Dec. 20, 1960 F. SCHOBER 2,964,838

METHOD OF PRESSING BEVEL GEAR WHEELS AND THE LIKE FROM STEEL

Filed July 23, 1956

3 Sheets-Sheet 1

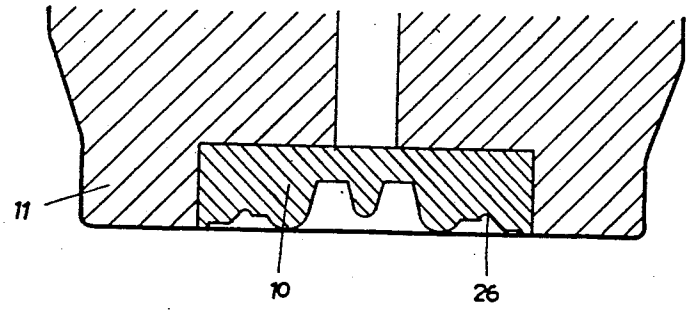
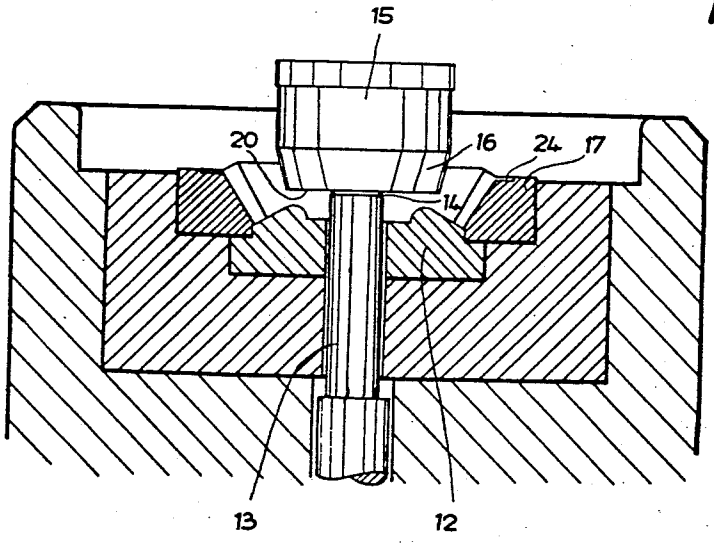


Fig. 1



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Fig. 2

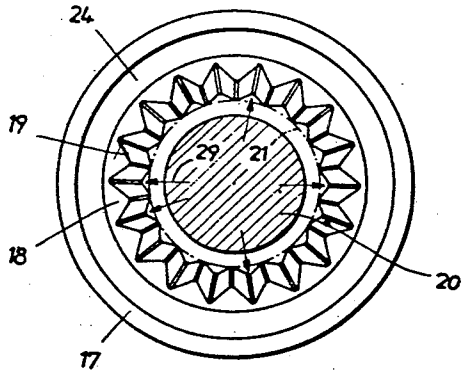
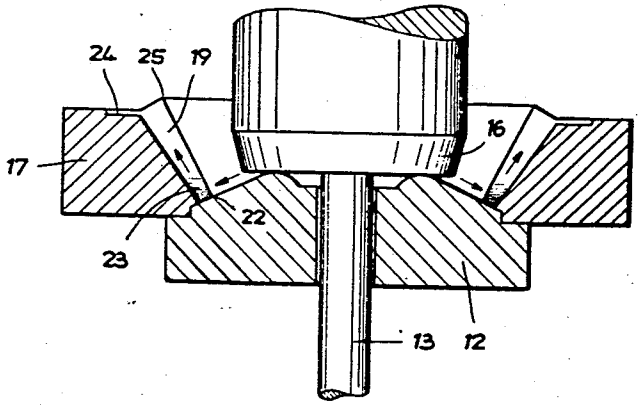


Fig. 3



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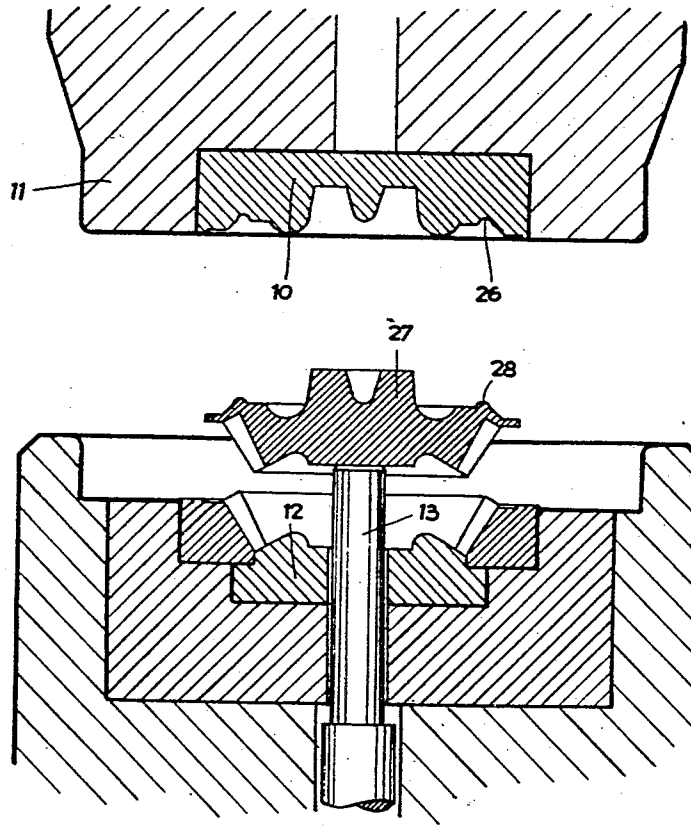


Fig. 4

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2,964,838

METHOD OF PRESSING BEVEL GEAR WHEELS AND THE LIKE FROM STEEL

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6 Claims. (Cl. 29—159.2)

The present invention relates to a method of hot forging toothed wheels particularly bevel gears, and to a metal blank and apparatus for carrying out the method of the invention.

The object of the invention is to shape, for example from a cylindrical steel blank in a press with suitably shaped dies in a single stroke, a bevel gear the teeth of which have a precision at least equal to that of cut teeth and which therefore need no finishing. The invention further aims at designing and disposing the dies in such a way that their life is adequate for mass production, i.e. they can receive 5,000 to 10,000 blows from the press without being destroyed or becoming unusable. Thus, with the same set of dies, up to 10,000 bevel gear wheels should be produced, all having a high degree of precision.

Further, the invention aims at producing in the teeth of a bevel gear thus manufactured a grain flow in which straightened (parallel) grains lie above each other in several layers with the object of obtaining greater strength in the teeth than can be achieved at present with cut bevel gear wheels of steel.

The present invention provides a method of hot forging toothed wheels particularly bevel gears using opposed dies and a tooth forming matrix associated with one of said dies which comprises locating a metal blank between the dies and bringing said dies together under pressure to press said metal blank therebetween said pressing action resulting in effecting radial flow of the metal from the blank progressively over the width of the tooth forming spaces of the matrix from one end of each said tooth forming space to the other.

To fulfil the conditions required the invention proposes various measures which can be applied either singly or in combination. First, to ensure that the part of the die which shapes the teeth, subsequently referred to as the "tooth shaping matrix," is not destroyed by the blows from a press of, e.g. 1,000 ton and over, this tooth shaping matrix is so placed that it lies outside the range of the vertically acting striking force of the press. The ideal shape for the tooth shaping matrix is a ring, having on the inner side tooth spaces into which the plastic material of the heated blank is forced, or more correctly "injected." For this reason the axis of the ring is vertical and the inner cover of the ring forms, as it were, an outer cover for the upper die (punch) and the lower die, whereby the external contours of these dies are at a short distance from the internal contours of the tooth shaping matrix ring. Such a design and disposition of parts ensures that the material which is compressed between the upper and the lower die can flow in a radial direction into the tooth spaces of the matrix ring without the possibility of the teeth of the matrix ring being struck by the descending punch.

According to the invention the dimensions of the metal blank are such that its largest cross sectional dimension is smaller than the smallest internal diameter of the tooth shaping matrix; i.e. if the metal blank is cylindrical its external diameter is smaller than the smallest internal diameter of the matrix. It is placed on the centre of the lower die, which as is known is fitted with an ejector, and is then subjected to blows from the punch.

So that the blank shall start to flow from the end facing the lower die first, thus filling the tooth spaces of the tooth shaping matrix from below upwards, the blank which is preferably cylindrical has a part which tapers downwards, e.g. is of frusto-conical form for a portion of its length, whereby the diameter of the end surface of this portion must be smaller than the smallest internal diameter of the tooth shaping matrix ring, so that the plastic material of the steel blank in the region of this frusto-conical portion must first follow a short radial path before it flows into the tooth spaces of the matrix.

Previous investigations of this method point out that when the blank is thus shaped on the side facing the lower die the material at the free end of the truncated cone begins to flow first and it fills first the lowest parts of the matrix tooth spaces which extend upwards on a slope, after which the remainder of these tooth spaces is filled up by the material flowing in afterwards. Obviously then, the teeth are built up from below upwards, with the consequence that roughly parallel grain strata appear and these, as has been proved by tests, impart the extraordinarily high strength of the teeth of the finished bevel gear.

Should the blank start to flow at any other point in its length, for example half way up, the plastic material would flow in first to the middle or upper parts of the tooth spaces and not until later on would the lowest parts of the tooth spaces of the matrix be filled, which would render impossible a homogeneous building up of the gear wheel from below upwards, which according to previous tests is most desirable.

It is within the scope of the invention to move the tooth shaping matrix, in contrast to the arrangement just described, to the upper die, in which case the tapering of the blank in the form of a truncated cone would have to be made at the upper end. The invention further embraces any measures which serve, or contribute to control the flow condition of the heated blank in such a way that the flow commences in the region of the smallest diameter. Such measures could include, for example, an additional heating of the truncated cone part by the transformation of kinetic energy into heat energy, or the use of electrical energy for the overheating of this part.

In order that the invention may clearly be understood and carried into effect the same will now be described by aid of the accompanying drawings in which:

Figure 1 represents a vertical section through the dies of a press, the press having a matrix for forming bevel gears, a suitably shaped metal blank being shown located in position.

Figure 2 is a top plan view of the tooth forming matrix, the metal blank appearing in section.

Figure 3 is a view of the lower die and tooth forming matrix showing the metal blank at the commencement of pressing.

Figure 4 is a view similar to Figure 1 but showing a formed bevel gear as it is removed from the die by an ejector.

Referring to the drawings, the reference numeral **10** indicates the upper die which is inserted in the punch 11 of a 1,000 ton press. **12** is the lower die in the centre bore of which an ejector **13** moves up and down. The tooth shaping matrix **17**, shaped approximately as a ring with internal toothing, is inserted in the lower die **12**. This matrix is shaped like the negative of the bevel gear to be produced and has teeth **18** and tooth spaces **19** (Fig. 2). On the even upper surface **14** of the ejector **13** the metal blank **15** is placed before pressing op-

erations begin. The metal blank is in the form of a cylinder one end of which is tapered to provide a portion of the length of the blank of frusto-conical form. The diameter of the bottom surface 20 of the portion 16 is smaller than the internal diameter 21 (Fig. 2) of the matrix which joins the edges 22 (Fig. 3) of the teeth 19.

The top edges 25 of the teeth 19 project above the surface of the matrix 17. For this reason there is in the upper die a corresponding recess 26 which acts as a kind of by-pass valve and in addition prevents the upper die 10 from touching the top edges 25 of the teeth of the matrix 17 when the press descends. When descending the upper die is intercepted by a surface of the lower die so that the blow cannot possibly have an effect on the expensive and delicate matrix 17.

The finished bevel gear 27 in Fig. 4 shows at 28 a ridge-like elevation which is formed by the recess 26 in the upper die.

The method of the invention is carried out as follows: The steel blank, heated to forging temperature, is placed on the smooth surface 14 of the ejector 13 with the smooth bottom surface of the portion 16 as shown in Fig. 1 the ejector being positioned so that the metal blank is supported between the dies with a portion of the metal blank extending into the matrix. The hammer stroke of the press follows at once, whereby the upper die 10 strikes the blank 15 from above, when the latter, by the return movement of the ejector 13, is first pressed downwards until it is in contact with the upper surface of the lower die. The blank begins to flow first at its bottom surface 20 and the molten material is forced, or rather "injected" radially in all directions on to the tooth spaces of the matrix 17. As a result, as shown in Fig. 3, the lowest parts 23 of the tooth spaces 19 become filled first and the material flowing in afterwards fills the spaces completely from the bottom upwards. The grain flow of the teeth of the finished gear wheel can be judged approximately from the parallel lines which are drawn in Fig. 3 at 23. Excess material can flow off into the recess 24 in the matrix 17 and also into the groove 26 in the upper die 10 where it forms flash or a flange which can be cleaned off later by turning. Immediately after the pressing operation the ejector 13 rises and lifts the finished bevel gear 27, as shown in Fig. 4. The long life of the matrix 17 is ensured by the fact that it is stressed exclusively by the horizontal, radially acting components, of the force of the punch which acts in a vertical direction. These radial components of force are indicated by the arrows 29 in Fig. 2.

In addition to the importance of providing the correct volume of metal in the blank it is desirable that the dimensions controlling the shape of the blank should be such that the correct "flow" of metal during the pressing operation is assisted.

For example in the metal blank shown in the drawings the largest diameter of the blank is smaller than the smallest internal diameter of the tooth forming matrix, the smallest diameter of the blank being only slightly greater than the mean diameter of the raised annular rib of the lower die 12. Further the length of the portion of frusto-conical form is approximately one-third of the total length of the blank.

I claim:

1. In a method for press forging gears from material which will flow when subjected to pressure, comprising the steps of placing an elongated blank having an end portion of a compression resistance smaller than the remainder of the blank in a die matrix having a closed end face and a toothed annular surface of a size and shape identical with the peripheral surface of the gear to be produced, with said end portion of the blank facing said end face of the matrix and the peripheral surface of said blank transversely spaced from said toothed annular surface of said matrix; and pressing said end portion of reduced compression resistance against said closed end face of said matrix so as to cause the material of the blank to flow from said end portion thereof in transverse direction along said end face of said matrix toward said annular surface thereof and then in one direction along said annular surface, whereby the grain structure of the gear teeth thus formed will extend in only one direction substantially parallel to the annular surface portion of the die matrix.

2. A method for press forging gears from material which will flow when subjected to pressure, comprising the steps of providing an elongated substantially cylindrical blank of said material having a diameter smaller than the root diameter of the gear to be formed and having an end portion with a resistance against compression smaller than the remainder of said blank; placing said blank between a pair of dies one of which being a matrix die having a closed bottom face and a toothed annular surface of a size and shape identical with the peripheral surface of the gear to be produced, with said end portion of the blank facing said bottom face of the matrix and the peripheral surface of said blank transversely spaced from said toothed annular surface of said matrix; pressing said end portion of reduced compression resistance against said closed bottom face of said matrix by moving said dies toward each other so as to cause the material of the blank to flow from said end portion thereof in transverse direction along said bottom face of said matrix toward said annular surface thereof and then in only one direction along said annular surface, whereby the grain structure of the gear teeth thus formed will extend in only one direction substantially parallel to the annular surface portion of the die matrix; and closing said dies while compressing the remainder of the blank so as to fill the space between the dies completely with said blank material.

3. A method for press forging gears from material which will flow when subjected to pressure, comprising the steps of forming an elongated substantially cylindrical blank of said material having a diameter smaller than the root diameter of the gear to be formed and having an end portion of substantially frusto-conical shape with the small diameter of the frustum located at the end thereof; placing said blank between a pair of dies one of which being a matrix die having a closed bottom face and a toothed annular surface of a size and shape identical with the peripheral surface of the gear to be produced, with said end portion of the blank facing said bottom face of the matrix and the peripheral surface of said blank transversely spaced from said toothed annular surface of said matrix; pressing said end portion of reduced cross section and therefore reduced compression resistance against said closed bottom face of said matrix by moving said dies toward each other so as to cause the material of the blank to flow from said end portion thereof in transverse direction along said bottom face of said matrix toward said annular surface thereof and then in only one direction along said annular surface, whereby the grain structure of the gear teeth thus formed will extend in only one direction substantially parallel to the annular surface portion of the die matrix; and closing said dies while compressing the remainder of the blank so as to fill the space between the dies completely with said blank material.

4. A method for press forging gears from material which will flow when subjected to pressure, comprising the steps of providing an elongated substantially cylindrical blank of said material having a diameter smaller than the root diameter of the gear to be formed; heating said blank at one end thereof to a higher temperature than the remainder of the blank; placing said preheated blank between a pair of dies one of which being a matrix die having a closed bottom face and a toothed annular surface of a size and shape identical with the peripheral surface of the gear to be produced, with said end portion

of the blank facing said bottom face of the matrix and the peripheral surface of said blank transversely spaced from said toothed annular surface of said matrix; pressing said end portion of higher temperature and therefore reduced compression resistance against said closed bottom face of said matrix by moving said dies toward each other so as to cause the material of the blank to flow from said end portion thereof in transverse direction along said bottom face of said matrix toward said annular surface thereof and then in only one direction along said annular surface, whereby the grain structure of the gear teeth thus formed will extend in only one direction substantially parallel to the annular surface portion of the die matrix; and closing said dies while compressing the remainder of the blank so as to fill the space between the dies completely with said blank material.

5. A method for press forging gears from material which will flow when subjected to pressure, comprising the steps of providing an elongated substantially cylindrical blank of said material having a diameter smaller than the root diameter of the gear to be formed; heating said blank at one end thereof to a higher temperature than the remainder of the blank; placing said preheated blank between a pair of dies one of which being a matrix die having a closed bottom face and a toothed annular surface of a size and shape identical with the peripheral surface of the gear to be produced, with said end portion of the blank facing said bottom face of the matrix and the peripheral surface of said blank transversely spaced from said toothed annular surface of said matrix; resiliently supporting said blank substantially at the center of said end portion thereof spaced from said closed bottom face of said die matrix; pressing said end portion of higher temperature and therefore reduced compression resistance against said closed bottom face of said matrix by moving said dies toward each other so as to cause the material of the blank to flow from said end portion thereof in transverse direction along said bottom face of said matrix toward said annular surface thereof and then in only one direction along said annular surface, whereby the grain structure of the gear teeth thus formed will extend in only one direction substantially parallel to the

annular surface portion of the die matrix; and closing said dies while compressing the remainder of the blank so as to fill the space between the dies completely with said blank material.

6. In a method for press forging gears from a blank which will flow when subject to pressure and which has an end portion of a compression resistance smaller than the remainder of the blank, the steps of placing the blank substantially coaxially within a die formed at its outer periphery with a plurality of teeth-forming grooves distributed about the axis of the die and extending between the ends thereof; first spreading the material of said end portion of said blank across the die to one end of said periphery thereof; then directing the blank material which reaches said periphery longitudinally therealong to the opposite end thereof; and finally compressing the remainder of the blank to form the remainder of a gear, whereby the teeth of the thus formed gear will be formed only by the material of said end portion of the blank which flows longitudinally of the teeth-forming grooves during the formation of the gear teeth.

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