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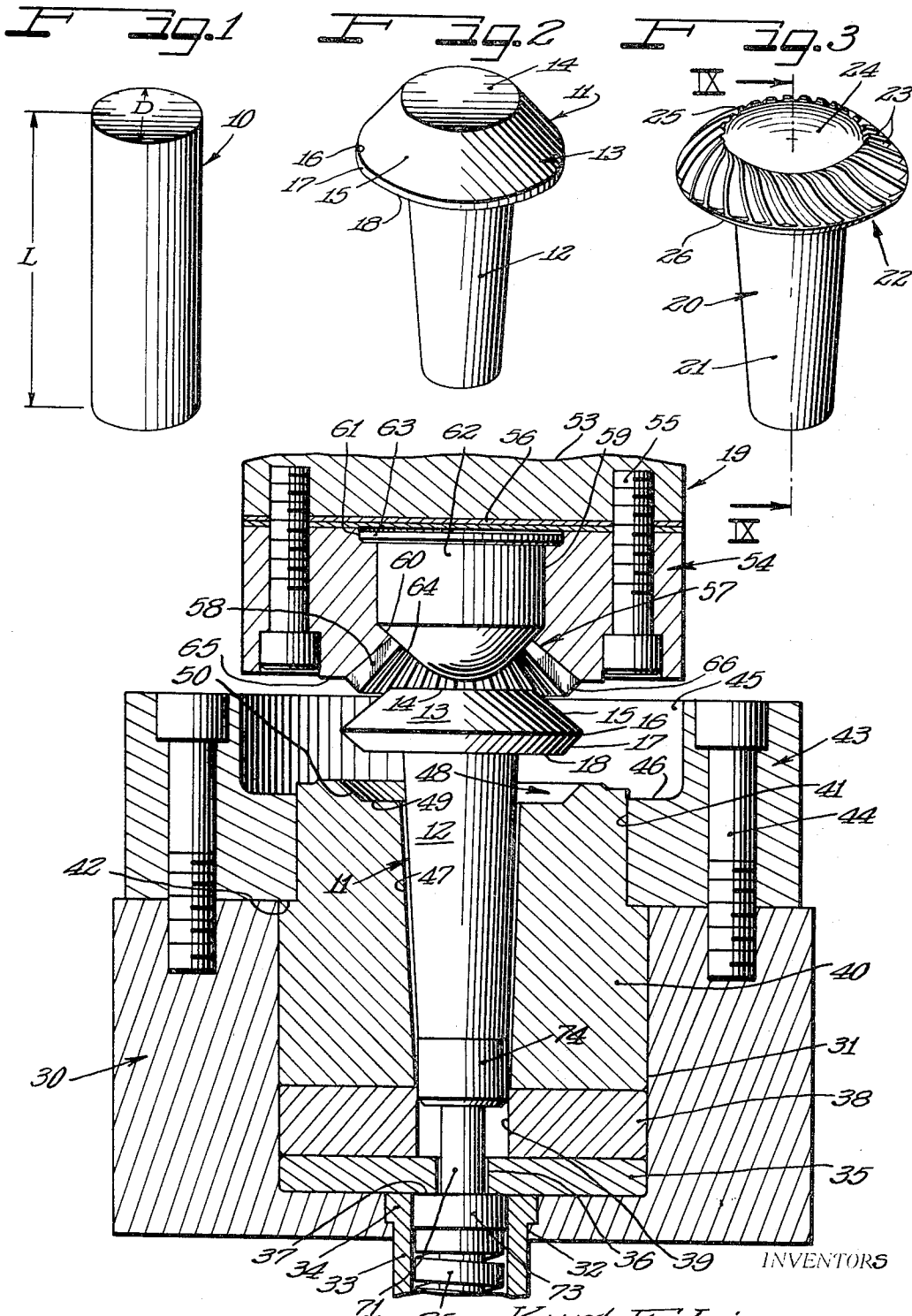
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3,429,172

METHOD OF MAKING GEAR FORGING APPARATUS

Filed Oct. 5, 1965

Sheet 1 of 4



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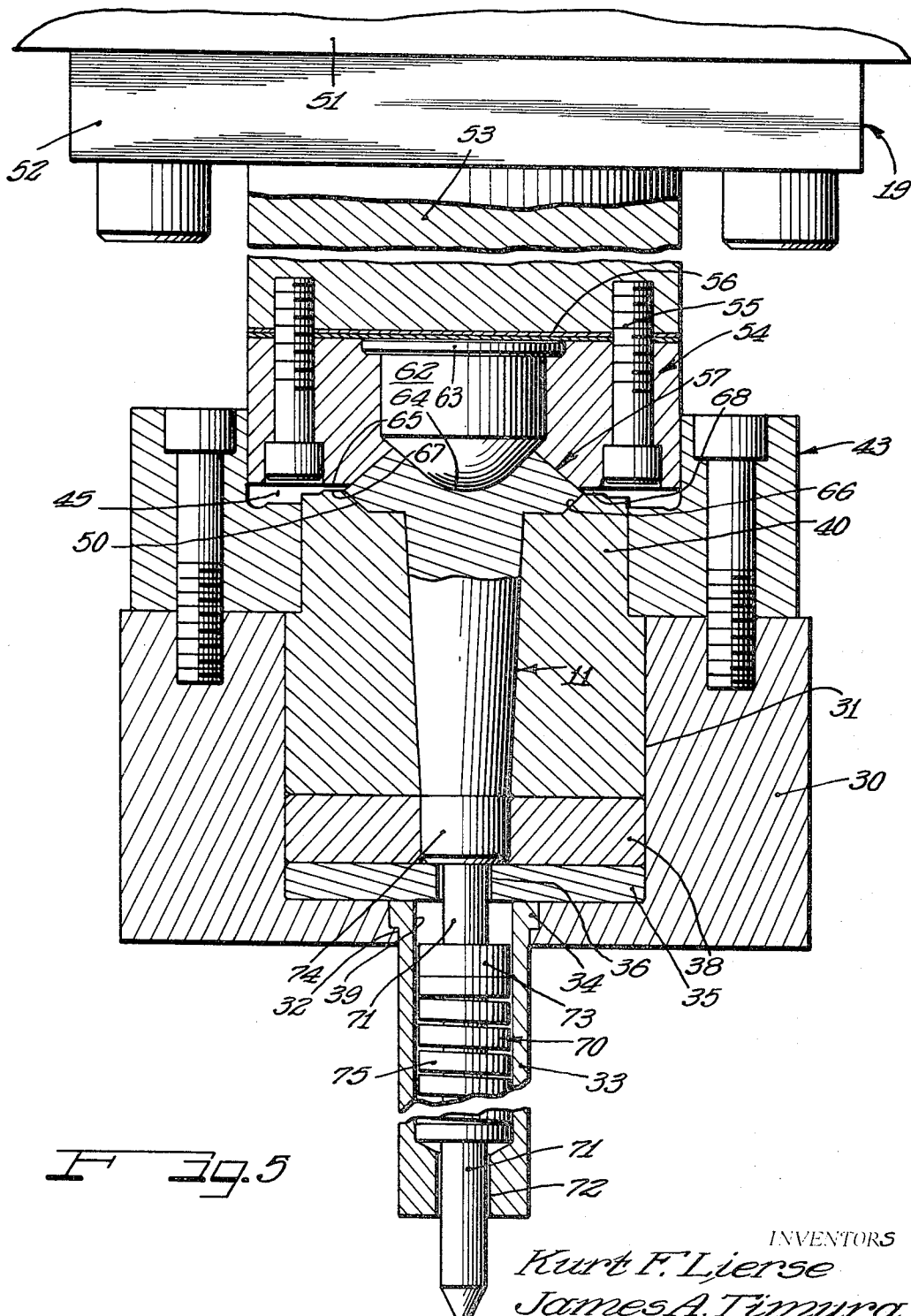


FIG. 39.5

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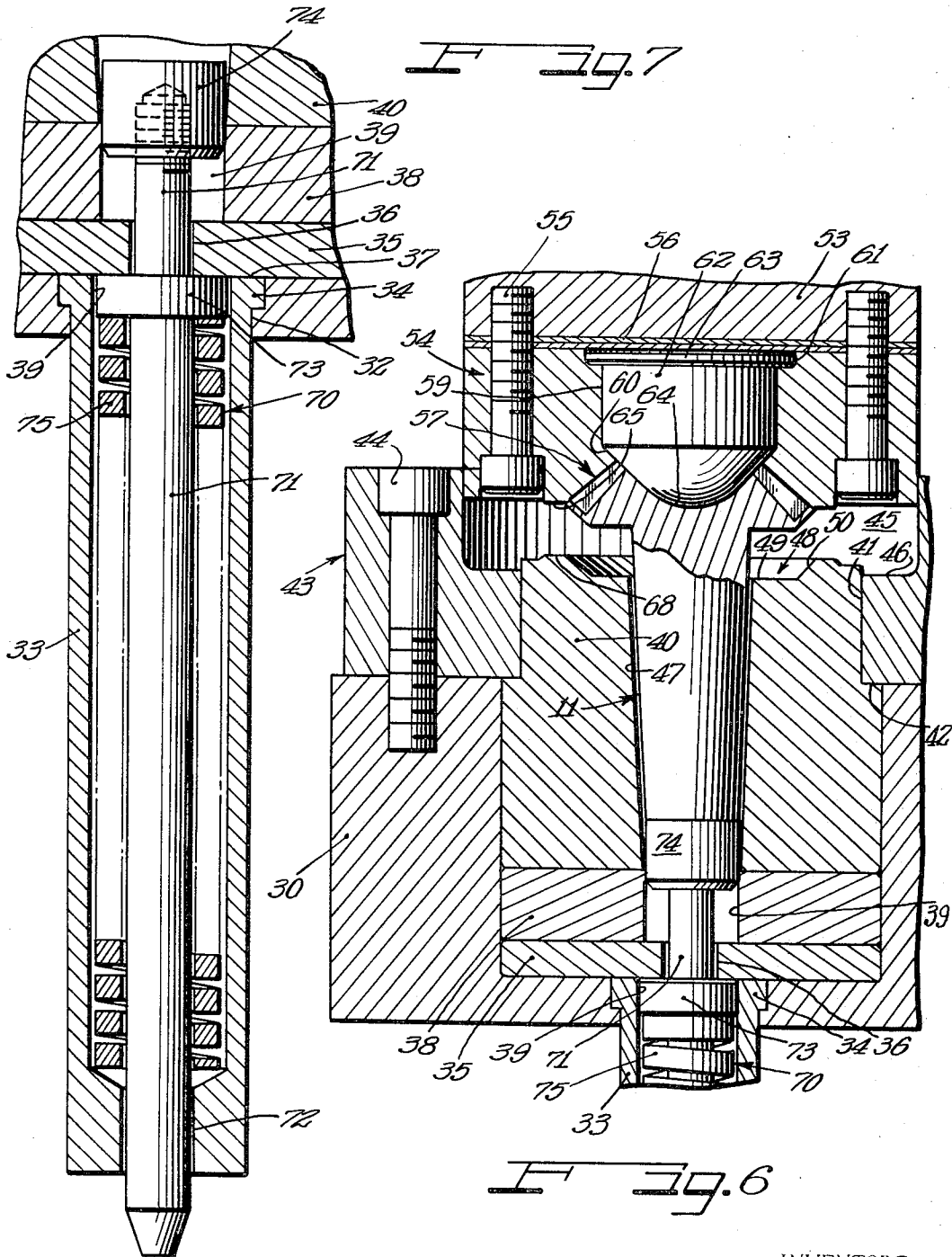
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Sheet 3 of 4



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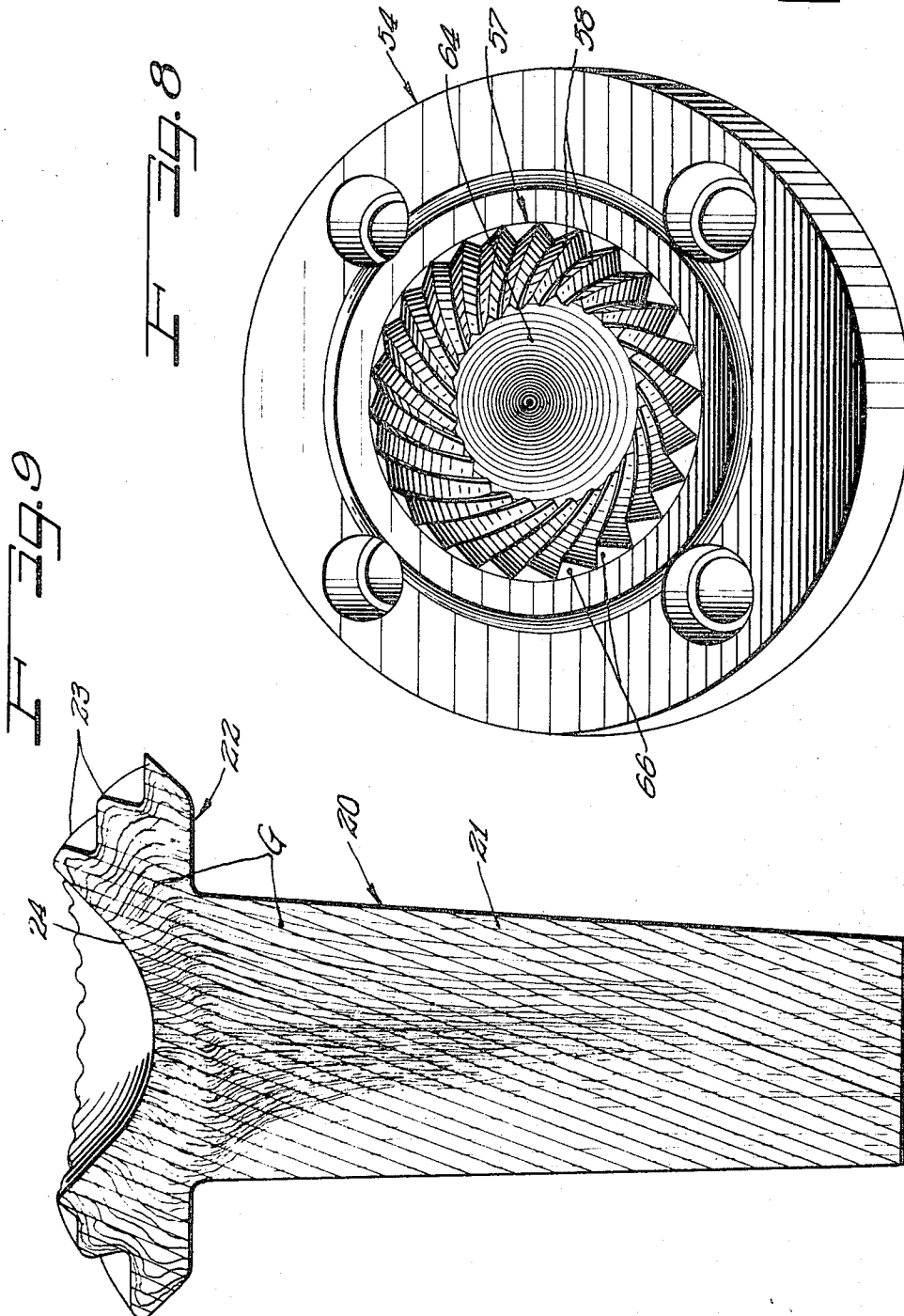
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Sheet 4 of 4



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3,429,172

## METHOD OF MAKING GEAR FORGING APPARATUS

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8 Claims

Int. Cl. B21d 22/02, 45/00

### ABSTRACT OF THE DISCLOSURE

This invention relates to die forging apparatus which causes the forged article to follow the punch until the article is released from the die, thereby preventing damage to the punch formed portion of the article. Specifically, this invention relates to spiral gear forging apparatus which releases the gear from the die before the gear is released from the punch, thereby protecting the spiral gear teeth. The invention includes the method of making forged articles to protect punch formed portions of the articles.

The invention will be hereinafter described as embodied in a single impact die forging apparatus for making beveled gears with spiral teeth, but it should be understood that the principles of this invention are generally applicable to die forging and, therefore, the invention is not limited to the specifically described and illustrated embodiment.

According to this invention, beveled gears with spiral teeth and integral shaft or hub portions are formed from cylindrical metal rods which are initially upset on one end thereof to provide an enlarged frusto-conical head approximating the size and shape of the gear to be formed therefrom. The head has a flat end face acted on by the nose of a punch which is surrounded by a punch die having a tapered recess formed with a ring of spiral teeth to create the tooth cavities to form the gear teeth. This punch cavity conforms generally in contour with the head of the blank so as to rather snugly receive this head. The stem or shank of the blank fits into a fixed die cavity having a recess for receiving the large end of the head of the blank. When the punch is moved toward the die, the nose thereof engages the end wall of the head of the blank to move metal generally radially into the tooth forming cavities of the surrounding punch die while at the same time bottoming the blank into full conformity with the stationary die. The apparatus is equipped with a spring loaded support platform for the blank in the fixed die so that when the punch is retracted, after the forging operation has been completed, the spring load on the forged gear will cause the gear to retract with the punch until the gear is free of the fixed die. Further retraction of the punch from the die will then permit the gear to be "unthreaded" from the punch. Normally, contraction of the metal on cooling, as the die is opened, will be sufficient to release the gear from the punch so that the gear will drop away from the punch. However, if the gear continues to adhere to the punch, it may easily be "unthreaded" therefrom by the die operator. The spring loaded platform automatically ejects the gear from the die as the punch is retracted from the die, but the spring load is arrested or is not sufficient to hold the die against the punch during the final stages of the opening of the apparatus.

It is, then, an object of this invention to provide die forging apparatus which causes the forged work piece to follow the punch of the apparatus until such time as the

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work piece is freed from the die and can be released from the punch without damage.

A further object of this invention is to provide die forging apparatus specially adapted for making bevel gears with spiral teeth wherein the gear teeth are protected against damage by a spring loaded platform in the die.

Another object of this invention is to provide gear forging apparatus which causes the forged gear to automatically follow the punch until such time as it can be released without damage to the gear teeth formed by the punch.

Another object of the invention is to provide a method of making forged gears with spiral teeth wherein the tooth forming mechanism is kept in full engagement with the forged gear until such time as the gear can be released without damaging the teeth.

A still further object of this invention is to provide a method of making forged gears with spiral teeth wherein the teeth are protected against damage such as normally occurs in the release of the forging from the apparatus.

Other and further objects of this invention will be apparent to those skilled in this art from the following detailed description of the annexed sheets of drawings which, by way of a preferred example, illustrate one embodiment of the invention.

On the drawings:

FIGURE 1 is an isometric elevational view of a slug from which the gears of this invention are made;

FIGURE 2 is an isometric view of a headed blank formed from the slug of FIGURE 1;

FIGURE 3 is an isometric view of a finished bevel gear with spiral teeth formed from the blank of FIGURE 2 according to this invention;

FIGURE 4 is a fragmental cross-sectional view with parts in elevation of the forging apparatus of this invention illustrating the apparatus in open position and the blank of FIGURE 2 as seated in the die of the apparatus;

FIGURE 5 is a view similar to FIGURE 4, but showing the apparatus in closed position;

FIGURE 6 is a view similar to FIGURE 5, but illustrating the manner in which the forged gear follows the punch during the initial stages of opening of the apparatus;

FIGURE 7 is a cross-sectional view, with parts in elevation, of the automatic ejection mechanism of the apparatus of this invention;

FIGURE 8 is an isometric view of the punch illustrating the spiral tooth forming recesses surrounding the nose of the punch; and

FIGURE 9 is a cross-sectional view of the finished gear taken generally along the line IX-IX of FIGURE 3, and illustrating the grain flow lines developed in the metal by the forging operation.

As shown on the drawings:

In FIGURE 1, the reference numeral 10 designates generally a length of metal bar stock or rod of cylindrical shape preferably having a good polished finish and composed of a carburizing grade of steel such as AISI 9310. The diameter D of the rod 10 is substantially less than the diameter of the gear to be formed therefrom and the length L of the rod is substantially greater than the length of the finished gear and stem to be formed therefrom.

The rod 10 is heated rapidly, preferably in an inert atmosphere or by induction heating to forging temperatures around 1800° F. The rod is then upset on one end thereof to form the blank 11 of FIG. 2. This blank has a slightly tapered stem portion 12 and an enlarged frusto-

conical head 13. The stem 12 increases in diameter from the end thereof toward the head 13. The head 13 has a flat end face 14 and a tapered side 15 diverging from this face 14 to a maximum circular periphery 16. From this periphery 16, the head is beveled inwardly at 17 to a flat radial shoulder 18, better shown in FIGURE 4.

The blank 11 of FIGURE 2, while still heated at the forging temperatures, around 1800° F., is then die forged in a single stroke by the apparatus 19 of this invention, shown in FIGURES 4-6, to form the finished gear 20 shown in FIGURE 3. This gear 20 has a tapered stem 21 of more accurate dimensions than the starting stem 12 and a beveled gear head 22 with spiral teeth 23 therearound surrounding a depressed end face 24. The teeth 23 follow a helical path from the periphery 25 of the end face 24 to a circular base 26. The peripheries 25 and 26 conform generally with the periphery of the end face 14 and the circular periphery 16 of the blank 11.

After the gear 20 is die forged by the apparatus 19 of this invention, it is air cooled, heated to temperatures of about 1550° F. for about one hour in an inert atmosphere, oil quenched, and tempered at 1100° F. for about two hours followed by air cooling.

The apparatus 19 for forming the gear 20, as shown in FIGURES 4-6, includes a fixed bed or base 30 with a die well 31 having a counterbored opening 32 through the bottom thereof which receives a tube 33 having a flanged end 34 seated in the counterbore. A spacer pad 35 is bottomed in the well 31 and overlies the flanged end of the tube 33, but has a hole 36 aligned with the center of the tube. The pad 35 provides an end shoulder 37 for the interior of the tube. A second spacer 38 rests on the spacer pad 35 and has an aperture 39 therethrough of larger diameter than the hole 36. A die 40 rests on the spacer 38 and has a reduced diameter top end portion 41 projecting above the top of the bed 30. A radial shoulder 42 is substantially flush with the top surface of the bed and a clamping ring 43 surrounds this portion 41 and overlies the shoulder 42 to secure the die 40 to the bed. Cap screws 44 extend through the ring 43 and are threaded into the bed 30 to tighten the ring on the bed. The ring 43 has an open top cylindrical well 45 with a flat bottom 46 at a level slightly below the top of the die 40.

The die 40 has a tapered hole 47 therethrough converging from a shallow open top recess 48 to the spacer 38. The recess 48 has a flat radial bottom 49 and a diverging side wall 50 to receive and shape the end wall 18 and beveled side 17 of the head 13 of the blank 11. The small end of the tapered hole 47 mates with the hole 39 through the spacer 38 and diverges upwardly and outwardly therefrom to the center of the radial wall 49 of the recess 48.

A ram 51 carries on its bottom face an adapter plate 52 from which depends a die punch adapter 53. A punch 54 is secured to the bottom face of the adapter 53 by screws 55 and shims 56 are provided between the bottom of the adapter 53 and the top of the punch 54 for correctly locating the punch relative to the die. The punch 54 has a sliding fit in the well 45 of the clamp ring 43 and the shims 56 will determine the exact position for the punch at the bottom of its stroke as shown in FIGURE 5.

The punch 54 is also a die and has an open bottom die recess 57 with the spiral tooth forming ribs 58 therearound, as best shown in FIGURE 8. The recess 57 converges from the bottom face of the punch at about the same angle as the side wall 15 of the head 13 of the blank 11. The punch 54 has a cylindrical central aperture 59 bottomed by an inclined shoulder 60 which converges to the top of the recess 57. A counterbore 61 is provided in the top of the aperture 59. A replaceable nose member 62 snugly fits in the aperture 59 and has an outturned flange or rim 63 seated in the counterbore 61. The shims 56 overlie the top of the nose 62 and cooperate with the bolts 55 to clamp the nose in the aperture 59 between

the shims and the shoulder at the bottom of the counterbore 61. The nose 62 has a rounded leading end 64 projecting into the center of the recess 57, thereby providing a convex bottom for the recess.

The helical teeth or ribs 58 which form the helical teeth 23 for the finished gear 20 project beyond the bottom face 65 of the punch 54, as shown in FIGURE 4, and thus have inclined end edges 66 of triangular configuration, as best shown in FIGURE 8. The tooth configuration in the die recess 57 can be made by electrical discharge machining where the electrode is a gear of the exact tooth contour for the die to be formed and an electrical discharge vaporizes the die metal into conformity with the gear electrode. The process is carried out in an oil bath. Of course, the die could also be machine cut and hand finished. A polished finish is provided in the die so that the teeth 23 of the gear 20 will be ready for use without additional polishing or machining. The nose piece 62 is replaceable and the contour of the leading end 64 of the nose can be varied as desired to effect the proper movement of metal for causing the head 13 of the blank to conform fully with the die cavity.

When the die 54 is in the closed position of FIGURE 5, the bottom face 65 of the punch 54 is very close to the top end 67 of the die 40, leaving only a very narrow gap 68 therebetween for escape of flash. It will be noted that the projecting ends 66 of the teeth 58 are bottomed in the recess 48 of the die with their edges mating with the tapered side wall 50 of this recess.

The tube 33 slidably supports a spring platform mechanism 70 of this invention which carries the blank 11 in a raised position when the die is open. This mechanism 70 includes a rod or pin 71 with a bottom portion slidably guided in a bearing 72 at the bottom of the tube 33 and with a collar 73 slidably guided in the top portion of the tube. The pin projects upwardly from this collar 73 freely through the aperture 36 in the spacer pad 35 into the aperture 39 of the spacer 38. The top end of the pin is threaded and receives a platform head 74 freely slidable in the aperture 39 and into the bottom portion of the tapered hole 47 of the die 40.

A coiled spring 75 is bottomed in the tube 33 around the pin 71 and acts on the collar 73 to lift the pin to the position of FIGURE 4 with the collar 73 pressed against the spacer pad 35. In this position, the pin carries the platform head 74 at a level projecting into the die cavity 47 so that when the blank 11 is dropped into the die 40, it will rest on the head 74 and the head 13 of the blank will be above the recess 48 of the die. In this position, the blank 11 is free in the die.

As the punch 54 is moved toward the closed position of FIGURE 5, the leading end 64 of the punch nose 62 engages the flat end wall 14 of the blank head to press the blank into the die 40, thereby compressing the spring 75 and moving the platform head 74 into the aperture 39 of the spacer 38 where the head will then bottom on the spacer pad 35, as shown in FIGURE 5. The head 74 thereby becomes a fixed plug closing the bottom of the die hole 47 flush with the bottom of the die 40. As the closing of the die progresses, the leading end 64 of the nose 62 will pierce the end wall 14 of the blank head and cause an outward flow of metal into full conformity with the die cavity provided by the die recess 48 and the punch recess 57. The teeth 23 of the finished gear will thus be formed by filling the spiral grooves between the teeth formers 58 of the recess. Since, as explained above, the only escape path for the confined metal is through the very narrow gap 68 between the top 67 of the die and the bottom 65 of the punch, and since this escape path is at the outer circumference 16 of the blank head, any flash is easily removed and is beyond the extremities of the gear teeth.

Upon completion of the closure stroke of the apparatus 19, the ram 51 is raised whereupon the compressed spring 75 will force the platform head 74 upwardly to cause the finished gear 20 to follow the punch 54 until the collar

73 is again bottomed on the spacer pad 35. However, at this level, the finished gear 20 is completely free of the die surfaces and can rotate so as to be unthreaded from the spiral teeth forming ribs in the punch cavity 57. The finished gear is then free to drop off of the punch with a twisting or rotating action or if the finished gear remains in engagement with the punch, the press operator can easily rotate the stem 21 to loosen the gear from the punch.

As shown in FIGURE 9, the working of the metal from the original cylindrical slug 10 through the intermediate blank 11 into the finished gear 20 creates circular grain flow lines of increasing diameters, the outermost of which bow outwardly from the longitudinal axis of the gear to define the head area of the gear and the teeth surfaces only with the sides of the flow lines. The grain flow lines are generally coaxial with the center of the gear, radiating outwardly therefrom in successively surrounding circles that are squeezed together in the root areas of the gear teeth. This increases the toughness and strength of the teeth at the high stress areas of the gear. The ends of these lines are not exposed to wear and a very strong impact resisting structure is provided with smooth surfaces. As shown, the grain lines G extend generally axially through the stem 21 of the gear, are bowed outwardly in the head area and then form the surfaces of the head and the surfaces of the teeth surrounding the head with their sides only.

From the above descriptions it will, therefore, be understood that this invention provides die forging apparatus which releases the forged article from a fixed die allowing it to follow a moving die punch so that the punch formed surfaces will not be damaged.

Although minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent granted hereon, all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim:

1. Die forging apparatus which comprises a fixed die having an aperture therethrough adapted to receive a work piece, a punch coacting with said die having a die recess for forming a portion of the work piece, said punch and die coacting to form a closed die cavity, a work piece supporting platform movable in the aperture of the die, means urging said platform to an elevated position in the die for holding the work piece free from the die, stationary means bottoming said platform to provide a fixed closure for the central aperture of the die, said punch on its closure stroke first moving the work piece to lower the platform against said stationary bottoming means and then coacting with the die to forge the work piece into conformity with the die and punch cavities, and said platform raising the forged article with the punch on the opening stroke thereof to a level where the forged article is free of the die.

2. Die forging apparatus which comprises a fixed die having a central vertical aperture therethrough and a die shaping cavity at the top end of the aperture, a work piece supporting platform slidably mounted in the aperture of said die and bottomed at the bottom of the die against a stationary surface to form a fixed plug for the aperture, a punch coacting with said die having a die recess cooperating with the die and bottomed plug to form a closed die cavity, means urging the platform to carry the work piece above the die cavity and effective to cause the finished forging to follow the punch on the opening stroke of the apparatus until the forged article is free from the die and can drop off of the punch without damage.

3. Die forging apparatus which comprises a fixed die having a vertical central aperture therethrough and a die shaping cavity at the upper end thereof surrounding the aperture, a punch coacting with said die having an open bottom recess coacting with the die cavity of the die to

form a substantially closed die cavity, a plug fixedly bottomed in the die against a stationary surface at a level flush with the bottom of the die aperture for supporting a work piece in the die and for closing the bottom of the central aperture, spring means urging said plug upwardly from said stationary surface into the aperture of the die to carry the work piece free of the die when the punch is retracted from the die, and said spring means being effective to cause the work piece to follow the punch on the opening stroke of the apparatus, thereby preventing damage to the forged article in retracting the punch away from the article.

4. Die forging apparatus which comprises a die bed having a die receiving well, a tube depending from the bottom of the well in communication therewith, a die clamped in said well having a central aperture aligned with the tube, a plug closing the bottom of the central aperture of the die, nonmovable means at the bottom of the die seating said plug to form a fixed bottom for the central aperture of the die, a spring loaded pin slidably mounted in the tube and carrying the plug above the bottom of the die, means on said pin limiting the upward stroke of the plug, a punch coacting with said die having a work piece shaping cavity, said punch engaging the work piece on the closure stroke of the apparatus to bottom the plug in the die and coact with the die for forming a forged article, and said spring acting on the plug during the opening stroke of the punch to cause the forged article to follow the punch until it is free from the die.

5. A gear forging apparatus which comprises a fixed die having a vertical central aperture therethrough and a die forming cavity surrounding the upper end of the aperture, a vertically movable punch having an open bottom recess cooperating with the recess in the top of the die to form a closed die cavity at the bottom of the pressure stroke of the punch, a spring loaded work piece support in the bottom of the die forming a closure plug for the die, means bottoming said plug to provide a fixed bottom for the die cavity, said die cavity adapted to receive the stem of a headed blank with the end of the stem supported on the plug, said recess of the punch having contours for shaping the head of the work piece into tapered spiral gear teeth, and said plug being effective to cause the forged gear to follow the punch on the opening stroke thereof until the forged gear reaches a level in the die where it is free to rotate in the die, whereupon the forged gear can drop free of the punch without damaging the spiral teeth thereon.

6. A gear forging apparatus for producing gears from a work piece having an axial stem and an enlarged tapered head on one end of the stem to form helical teeth around the head which comprises a fixed die having a stem receiving aperture therethrough and a head receiving recess surrounding the aperture, a punch having a helically toothed recess coacting with the die recess to shape the head of the work piece and form helical gear teeth therearound, a nose on said punch for piercing the end face of the head of the work piece for moving metal into conformity with the die and punch recesses, a spring loaded support platform for the work piece in the die effective to raise the forged gear with the punch during the opening stroke of the apparatus until the gear is free of the die, and means bottoming said platform to provide a fixed closure for the die aperture whereby the finished gear is forged in a closed die and released from the die so that it may be unthreaded from the punch without damaging the helical teeth.

7. The method of die forging a metal article between a punch and a die on a closure stroke of a press which comprises supporting a work piece in the die on a movable closure plug for the die, moving the plug away from the punch, fixedly bottoming the plug in the die before the completion of the closure stroke and urging the plug against the finished forging when the punch is moved

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away from the die to cause the forging to follow the punch until it is free of the die.

8. The method of die forging gears which comprises upsetting a cylindrical rod to form a headed member with a stem portion and an enlarged head having a tapered periphery on the end of the stem portion, seating the stem of the member into the aperture of a die on a spring-loaded platform in the die, fixedly bottoming said platform in the die, impacting the head of said member between the die and a punch having a recess coacting with the die to form helical gear teeth on the head of the member, retracting the punch from the die after the impacting step, moving the finished forging with the punch to a level where the forging is free from the die, and unthreading the forging from the punch.

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U.S. Cl. X.R.