Sept. 25, 1951 G. L. MILLER 2,569,248

METHOD OF MAKING HOLLOW AXLES

Filed Feb. 11, 1946 2 Sheets-Sheet 1

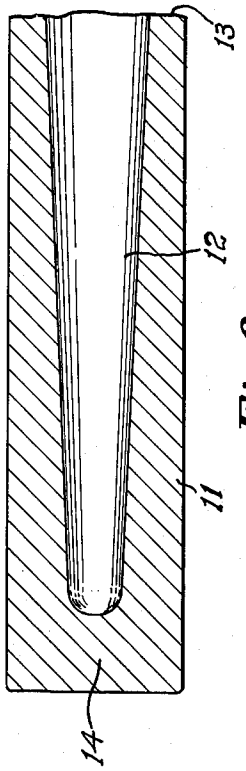
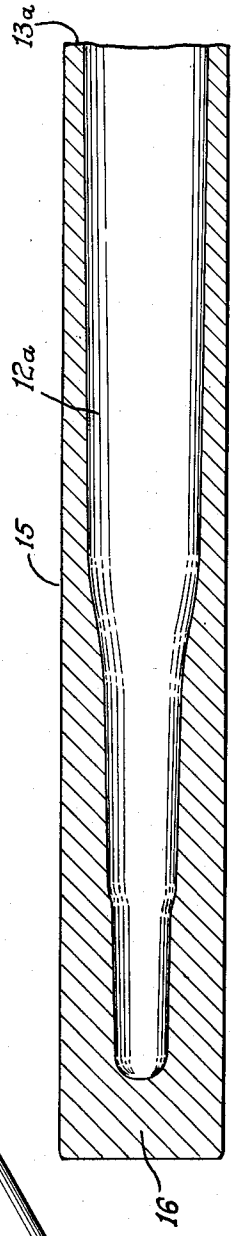


Fig. 2



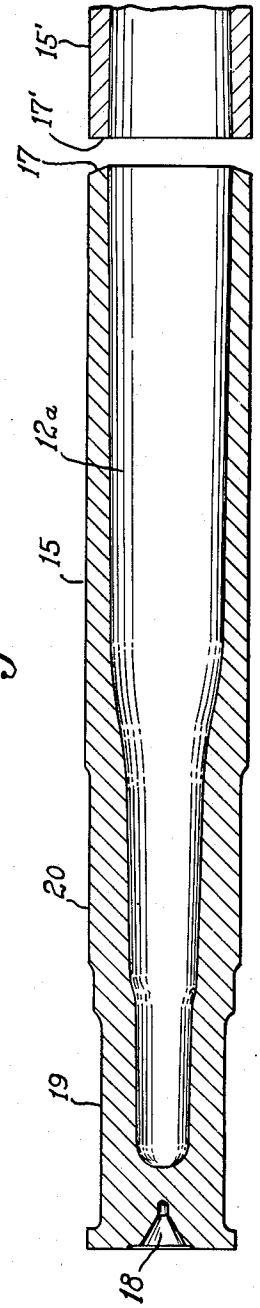


Fig. 3

Fig. 4

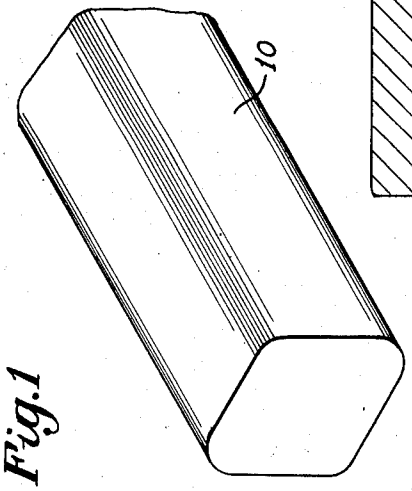


Fig. 1

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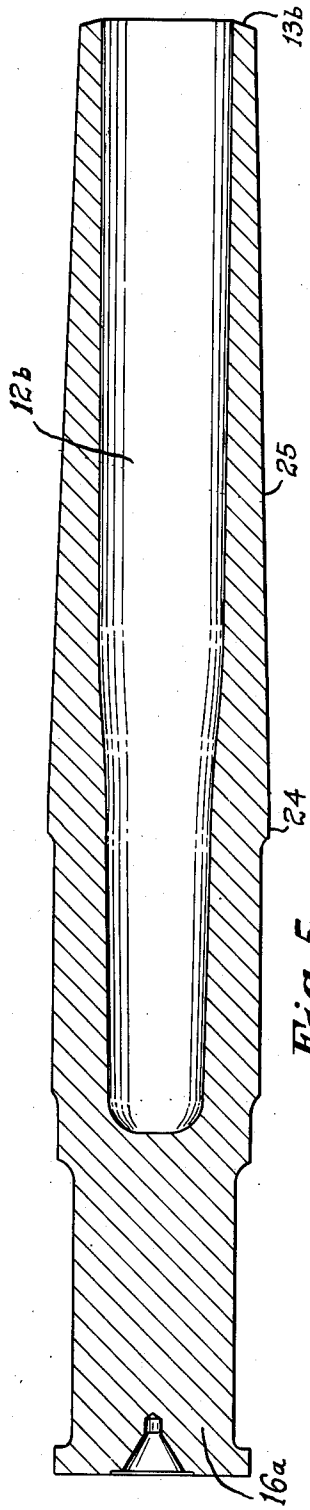


Fig. 5

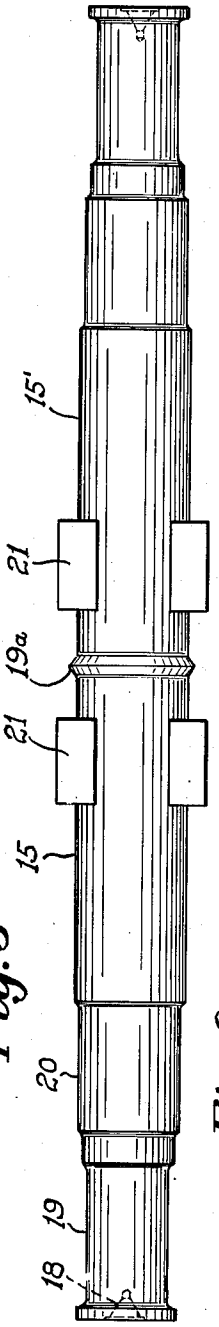


Fig. 6

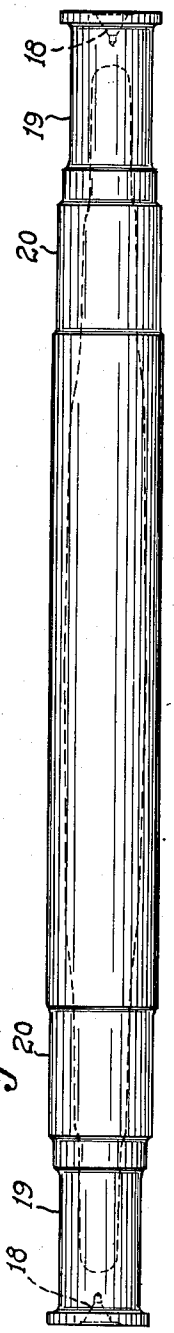


Fig. 7

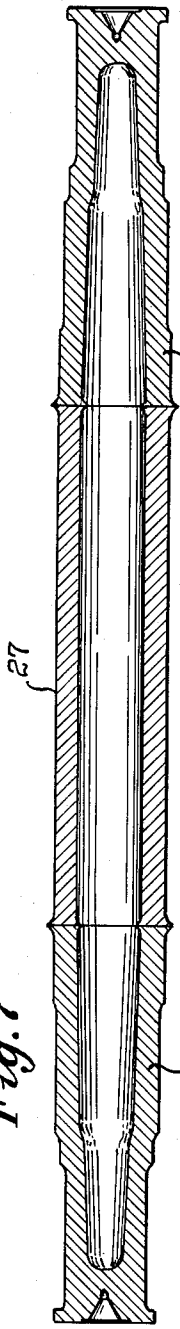


Fig. 8

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METHOD OF MAKING HOLLOW AXLES

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3 Claims. (Cl. 29—165)

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The invention relates to the manufacture of hollow forgings and more particularly to such forgings as may be adapted for use upon railroad equipment and other cars, engines and structures in which axles or hollow forgings may be used.

It is usually customary under present practice to make the axles for railroad equipment solid and in one piece. In spite of lighter weight, greater fatigue life and other advantages of a hollow axle, as compared with a solid axle, a relatively small number of tubular axles have been produced for use in railroad equipment. The tubular axles that have been produced for such purpose have been made from seamless tubes. Such tubular axles are not only expensive to produce, but they are difficult to make, requiring full steel mill operations through to the finished tube before starting operations on making the tubular axle, and the making of the tube and tubular axle require so many heating operations such as heating to roll through the blooming mill, heating to roll into bar stock, heating to pierce the bars in the tube mill, heating for upsetting tube ends, heating for forging the ends and finally the treating, that a high percentage of decarburization is formed on the outside and inside of the axle due to the open ends of the tube, hence a very definite weakness results in the finished axle. The decarburization destroys the carbon in the outer surface of the tube by heating so often in an atmosphere in which the concentration of the decarburized gases exceed a certain value, and carbon is the most important element in steel, hence, part of the life of the steel is destroyed by the process of making the tubular axle.

The solid axle has many disadvantages and no advantages, nor is it as strong for equal size as the hollow axle. It has extreme weight, the steel costs more; high labor cost in forging; development of thermal cracks due to the great mass and heavy sectional areas; cannot be forged concentric; no residual compressive stresses can be obtained on the outside diameter when heat treated due to the slow dissipation of heat because of the great mass and the annealing effect caused by the slow dissipation of the heat, hence not as strong; more time is required in the heating furnace preparatory to forging because of the great mass; heavier to handle in all operations of manufacture and finally excessive unsprung weight in the finished car truck and by actual test does not have the fatigue life equal to the hollow axle.

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The tubular axle also has serious objections in that it is very expensive to make both for raw material and labor and the many heating, upsetting and forging operations. Heavy decarburation is formed because of the many heatings on the outside diameter and the inside diameter, because of the open ends residual compressive stresses are offset in the quenching operation; non uniformity of metal thickness of sectional areas in the upset ends; flow lines and grain structures are distorted in the upset ends causing a weakness where the stresses are the highest in the finished tubular axle.

It will be noted from the above the practical and economical difference in the manufacture of my hollow axle as against the present tubular axle, especially in the cost of raw material required and also the labor. I start to make my axle from a piece of steel cut or broken from a billet, which is a product from the early operations in the steel mill, hence, low in cost compared to a finished tube, which is the last operation in the tube mill after the steel has passed through all the operations in the steel mill. The present tubular axle is fabricated from a piece of finished seamless steel tubing. I also wish to point out, in making a tubular axle, it is necessary to upset each end of the tube in order to get heavier or thicker metal in the axle where the greatest stresses are imposed, that is, at the journal and wheel seat locations, in this upsetting operation it is commercially physically impossible to get a uniform flow of the metal at these locations, resulting in thinner walls on one side and thicker walls on the other which results in an eccentric structure and a weakness on the thin side and will also cause the finished axle to run out of balance when installed in a car truck. This upsetting operation also causes a deformation of the molecular structure of the material causing the grain and flow lines of the steel to be distorted and having a tendency to separate which is very detrimental since it occurs in the areas that are most highly stressed.

These conditions do not obtain in my design of hollow axle, the wall thickness in all locations and the concentricity are fully controlled, on the outside diameter by the draw heads and on the inside diameter by the forming mandrel when the halves are being forced through the draw bench, also the flow lines and grain structure of the steel in my method of making axles has been formed in the most ideal condition to resist the maximum stresses imposed subsequently, and in addition, since my forgings are formed com-

plete by only one heating operation (the piercing drawing) there is little or no decarburization effect in the finished axle. The labor cost is also low as I can pierce and draw each half of the axle in two minutes and can weld the two halves together in five minutes, by actual test.

The axle when in service is under high fatigue stress, a reversal of these stresses occurs twice per each revolution of the wheel, by making my axle with closed ends and uniform sectional areas I have a product that lends itself ideally to the best known form or structure that subsequently is to be heat treated to incorporate residual compressive stresses on the outside diameter, the closed ends of the axle prevent the quenching medium from entering the hollow interior area, hence quenching occurs only on the exterior surface and the compressive stresses are thus formed on the outside wall of the axle only, subsequent applied stresses to the axle must overcome the residual compressive stresses inherently built into the axle before fatigue in the axle becomes effective, hence, my axle has a greater load carrying capacity and longer life than a solid or tubular open end axle, in which, due to their designs, beneficial compressive stresses are not obtained by the process of heat treating. Therefore it will be noted from my description that my hollow axle thus formed and with closed ends, when heated and quenched will produce compressive stresses on the exterior walls but will not produce compressive stresses on the interior walls since no quenching medium can contact the interior walls, this, as related above, produces a product that is superior for subsequent service where fatigue stresses are applied. In the tempering operation, which is subsequent to the heating and quenching operation care and good judgment must be exercised as temperatures too high will relieve the compressive stresses and therefore destroy the high fatigue value of the product. These desirable and very important features are not now obtainable in the orthodox or conventional type of axle now in common use.

The object of the present invention is to provide a method of making a product hollow which has many advantages, including the combined advantages of solid axles and tubular axles as made under present practice, with none of the disadvantages of either.

A further object is to provide a method of making hollow products with solid ends which prevent quenching coolant from entering the hollow interior when heat treating, thus producing improved physical structure by introducing residual compressive stresses in the exterior surface only the obtaining better depth hardness in the heat treating operation.

A still further object is to provide such a method of making a product in which the wall thickness is uniform and eccentricity held to a minimum.

Another object is to provide a method of this character in which the basic material used for making the hollow axle is economical to purchase because of minimum operations in the steel mill, by using a rough billet in which all operations necessary to the making of the hollow axle or product are proven practice and commercial facilities are available for all of said operations.

Still another object of the invention is to provide a method of making hollow axles or products by forging, in which the hot working of the forging produces an ideal physical structure.

A further object is to provide a novel method

of making a hollow axle which consists in cutting a piece of desired length from a round, or round cornered square billet, heating the piece to forging temperature, piercing it to a point near one end in a forging press with a tapered piercing punch or bar, removing the piece, while still hot, to a draw bench and forcing it through a series of draw heads of progressively smaller diameters until it is reduced to the proper outside diameter, trimming off their regular open end of the partially completed product, welding the open ends of two such pieces together, and then machining off the welding flash or fin and rough machining journal bearings, wheel seats and overall length, then heat treating.

The above objects, together with others which will be apparent from the drawings and following description, or which may be later referred to, may be attained by producing the hollow axle or other products in the manner hereinafter described in detail and illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a piece of steel broken from a billet, of sufficient size to make one half of the hollow axle;

Fig. 2 is a longitudinal section of the forging after it has been heated and pierced in the forging press;

Fig. 3 a longitudinal section of the partially completed product after it has been passed through the draw bench;

Fig. 4 a longitudinal section of one forging for one half of the axle and the open end portion of another similar forging, prepared for welding;

Fig. 5 a longitudinal section of a tapered forging prepared for welding;

Fig. 6 a side elevation of two forgings held in grip dies on a welding machine;

Fig. 7 a side elevation of the completed axle, and;

Fig. 8 a longitudinal section through two pierced forgings welded to opposite ends of a center tubular member to form a hollow axle.

In carrying out the improved method of making hollow axles or cylindrical products, a round, or round cornered square billet of commercial length, of either alloy or plain carbon steel, such for instance as S. A. E. 1040, furnishes the material from which the axles or hollow products are made.

A piece of the billet of proper length may be cut or broken therefrom by cutting the edge of the billet with a torch, at a predetermined length, and breaking this length off of the billet in a bulldozer, or other machine, providing a billet or bar blank as indicated generally at 10 in Fig. 1, of suitable dimensions to produce one half of a hollow axle, or cylindrical product.

The blank 10, shown in Fig. 1, is then heated to forging temperature and pierced in a forging press, using a tapered piercing punch or bar to produce the partially completed forging indicated generally at 11 in Fig. 2, having the tapered, longitudinal opening 12 extending from the irregular open end 13 to a point near the other or closed end of the forging as indicated at 14.

The forging as indicated at 11 in Fig. 2, is then removed from the forging press to a draw bench and while still hot from the original heat is forced through a series of draw heads of progressively smaller diameters until at the end of the draw bench the forging has been reduced to the desired outside diameter and a little longer than the required overall length as indicated at 15 in Fig. 3.

The piercing rod on the draw bench is also tapered and is of suitable dimensions and shape to make the tapered longitudinal opening 12a in the forging to predetermined size and shape. The partially completed product as indicated generally at 15 in Fig. 3, having the irregular open end 13a and the closed end 16 is then removed from the draw bench and allowed to cool.

After the forging shown in Fig. 3 has cooled sufficiently the irregular open end 13a is cut off to the proper length and prepared for welding, preferably by bevelling the same as indicated at 17 in Fig. 4. A center 18 may be turned in the closed end of the forging, and with the piercing rod or mandrel protruding from the open end thereof, the journal portion 19 and wheel seat 20 may be rough turned in a lathe. This forging may form one half of the hollow axle or other hollow product, and a similar forging as indicated at 15' in Fig. 4 has the irregular open end thereof cut off to the proper length as indicated at 17'.

The two forgings, indicated generally at 15 and 15', are then placed in grip dies, indicated generally at 21 in Fig. 6, in a flash butt welding machine, or other welding fixture or apparatus, with the trimmed off ends of the two forgings aligned and then brough close together and these open ends of the two forgings are welded together, forming the flash or fin indicated at 19a in Fig. 6. A one-piece axle is thus formed with hollow center and closed ends.

The axle as shown in Fig. 7 may then be heated, quenched and tempered to the proper hardness and when cooled is ready for the final finish on the journal bearings, wheel seats and overall length.

The hollow axle with solid ends produced in this manner has many advantages over the conventional solid axle and also over such open ended tubular axles as have been made in the past. As against the solid axle this hollow axle is approximately 30% lighter in weight and there is thus less weight to handle in plant operations and when installed in any railroad equipment or the like.

The hollow axle is interchangeable with the conventional solid axle. The basic material used in the manufacture of the hollow axle is economical to purchase because of minimum operations in the steel mill; commercial facilities are available for every operation required in the manufacture of this hollow axle and all operations necessary to the making of the hollow axle are proven practice.

The hot working of the forging produces an ideal physical structure, the solid ends preventing quenching coolant from entering the hollow interior of the axle thus producing an ideal physical structure, and better depth hardness is obtained in the heat treating operation.

The hollow axle or other cylindrical product has approximately 40% greater fatigue life than a solid axle or other cylindrical product, the factor of safety is higher, and stress concentration is less at the inner face of the wheel hub when used on railroad car trucks. The hollow axle permits of a better wheel seat because when pressing the wheel on the solid axle it very often happens that the axle and wheel are stressed beyond the elastic limit of the material, this condition will cause loose wheel. The hollow axle will yield when pressing the wheel on, hence reduces the possibility of loose wheels, and the hollow axle is more flexible and hence will absorb more shock.

Furthermore the hollow axle reduces maintenance cost and is more economical to manufacture and use. The wall thickness is uniform and eccentricity is held to a minimum and the solid ends permit of turing centers by means of which the axle may be more economically and accurately machined.

From the above description and the illustrations accompanying this specification it is obvious and apparent, to those skilled in the art that I have discovered a new, better and more economical process and method of making axles, one which by actual test has proven practical and will be superior to what is now being universally used. I am desirous of obtaining United States Letters Patent covering my discovery and I therefore claim the following.

I claim:

1. The method of making a hollow axle which consists in providing a billet blank of proper size to form one-half portion of the axle, heating the blank to forging temperature, forging the hot blank to produce an elongated straight forging having a tapered, longitudinal opening located through one end of the forging and terminating near the other end thereof, forcing the forging through a series of draw heads of progressively smaller diameters to increase the length and reduce the outside diameter of the forging and form the tapered opening therein to a predetermined size, trimming the open end of the forging, forming a turning center in the closed end of the forging and rough machining a journal bearing and wheel seat adjacent to said closed end, placing the trimmed end of the forging in a welding position relative to the trimmed open end of a similar forging and welding said forgings together and trimming the exterior forging flash, then heating, quenching and tempering the axle to retain the residual compressive stresses on the outside of the axle and to obtain a relatively tough and normal structure of the inside walls of the hollow section of the axle that has not come in contact with the quenching medium, because of the closed ends, and finally finishing the journal bearings, wheel seats and overall length.

2. The method of making a hollow axle which consists in providing a billet blank of proper size to form one-half portion of the axle, heating the blank to forging temperature, forging the hot blank to produce an elongated straight forging having a tapered longitudinal opening located through one end of the forging and terminating near the other end thereof, forcing the forging through a series of draw heads of progressively smaller diameters to obtain uniform flow lines of the metal and form a dense molecular structure and to increase the length and reduce the outside diameter of the forging and form the tapered opening therein to a predetermined size, thereby reducing the weight and materially increasing the ultimate strength of the finished axle, trimming the open end of the forging, forming a journal bearing and wheel seat adjacent to the closed end of the forging, placing the trimmed ends of the forging in a welding position relative to the trimmed end of a similar forging, rigidly holding the two forgings in perfect alignment to obtain perfect commercial concentricity, then welding said forgings together and trimming the exterior forging flash, then heating, quenching and tempering the axle to retain the proper residual compressive stresses on the outside of the axle and to obtain a relatively tough and normal structure, free from ten-

sile stresses, of the inside walls of the axle that has not come in contact with the quenching medium because of the closed ends, and finally finishing the journal bearings, wheel seats and overall length.

3. The method of making a hollow axle which consists in providing a billet blank of proper size to form one-half portion of the axle, heating the blank to forging temperature, forging the hot blank to produce an elongated straight forging having a tapered longitudinal opening located through one end of the forging and terminating near the other end thereof, forcing the forging while still hot from the forging heat through a series of draw heads of progressively smaller diameters to obtain uniform flow lines of the metal and form a dense molecular structure and to increase the length and reduce the outside diameter of the forging and form the tapered opening therein to a predetermined size, thereby reducing the weight and materially increasing the ultimate strength of the finished axle, trimming the open end of the forging, forming a journal bearing and wheel seat adjacent to the closed end of the forging, placing the trimmed ends of the forging in a welding position relative to the trimmed end of a similar forging, then welding said forgings together and trimming the exterior forging flash, then heating, quenching and tempering the axle to retain the proper residual compressive stresses on the outside of the axle and to obtain a relatively tough and normal

structure, free from tensile stresses, of the inside walls of the axle that has not come in contact with the quenching medium because of the closed ends, and finally finishing the journal bearings, wheel seats and overall length.

GEORGE LEE MILLER.

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