May 18, 1937. R. L. TEMPLIN 2,080,641

METHOD OF PRODUCING LOCOMOTIVE CONNECTING RODS

Original Filed June 22, 1934

Fig. 1.

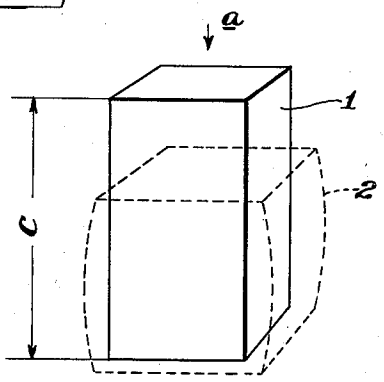


Fig. 4.

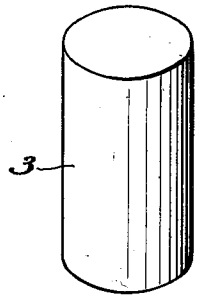


Fig. 5.

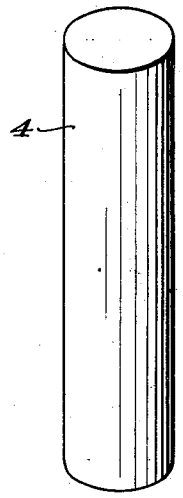


Fig. 2.

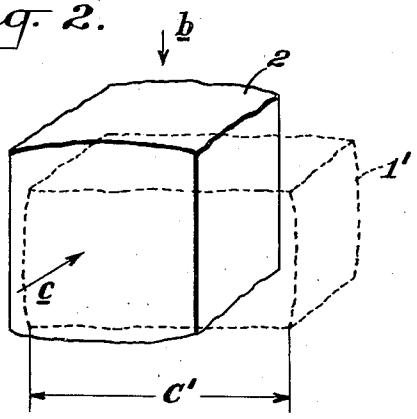
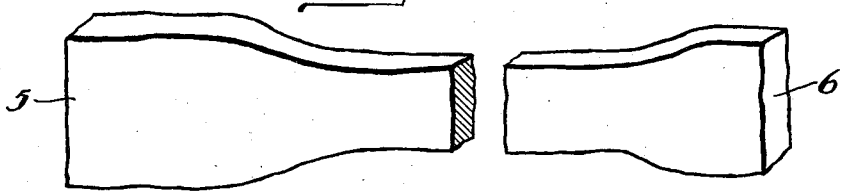


Fig. 3.



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METHOD OF PRODUCING LOCOMOTIVE CONNECTING RODS

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Original application June 22, 1934, Serial No. 731,876. Divided and this application August 25, 1936, Serial No. 97,803

4 Claims. (Cl. 29—156.5)

The invention relates to metal working and in particular concerns the method of producing forged locomotive connecting rods. The present application is a division of my copending application, Serial No. 731,876, filed June 22, 1934.

In the metal working arts recognition has been accorded to the beneficial effects of working in relation to grain refinement and improvement in mechanical properties of the metal. Inseparable from the advantages which may be said to result from the working methods commonly employed, as in rolling or drawing, are certain inherent disadvantages. Perhaps one of the most important of these is represented by the phenomenon generally referred to as the production of directional properties in the metal. Thus it is well known that in the case of rolled shapes, for example, the tensile strength will be greater in the direction of rolling than transversely thereto. Many attempts have been made to avoid or minimize the directional effect of rolling and kindred working operations but, so far as I am aware, none of the methods now known to the art are completely effective; and in some cases they are of doubtful value.

The designs of roll passes and of forging dies are illustrative of the means commonly adopted to work the metal in such a way as to tend toward refinement of the grain structure and the elimination of directional properties. The improvement obtainable by such expedients is quite limited, however, and is largely dependent upon size and shape of the metal stock which is used, in relation to the size and shape of the product or intermediate product which is to be fabricated.

It is an object of the present invention to provide a method of producing locomotive connecting rods which are characterized by substantial freedom from directional properties and which will show in this respect a far greater improvement than is obtainable by any of the methods which heretofore have been employed. Another object is to provide a method of preparing connecting rods characterized by an improvement in mechanical properties and more particularly by an increased fatigue limit.

A more specific object of my invention is to teach a method of preparing aluminum connecting rods which are characterized by freedom from directional properties and by an attendant improvement in physical properties in all directions with a marked improvement in fatigue limit. I have conducted fatigue tests on specimens cut out of large aluminum alloy forgings such as are made for locomotive connecting rods and have found that the fatigue strength is appreciably below that of wrought metal of similar composition produced in smaller sizes, such as rod or sheet or even small forgings. It is therefore a special object of my invention to provide a method of preparing aluminum forging stock suitable for use in the fabrication of locomotive connecting rods, airplane propellers and similar articles where the amount of working normally performed in the fabricating steps is comparatively small by reason of limitations imposed by the size of ingot or stock available. The method which is described herein will also be found applicable, however, in the production of smaller articles by forging or by other fabricating methods since in every case it will be found possible to start the forming operations with stock more nearly conforming to the size of the article which is to be made; and since the stock which is produced in accordance with the method described is quite free from directional properties, the product will also be comparatively free from directional properties. This, of course, would not be true where forming operations are relied upon for the grain refining effect, in which case there is always a tendency toward production of directional properties. Where cold working must be relied upon for the production of optimum mechanical properties it is likewise possible to start the forming operations with stock more nearly conforming to the size of the article which is to be made.

These are the principal objects of the invention. Others will appear from the following description in which there will be occasion to refer to the appended drawing in which

Fig. 1 shows in perspective a metal ingot or billet suitable for processing in accordance with my novel method. Fig. 2 shows the same billet at the end of the first step of the method. Fig. 3 is a perspective view of a blank for a locomotive side rod forging such as would be produced in accordance with my invention following the working or kneading steps indicated in Figs. 1 and 2.

Fig. 4 shows a cast or machined billet such as commonly employed in extruding operations; and Fig. 5 shows the same body after it has been subjected to the first step of my method which, in the specific embodiment illustrated, has been performed by die expressing or, as more commonly referred to, by extrusion.

I have found that if an elongated ingot or billet be first upset in one direction and then worked back as by forging or extrusion to substantially its original form, with a number of repetitions of this cycle, a very considerable improvement in

mechanical properties is obtained and the forging stock or other stock so produced possesses physical properties which are very similar in all directions. It is particularly to be observed that in this cyclical process which I have devised the working or kneading of the metal is accomplished without any reference whatsoever to the form or shape of the article which subsequently is to be produced therefrom. Thus it is possible to carry the process through the required number of cycles to produce optimum properties irrespective of the form of the product or subsequent methods of fabrication. Hence, the invention as I have conceived it relates to the preparation of stock, and the method employed is characterized by its cyclical nature and by the fact that the metal is worked back to its original form—or to substantially its original form—one or more times.

Throughout the balance of the specification and in the appended claims the term "billet" is used in a generic sense and will be understood to include, for example, the "ingot" and the "bloom" as well as the "billet" as these terms are customarily employed. This definition is necessitated by reason of the fact that the method described can be performed either by forging or by extrusion and the terminology in the two fields is not entirely consistent. The cast body of aluminum, for example, that is used in extruding shapes is generally known as an extrusion "billet" whereas the cast body of metal used in rolling is called an "ingot". It will be understood that the body of metal shown in Fig. 1 as the starting point of the process may, properly speaking, be neither an ingot nor a billet but a block of metal cut out of an ingot. This also comes within the purview of my definition of the term "billet" as used herein.

The term "aluminum" as used herein and in the appended claims is intended to comprise both aluminum and alloys in which aluminum forms the principal constituent.

The billet 1 may be cast as an ingot or it may be produced in any convenient manner from a larger body of metal. Assuming that it is desired to make stock for forging, the amount of metal in billet 1 should be about that which will be required to produce the finished forging. Billet 1 is upset as by press or hammer forging, into the form shown by the dotted lines 2, the forging pressure being applied in the direction indicated by the arrow *a*. The upset billet 2 is then turned up on one of its sides, as shown in Fig. 2, and forging pressure applied in the direction of the arrow *b*. It is then turned between the forging dies so that pressure can also be applied in the direction of the arrow *c*. By means of forging pressures *b* and *c* the upset billet 2 is "drawn" back again to substantially the form of the original billet 1, as indicated by the dotted lines at 1'. Thus, the dimension C' is approximately the same as the height C of the original billet 1. The steps of upsetting and then returning the deformed billet to substantially its original form are then repeated a number of times. I prefer to repeat the cycle at least three times and in some cases it may be desirable that it be repeated six times or more. In the case of aluminum it is preferable to carry out the operations of upsetting and drawing at an elevated temperature. Between 500° F. and 840° F. is recommended in the case of very large forgings. I have in contemplation however, the possibility of kneading the metal at room temperature. Where elevated temperatures are desired reheating may be effected between successive working cycles or between successive steps of a given cycle.

Figs. 4 and 5 are intended to indicate the successive forms of a billet when processed in accordance with my method when the kneading is to be accomplished by extrusion instead of by forging, Fig. 4 representing the billet at the beginning and end of the cycle and Fig. 5 representing the intermediate form of the billet. When the kneading is to be performed by extrusion I prefer a reduction of at least 50 per cent in the cross sectional area of the billet, with a corresponding elongation. Thereafter the extruded billet is returned to substantially its original form by an upsetting or die forging operation. Apparatus by which the original billet 3 may be extruded to form the elongated billet 4 is well known in the art and need not be here described. One form of apparatus suitable for returning billet 4 to its original form 3 is described in my copending application, Serial No. 731,877, issued February 4, 1936 as Patent No. 2,029,800.

It will be seen that the method described in connection with Figs. 4 and 5 is the same as that described in connection with Figs. 1 and 2, the only difference being in the apparatus which is utilized in the performance of the method. In each case the billet (1 or 3) is subjected to a mechanical working cycle consisting in deforming it by the application of a working pressure and returning the deformed billet (2 or 4) to substantially its original form by further application of a working pressure. In each case this working cycle may be repeated a sufficient number of times to produce optimum physical properties and maximum fatigue resistance. I have found, however, that when the method is performed by the combined steps of extrusion and die forging two or three cycles are usually sufficient to produce optimum properties in aluminum. After the third cycle the aluminum alloys tested showed greatly improved properties and further repetitions of the cycle did not produce any substantial change. The mechanical properties investigated include tensile strength, yield strength, elongation and reduction in area. It will of course be understood that some aluminum alloys may require a greater number of repetitions of the cycle than others.

As an example whereby the exact nature of my invention may be completely understood reference will be made to the production of side rods for locomotives. For this purpose aluminum alloy forgings have rapidly been increasing in favor by reason of their strength and lightness. The weight consideration is particularly important in machine parts having rapid reciprocatory motion, from the standpoint of avoiding inertia losses, and in the case of locomotive side rods the reduction in weight is especially important since it reduces the "rail hammer" caused by the reciprocating parts. As previously indicated, the problem of attaining satisfactory fatigue limits in large forgings of this sort is much more serious than in the case of wrought metal of similar composition produced in smaller sizes, such as rod or sheet or smaller forgings. A 7x7x15 inch billet was taken from a 20x20x72 inch aluminum alloy ingot containing approximately 4.5 per cent of copper, 0.8 per cent silicon, and 0.8 per cent manganese. This billet was upset to a 9 inch cube, then drawn back again to its original dimensions. This cycle was repeated six times and then the billet was reduced 50 per cent at one end, as at 5 in Fig. 3, and 80 per cent

at the other, as at 6 in the same figure. The final dimensions, 8x2⅞ inch (50 per cent reduction) and 3⅞x2½ inch (80 per cent reduction), are proportional to those of the large and small cross heads of a typical locomotive side rod. It was necessary to reheat the metal twice, for the operations of upsetting and drawing were carried out between temperatures of 840° F. and 500° F. Specimens taken from a finished forging blank and subjected to a rotating beam fatigue test, showed an average endurance limit in the transverse direction of 13,000 pounds per square inch, based on 500,000,000 cycles, as compared with an average endurance limit in the same direction of 11,000 pounds per square inch for specimens taken from blanks forged in the usual manner. It will be observed that this represents an improvement of about 18 per cent over the results obtainable by the methods known to the prior art. Longitudinal and transverse test specimens showed the following average values for tensile and yield strengths:

	Longitudinal	Transverse (vertical*)	Transverse (horizontal*)
Tensile strength (pounds per sq. in.)	56025	54860	55100
Yield strength (pounds per sq. in.)	35343	35217	34500

* As viewed in Fig. 3.

It will be seen from these results that the forgings produced showed very little tendency toward directional properties.

Similar tests were made on specimens taken from 99 per cent aluminum stock prepared in accordance with the specific embodiment of my method described with reference to Figs. 4 and 5 of the drawing. The results of these tests are given in the table:

	At the completion of 2 cycles		At the completion of 4 cycles	
	Longitudinal	Transverse	Longitudinal	Transverse
Tensile strength (lbs./sq. in.)	22310	22240	21630	22110
Yield strength (lbs./sq. in.)	19600	20300	18300	21600
Percent elongation	17.5	18.0	18.0	18.0

The foregoing data give a comparison between longitudinal and transverse properties both at the end of the second cycle and at the end of the fourth cycle; that is, in the first case the extrusion and upsetting to the original form is performed twice and in the second case four times. The results clearly show that stock prepared in accordance with the method disclosed herein is characterized by substantial freedom from directional properties.

It will be seen that by my invention I have provided a method of producing locomotive connecting rods which can conveniently be performed with existing equipment; which results in improved mechanical properties—especially as to fatigue limits; and effects a marked decrease in tendency toward directional properties. The method which I have devised also makes possible the production from standard sizes of ingot, of large aluminum alloy forgings characterized by a high fatigue limit.

I claim:

1. Method of producing a forged locomotive connecting rod which comprises providing an aluminum billet, upsetting said billet by applying a forging pressure in the direction of its longest dimension, returning said upset billet to substantially its original form by the further application of forging pressure in directions normal to the initial forging pressure, effecting a differential reduction in the cross section of the worked billet thus formed, and thereafter subjecting it to the action of forging dies to bring it to the desired form.

2. Method of producing a forged locomotive connecting rod which comprises providing an aluminum billet, subjecting said billet to a mechanical working cycle consisting in upsetting said billet by applying a forging pressure in the direction of its longest dimension and returning said upset billet to substantially its original form by further application of forging pressure in directions normal to the initial forging pressure, repeating said mechanical working cycle at least two times, reducing the cross section of the worked billet thus formed approximately 50 per cent at one end and approximately 80 per cent at the other, and thereafter subjecting it to the action of forging dies to bring it to the desired form.

3. Method of producing a forged locomotive connecting rod which comprises providing an aluminum billet, subjecting said billet to a mechanical working cycle at an elevated temperature consisting in upsetting said billet by applying a forging pressure in the direction of its longest dimension and returning said upset billet to substantially its original form by further application of forging pressure in directions normal to the initial forging pressure, repeating said mechanical working cycle at least two times, reducing the cross section of the worked billet thus formed approximately 50 per cent at one end and approximately 80 per cent at the other, and thereafter subjecting it to the action of forging dies to bring it to the desired form.

4. Method of producing a forged locomotive connecting rod which comprises providing an aluminum billet, subjecting said billet to a mechanical working cycle at a temperature of between about 500 and 840 degrees Fahrenheit consisting in upsetting said billet by applying a forging pressure in the direction of its longest dimension and returning said upset billet to substantially its original form by further application of forging pressure in directions normal to the initial forging pressure, repeating said mechanical working cycle at least two times, reducing the cross section of the worked billet thus formed approximately 50 per cent at one end and approximately 80 per cent at the other, and thereafter subjecting it to the action of forging dies to bring it to the desired form.

RICHARD L. TEMPLIN.