July 11, 1939. J. H. FRIEDMAN 2,165,472

AXLE AND METHOD OF MAKING SAME

Filed Oct. 28, 1936 2 Sheets-Sheet 1

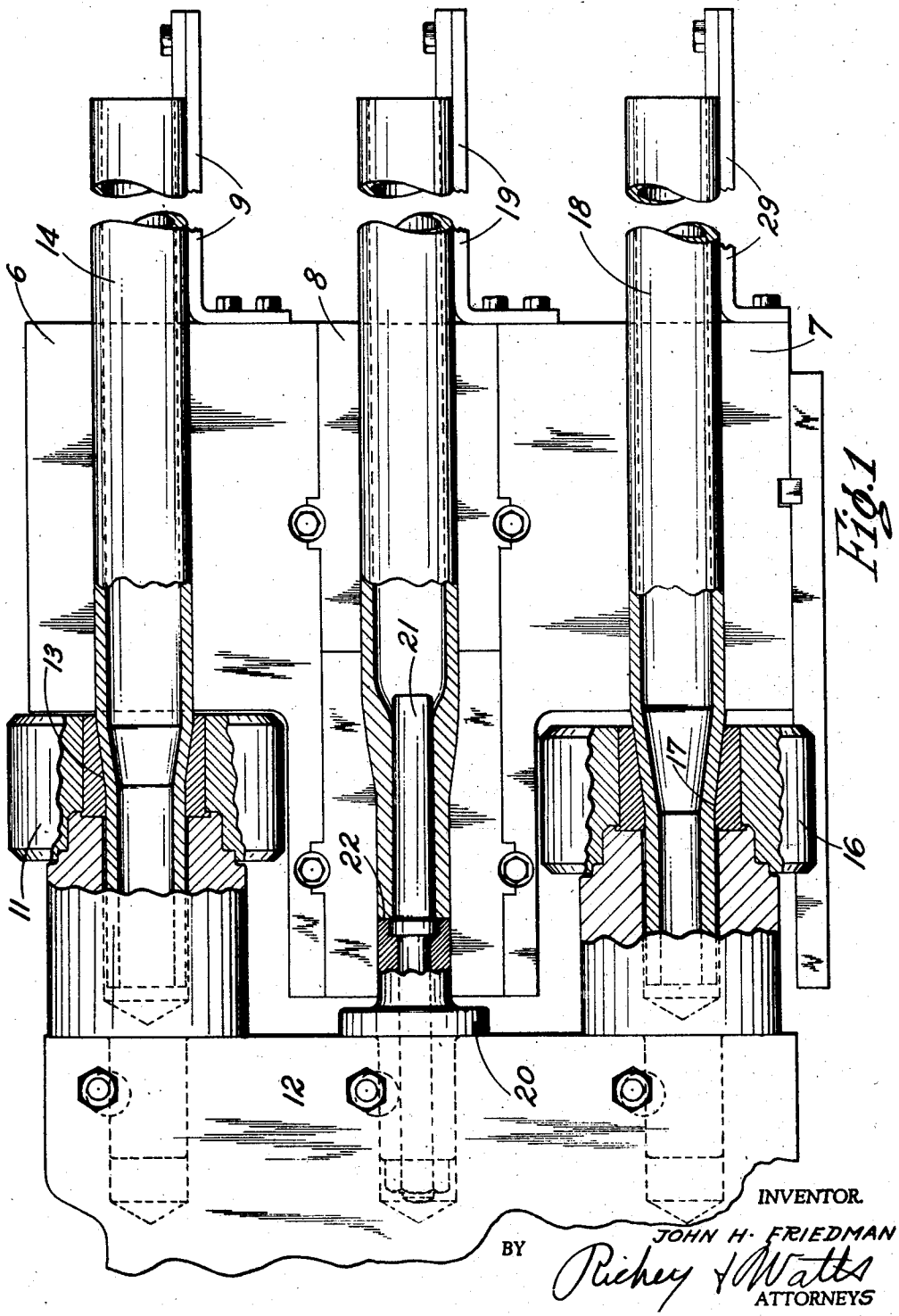

Fig. 1

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Fig. 2

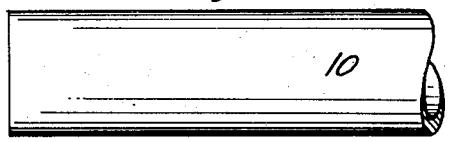


Fig. 3

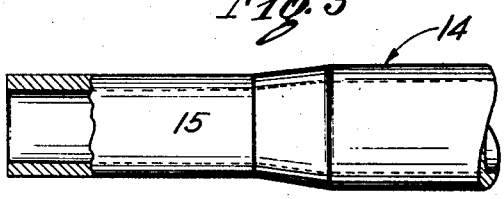


Fig. 4

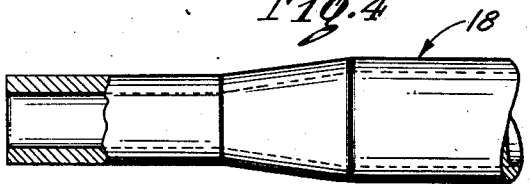


Fig. 5

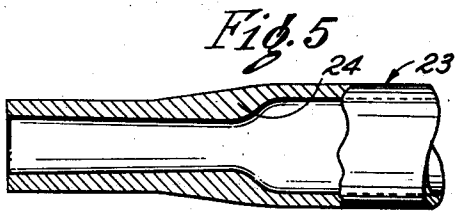
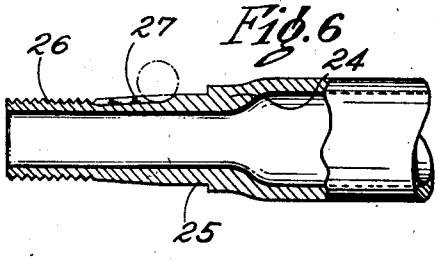


Fig. 6



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AXLE AND METHOD OF MAKING SAME

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5 Claims. (Cl. 29—153.1)

This invention relates to axles, axle forming apparatus and methods of making axles and more particularly to an improved tubular type of rear axle, the apparatus and methods associated therewith.

The advantages of the tubular type of rear axle which flow from its strength per unit weight and low cost has resulted in a general acceptance of said type by the automotive truck industry. To shape the outer end of the tubular axle to fit the rear wheel of the vehicle it is conventional to taper the end of the axle and provide the tapered portion with a key seat to key the wheel to the axle, a bearing shoulder to support the axle in the axle housing and a threaded portion at the outer end to retain the wheel on the axle. To strengthen the axle at the outer or wheel end thereof, it has been proposed to thicken the tubular walls by tapering this portion of the axle. Ordinarily the tapering is carried out by a swaging operation upon the end of the axle after the same has been heated to a forging temperature. This method, while effective to thicken the walls, appears to adversely affect the grain structure of that portion of the blank which is swaged. The swaging operation is a relatively slow, expensive operation and the working in the swaging dies tends to produce laminations or folds in the metal and produce areas of unequal hardness and unequal grain size. When an axle formed according to the above outlined swaging method fails in use, it is found that usually the failure is due to the fatigue of the metal and it is believed that this fatigue is accelerated by the numerous folds, laminations and unequal grain size caused by the swaging.

It is among the objects of my invention to provide an axle of the tubular type having a reduced wheel attaching end and a method of making the same wherein the reduced portion of the axle will have improved grain structure characteristics and wherein the method will effect economies in manufacture over the prior art methods. More specifically it is an object of my invention to provide a tubular axle having a reduced end wherein the reduction is carried out by successive cold working and hot working steps so that the hot working step will effect an annealing action throughout the portion of the tube previously cold worked. It is a further object of my invention to provide a method of making a tubular axle having a reduced end portion wherein the reduction is effected by successive extrusion and upsetting operations. It is a further object of my invention to provide a method according to the preceding object in which the extrusion is carried out cold and the upsetting is carried out upon a heated blank. It is a further object of my invention to provide a tubular axle having a reduced portion with thickened walls which have grain structure characteristics resulting from successive cold extrusion and hot upsetting. It is a further object of my invention to provide a tubular axle with a reduced end portion with the greatest wall thickness at the juncture between the reduced end and the body of the axle. Further objects and advantages relating to the novelty of the finished article and economies associated with the manufacture of same will appear from the following specification and the attached drawings wherein:

Figure 1 is a sectional view with parts broken away showing a plurality of axle blanks as arranged in a forging machine for carrying out the extrusion and upsetting operations according to my invention.

Figure 2 is an elevation of a tubular blank prior to the working thereof according to my invention.

Figure 3 is an elevation with parts in section showing the blank resulting from the first extrusion step.

Figure 4 is a view similar to Figure 3 showing the blank resulting from a second extrusion step.

Figure 5 is a view similar to Figures 3 and 4 showing the blank following an upsetting step.

Figure 6 is a view similar to Figures 3 to 5 showing the axle blank as milled and threaded and ready for assembly.

To avoid the structural defects inherent in the prior art swaged tubular axle and the disadvantages associated with the prior art methods of forming tubular axles and to attain the objects of my invention as outlined above I prefer to work the tubular blank by first forcing the end of same through one or more extrusion throats while cold and thereafter heating the extruded portion and upsetting the same. The above operations may be conveniently carried out on a conventional forging machine and I have shown in Figure 1 portions of such a forging machine having stationary gripping dies 6, 7 and 8. A complementary group of movable gripping dies (not shown) are adapted to cooperate with dies 6, 7 and 8 to securely grip the tubular blanks during the working thereof. To measure the extent of working carried out an adjustable stop or gauge 9 is employed which is arranged to abut

the inner end or unworked end of the tubular blank. A tubular blank such as 10 of Figure 2 is arranged in the gripping die 6 and projects beyond the forward face thereof in alignment with an extrusion die 11 carried by the header slide 12 of the forging machine. The extrusion die 11 is provided with a restricted throat as at 13, and as the header slide moves forward toward the gripping dies the extrusion die is forced over the projecting end of the blank 10. The first extrusion operation results in a blank indicated generally as 14 in Figure 3, which is provided with the reduced end portion 15.

In this connection I have found that a seamless tubular steel blank having a diameter of about $3\frac{25}{32}$'' may be successfully reduced to have a diameter as at 15 of $3\frac{3}{16}$''. Those skilled in the art, however, will understand that with the various types of materials and machines available greater or lesser reductions may be carried out by the method I have described. As will be noted by comparison of Figures 2 and 3 the portion of the blank which is reduced in the first extrusion step is somewhat elongated by the extrusion and the walls thereof are thickened. Referring again to the proportions mentioned above by way of example I find that the wall thickness during the first extrusion is increased from about $\frac{29}{64}$'' to about $\frac{15}{32}$''.

Following the first extrusion step the resultant blank 14 is moved to a lower blank gripping section at 7 of the gripping dies. The blank may be adjusted at its inner end by abutment with a gauge 29 as in the first instance and a second header slide die 16 is forced over the projecting end of the blank 14. The die 16 is provided with an extrusion throat 17 having a lesser diameter than that of the extrusion die 11. The reduction in diameter on the blank and the elongation of the blank effected by the second extrusion step is indicated in the blank 18 in Figure 4. Referring again to the specific example given in connection with this description of my method I find that the wall thickness during the second extrusion is increased from about $\frac{15}{32}$'' to about $\frac{1}{2}$''. In the second extrusion step a more gradual taper is formed by the entrance to the extrusion die 16 and the diameter is reduced from about $3\frac{3}{16}$'' to $2\frac{3}{4}$''.

Following the working of the blank by extrusion which is carried out cold so that extrusion lubricants may be employed and so as to improve the grain structure of the extruded portion, the outer end of the blank is heated by any suitable means to a forging temperature. The blank is then transferred to a third gripping section 8 in the gripping dies, which section is in alignment with an upsetting tool 20 carried by the header slide. While at this work station the blank is adjusted by gauge 19. The upsetting tool is preferably provided with a mandrel 21 arranged to project within the extruded tubular portion of the blank and the annular face 22 abuts the end of the blank 18. As the header slide moves forward the heated end of the blank 18 is upset by anvil face 22, and acquires the proportions illustrated by blank 23 in Figure 5. The upsetting operation thickens the walls further and reduces the length of the portion heretofore extruded. This operation results in the production of a wheel attaching portion about $2\frac{13}{16}$'' in diameter having a wall thickness of about $\frac{5}{8}$'' where carried out on a blank according to the example.

The greatest thickening of the tube wall results at 24, the juncture between the largest diameter of the tube and the reduced or wheel attaching portion of the tube. This provides an amount of metal which will safely permit the milling of the outer bearing shoulder 25 of the axle. It will be understood that the portion of the axle projecting beyond the bearing shoulder functions as a cantilever beam and that the maximum stress in the metal occurs at this point. The heating of the end of the blank to facilitate the upsetting anneals that portion of the blank which has heretofore been cold worked and the result is a tubular axle with a reduced end portion having uniform grain size throughout, free of laminations or folds and with walls adequately thickened to resist the stresses imposed thereon.

Following the extrusion and upsetting operations above described the axle blank is milled as shown in Figure 8 and is provided with a threaded extremity as at 26, a key seat at 27 and an annular bearing shoulder 25. The thickening of the walls provides ample material to permit safe milling of the key seat 27. It will be understood that the extrusion, upsetting and annealing as provided by my method will result in a key seat 27 wherein the metal of the seat is hard, of uniform grain size throughout, free of laminations and therefore less subject to failure by shearing out the key seat than the prior art structures.

Although I have described my invention in connection with a rear axle for a vehicle those skilled in the art will appreciate that the method is well suited to the formation of other articles such as, for instance, pipe joints, and that although I have described a preferred method of carrying out my invention in considerable detail, I do not wish to be limited to the precise axle structure shown or method described other than by the appended claims.

I claim:

1. That method of making a tubular axle having a reduced end portion with thickened walls which comprises extruding the end portion of a tubular blank while cold, heating said extruded portion and thereafter upsetting the heated extruded portion to shorten same and effect an increase in the diameter and an increase in wall thickness.

2. A tubular axle comprising a main body portion and an extruded and upset end portion, a length of the wall of said end portion immediately adjacent said body provided with a taper having a progressive outside diameter reduction toward the end of the axle, the interior of said end portion having a progressively decreasing diameter towards the main body of the blank through the same length whereby the maximum wall thickness is provided at the juncture between the main body portion and the extruded upset end.

3. That method of forming a tubular rear axle which comprises extruding a portion of the length of a tubular blank while cold, heating said extruded portion, confining the walls of said heated extruded blank between a mandrel and a die and upsetting the extruded and heated portion of the blank into the confines of the die and against said mandrel to increase the outer diameter and reduce the inner diameter of said extruded and heated end portion.

4. The method of making a tubular axle comprising extruding the end portion of a tubular metal blank while cold to form an end portion of reduced diameter joined to the main body of the blank by a tapered portion, and thereafter heating and upsetting the reduced end portion and the tapered portion so as to work the metal

of the tapered portion and increase the wall thickness thereof.

5. A tubular metal axle comprising a main body portion and a cold extruded and hot upset reduced end portion integrally joined to the body portion by an upset tapered portion, said tapered portion having a wall of substantially greater thickness than either the body portion or the reduced end portion, and said reduced end portion having a grain structure characteristic of that produced by first cold extruding and thereafter hot upsetting the metal.

JOHN H. FRIEDMAN.