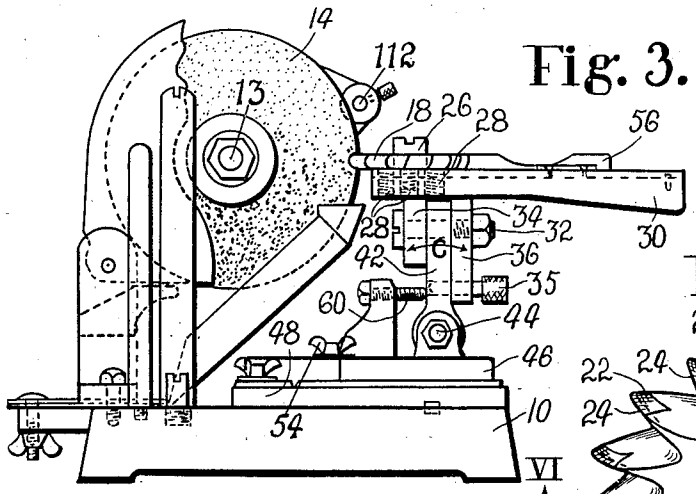


Fig. 7.

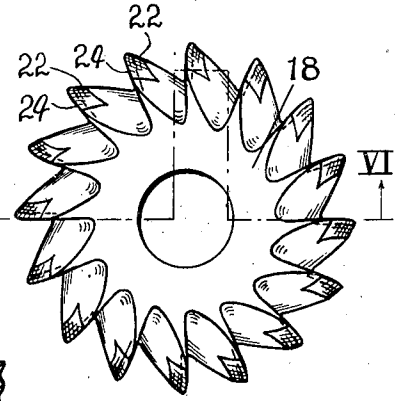


Fig. 4.

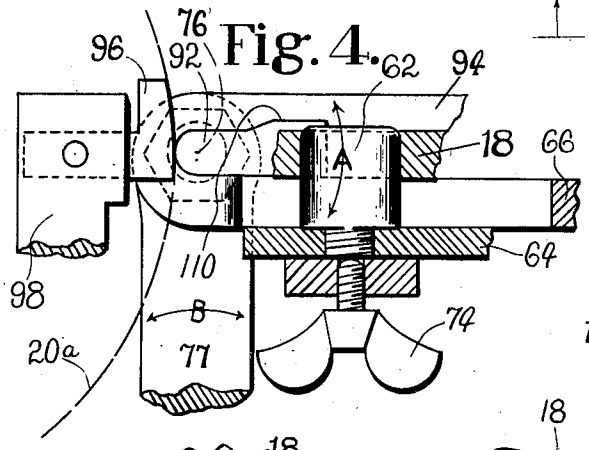


Fig. 5.

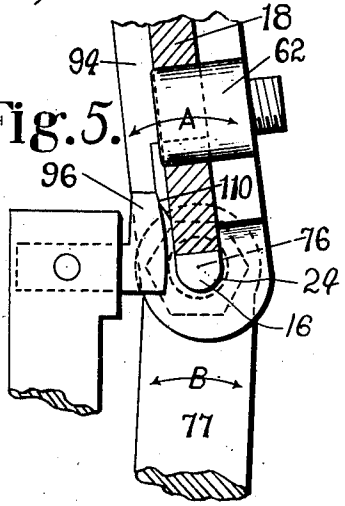
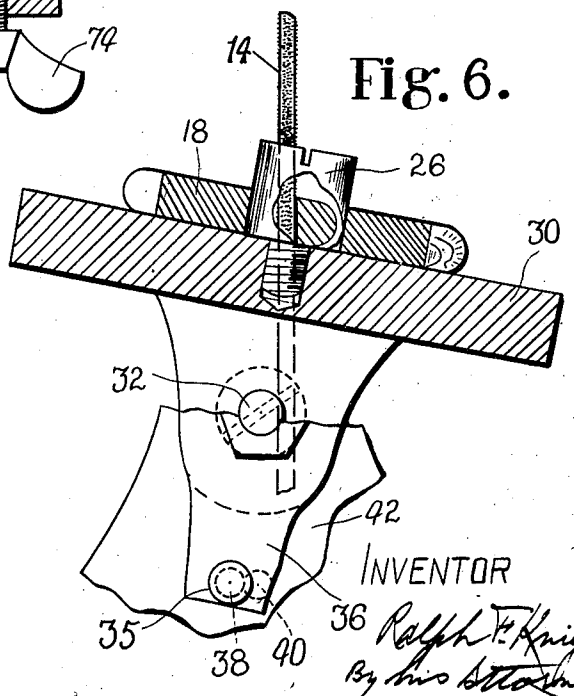


Fig. 6.



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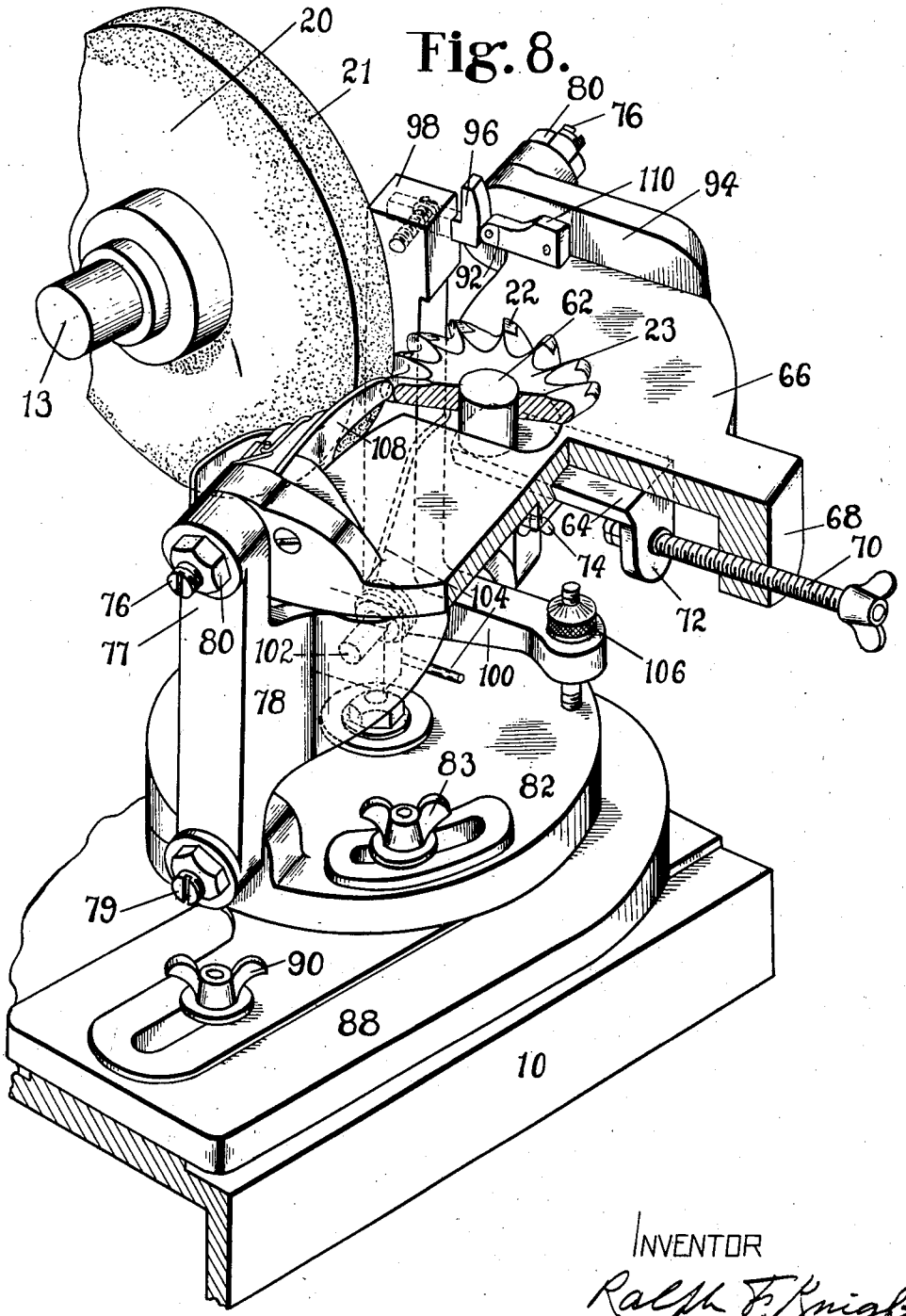
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ABRADING MACHINE

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Fig. 8.



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Patented Jan. 15, 1935 1,987,832

UNITED STATES PATENT OFFICE

1,987,832

ABRADING MACHINE

Ralph F. Knight, Beverly, Mass., assignor to United Shoe Machinery Corporation, Paterson, N. J., a corporation of New Jersey

Application January 3, 1930, Serial No. 418,392

1 Claim. (Cl. 51—225)

This invention relates to abrading machines and is illustrated as embodied in a machine for grinding the teeth of rotary-toothed cutters to a predetermined shape, although certain features of the invention are not limited to the abrading of such cutters. The invention is particularly adapted for grinding the teeth of cutters for use in the manufacture of wood heels.

In the so-called operation of hand-concaving wood heel blanks, the heel blank is placed on a flat table through which a rotary cutter projects, and the blank is pushed and turned by hand to carry its heel-seat portion over the cutter. The blank, as it is being cut, is fed substantially parallel to the axis of the cutter, and, at the same time, it is turned slowly so that the periphery of its heel-seat surface at the point being operated upon, is maintained normal to the plane of the cutter. This movement causes the cutter to cut to a considerable extent on the sides of the teeth and, in order to provide proper clearance, each tooth must have a clearance, or be "backed-off" as it is usually termed, around its entire cutting periphery; in other words, the cutting edge of each tooth must be produced by the meeting of the front plane face of the tooth with one or more faces which make an acute angle with the front face at all points of the cutting periphery of the tooth.

It has been found that, if the cutter, thus shaping the heel seat with its side face only, leaves a sharp corner in the work between the progressively finished portion of the heel-seat surface and the portion to be operated upon, the cutter will cut rapidly but will tear the wood, especially breaking out the thin narrow rim around the attaching surface of the heel, and besides will be liable to catch in the heel so that the heel will be thrown out of the operator's hand, with injury to the heel and possibly to the operator. However, if, instead of the sharp corner referred to, a fillet is formed by the cutter, the rim is supported by the fillet and also the heel may be moved without danger of the cutter catching in the heel. Accordingly, the contour of the cutting edge must be a smooth curve which merges with the progressively finished surface of the heel produced by the cutter. In order to form the desired curve to produce such a fillet, and still make a cutter easy to manufacture, the front face of each tooth is conveniently made either approximately semi-circular or approximately semi-elliptical and, accordingly, in order to obtain a cutting edge at the periphery of the front face with the proper clearance, the "backed-off" face of the cutter is a single curved surface which intersects the plane front face of the cutter to form a cutting edge of the desired shape. Expressed in another way, the surface of each tooth, rearwardly from its cutting edge, is substantially conical with the larger end of the cone at the cutting edge. Another advantage of a cutter having teeth of this shape resides in the fact that the chips that are made by the cutter, as the work is passed over it, are comparatively thick at the side of the cutter (or are "roughing" chips) while the chips made by the ends of the teeth, where they merge with the progressively finished portion of the heel seat, are thin, "finishing" chips which leave the finished work with a smooth surface. Because these finishing chips are thin, the tendency to break the rim is still further lessened provided, of course, that the teeth are kept sharp.

In the usual types of milling cutters for operating upon metal, the backing-off or clearance is comparatively slight and they rotate at a comparatively low speed and the work is fed to them at a comparatively slow rate. Accordingly, they are ground on the front or substantially radial faces of the teeth to sharpen them and the inaccuracy with which they are ground in practice is so slight that the height and width of the teeth remain suitably uniform to secure proper operation. However, when a cutter is to operate upon wood or similar materials, where its speed is much greater, it is necessary that the height and width of the teeth be maintained uniform with as high a degree of accuracy as possible in sharpening the teeth.

The above-described method of grinding the teeth on the front or radial faces is not sufficiently accurate to produce a properly operating cutter where the cutter is backed-off sufficiently to operate on wood and similar materials because such increased backing-off causes the length of the teeth to change rapidly as the radial faces are ground progressively backward so that any irregularity in angular spacing of the front faces causes a corresponding and marked irregularity in the length of the teeth.

Because of the above conditions it is a principal object of the invention to produce a grinding machine that will grind, instead, the "backed-off" or substantially conical faces of the teeth and produce a cutter of such a degree of accuracy that it will operate properly on wood and similar materials and which machine can be operated, without liability of injury to any tooth due to excessive grinding, by mechanics of ordi-

nary skill who can handle the cutter manually, with an uninterrupted surging motion, in substantially the same manner as in ordinary hand-grinding but in which the final shape given to the teeth will be predetermined by adjustments of the machine.

A further object of the invention is to produce a machine particularly adapted to grinding cutters for hand-concaving of wood heel blanks.

In order to secure the desired accuracy, all of the teeth of such a rotary cutter should have the same size and contour and the cutting edges of all of the teeth should have their corresponding points alined in the circumferences of corresponding circles lying in planes perpendicular to the axis of rotation of the cutter with the centers of the circles in that axis. This alinement of corresponding points in the teeth of the cutter will be referred to hereinafter as "circumferential alinement". Such alinement enables each tooth to perform its proportionate share of the work of the cutter in removing material so that chattering is prevented and no ridges or waves are left on the work, while the wear and tear is greatly reduced on the machine in which the cutter is used.

In the machine shown in the drawings, the tool for sharpening the teeth is an abrading wheel, and the tool and the cutter are relatively so moved as to give the desired conical shape to the teeth of the cutter.

For giving a clearance to the teeth, an important feature of the invention consists in mounting the cutter and the tool so that one may be turned about the other on an axis which is oblique to and within the backed-off face of the tool being ground. Thus the axis of relative rotation and the backed-off face of the tooth diverge toward the cutting edge of the tooth and the said axis is the axis of the conical surface being formed on the backed-off face of the tooth. Preferably, this axis will be so located relatively to the front face of the tooth that the backed-off face makes a substantially constant angle with the front face, thus giving a substantially constant angle of clearance around the entire cutting periphery of each tooth.

In the illustrated machine the cutter is supported on a plate or swinging table, and the table is supported on a pivotal axis which may be adjusted, as hereinafter set forth, to coincide with the axis of the conical surface to be ground. The illustrated tool for grinding each tooth is a flat-faced or cylindrical grinding wheel, the operating elements of the cylinder coinciding in turn with successive elements of the conical surface being formed on the tooth. The axis of relative rotation above-mentioned is thus similarly oblique to the axis of the wheel and to the conical surface of the tooth.

In order to provide for forming conical surfaces of various conical angles, so as to give any angle of clearance within wide limits, the axis of relative rotation has, in accordance with another feature of the invention, been made angularly adjustable relatively to the axis of the grinding wheel. To this end, in the illustrated machine, the swinging table and its pivotal axis are mounted on an angularly adjustable swivel base, the axis of angular adjustment being perpendicular to the plane of the cutter in its mean position. This arrangement, by adjusting the angle between the axis of relative rotation and the axis of the grinding wheel, correspondingly adjusts the conical angle of the surface formed on the tooth or the clearance.

In order to present the cutter teeth to the tool in succession, it is necessary to provide for retracting the cutter from the tool in order to allow the newly formed tooth to clear the tool and permit the cutter to be turned on the table to present the next tooth to the tool. To this end, the pivotal axis of the swinging table is pivotally supported on a swinging carrier pivotally mounted on the swivel base so as to swing about an axis near the swivel base, and thus permit movement of the table and cutter away from the tool.

Inasmuch as the axis of relative rotation is thus movable relatively to the tool, another feature of the invention consists in providing means for holding it in the proper position while each tooth is being ground. To this end, the swinging table is provided with a cam having a shape corresponding to the shape of the rear face of the tooth being formed. As the swinging table is swung manually by the operator on the axis of relative rotation, the cam runs against a fixed member or abutment having a shape corresponding to the effective surface of revolution of the tool, thus holding the cutter and the tool in the proper relationship at all times, and insuring that the faces formed on all the cutter teeth shall be exactly alike.

An additional feature of the invention consists in the provision of a projection on the cam or former so that, after as much of the contour of a tooth has been ground as is necessary, the tooth is withdrawn from the grinding wheel by the action of the projection on the cam coming into contact with the abutment as the swinging of the cutter about the axis in its own plane is continued.

Another feature of the invention consists in means to adjust the position of the cutter with respect to the axis around which the cutter is swung in order to control the amount of material to be ground from the cutter and so to permit the cutter to be ground for the maximum number of times before it is reduced to a size too small for the work it is designed to do.

Because, according to the present invention, each tooth is accurately positioned on the swinging member and because the path of movement of each tooth with respect to the grinding wheel is determined by the follower and fixed abutment, each tooth is ground to a predetermined height and contour so that the corresponding portions of each tooth are in circumferential alinement even if there should be inaccuracies in the circumferential spacing of the teeth due to grinding initially the substantially radial faces to different extents or for other reasons. Accordingly, when the cutter is used, each tooth will perform its proportionate share of the cutting operation and, if necessary, the cutter may be operated at high speed without chattering.

Other objects and features of the invention will be apparent from the following description when read in connection with the accompanying drawings in which it should be noted that certain parts, which are arranged to swing, are not illustrated in their positions of rest but are shown in positions through which they pass while they are held and moved by the operator.

In these drawings,

Fig. 1 is a plan view of the grinding machine fitted with an electric motor drive;

Fig. 2 is a side elevation viewed from the right of Fig. 1;

Fig. 3 is a side elevation viewed from the left of Fig. 1;

Fig. 4 is a detail of construction showing the cam or former by which the teeth are given a predetermined shape;

Fig. 5 is a view similar to Fig. 4 with the parts in a different position;

Fig. 6 is a detail of construction showing the arrangement of parts by which the front, or substantially radial, faces of the teeth of the cutter may be ground when necesary, the cutter being shown in section, with the section taken along the section line VI—VI of Fig. 7;

Fig. 7 is a side elevation of one form of rotary toothed cutter which the grinding machine of the present invention is designed to sharpen this form having the front, or substantially radial, faces of the teeth inclined at an angle to the axis of the cutter;

Fig. 8 is a perspective view of the mechanism shown in the right-hand portion of Fig. 1; and

Fig. 9 is a perspective view of a portion of the rotary toothed cutter of Fig. 7 with a portion of the abrading tool shown operating upon one of the teeth.

The mechanism of the illustrated grinding machine is mounted upon a bed plate 10. To this bed plate is secured an electric motor 12 upon the left-hand end of the shaft 13 of which (Fig. 1) is mounted a thin grinding wheel 14 for grinding the front, or substantially radial, faces 16 of the teeth of a cutter 18 which may occasionally be necessary for various reasons of wear or damage. Upon the right-hand end of the shaft 13 is mounted a wider grinding wheel 20 having a straight peripheral face 21, parallel with its axis, for grinding the curved surfaces 22 of the teeth of a cutter 23 which surfaces 22 intersect the front faces 16 to form the cutting edges or contour 24 of the cutter. It should be understood that the cutters 18 and 23 are identical and of the kind shown in detail in Fig. 7, each being shown, for convenience, in a position to illustrate the action of the grinding mechanism of the present invention in grinding the specified portions of their teeth.

In order to grind the front faces 16, the cutter is placed in the position of the cutter 18 (Fig. 1) on a stud 26 which may be secured on a carrier 30 in any one of a series of tapped holes 28 therein, according to the diameter of the cutter. The carrier 30 (Fig. 3) is mounted to tilt about an axis at right angles to the direction of the shaft 13 of the motor, this axis comprising a bolt 32 passing through depending lugs 34 and 36 on the carrier. The carrier is held in tilted position by a locking pin 35 which passes through the lower end of the lug 36 and enters either one of the holes 38 and 40 in a swinging arm 42. When the locking pin 35 is in the hole 38, as indicated in Fig. 6, the cutter is mounted for grinding the front faces of the cutter at an angle to the axis of the cutter while, with the pin 35 in the hole 40, each face 16 of the cutter will be ground parallel with the axis of the cutter. The swinging arm 42 is pivotally mounted at 44 on a slide base 46 and swings as indicated by the arrow "C" (Fig. 3). The slide base 46 is arranged to slide on another slide base 48 to and from the wheel 14. The two slide bases 46 and 48 are clamped together by the clamp screw 50. The slide base 48 is arranged to slide on the bed plate 10 in a direction parallel to the axis of the grinding wheel in order to locate a tooth of the cutter on the carrier 30 in a position to be ground by the flat lateral face of the wheel 14. When thus located, the slide base 48 is locked in adjusted position by the clamp screws 52 and 54. When the cutter 18 is suitably positioned by the above-described adjustments for grinding the front faces of its teeth, each tooth is positioned in turn and is held fixedly in that position for grinding by means of a sliding thumb member 56 mounted on the carrier 30 which has a notched end 58 to engage that tooth which is diametrically opposite the one to be ground.

After being properly positioned, the carrier 30 and its swinging arm 42 are swung about the pivot 44 to bring the cutter against the side of the wheel 14 which then grinds the face 16 to an amount determined by the adjustments. In order to prevent the cutter from being swung too far across the wheel 14, an adjustable stop screw 60 (Fig. 3) is mounted on the slide base 46 in position to limit the motion of the arm 42 towards the wheel. To grind the other teeth, the thumb piece 56 is brought towards the operator and each succeeding tooth is positioned in the notch 58 and its opposite tooth brought into position to be ground, the operation being repeated until all of the teeth of the cutter have been ground. After these faces 16 of the teeth are once ground it will rarely be necessary to repeat the operation because the sharpening of the teeth is done by grinding the curved faces 22 in the manner about to be described. However, after the curved faces 22 have been shortened by repeated grinding, it may be necessary to "throat out" between the teeth, i. e., to grind the front faces 16 again as above described in order that the teeth may work properly.

For grinding the curved faces 22, the cutter is placed, as shown at 23 (Figs. 1 and 8), on a stud 62 which is mounted on a slide 64. This slide is mounted in a slideway in a swinging table 66, which member has a downwardly extending lug 68 on the end facing the operator. Through the lug 68 is an adjusting thumb screw 70 which engages a downwardly extending lug 72 of the slide 64 in such a manner that the slide and its stud 62 may be accurately positioned by the thumb screw 70 and then clamped in position by a clamp screw 74. The swinging table 66 is mounted by means of two cone-pointed screws 76, to swing (as indicated by the double arrow "A", Figs. 4 and 5) through a partial revolution about the axis of the screws 76 which are carried by upstanding arms 77 on a bifurcated swinging carrier 78. The screws 76 may be adjusted to take up back lash and may then be locked in position by the lock nuts 80. The swinging carrier 78 is mounted in a similar manner to swing (as indicated by the double arrow "B", Figs. 4 and 5) about a second axis 79 parallel with the above-mentioned axis 76. The second axis 79 is carried on a swivel base 82, which may be clamped in adjusted angular position by the clamp nut 83. The angular position of the base 82 is indicated by an index mark 84 (Fig. 2) and a graduated scale 86. These indicate the angle that the two parallel axes make with the axis of the grinding wheel and consequently the angle of clearance that will be given to the teeth of the cutter. This angle is small or much less than 45 degrees. This scale is located on a slide base 88 upon which the swivel base 82 is mounted and to which it is clamped by the nut 83. The slide base 88 may be ad-

justed on the bed plate 10 in a direction parallel to the axis of the grinding wheel and, when properly adjusted, it is clamped in position on the bed plate by means of clamp screws 90. By means of the above adjustments the cutter may be adjusted to any desired position with respect to the grinding wheel 20.

When the cutter 23 is properly positioned, as above, the center of curvature of the contour of the tooth to be ground will be substantially in the axis 76 about which the swinging member 66, and the cutter itself, may swing through a partial revolution. This axis is perpendicular to the direction of the axis of the cutter and of the stud 62 upon which the cutter is mounted. It should be noted that, as each tooth is brought into position to be ground, the axis of the screws 76 always bears the same relation with respect to the axis of the cutter and to the tooth being ground.

The contour that is given to the cutting edges 24 of the cutter by grinding the curved surfaces 22 of the cutter teeth is determined by a cam 92 (Fig. 8) which is secured to the inside of the right-hand arm 94 of the swinging member 66. The center of curvature of the cam, if the cam is substantially semicircular in shape, is preferably located substantially in line with the axis about which the member 66 swings, i. e., the axis of the pivots 76 and, if the cam is somewhat elliptical in shape, it is located in as nearly a similar position as possible. Such an arrangement gives smooth operation of the parts and is convenient to operate. Also, with the cutter positioned as above described, it permits the cutter to be sharpened with the removal of the least amount of material possible.

The cam 92 is arranged to engage a stop or abutment 96, the engaging face of which has a curvature approximately that of the grinding wheel, being of a somewhat smaller diameter than a new wheel but of a larger diameter than a wheel that is worn sufficiently to be discarded; in other words, it has approximately the average curvature of the grinding wheel 20 during its useful life. This curvature is indicated by the dash line 20*a* in Fig. 4. The stop 96 is mounted on an adjustable arm 98 which is part of a bell crank lever, the other arm of which is shown at 100, and which is pivotally mounted on a shaft 102 on the swivel base 82. A torsion spring 104 tends to force the arm 98 toward the axis of the grinding wheel but movement is prevented by an adjustable stop nut 106 which engages the arm 100 of the bell crank lever. This adjustment permits the abutment 96 to be kept in alinement with the face 21 of the wheel 20. The adjustment at 70—72 permits the placing of the stud 62 so that the back faces of the teeth being ground will be properly alined with the cam 92.

To locate the cutter 23 circumferentially so that the tooth to be ground is properly positioned, a spring stop finger 108 is provided, as shown in Figs. 1 and 8. This spring finger presses into the notch in front of the tooth to be ground and settles to the bottom of the notch, thus holding the cutter positively in position. During the grinding operation the cutter is held by the operator firmly against the spring finger 108 to maintain the stop finger in the bottom of the notch. The spring finger 108 will yield in order that the cutter may be revolved and brought into position to grind a succeeding tooth.

The operation of the machine in grinding the curved surfaces 22 of the teeth will now be described. After the cutter has been positioned on the stud 62 and after the stop 96 has been adjusted and after the previous adjustments at 83 and 90 have been made, the thumb screw 70 is adjusted with the swinging member 66 in the level position indicated in Figs. 1, 2 and 4, so that the desired amount of material will be removed. The swinging member 66 and the cutter secured thereto are then given, manually, a compound motion, in a plane located at an angle somewhat less than 90 degrees to the axis of the grinding wheel, to grind the surface 22 of the tooth, this compound motion consisting of a motion of approach to the wheel about the axis of the screws 79 and a motion of rotation about the axis of the screws 76. First, the swinging member 66 is dropped to its lowest position and is gradually swung forwardly about the axis 79, during which time material is removed from the cutter, until the cam 92 meets the stop or abutment 96. When this takes place and no more forward movement is possible at that level, the swinging member 66 is gradually lifted or swung about the axis 76 and forward pressure of the cam 92 against the abutment 96 is maintained, the cutter thus being ground progressively, without interruption, until the swinging member 66 has been lifted or swung to substantially a vertical position and the entire contour of the tooth has been ground. The rear raised part 110 of the cam then comes in contact with the stop or abutment 96 (Fig. 5) which causes the carrier to swing backward slightly about the axis 79 and free the cutter from contact with the grinding wheel. This completes this grinding operation on this tooth. Succeeding teeth are then treated in a similar way until all the teeth have been ground. It will thus be seen that the cutter grinding operation itself is the same as a purely manual operation except that the mechanisms used constrain and limit the manual control of the cutter so that all the teeth are ground to the same exact shape and length to bring all the teeth into circumferential alinement with their cutting edges ground to the proper degree of sharpness.

If it should happen that some teeth of the cutter were originally shorter than others because they were "throated out" too much, or because they have become worn more than others, or embody imperfections due to manufacturing processes which are present because the cutter has not previously been ground on this machine, it may be that the initially shortest tooth will not have been reduced to a cutting edge and so the other teeth, although they may be sharp, are still longer than said shortest tooth. In such case, the thumb screw 70 is turned slightly to advance the stud 62 and the cutter toward the grinding wheel and all of the teeth are ground again, the operation being repeated, if necessary, until all of the teeth have been reduced to the length of the shortest tooth and that tooth has become sharp. When this has been done, it will be found that all of the teeth are sharp and the contours of all of the teeth are circumferentially alined so that the cutter is in condition to be mounted in a machine for operating on work to be treated, irre-

spective of whether the teeth are equally spaced circumferentially or not.

In order to maintain the grinding wheels 14 and 20 with true grinding surfaces, a movable rod 112 is provided upon which a diamond or other truing device may be mounted to operate on either wheel, in such a manner that it may be passed across the working face of that wheel and true its surface in the usual manner.

It will be noted that the machine of the present invention, while easy to adjust and operate, is capable of grinding cutters of the general type shown with extreme accuracy, which is essential for a satisfactorily operating cutter.

Having described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:—

In a machine of the class described, a grinding wheel having a peripheral abrading face, a cutter carrying member, means for rotatably mounting the carrying member on two parallel axes about which it may be moved manually without interruption with a compound motion of translation and rotation to bring successive portions of the cutting profile of each tooth of a toothed cutter mounted on said member into abrading contact with the wheel, said compound motion carrying the axis of the cutter in a plane that intersects the plane in which the wheel rotates at an angle substantially equal to the clearance angle desired on the back of the tooth being ground, a cam having its center of curvature substantially in one of said parallel axes, a raised part on said cam, and an abutment to cooperate with said cam, whereby the cam and abutment control said compound motion to grind all of the teeth into circumferential alinement and to separate each tooth from the wheel when the grinding operation thereon is completed.

RALPH F. KNIGHT.