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F. SINGER
HOT FORGING
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2 Sheets-Sheet 1

Fig. 1.

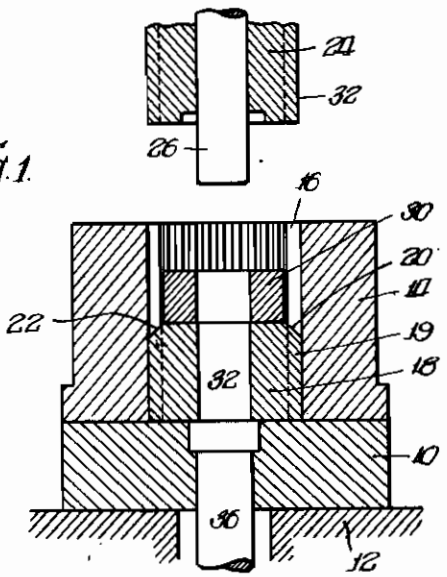

Fig. 2.

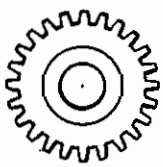

Fig. 3

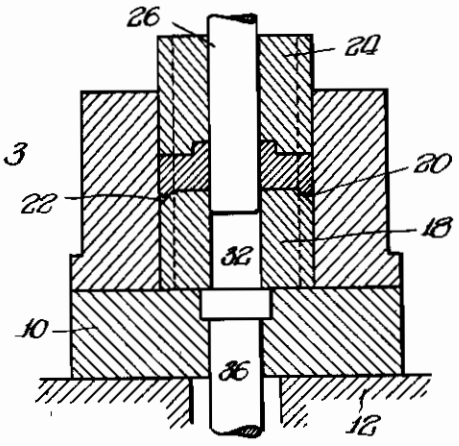

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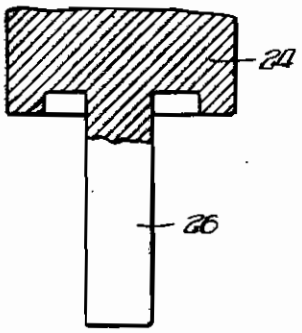
Fig. 4



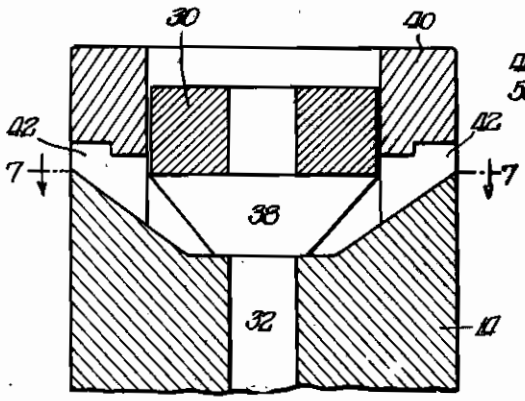


Fig. 5

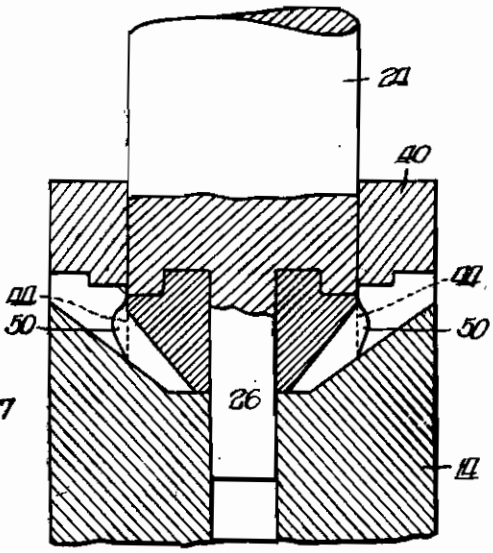


Fig. 6

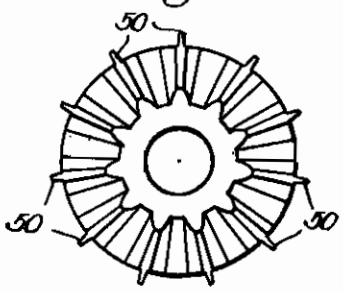
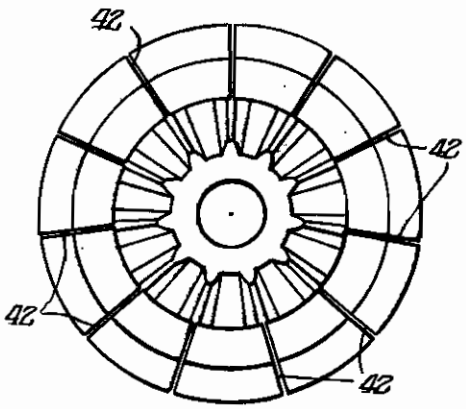


Fig. 7



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ALIEN PROPERTY CUSTODIAN

HOT FORGING

Fritz Singer, Starnberg, Germany; vested in the Alien Property Custodian

Application filed February 18, 1938

This invention relates to a new and improved hot forging process for the manufacture of metal articles, such, for example, as gears, and an important feature therein consists in permitting the material of which the teeth of the gears are formed to flow beyond the finished form of the teeth in a direction other than opposite to the direction of applying the forging pressure.

Gears of ordinary or alloy steels, to which materials this invention is particularly applicable, are produced even today almost exclusively by cutting tool operations, such as machining or milling, despite the fact that this method is expensive, involves a considerable waste of material, and additionally, produces gears the grain or fiber formation of which does not conform to modern technological requirements.

Heretofore it has repeatedly been proposed to produce gears by hot forging in dies. When this was attempted, however, it was found that metals, the forging of which is rather difficult, such as steel and steel alloys, set up a high resistance to deformation and thereby prevented the complete filling in of the space of the dies to be occupied by the teeth. Accordingly, even when employing the highest pressure forces the formation of the teeth left much to be desired. The enormous power requirement and the excessive stress on the tools connected therewith caused the economy of the hot forging method to appear of doubtful benefit so that the method has heretofore been made use of only in special cases.

A method of hot forging gears has heretofore become known according to which the die and the punch are so shaped that an opportunity is afforded to the material to spread beyond the finished tooth-form simultaneously in two direction viz. in the direction of the punching pressure, as well as in the opposite direction. However, as may be demonstrated by punching holes in round metal blocks, the material, when it is given the opportunity to rise up vertically opposite to the direction of the punching pressure, sets up by far less resistance to displacement in this direction than to displacement in the direction of or transversely of the punching pressure, and accordingly, no successful or exact shaping of the teeth can be achieved by this prior method.

According to the present invention, the obstacles which have heretofore stood in the way of the general use of hot forging in the manufacture of gears have been eliminated. By giving the material an opportunity to spread beyond the finished form of the teeth, except in a direction opposite to the direction of the punching pressure, not only is an accurate filling in of the tooth-form achieved but also the power requirement and the wear on the tools are considerably reduced. In contrast to the known methods, according to which a die exactly corresponding to the finished form is produced, it is true that the novel method herein disclosed embodies the disadvantage of a slight excess consumption of material which is formed on the ends of the teeth. This drawback, however, is insignificant and it is more than counterbalanced by the advantage that results from an exact filling in of the teeth-forms with substantially less power consumption and an important saving in the cost of the tools. Even in accordance with present-day practice forged gears are customarily subjected to a subsequent machining operation, and accordingly, the slight excess machining necessary for removing the excess material that is formed on the teeth in accordance with the practice of the present invention has practically no importance.

The gear blanks forged hot with slight excess dimensions are brought to exact dimensions by a cold drawing operation. By the cold drawing not only the highest degree of accuracy of shape but simultaneously a cold hardening of the sides of the teeth may be achieved.

Other objects and features of the invention will become apparent from a reading of the following specification in the light of the accompanying drawings, in which

Figure 1 is a vertical section of the tool with a billet or work piece inserted therein;

Figure 2 is a plan view of a gear that may be produced by the arrangement shown in Figure 1;

Figure 3 is a view similar to Figure 1 showing the parts in position at the completion of a forging operation;

Figure 4 is a vertical view in section similar to Figure 1 showing the parts at the commencement of a forging operation for the production of a beveled gear having a central bore;

Figure 5 is a view in vertical section of the parts shown in Figure 4 with the punch in position at the completion of the forging operation;

Figure 6 is a top plan view of a forged beveled gear produced by the arrangement illustrated in Figures 4 and 5; and

Figure 7 is a top plan view in section taken along the line 7—7 of Figure 4.

As shown in the drawings, a base plate 10 resting on the bed or frame 12 of the press is provided with a container 14 the inner wall of which is formed with tooth-like projections 16,

the shapes of which correspond to the shapes of the teeth formed on the gear illustrated in Figure 2. Located within the central recess of the container **14** is a die block **18** in the form of an insert and the outer surface of the die is provided with teeth **19** of the same shape as the teeth of the gear shown in Figure 2. The teeth **19** have interlocking engagement with the toothed recesses **16** formed in the wall of the container **14**, by means of which arrangements rotary displacement of the die block **18** relatively to the container is adequately prevented. The die block **18** is cut away or beveled at **20**, **22** to form an annular recess into which excess material of the teeth of the gear may spread during the forging operation. This latter feature is illustrated in Figure 3, as will be more fully described hereinafter. Located directly above the container and adapted to engage therein is a punch **24** provided with a centrally mounted plunger **26**, the purpose of which is to descend through a central opening formed in the work piece **30** and enter the bore **32** of the die block **18**, as shown in Figure 3. The punch **24** is likewise provided with gear teeth **32** on its exterior surface which are adapted to mesh with the recesses **16** formed on the inner wall of the container.

In operation the heated work piece **30**, which may be termed a billet, slug or the like, is placed in position within the container **14**, whereupon the punch **24** and plunger **26** descend. The plunger **26** enters the bore **32** of the lower die block and as the working face of the punch strikes the work piece it forces the latter to flow laterally into the recesses **16** formed on the inner wall of the container **14** and also allows excess material to flow downwardly and laterally or transversely, as shown in Figure 3, to occupy the annular recess formed in the die block **18**. By means of this provision the teeth of the gear, as illustrated in Figure 2, are firmly and completely formed. Thereafter the surplus material which flows into the annular recess of the die block **18** may be removed by milling, machining or the like.

In order to remove the completed gear from the container **14** there is provided a movable ram or ejecting device **36** which is arranged for vertical movement. As this member ascends the gear is moved upwardly until it emerges from the mouth of the container and may thereupon be removed manually.

In Figures 4 to 7, inclusive, is shown a similar arrangement by means of which a beveled gear may be produced. As therein illustrated, the container **14** is provided with a recess **38**, the shape of which conforms to the shape of the beveled gear to be produced. Mounted on the container is a hollow steel cylinder **40** which initially receives the work piece or billet **30**. The punch **24** is provided with the customary plunger **26**, the latter being adapted to descend through the opening in the work piece and into the bore **32** of the container **14**. The container is provided with radially extending slots or apertures **42** which permit the material of which the teeth are formed to spread laterally or transversely to the direction of the punching pressure beyond the finished tooth-form.

In operation the punch descends from the position that it occupies in Figure 4 until it strikes the work piece and causes it to flow into the position that it occupies in Figure 5. As shown in the latter Figure, the teeth of the gear, which in their finished form will be defined by the dotted line **44**, have spread laterally through the radial openings or slots **42** and in this condition form surplus portions **50**, **50** which may be seen in Figure 5 and also may be seen in Figure 6. These projections or this excess material may be removed by cutting or machining operations which do not cause any substantial additional work in the finishing operation of the beveled gear.

FRITZ SINGER.