Oct. 27, 1970 J. E. M. TAYLOR 3,535,762

CONCENTRIC TUBE FORGING

Filed Sept. 14, 1967 3 Sheets-Sheet 1

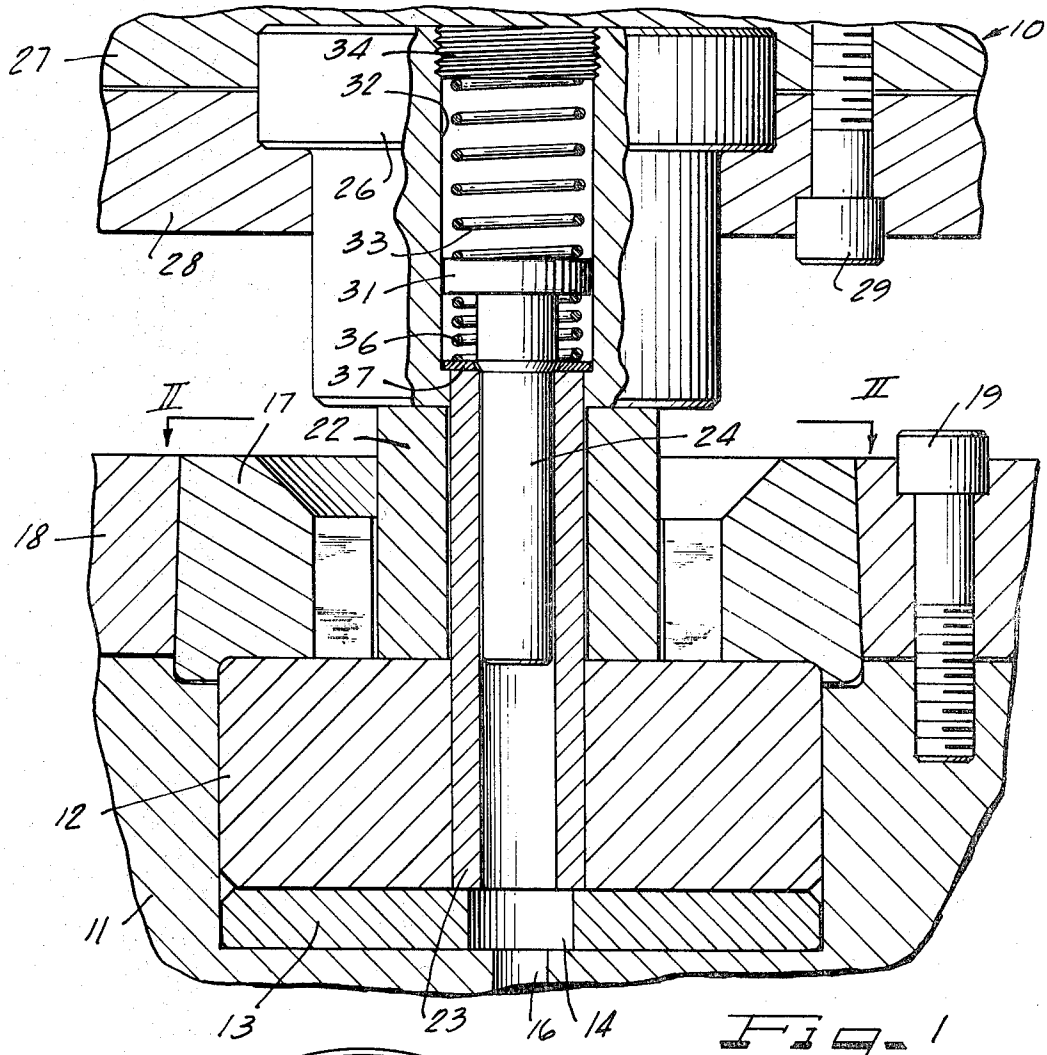


Fig. 1

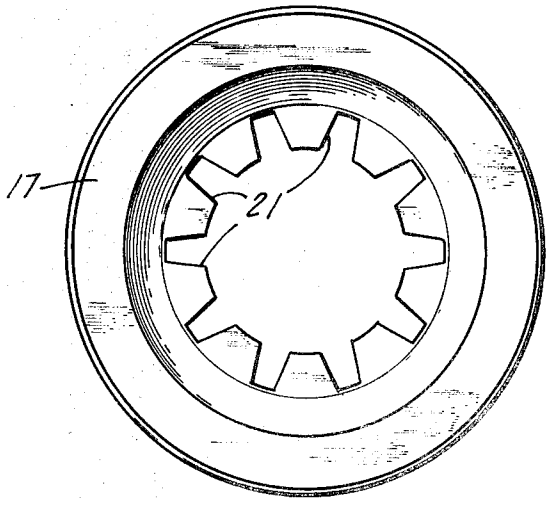


Fig. 2

INVENTOR.

JOHN E. M. TAYLOR

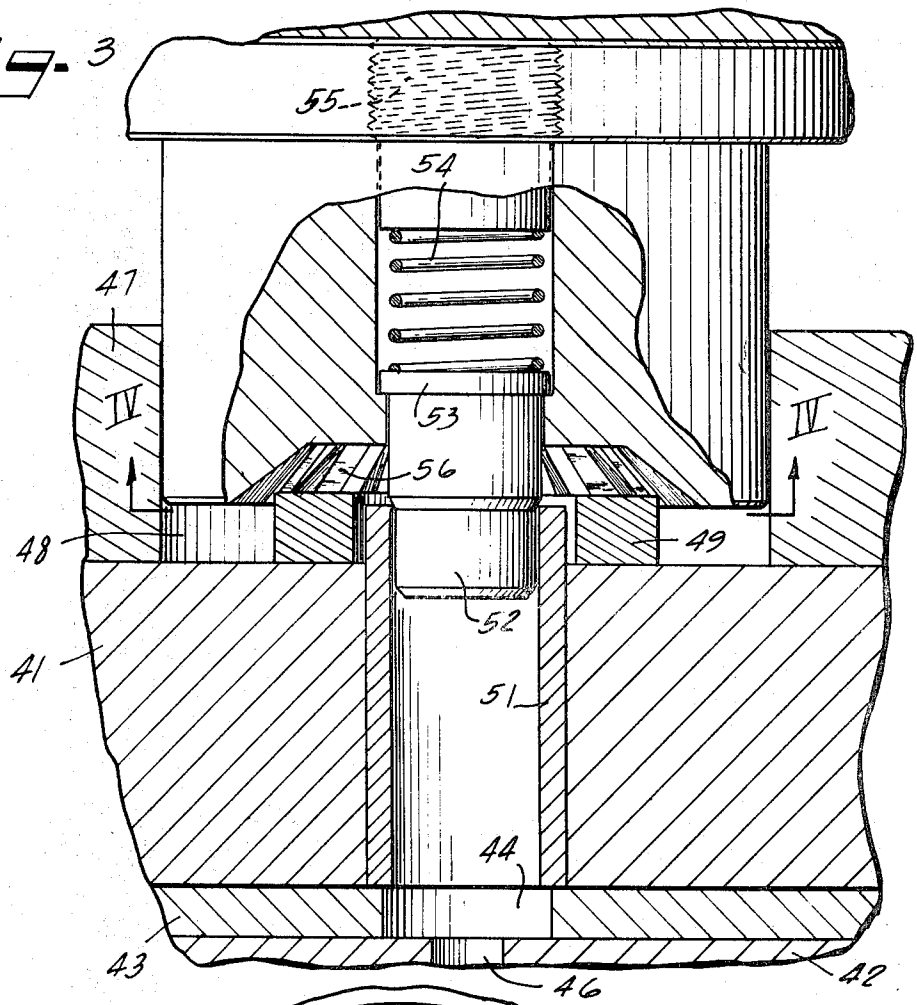
BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

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Fig. 3



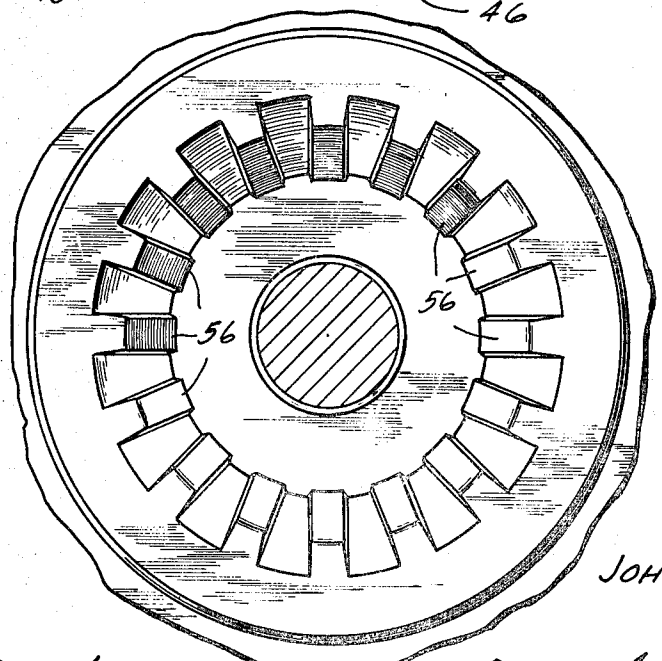


Fig. 4

INVENTOR.
JOHN E. M. TAYLOR

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

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Fig. 5

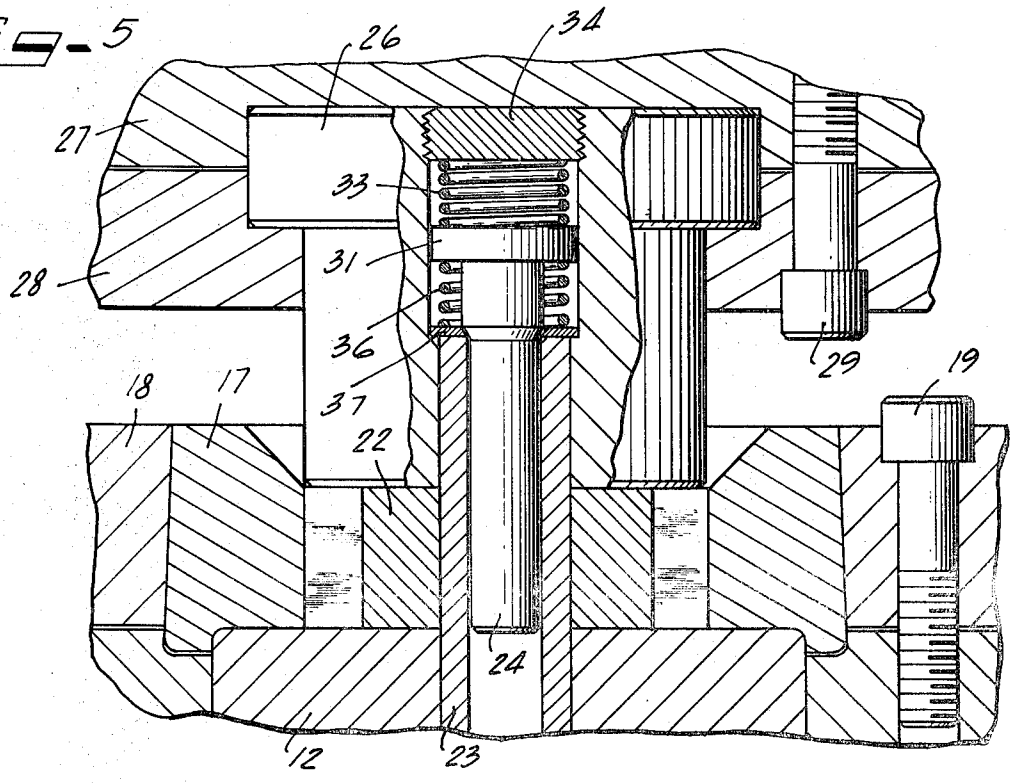
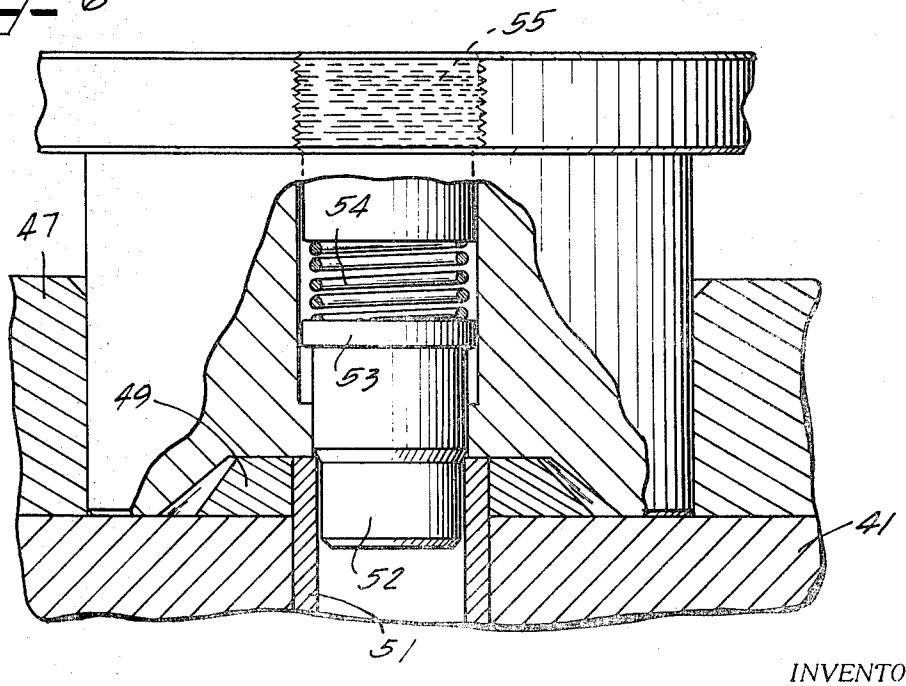


Fig. 6



INVENTOR.
JOHN E. M. TAYLOR

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

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3,535,762

CONCENTRIC TUBE FORGING

John E. M. Taylor, East Cleveland, Ohio, assignor to TRW Inc., Cleveland, Ohio, a corporation of Ohio

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Int. Cl. B21d 53/28; B23p 15/14; B21h 5/00; B29d 15/00; B21k 1/30
U.S. Cl. 29—159.2 10 Claims

ABSTRACT OF THE DISCLOSURE

Simultaneous forging and bonding wherein a shaft is supported in a forging die, a heated deformable billet is placed around the shaft, and a punch deforms the billet into a forged periphery while also bonding the billet to the shaft.

BACKGROUND OF THE INVENTION

This invention is in the field of method and apparatus for simultaneously forging precision shapes such as gear teeth on a billet while joining the billet to a shaft. It involves positioning a shaft within a die, positioning a centrally apertured forging billet coaxially on the shaft, the billet being at a temperature at which it is relatively plastic, the temperature being insufficient to soften the metal of the shaft significantly, and applying sufficient forging pressure to the billet to shape the billet into a desired form and to bond the resulting shape to the shaft.

DESCRIPTION OF THE PRIOR ART

The prior art contains a large number of examples of the precision forging of gear wheels and the like, much of it of German origin. For example, reference is made to German Pats. Nos. 703,370; 704,320; 899,892; 911,692; 942,125; 954,838; 1,037,817; 1,048,766; and 1,052,779.

For typical United States patents on forged gears, reference is invited to U.S. Pats. Nos. 2,393,628 and 3,258,834. Thus, it is well known from the prior art that gears and other precision shapes can be forged to relatively close tolerance without the necessity of additional machining operations. The persent invention provides an extension of this technique, whereby forging of the gear or other precision shape is accomplished with the bonding of the shaped article to a shaft contemporaneously with the forging operation.

SUMMARY OF THE INVENTION

Precision forging has been employed in the past to achieve several advantages, among them being the reduction of or elimination of machining operation on the part, reduction of scrap material produced and increasing the strength of the parts in critical areas by control of their grain orientation. The process has been applied to a wide variety of forgings such as splines, sector gears and companion flanges. Many of these parts are to be mounted on shafts, some of considerable length. In some cases, the shafts must have axial bores extending therethrough. The present invention is directed to an economical method for forging a highly configured member of larger diameter onto a length of bar or tubing at any point on its length. The process is not confined to shafts of circular configuration, as the shafts may have any type of cross-sectional configuration.

One of the advantages of the present invention is the fact that the shaft and the forged shape can be composed of different materials, provided the shaft has a softening point in excess of the forging temperature employed for the shaped element. The invention also provides a low cost method for joining a precision forged shape on a shaft, whether solid or hollow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary view, partly in elevation and partly in cross-section of an apparatus suitable for the practice of the present invention;

FIG. 2 is a cross-sectional view taken substantially along the line II—II of FIG. 1;

FIG. 3 is a fragmentary view, partly in elevation and partly in cross-section of a modified form of assembly which can be used in the practice of the present invention;

FIG. 4 is a cross-sectional view taken substantially along the line IV—IV of FIG. 3;

FIG. 5 is a view similar to FIG. 1 but illustrating the position of the components during the forging and bonding operation; and

FIG. 6 is a view similar to FIG. 3, but illustrating the position of the components during the forging and bonding step.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, reference numeral **10** indicates generally the forging die assembly which can be employed in the practice of the present invention. The die assembly **10** includes a bottom bolster **11** having a recess therein which accommodates a back-up block **12** therein. The back-up block **12** rests on a shim **13** through which a kicker pad **14** and its associated shaft **16** are arranged to reciprocate to eject the finished piece from the die.

A forging die ring **17** is tightly received within a forging die ring clamp **18**, the latter being secured to the back-up block **11** by means of bolts **19** or the like.

The assembly shown in FIGS. 1, 2 and 5 is arranged to simultaneously forge a spur gear and join the same to a hollow shaft. To that end, the internal periphery of the forging die ring **17** is provided with gear teeth shaping cavities **21** as best illustrated in FIG. 2 of the drawings. As best seen in FIG. 1, the internal diameter of the cavity in the forging die ring **17** is sufficiently large to losely receive a billet **22** to be forged, the billet in this instance being a hollow cylinder. Simultaneous with the forging operation, the forged shape is joined to a shaft **23** consisting of a hollow tube extending through the back-up block **12** and engaging the kicker pad **14** as shown in FIG. 1.

The tube **23** is centered in the die assembly by means of a cylindrical mandrel **24** which forms part of the punch assembly. The mandrel **24** is received in floating relation within a punch element **26**, the latter being secured between a top bolster **27** and a punch clamp **28** by means of bolts **29** or the like. The mandrel **24** has a headed portion **31** which is received in sliding relation within an axial bore **32** formed in the punch **26**. A coiled spring **33** is disposed between the headed portion **31** of the mandrel **24** and a plug **34** which is received in threaded engagement in the top of the punch **26**. A second coil spring **36** is positioned between the lower surface of the headed portion **31** and a stripper ring **37**.

In operation, the billet **22** is slipped down over the free end of the tube **23**, the billet **22** being heated to a forging temperature. In the case of steel or the like, a temperature of about 1900° F. or so would be appropriate. The billet may be pre-coated with a flux capable of dissolving oxides on the billet. The press assembly is then tripped and the punch **26** descends, clearing the tube **23** and exerting a compressive force on the billet **22**. Continued movement of the punch **26** causes the metal of the billet **22** to be compressed axially and to flow radially outwardly to fill the gear teeth forming recesses **21** in the forging die ring **17**. At the same time, the extreme compaction of the metal billet **22** causes it to flow radially inwardly and become bonded to the outer periphery of the

tube 23 with a metallurgical bond. The lower extension of the mandrel 24, being disposed in the area where the billet 22 is plasticly urged against the tube 23, supports the tube 23 against inward bulging which is particularly necessary when a thin walled tube is being employed.

After the metal of the billet 22 has been extruded radially to fill the cavity of the forging die ring 17 and to bond itself to the outer periphery of the tube 23, the punch 26 is raised. The spring loaded stripper ring 37 is provided in the event there is a tendency for the tube 23 to seize on the floating centering mandrel 24. The forged part is then raised by the kicker pad 14 and removed from the die assembly.

The provision of the floating centering mandrel 24 with the springs 33 and 36 acting on the headed portion 31 of the mandrel is particularly useful where it is required to provide close control of shaft runout. In other instances, of course, the floating type mandrel may not be necessary.

The embodiments shown in FIGS. 3, 4 and 6 are closely similar to those of the other figures, but differ mainly in the fact that the shaping portion of the assembly is provided on the punch rather than in a forging die ring. In the embodiment illustrated in the drawings, reference numeral 41 refers to a back-up block which is bottomed on a bottom bolster 42 with a shim 43 being interposed therebetween. A kicker pad 44 secured to a shaft 46 is provided for ejection purposes. A forging die ring clamp 47 holds a forging die ring 48 over the back-up block 41. A forging billet 49 of annular configuration is loosely received in the forging die ring 48 with its inner periphery spaced from the outer periphery of a tubular shaft 51 as shown in FIG. 3.

The punch assembly includes a mandrel having a lower extension 52 serving to center the tube 51 and to prevent buckling thereof during forging operation. The mandrel 52 has a headed portion 53 against which a spring 54 is bottomed. The other end of the spring is bottomed against a plug 55 in threaded engagement within a suitable bore provided in the punch assembly.

As best illustrated in FIG. 4, the bottom end of the punch assembly is provided with gear teeth shaping recesses 56 which, during the forging operation, operate on the billet 49 to force the metal to flow radially thereby filling up the recesses 56, and causing bonding to occur between the inner periphery of the billet 49 and the outer periphery of the tubular shaft 51. This condition is illustrated in FIG. 6 of the drawings. At the completion of the forging operation, the punch is raised, and the kicker pad 44 ejects the forged gear, now bonded to the tubular shaft, from the die assembly.

As previously mentioned, the metal of the forged shape and the metal of the shaft may be different as, for example, when the forged shape is composed of steel and the shaft is composed of titanium. This type of construction permits a reduction in weight, lower cost or both. Another variation consists in providing a gear with a steel toothed ring and a titanium web.

In the event that a very high torque application is required, the shaft to which the gear is joined can be knurled, flattened or grooved prior to forging in order to provide a higher strength bond between the gear and the shaft.

While the foregoing description has dealt primarily with the formation of gears, it should be understood that the techniques involved are equally applicable to the manufacture of any other precision forged shapes, including articles such as cams.

From the foregoing it will be understood that the present invention provides an economical means for simultaneously forging a precision shape onto one element while bonding that element along a predetermined portion of a shaft, whether hollow or solid. Through the use of the process and apparatus of the present invention, one can use dissimilar metals in the shaft and in the forged portion to utilize the best properties of each.

It should be understood that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:

1. The method of simultaneously forming a forged shape and joining said shape to a shaft which comprises positioning a shaft within a die, positioning a centrally apertured forging billet coaxially on the shaft, said billet being at a temperature at which it is relatively plastic, which temperature is insuffiicent to soften the metal of said shaft significantly, applying sufficient forging pressure to said billet to shape the billet by a substantial axial compression into a desired form and to bond the resulting shape to said shaft, and removing the forged piece from the die.

2. The method of claim 1 in which said billet is positioned in a forging die ring having internal teeth therein for forming gear teeth on the shaped billet.

3. The method of claim 1 in which said shaft is hollow.

4. The method of claim 3 which includes the step of supporting the hollow interior of said shaft during forging to thereby prevent buckling.

5. The method of claim 1 in which said billet and said shaft are composed of different metals.

6. A forging apparatus comprising means for supporting a shaft in upright position, a forging die ring positioned about said shaft when so supported, a reciprocable punch having a relieved portion arranged to slide over said shaft when so supported, a hollow billet loosely received about said shaft, said die ring and said punch cooperating to define a forging cavity of substantially smaller axial extent than said billet, whereby a forging blow delivered by said punch serves to compress the billet substantially, to simultaneously reshape said billet in said forging cavity and to metallurgically bond the inner diameter of said billet to said shaft.

7. A forging apparatus according to claim 6 wherein said die ring has internal teeth formed thereon to shape the periphery of said billet with gear teeth while the internal edge of said billet is bonded to said shaft.

8. A forging apparatus according to claim 6 wherein said punch has teeth forming protuberances thereon arranged to form gear teeth in said billet while the internal edge of said billet is bonded to said shaft.

9. A forging apparatus according to claim 6 which also includes a centering mandrel as part of said punch, said centering mandrel being arranged to be seated within a tubular shaft.

10. The forging apparatus of claim 9 in which said centering mandrel extends through the shaft to prevent buckling of said shaft during the forging operation.

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JOHN E. CAMPBELL, Primary Examiner

V. A. DiPALMA, Assistant Examiner

U.S. Cl. X.R.

29—475, 493, 497.5