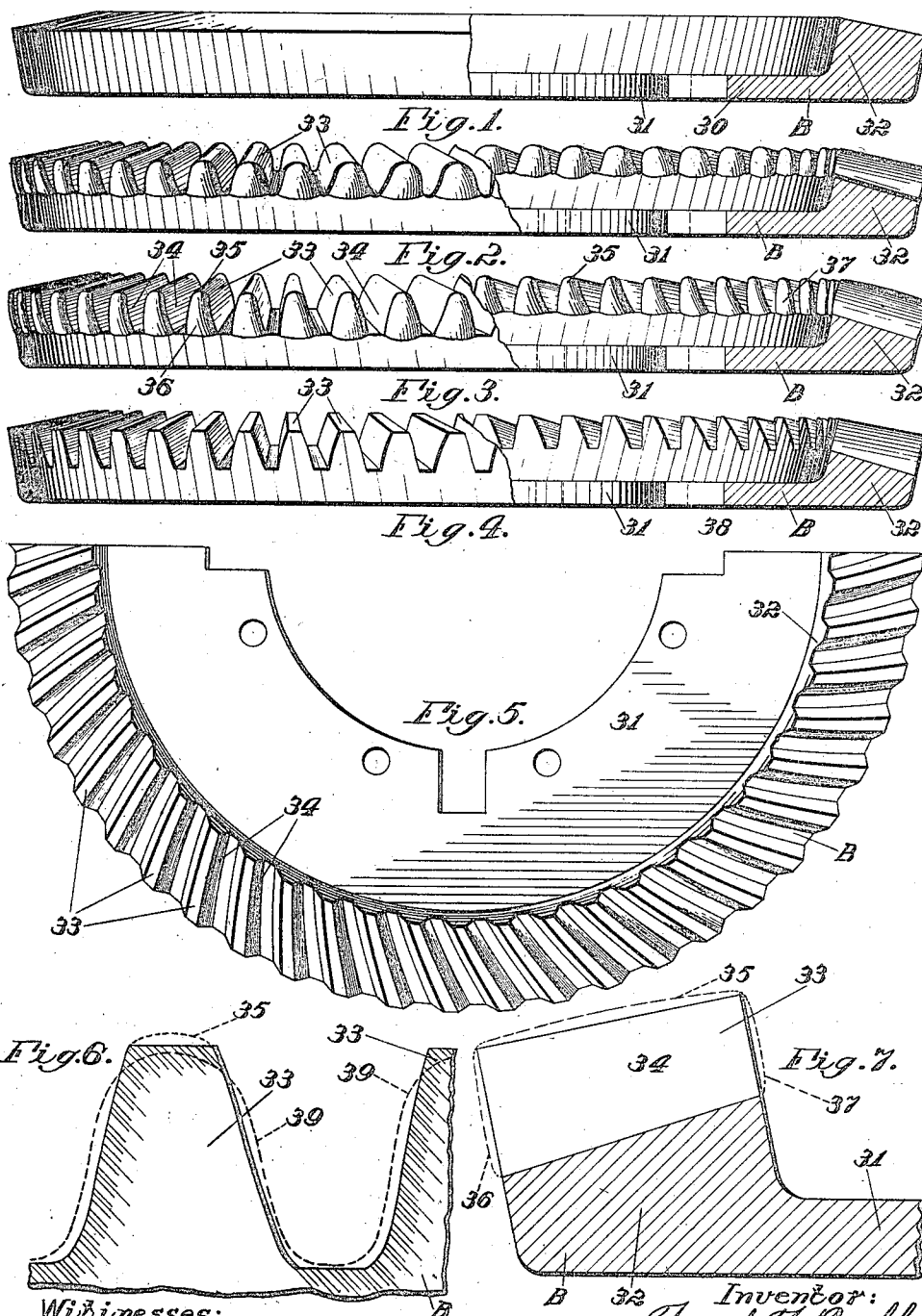


F. F. BEALL.
GEAR MANUFACTURE.
APPLICATION FILED DEC. 23, 1914.

1,305,050. Patented May 27, 1919.
3 SHEETS—SHEET 1.



Witnesses:
Clair J. Lott,
L. R. J. C. Lott.

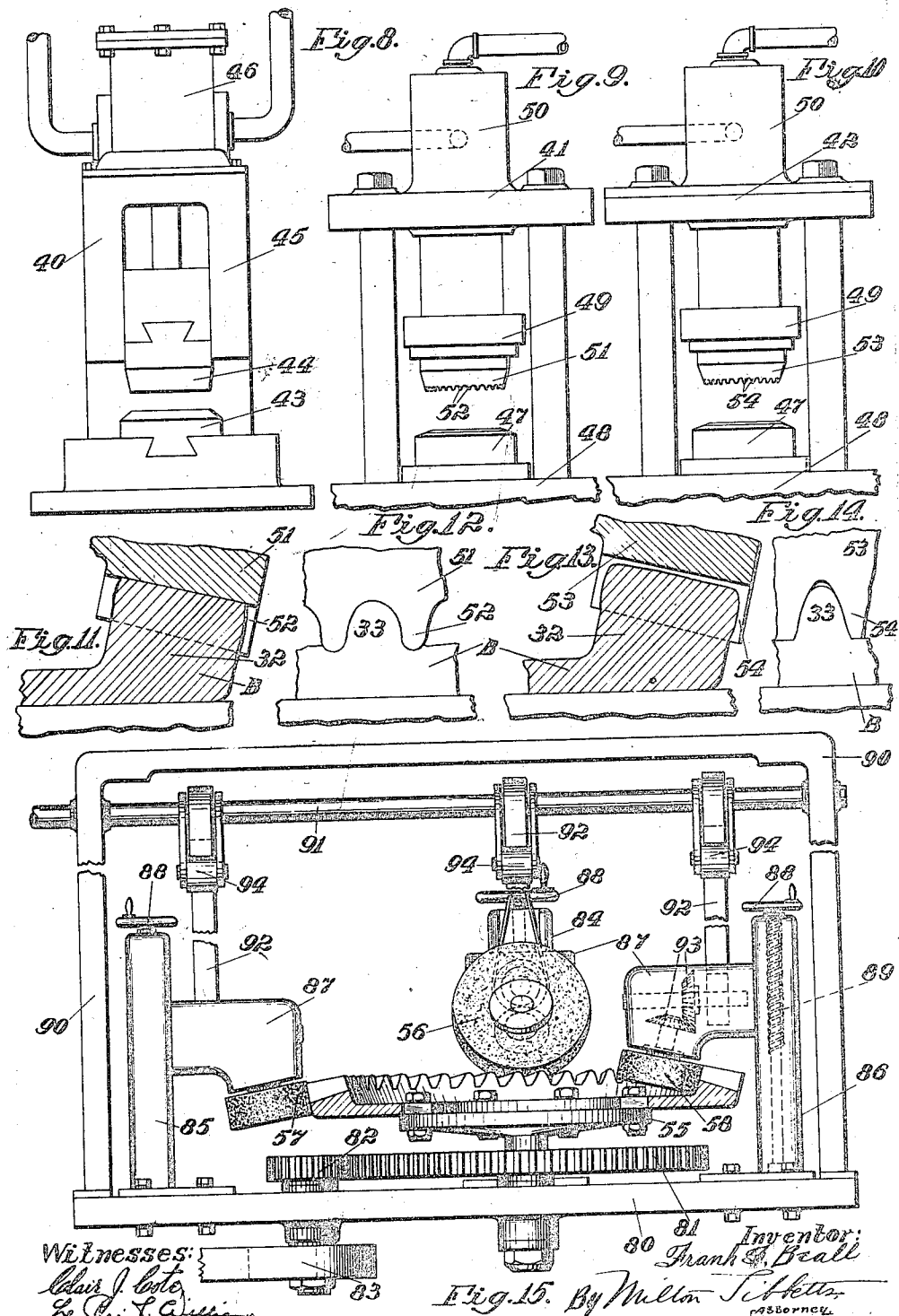
Inventor:
Frank F. Beall
By *William T. Lott*
Attorney.

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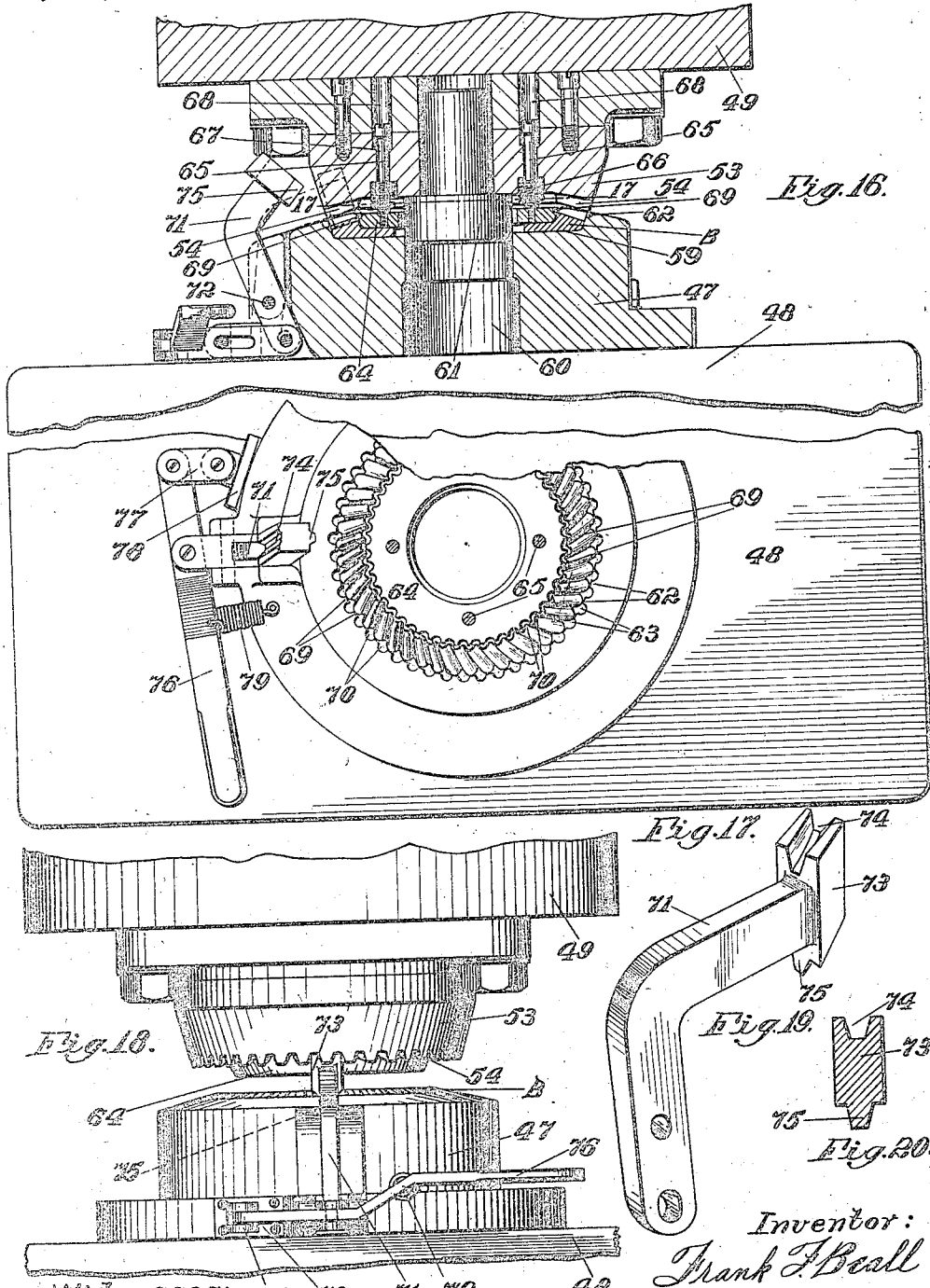
Witnesses:
Edw. J. Cote
L. J. C. Cote

Inventor:
Frank F. Beall
Fig. 15. By Milton S. Hester
Attorney

1,305,050.

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3 SHEETS—SHEET 3.



Witnesses: 77 78 71 79
Clair J. Loto,
R. P. Williams.

Inventor:
Frank F. Beall
By Milton S. Lott,
Attorney.

UNITED STATES PATENT OFFICE.

FRANK F. BEALL, OF DETROIT, MICHIGAN, ASSIGNOR TO PACKARD MOTOR CAR COMPANY, OF DETROIT, MICHIGAN, A CORPORATION OF MICHIGAN.

GEAR MANUFACTURE.

1,305,050.

Specification of Letters Patent.

Patented May 27, 1919.

Application filed December 23, 1914. Serial No. 878,733.

To all whom it may concern:

Be it known that I, FRANK F. BEALL, a citizen of the United States, and resident of Detroit, Wayne county, State of Michigan, have invented certain new and useful improvements in Gear Manufacture, of which the following is a specification.

This invention relates to gear manufacture, and particularly to bevel or other crown gear wheels and their manufacture.

The invention comprises a method of forging or pressing gears into shape as distinguished from cutting or casting them. Gear cutting is an expensive operation and cast gears are not suitable for many purposes. One of the objects of the present invention is to produce gears of hard metal such as steel and at much less cost than cut gears.

Other objects will appear from the following description taken in connection with the drawings, in which:—

Figure 1 is a part elevation and part section of a gear blank in the form in which it leaves the drop hammer;

Fig. 2 is a similar view of the blank after leaving the roughing die;

Fig. 3 is a similar view of the blank after leaving the finishing die and before the excess metal has been removed;

Fig. 4 is a similar view of the finished gear;

Fig. 5 is a plan view of half of a finished gear like that shown in Fig. 4;

Fig. 6 is a fragmentary enlarged end elevation of several of the teeth of the finished gear showing in dotted lines the contours of the teeth in various stages of completion;

Fig. 7 is an enlarged sectional view of the finished gear showing in dotted lines the contours of a tooth in various stages of completion;

Fig. 8 is an elevation of a drop forge hammer of the type used for roughing out the gear blank shown in Fig. 1;

Fig. 9 is an elevation of a press adapted for carrying out one of the pressing operations of the invention;

Fig. 10 is a press similar to that shown in Fig. 9 and is adapted for carrying out

another of the pressing operations of the invention;

Fig. 11 is a fragmentary section through the roughing die showing it in operating relation with the gear blank;

Fig. 12 is an end view of the die and blank shown in Fig. 11;

Fig. 13 is a view similar to Fig. 11 showing the finishing die;

Fig. 14 is an end view of the die and blank shown in Fig. 13;

Fig. 15 is an elevation and part sectional view through a grinding machine for performing certain grinding operations on the gear;

Fig. 16 is an enlarged vertical section through one of the die presses showing the blank in position;

Fig. 17 is a plan view or horizontal section on the line 17—17 of Fig. 16;

Fig. 18 is an enlarged side view of a part of one of the die presses showing the locating lever in position;

Fig. 19 is an enlarged perspective view of the locating lever; and

Fig. 20 is a transverse section through the head of the locating lever.

This invention involves die pressing a blank to form teeth by displacing the metal of the blank with space forming die parts so that metal extends beyond the normal limits, as the tops, for instance, of the teeth, and then removing the excess, as by grinding or machining. The blank may be so supported that some excess metal will be pressed outwardly at the ends of the teeth, and this excess metal may likewise be removed.

The invention also involves die pressing a blank having teeth of abnormal proportions so that the teeth are pressed into the desired shape. As illustrated herein, a blank having teeth of abnormal thickness is die pressed so that the sides of the teeth are compressed to the desired face contour. The abnormally thick teeth may be formed by forging or die pressing with a roughing die.

In the form of the invention particularly set forth herein, a gear blank having a plain face is drop forged, is then placed in a die press where a roughing die forms teeth of

abnormal thickness and preferably of less height than the required finished tooth, is then subjected to a second die pressing operation in which a finishing die compresses the thick teeth to the desired contour and forces excess metal outwardly beyond the normal tops and perhaps at the ends of the teeth, and is then machined or ground to remove the excess metal. The last step is the hardening of the finished gear. Gears made by this method will be found in most cases to be accurate enough for the finest work, but if desired a finishing cut may be made on the faces of the teeth before hardening to give a still greater degree of accuracy.

A gear made in accordance with the above referred to method is shown herein and comprises teeth the faces of which are compressed and die finished leaving the metal denser at and adjacent said faces, and the tops and ends, of which have a cut finish where the excess metal has been removed either by machining or grinding.

Referring to the drawings, B represents generally a gear blank and in Fig. 1 it is a plain blank 30 having a web portion 31 and a portion 32 in which the gear teeth are to be formed. In Fig. 2 the blank B is shown as having teeth 33 which are thick relative to the spaces between them and not as high as the teeth of the finished gear should be. As shown the teeth and spaces have no sharp corners it thereby being possible to form such a blank either by a quick rough pressing process or by drop forging. As shown also, the teeth are arranged in a generally diagonal direction and are curved lengthwise, but other desired forms of teeth may be made.

In Fig. 3 the gear blank B is shown as having its teeth 33 formed with correct faces 34 but an excess of metal extends above the normal tops of the teeth as shown at 35, the dotted line 35' representing the normal top of one of the teeth. Some of the excess metal has also been pressed outwardly at the ends of the teeth as at 36 and 37. Aside from the excess metal above referred to, the teeth of the gear shown in Fig. 3 are perfectly formed and would be ready for use.

In Figs. 4 and 5 the gear blank B has become a finished gear 38, the excess metal above referred to having been entirely removed either by machining or grinding, thus leaving a cut finish at the tops and on the ends of the teeth. In Figs. 6 and 7 enlarged views of gear teeth are shown, 35, 36 and 37 representing in dotted lines the excess metal that has been removed, and these views illustrate the clean sharp edges that are obtained by thus pressing the teeth and subsequently removing the excess metal. In these figures also the dotted line 39 traces an outline of the tooth 33 of the gear shown in Fig. 2 as it comes from the roughing die.

Figs. 8 to 20 inclusive, illustrate a method of and suitable machinery for making gears like that above described. By this method, with some metals and with some sizes of gears the various forging and pressing steps may be carried out with one heating of the blank. For this purpose a suitable drop hammer 40 and two presses or similar machines 41 and 42 should be grouped together so that the gear blank may first be forged at its greatest heat by the drop hammer 40, then transferred immediately to the press 41 where it receives the roughening operation, and then placed in the press 42 to be pressed under the finishing die. Under certain circumstances, however, it may be desirable to reheat the blank between either the first and second or the second and third operations, or both. Also it will be understood that a single press may be used instead of two presses by changing dies between operations, but this might necessitate reheating of the blank in all cases. Also, a single die pressing operation is sufficient for some gears, the finishing die being used following the roughing operation.

The drop hammer 40 may be a steam hammer as shown and the dies 43 and 44 are shaped to produce the blank 30 shown in Fig. 1. The die block 43 is the stationary die and the die 44 is reciprocated toward and from the die 43 by the piston rod 45 and its piston operating in the steam cylinder 46. The presses 41 and 42 shown in Figs. 9 and 10 are identical except in the forms of their upper dies. In each, 47 represents the lower or stationary die resting on the table 48, and 49 is the press ram or support for the upper or movable die. The ram is operated by hydraulic pressure through a piston in the cylinder 50.

The press 41 has the roughing die 51 secured to its ram, and as the die moves downwardly its space forming parts 52 press into the blank B as shown in Figs. 11 and 12, forming thick and comparatively low teeth as shown in Figs. 12 and 2, and in dotted lines in Fig. 6. The press 42 has the finishing die 53 secured to its ram, and as this die descends upon the blank that has been transferred from the press 41 the abnormally thick teeth are compressed between the space forming parts 54 of this die as shown in Figs. 13 and 14, thus condensing the metal along the tooth faces and forming a gear like that shown in Fig. 3. In this operation there is a slight excess of metal which is allowed to flow beyond the normal tops of the teeth, as shown at 35 in Fig. 6, and outwardly to a limited extent at the ends of the teeth, as at 36 and 37 in Fig. 7.

From the press 42 the gear or blank is transferred to a machine for removing the excess metal from the tops and ends of the teeth. Such a machine is shown in Fig. 15.

The gear is secured to a rotating table 55 and grinding wheels 56, 57 and 58 are properly set to cut away the excess metal, thus leaving the gear teeth of perfect form and with clean cut edges, as shown in Figs. 4 to 7 and 15.

Ordinarily the gear thus completed will be sufficiently accurate for use, but if desired a machining or grinding process may be carried out on the faces of the teeth before it is case hardened. Case hardening gives the desired wearing qualities to the faces of the teeth and is particularly efficient when combined with the compressing of the gear teeth as herein described.

More particularly referring to the presses, attention is called to the further showing in Figs. 16 to 20 inclusive. The gear blank B is shown in position in the depression 59 in the die block 47. The latter is formed with a central bore 60 to receive a centering stud or pilot 61 extending from the center of the ram 49 and die 53. The die block 47 also has a series of projections 62 at the edge of the depression 59 for supporting the ends of the teeth of the gear during the pressing operation, it being understood that the inner faces of these projections are positioned slightly removed from the blank so that the metal of the teeth may be pressed outwardly a little beyond normal and later removed, as hereinabove described. The spaces 63 between the projections 62 provide clearance for the outer ends of the space forming parts 54 of the die 53 as the die descends vertically to form the gear.

In addition to the pilot 61 extending from the upper die 53, the latter is provided with a presser plate 64 which has a series of bolts 65 forming a sliding connection between the die and the plate. Springs 66 surround the bolts 65 and tend to press the plate downwardly away from the die, this movement being limited by the heads of the bolts striking the shoulders 67 in the bores 68 in which the bolts operate. This presser plate 64 follows the pilot 61 in contacting with the blank during the descent of the ram and the springs hold the blank yieldingly in the depression 59 in position to be acted upon by the die 53. The plate, like the die 47, is formed at its edge with a series of projections 69 for supporting the inner ends of the teeth of the gear during the pressing operation, and the spaces 70 between the projections 69 provide for die clearance the same as spaces 63.

Means are provided for accurately locating or positioning the blank circumferentially before the upper die is brought down on the blank, as when the blank receives a roughing operation in one press or by one die and a second or finishing operation in a second press or by another die. After one die has started the formation of tooth spaces

in the blank it is necessary that the blank should be properly located under the second die so that the space forming parts of the second die will accurately enter the spaces already roughly formed in the blank. In the present invention this circumferential positioning is done by a locating lever 71 which may be pivoted as shown to the stationary die block 47 at 72. The head 73 of this lever has a groove in one of its operating faces and a tooth on the opposite face and in the form shown the groove 74 is in its upper face and is adapted to receive one of the teeth or space forming parts 54 of the die 53, and the tooth 75 is in its lower face and is adapted to engage in one of the spaces between the teeth of the roughed out blank.

The lever 71 is shown in full lines in Fig. 16 in inoperative position and in dotted lines in operative position for locating the blank in proper circumferential relation to the die 53. Fig. 17 shows the lever inoperative and Fig. 18 shows how it lines up the teeth and spaces of the die and blank respectively. In operation, the blank is roughly positioned by hand with the tooth 75 of the locating lever in one of the tooth spaces of the blank. The ram is then brought down slowly until one of the die teeth enters the groove 74 and thereby definitely and accurately locates the blank under the presser plate. Then the ram is raised sufficiently to permit the lever 71 to be removed and then brought down for the pressing operation.

The lever 71 may be manually operated by a pivotally connected hand lever 76 mounted on the die block 47 as by a link 77 and bracket 78. A spring 79 retracts the hand lever 76 and keeps the lever 71 normally in the inoperative position shown in full lines in Fig. 16.

More particularly referring to the machine shown in Fig. 15, it will be seen that it comprises a base 80 upon which is suitably mounted the rotating table 55 operated by a pair of gears 81, 82, and a belt and pulley 83. Standards 84, 85 and 86 adjustably support the three brackets 87 in which are respectively mounted the grinding wheels 56, 57, and 58, hereinabove referred to. The brackets 87 are manually adjustable vertically as by hand wheel 88 and screw and nut connection shown in dotted lines at 89. A frame 90 supports shafting 91 for driving the three grinding wheels as through belts 92 and gears shown in dotted lines at 93. Suitable belt tighteners 94 keep the belts tight as the grinding wheels are adjusted during the operation of the machine. Thus it will be seen that by a single operation the excess metal is removed from the tops and ends of the gear teeth and the gear given an accurate and clean finish.

It will be understood that the invention is

not limited to the specific gear, method and machine herein shown and described, but is capable of modification in various ways without departing from the scope of the claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:—

1. The method of making gears consisting of die pressing a blank to form teeth by displacing the metal with space forming die parts, and permitting unobstructed flow of excess metal beyond the normal tops of the teeth, and then removing such excess metal.
2. The method of making gears consisting of forming a blank with teeth of abnormal thickness, then die pressing to compress the sides of the teeth to the desired face contour and causing excess metal to flow beyond the normal tops of the teeth, and then removing such excess metal.
3. The method of making gears consisting of forming a blank with teeth of abnormal thickness, then die pressing to compress the sides of the teeth to the desired face contour, and causing excess metal to extend beyond the tops of the teeth, then removing such excess metal, and then case hardening the gear.
4. The method of making gears consisting

in forging the blank, then die pressing the blank to form teeth having the desired face contour with the excess metal pressed outwardly beyond the normal tops of the teeth, and then removing such excess metal.

5. The method of making gears consisting in forging the blank, then die pressing the blank to form teeth of abnormal thickness and of less height than required in the finished gear, then subjecting the blank to a second die pressing which compresses the sides of the teeth to the desired face contour while permitting the excess metal to flow beyond the normal ends and tops of the teeth, and then removing such excess metal.

6. The method of making gears consisting in die-pressing the blank to form teeth of abnormal thickness and of less height than required in the finished gear, then die-pressing to compress the sides of the teeth to the desired face contour while permitting the excess metal to flow beyond the normal tops of the teeth, and then removing the excess metal.

In testimony whereof I affix my signature in the presence of two witnesses.

FRANK F. BEALL.

Witnesses:

LE ROI J. WILLIAMS,
CLAIR J. COTE.