

Aug. 3, 1943.

W. A. TRYON

2,325,989

PRODUCTION OF GEARS OR THE LIKE

Filed July 22, 1940

2 Sheets-Sheet 1

Fig. 1.

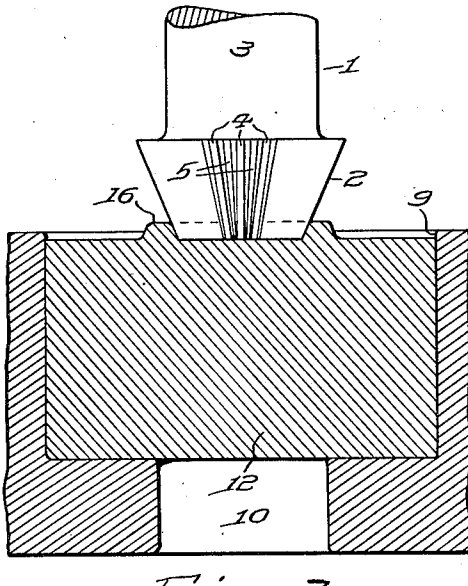


Fig. 2.

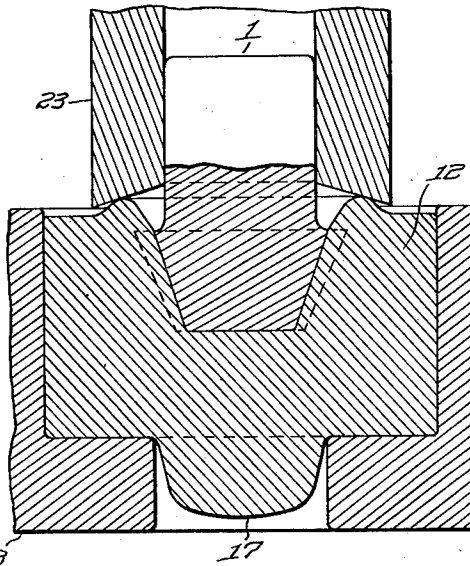


Fig. 3.

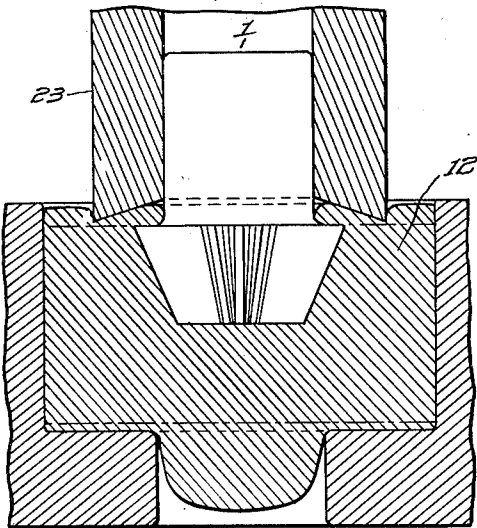


Fig. 4.

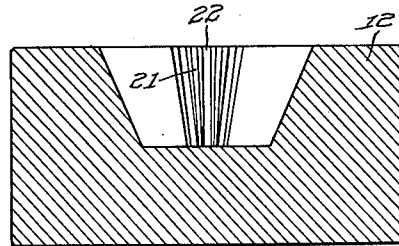
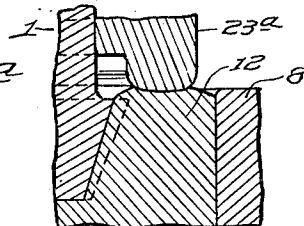


Fig. 3a



WITNESS

G. J. Hartman.

INVENTOR  
William A. Tryon.

BY *Genge K. Helms*  
ATTORNEY

Aug. 3, 1943.

W. A. TRYON

2,325,989

PRODUCTION OF GEARS OR THE LIKE

Filed July 22, 1940

2 Sheets-Sheet 2

Fig. 5.

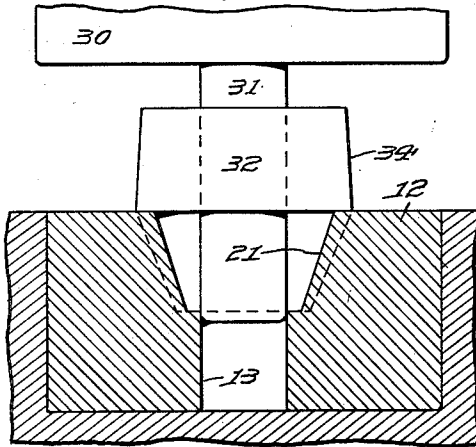


Fig. 6.

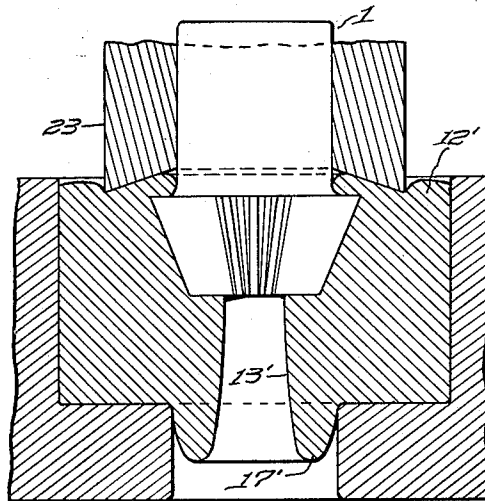


Fig. 7.

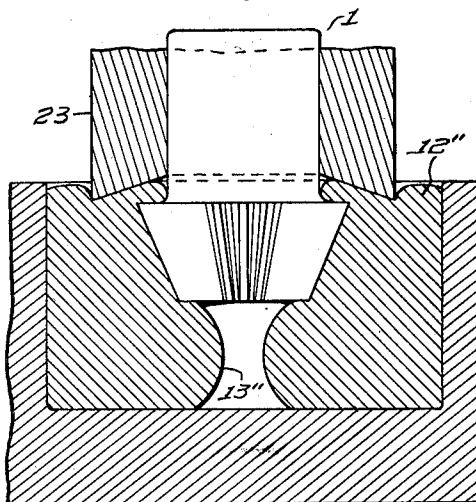


Fig. 8.

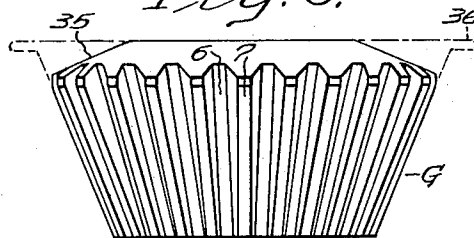


Fig. 9.

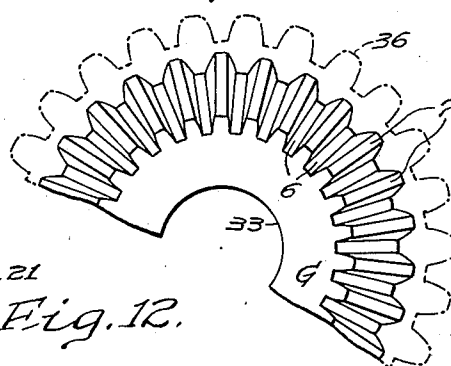


Fig. 10. Fig. 11.

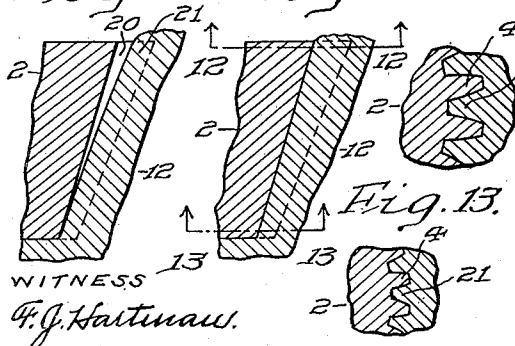
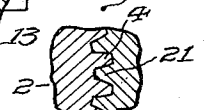


Fig. 12.

Fig. 13.



WITNESS  
G. J. Hartman.

INVENTOR  
William A. Tryon.  
BY *George K. Helber*  
ATTORNEY

## UNITED STATES PATENT OFFICE

2,325,989

## PRODUCTION OF GEARS OR THE LIKE

William A. Tryon, Geneva, N. Y., assignor to  
Trayer Products, Incorporated, Elmira, N. Y., a  
corporation of New York

Application July 22, 1940, Serial No. 346,796

10 Claims. (Cl. 76—107)

This invention relates to the manufacture of gears or the like on a low-cost production basis.

It has been suggested that bevel gears be made by pressing, forging or stamping them from metal blanks but attempts to do so commercially have been unsuccessful mainly because of the absence of practical and inexpensive methods of making suitable dies strong and accurate enough for forging ferrous and other metal gears comparable to those produced by individual machining.

My invention, however, provides a novel method of making gear-forging dies which does not require cutting or generating operations for each die that is made, and the dies, being integral, have considerably greater strength, especially in their teeth, than can be attained by composite assembled dies which have been proposed in an effort to solve the problem of low-cost production of accurate bevel gears by hot or cold forging.

It is consequently a principal object of this invention to provide a novel method of producing forging dies for bevel gears or the like with the requisite accuracy of conformation, dimensions and strength essential to commercial production of high-grade finished gears, thereby enabling the latter to be made in large numbers at moderate cost.

Another object is the provision of a novel gear forging die and a method of making such a die with a die cavity containing the accurate complement of the tooth contours of the desired gear, said method comprising a novel series of operations which facilitates the manufacture of a plurality of identical dies at relatively small expense whereby substantially unlimited quantities of the gears may be cheaply and rapidly produced with a degree of accuracy comparing favorably with and sometimes exceeding that attained by the laborious and expensive methods of gear production heretofore in vogue.

Other objects, purposes and advantages of the invention will be understood from the following description of its practice in the manufacture of a bevel gear or pinion of a usual type, reference being had to the accompanying somewhat diagrammatic drawings illustrating in

Fig. 1 the initiation of a preliminary step in the production of the forging die ultimately utilized in making the gear, the die blank and holder therefor being shown in fragmentary vertical section and the die forming tool or punch in diagrammatic side elevation;

Figs. 2 and 3 are generally similar views illus-

trating further steps in the formation of the die;

Fig. 3<sup>a</sup> is a fragmentary detail corresponding to a part of Fig. 3 but illustrating a modification in the practice of the invention;

Fig. 4 is a diagrammatic vertical section of the finished die;

Fig. 5 is a composite fragmentary side elevation, partly in vertical section, illustrating the manner in which the die is used in a press for making a gear from a blank;

Fig. 6 is a view generally corresponding to Fig. 3 which illustrates a different modification in the practice of the invention;

Fig. 7 is a similar illustration of another modification in the said practice;

Fig. 8 is an enlarged side elevation of a gear made in accordance with the practice partially illustrated in Fig. 5, with metal which is removed from the formed blank in finishing the gear indicated in broken lines;

Fig. 9 is a fragmentary face view of the same;

Fig. 10 is an enlarged detail showing the relation of a punch tooth space and adjacent die metal after completion of the operation illustrated in Fig. 2;

Fig. 11 is a similarly enlarged detail after completion of the operations illustrated in any of Figs. 3, 3<sup>a</sup>, 6 and 7, and

Figs. 12 and 13 are fragmentary sections on the lines 12—12 and 13—13 respectively in Fig. 11.

In the several figures like characters are used to designate the same parts.

Referring first generally to the practice of my method, it will be understood that it is not limited to the production of dies for bevel gears of any specific character or type and the gear or pinion and apparatus utilized in forming it, shown in the drawings and hereinafter more fully described, are thus mere arbitrary selections to facilitate a disclosure of the invention and explanation of its principles so as to enable them to be employed in the manufacture of any desired type or kind of bevel gear or the like.

It has heretofore been deemed impracticable, except perhaps by extremely laborious hand work, to produce an accurate integral die containing a die cavity defined in part by closely spaced projections larger in cross-section adjacent the outer end of the cavity than nearer its bottom as required by a bevel gear forging die, since milling and other available machines cannot be employed to form the intervening grooves or spaces necessary to produce such projections within a cavity. My invention is thus directed

broadly to a novel method whereby a die of this character may be manufactured by forging or analogous operations.

Referring now more specifically to the drawings, my invention contemplates the initial production of a master die or punch 1 preferably having a generally conical head 2 and a somewhat smaller diameter shank 3, the head comprising peripheral teeth 4 conforming in shape to but somewhat longer than those of the gear to be produced.

That is, the punch 1, as shown in Fig. 1 has teeth 4 alternating with tooth spaces 5 formed about its head, the general conformation of these teeth and spaces being substantially identical with those of the desired gear G (Figs. 8 and 9). These teeth are formed in the punch with the aid of an ordinary gear cutting machine or in any other way, but for reasons which will hereinafter appear the spaces 5 are made slightly deeper than spaces 6 between the teeth 7 of the gear G and the axial length of the teeth 4 is made to correspond to the axial thickness of the gear rather than to the axial length of its teeth 7. While for convenience only a few of the punch teeth 4 are shown in the drawings, it will be understood they actually extend entirely around the punch head, and that the punch is desirably suitably hardened and ground after the teeth have been formed in it; after grinding it is ready for use as hereinafter more fully explained.

The punch is used in association with a blank holder or anvil 8 formed of a relatively heavy block of metal having in one face a preferably cylindrical cavity 9 from the center of which a considerably smaller axial bore 10 is preferably extended through the bottom of the holder. In some instances the bore 10 may be omitted but I have found that best results are usually attained when the bore is employed.

A gear forging die is produced with the aid of the punch 1 and holder 8 just described, from a die blank preferably made of a suitable alloy steel and snugly fitting in the cavity 9 in the holder after the blank is heated to forging temperature, usually about 2000° F. and inserted therein. The axial length of the blank should not be greater and is desirably somewhat less than the depth of the cavity 9 so that the top surface of the blank when in the anvil lies either flush with or below the upper face of the latter. When the anvil embodies the bore 10 to which reference has been made, a solid die blank 12 may be used as shown in Fig. 1 or else a blank 12' having an axial bore 13' preferably of somewhat less diameter than bore 10 (Fig. 6) but if bore 10 be omitted from the holder, the blank 12' should then be provided with an axial bore 13'' (Fig. 7) of, preferably, somewhat greater diameter than the bore 13'. Under most conditions, however, I prefer to use the solid blank 12 and an anvil having a bore 10, and also to form on the upper surface of the blank an upstanding annular ridge or flange 16 having upwardly converging sides and a more or less flat top. The greatest inner diameter of this flange may appreciably exceed the minimum diameter of the head of the punch so the latter can readily enter it, but if it is desired to use the flange to facilitate centering the punch, it may form the boundary of a depression adapted to receive the end of the punch in a fairly snug fit. Insofar as the actual production of the die cavity in the blank is concerned, the presence or absence of

the flange is otherwise substantially immaterial but for reasons which will hereinafter appear I prefer to utilize it.

The blank 12, after being heated to forging temperature, is seated in anvil 8 and punch 1, preliminarily heated to about 400° F.-500° F., is centered above the blank, either with or without the aid of flange 16 and by means of an air hammer or other pressure applying device is forced into the heated metal as rapidly as possible so as to sink its head fully therein before the blank has appreciably cooled. As the punch enters and is progressively embedded in the blank some of the metal which it displaces apparently flows generally upward relatively to the punch through the lower ends of its tooth spaces 5 as indicated in Fig. 10, but not enough metal follows this course or enters the tooth spaces in a generally lateral direction to completely fill them; as is apparent from Figs. 11-13 the cross-sectional area of these spaces is less adjacent the end of the punch than remote therefrom and this may account, at least in part, for the failure of the metal to fill the spaces during this operation. The metal of the blank is also forced downwardly into bore 10 in the anvil to form a sprue 17 therein, or if the anvil is devoid of any such bore and the bored blank 12' (Fig. 7) is employed, it bulges inwardly into its central bore 13'', while if the bore 13' and bore 10 both be present (Fig. 6) some bulging of the blank 12' occurs in the former and a smaller sprue 17 tends to form in the latter. Little or no metal, however, normally flows upwardly in the vicinity of flange 16 although under some conditions there may be a small flow tending to round it out and crowd it outwardly upon itself to some extent, depending upon the relation of its inner diameter to the maximum diameter of the punch and other variables.

As has been stated, the metal entering the tooth spaces 5, which are of increasing cross-sectional area from their lower to their upper ends, does not entirely fill them during the progress of the punch into the blank with the result that if the punch were now merely withdrawn from the latter the impression left by it therein would not present an accurate complement of its teeth 4 and tooth spaces 5 and consequently could not be used to produce a gear corresponding thereto. Thus Fig. 10 suggests one formation which is sometimes produced with resulting tapered clearance 20 between each projection 21 in the die blank and the bottom of the adjacent tooth space 5 in the punch, but the shape and size of this clearance may change in accordance with operating conditions such as rapidity of action of the hammer, temperature of the blank, shape of the tooth spaces and the like, and the illustration (Fig. 10) is therefore not to be considered as necessarily representing its exact or invariable character.

However, in accordance with the invention the tooth spaces are filled with the metal of the blank by a subsequent operation now to be described which is designed not only to accomplish this result and thereby eliminate the clearance 20 irrespective of its shape and/or size, but, preferably, to cause in addition some of the metal to flow inwardly over the head of the punch and lock the latter within the blank since absolute concentricity between the die cavity and the perimeter of the die or blank, parallelism between its upper and lower faces and their location in planes normal to the axis of the die cav-

ity is ultimately more readily attained when the punch is first locked in the blank in this way.

More specifically, to this end I provide a hollow cylindrical collar 23 of inner diameter slightly greater than that of the shank of the punch and of outer diameter somewhat smaller than that of the anvil cavity, the collar being of such length that it will project above the upper end of the punch when positioned thereover with its lower end resting on the blank in the anvil. If the blank embodies the flange 16 or some substantial counterpart thereof, the lower end of the collar 23 is preferably beveled upwardly and inwardly as shown in Fig. 3 but if the die blank does not embody the flange, then the lower end of the collar may be counterbored to a size a little larger than the punch head and its edge slightly convexly rounded as in collar 23<sup>a</sup> shown in Fig. 3<sup>a</sup> or even may partake of other forms.

While the blank is still substantially at forging temperature after the punch has been forced into it, the collar is slipped over the projecting end of the punch and by means of the hammer or other pressure applying means is forced against the blank which operation causes a further flow of the metal effective to fill the tooth spaces 5 in the punch and also, especially when the flange 16 is provided, to drive some of the metal inwardly over the surface of the punch head substantially as shown in Fig. 3, the conformation of the collar with relation to the particular blank employed being such as to attain, primarily, the first of these results and preferably the second as well.

The collar may now be withdrawn and the die blank allowed to cool gradually either in the anvil or after removal therefrom, but whether locked in the blank by the inward flow of metal as just described or whether capable of immediate withdrawal from the blank, the punch is preferably kept in the die cavity until the blank has cooled at least to below scaling temperature thereby preventing access of air to the cavity until all danger of production of scale on the cavity surface has been eliminated as well as preventing material shrinkage and consequent deformation of the metal defining the cavity. After the blank has cooled to below scaling temperature, normally about 1000° F., the punch can safely be removed, either by simply pulling it out of the blank if it is not locked in place therein or by machining the blank preferably in the manner now to be described.

Since the punch shank 3 is coaxial with the punch head and thus with the cavity formed in the blank thereby, if the punch is rigidly locked to the blank the shank may be centered in a lathe chuck and a cut taken across the peripheral surface of the blank so as to true it up and/or bring it to a desired diameter. A transverse cut is then taken across the bottom of the blank to insure its being normal to the axis of the latter and a final cut taken across the top of the blank substantially coincident with the larger end of the punch head so as to remove the excess metal from the top of the blank and free the punch from its locked engagement therewith. These several cuts can be taken while the blank is supported on the punch and the shank of the latter centered in the chuck or, after the first two cuts have been taken and the periphery of the blank thus made exactly coaxial with the punch and cavity, the blank and punch while still locked together may be removed from the chuck, turned

end for end and the blank then centered in the chuck to facilitate the taking of the last transverse cut designed to free the punch as well as a subsequent transverse cut if required to reduce the cavity to proper depth. The bore 13', or 13'', if one is provided, is constricted during the die-forming operation, and it is also machined or bored out to a diameter substantially corresponding to that of the shaft or spindle bore of the gear G or a like bore is now fully formed in the die if a solid die blank has been used.

Of course if the action of the collar 23, or, more particularly, that of the collar 23<sup>a</sup> is not effective to cause the metal to flow over the head of the punch and lock it in place as hitherto described, the punch can be simply pulled out of the cavity after the die has cooled to the proper temperature and the necessary machine work on the blank then performed in the absence of the punch. It will be apparent, however, that this machining and the attainment of the desired accuracy and concentricity is considerably facilitated when the punch and blank are handled as a unit as above described.

As has been stated, the tooth spaces 5 in the punch are made somewhat deeper than the tooth spaces in the gear G, with the result that projections 21 in the die cavity produced by the metal forced into these spaces extend into the cavity farther than if the said projections were the exact complement of the tooth spaces 6 on the gear. This is desirable because, as has been found in practice, due to surface tension, entrapping of air between the inflowing metal and the punch surfaces, shrinkage of the metal on cooling or some other reason or reasons I am unable to positively explain it is apparently impossible to form projections 21 in the die cavity having sharp as distinguished from slightly rounded edges even when the tooth spaces 5 in the punch have sharp inner corners. Moreover, entrapped air in these spaces may cause some slight scaling at the tops of the projections 21, and the provision of surplus metal at these points enables them to be machined off and thereby reduced to exact conformity with the complement of the tooth spaces of the gear G. This operation, which of course cannot be performed until the punch has been removed from the die cavity, is preferably deferred until all other machining of the die blank has been completed, or at least until a surface has been formed thereon enabling accurate centering of the blank to be readily accomplished after removal of the punch from the die cavity.

As a result of leaving the punch in the die cavity while the blank is cooling to below scaling temperature, thereby maintaining the punch in intimate contact with the side surfaces of the projections 21 and the bottoms of the tooth spaces 22 in the die blank with consequent prevention of oxidation of the latter while highly heated, these surfaces possess a substantial polish and require no finishing whatever so that after the requisite machining has been completed, the blank is ready for hardening to prepare it for use as a forging die for making gears.

For this purpose the die is mounted in a coining or other press having a movable head 30 comprising a depending stud 31 with which the hole 13 in the die is aligned and which preferably substantially corresponds in diameter to the shaft or spindle with which the gear is to be used, so it can enter the hole 13 when the head 30 is brought toward the upper face of the die,

An annular gear blank 32, having a similar hole 33 in its center, and preferably having its outer annular peripheral surface 34 slightly tapered, is utilized for making the gear and is therefore made from steel or other metal of the desired analysis and I have found that where a strong, smooth and noiseless running gear is required, the blanks may advantageously be made of the steel known in the trade as "rim stock." The blanks can be produced from plate or strip stock by stamping with dies of appropriate form and I have found that this operation usually produces a suitable taper in the surface 34 but the source of the blank is unimportant provided it be an annular body of the desired metal, preferably tapered as aforesaid, and that its largest diameter substantially corresponds to the maximum diameter of the die cavity.

When such a blank is positioned on the die over its cavity, preferably with its larger face engaging the die, and the press head brought down on it, the stud 31 first enters the hole 33 in the blank, and then the hole 13 in the die, while the face of the press head forces the blank into the die cavity, forming in the blank gear teeth 7 and tooth spaces 6 of exactly the same conformation as those initially formed on the punch and entirely filling the die cavity around the stud 31 with the metal of the blank. The stud 31 accurately centers and sizes the shaft hole 33 in the blank and burnishes its surface, the pressure against the blank, and the metal flow induced thereby also producing similarly highly burnished and accurate working faces on the gear teeth 7 in the blank. The tooth spaces 22 in the die cavity may not be filled all the way to the top by the blank, but as the latter, after being formed on the press has to be machined to produce the back angle 35, as well as to remove any slight peripheral fins 36 that may form at its outer edge, this is unimportant so long as the spaces 22 of the die are filled to the full axial length required for the finished teeth. Consequently, after the forging or pressing operation, which may under some conditions require preliminary heating of the blank, and/or two or more forging impressions, depending usually upon the extent of metal displacement it entails and the kind of metal comprised in the blank, the latter is removed from the press and its back angle 35 formed by any suitable machining operation. If desired, a keyway, thread or the like now may be cut in its central hole 33 or the latter given some special conformation and the formed blank is then ready for hardening, or for immediate use as a finished gear if hardening is not required.

While my invention may perhaps most advantageously be utilized for making straight tooth bevel gears or pinions as described, helical or spiral bevel gears and pinions can be produced in accordance therewith in a generally similar way, if provision be made for effecting relative rotation between the punch and die while the latter is being formed and between the die and the gear blank during the making of a gear.

When putting a new die into use I preferably initially coin in it a few blanks of the normal size and shape but made of lead, as this tends to impart an additional polish to the surfaces of the die cavity and, perhaps because of adherence thereto of lead molecules or microscopic particles of lead, also apparently has a substantial lubricating effect during subsequent forging of actual gear blanks. For like reasons I usually

similarly coin a few lead blanks after each group of several hundred or more regular gear blanks has been made, as this practice substantially perpetuates the desirable conditions as to polish and lubrication initially produced by coining lead blanks in the die and tends to prolong the useful life of the latter.

It will thus be evident that the method and apparatus of my invention enable relatively inexpensive gear manufacture on a production basis and permit gears to be made much more rapidly than heretofore. Thus one coining press I have utilized in this way for making bevel gears about 2½" in outer diameter from rim steel blanks is capable of forming some 500 of them per hour when equipped with automatic blank feeding and discharge mechanism, and the blanks, after being formed by the press, only require machining of the desired back angle and hole conformation to finish them before hardening, while the quality of the gears so produced is equal to that of the highest grade gears made by the methods commonly employed.

While I have herein described the practice of the invention with considerable particularity, especially as it relates to the manufacture of a tapered gear or pinion of a specific form, it is to be understood the invention is equally adapted for the production of gears of different character as well as other articles, and that changes and modifications in its practice and in the character of apparatus utilized therefor will readily occur to those skilled in the art and may be made if desired without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim and desire to protect by Letters Patent of the United States:

1. A method of making a female forming die having a plurality of projections in its cavity of larger sectional area adjacent their outer than adjacent their inner ends, which comprises the steps of forming a male punch having in its surface indented spaces substantially corresponding to the complement of the projections to be formed in the die and having their side walls converging angularly toward the end of the punch, forcing the punch into a heated die blank to thereby partially fill said spaces with the metal of the blank and then positioning a collar about the punch and applying pressure therethrough to the adjacent surface of the blank in a direction parallel to the axis of the punch to thereby substantially fill said spaces with said metal.

2. A method of making a female forming die having a plurality of projections in its cavity of larger sectional area adjacent their outer than adjacent their inner ends, which comprises the steps of forming a male punch having in its surface indented spaces substantially corresponding to the complement of the projections to be formed in the die and having their side walls converging angularly toward the end of the punch, forcing the punch into a heated die blank to thereby partially fill said spaces with the metal of the blank, then positioning a collar about the punch and forcing it axially thereof to apply pressure to the surface of the blank about the perimeter of the punch to thereby substantially fill said spaces with said metal, and then cooling the blank to a temperature below scaling temperature of the metal of which it is formed before removing the punch.

3. In a method of making a gear forming die,

the steps of positioning a heated die blank in a holder having a cavity substantially conforming to the periphery of the blank, then while the blank is hot forcing thereinto a punch having indented spaces disposed in radial planes angularly to and tapering inwardly toward its axis with their side walls converging toward the end of the punch, and then, while the punch is disposed in the resultant cavity in the blank, forcing a substantially annular collar onto the blank adjacent the perimeter of the punch to thereby substantially fill said spaces with the heated metal.

4. In a method of making a gear forming die, the steps of positioning a heated die blank in a holder having a cavity substantially conforming to the periphery of the blank, then while the blank is hot forcing thereinto a punch having indented spaces disposed in radial planes angularly to and tapering inwardly toward its axis and each having a cross-sectional area smaller adjacent the end of the punch than remote therefrom, then, while the punch is disposed in the resultant cavity in the blank, forcing a substantially annular collar onto the blank adjacent the perimeter of the punch to thereby substantially fill said spaces with the heated metal, and finally cooling the blank to below 1000° F. before removing the punch.

5. The method of making a bevel gear forming die which comprises the steps of forcing into one face of a metal die blank heated to above scaling temperature a punch having teeth and interposed tooth spaces tapered toward the leading end of the punch and substantially conforming to the bevel gear to be produced, applying a collar against said face of the blank proximate the perimeter of the punch and moving it axially with respect thereto while the blank is still hot to force the metal of the blank into the tooth spaces of the punch and fill said spaces therewith, then cooling the blank to below scaling temperature and removing the punch and collar therefrom.

6. The method of making a gear forming die which comprises the steps of forcing into one face of a heated metal die blank a punch having a plurality of alternating teeth and tooth spaces respectively substantially conforming to but of greater depth than the teeth and tooth spaces of the gear to be formed, then while the blank is still hot applying pressure to the metal of the blank adjacent the punch to thereby substantially fill the tooth spaces therein, removing the punch from the blank and finally removing sufficient metal from the projections in the blank corresponding to the tooth spaces in the punch to reduce them to a depth precisely complementary to that of the tooth spaces of said gear.

7. The method of making a gear forming die which comprises the steps of forcing into one

face of a heated metal die blank a punch having a plurality of alternating teeth and tooth spaces respectively substantially conforming to but of greater depth than the teeth and tooth spaces of the gear to be formed, then while the blank is still hot applying pressure to the metal of the blank adjacent the punch to thereby substantially fill the tooth spaces therein and cause some of the metal to overlie a portion of the punch, cooling the blank, and then machining an exterior surface of the blank while utilizing the punch as a support therefor.

8. The method of making a gear forming die which comprises the steps of forcing into one face of a heated metal die blank a punch having a plurality of alternating teeth and tooth spaces respectively substantially conforming to but of greater depth than the teeth and tooth spaces of the gear to be formed, then while the blank is still hot applying pressure to the metal of the blank adjacent the punch to thereby substantially fill the tooth spaces therein and cause some of the metal to overlie a portion of the punch, cooling the blank, supporting the blank from the punch and while so supported machining an exterior surface of the blank, freeing the punch from the blank and finally removing sufficient metal from the projections formed therein corresponding to the tooth spaces of the punch to reduce them to a depth complementary to that of the tooth spaces of said gear.

9. A method of making a female forming die having a plurality of projections in its cavity of larger sectional area adjacent their outer than adjacent their inner ends, which comprises the steps of forming a male punch having in its surface indented spaces substantially corresponding to the complement of the projections to be formed in the die with their side walls converging toward the end of the punch, forcing the punch into a heated die blank to thereby partially fill said spaces with the metal of the blank and then applying pressure to the surface of the blank about the perimeter of the punch and in a direction generally parallel to its axis to thereby substantially fill said spaces with said metal.

10. In a method of making a gear forming die, the steps of positioning a heated die blank in a holder having a cavity substantially conforming to the periphery of the blank, then while the blank is hot forcing thereinto a punch having indented spaces disposed in radial planes and tapering inwardly toward its axis with their side walls converging toward the leading end of the punch, and then, while the punch is disposed in the resultant cavity in the blank, applying pressure to the blank adjacent the perimeter of the punch to thereby substantially fill said spaces with the heated metal.

WILLIAM A. TRYON.