





UNITED STATES PATENT OFFICE

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AXLE

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Our invention relates to tubular front axles for automobiles and the like and provides a novel axle construction, as well as novel means for and method of producing ⁵ the same.

While we show herein a tubular axle of the reverse Elliott type, and there is a certain advantage therein, the invention is not to be limited to such construction.

- ¹⁰ Forged axles are known and have been accepted in automotive construction. Tubular axles of the Elliott type are also known. In such known tubular axles the end yoke and spring pad are forged from solid metal and
- ¹⁵ the scrapping of considerable metal is entailed in the process of machining. This is avoided in our construction as the spring pads are of pressed steel and the knuckles in the end of the tubing can be forged very

20 nearly to the size required with much less work of machining and less waste of metal.

Our axle may also be embodied in the Elliott type and constitutes an improvement over devices of the prior art.

- ²⁵ In such tubular axles of the prior art the tubing is of the same section from end to end whereas in the axle of our invention the arms are upset from a region under the spring pad to the outer ends thus strengthening and
- ³⁰ stiffening the axle where the maximum bending moment occurs.

As compared with an axle of the same strength our axle is much lighter than an axle of either the solid forged type or the prior

- of either the solid forged type of the particular the bold in the particular embodiment herein shown is at least twelve pounds lighter than the corresponding size of forged axle. This saving in unsprung weight is, of course, a great advan-
- ⁴⁰ tage as is well known to those skilled in the art.

According to our invention, we upset the ends of a tubular blank to give the desired strength to the arms under the spring pad

and the parts of the arm extending outwardly towards the wheels. Forged knuckle pieces are inserted in the end of the tube and secured therein by one of a number of ways,

⁵⁰ as, for example, by welding, forging, pinning or a combination of these actions.

The axle is then formed to shape and the spring pads are welded in place. The spring pads are preferably made of sheet metal stampings, although for certain purposes forging may be used. 55

The forming is preferably done as hereinafter illustrated in a press, which, upon forming the axle, quenches it and holds it to form. This provides both heat treatment and prevents warping.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying our invention, we shall describe in conjunction with the accompanying drawings a specific embodiment ⁶⁵ of the invention.

In the drawings:

Fig. 1 is a side view of the upset blank with the knuckle pieces welded in position in the ends thereof; 70

Fig. 2 is a side view of the completed axle; Fig. 3 is a longitudinal section through the same:

Fig. 4 is a transverse section through one of the arms taken on the line 4-4 of Fig. 3; 75

Fig. 5 is a fragmentary view showing the manner of attaching the springs to the spring seat;

Fig. 6 is a fragmentary side view of a modified form of spring seat and shock absorber ⁸⁰ hanger;

Fig. 6A is a top plan view of the same;

Fig. 7 is a fragmentary longitudinal section through a modified form of axle employing the forged knuckle piece; 85

Fig. 8 is a longitudinal vertical section through the blank which is employed in manufacturing the axle;

Fig. 9 is a similar section through the blank after the first step of reducing the diameter of the end;

Fig. 10 is a similar section of the tube after the first upsetting operation;

Fig. 11 is a similar view of the end of the 95 tube showing a second upsetting operation to adapt the tube to be attached to the knuckle piece by a forging or pressing operation;

Fig. 12 is a longitudinal section through the tube and the knuckle piece showing the 100

metal of the tube pressed or forged into the welding, as by means of an electric arc, the recesses in the shank of the knuckle piece;

Fig. 13 is a section taken on the line 13--13 showing the excrescences of metal produced 5 by the second upset operation

Fig. 14 is a section taken on the line 14-14 of Fig. 12 showing the projection of the tube walls inwardly to grip the shanks of the knuckle piece;

10 Fig. 15 is a longitudinal vertical section through the end of the tube showing a modified form of connection between the tube and the shank of the knuckle piece;

Fig. 16 is a side view of a forming and ¹⁵ quenching press;

Fig. 17 is a front elevational view of the dies employed in the press of Fig. 16; and

Figs. 18 and 19 are a side view and a bottom plan view, respectively, of the pressed metal ²⁰ spring clip.

Referring now to Figs. 2, 3, 4 and 5, the completed tubular axle is shown in these figures and it comprises a tubular member 1 having the arms 2 and 3 with knuckle pieces

25 4 and 5 secured to the ends of the arm. The knuckle pieces 4 and 5 are drilled as indicated at 6 and 7 for the reception of knuckle pins for the front wheels.

The bores 6 and 7 are set at an angle so that ³⁰ the axis of the knuckle pin intersects the supporting surface at a point somewhat in advance of or at the bearing of the tire upon the road as is well known to those skilled in the The tubular member or body 1 is conart.

35 structed of a piece of seamless steel tubing, the blank therefor being shown in Fig. 8. The tube initially is of approximately $\overline{2}'/$ in diameter and has a wall thickness approxi-

mately $\frac{3}{16}$ ". The outer ends or arms 2 and 40 3 are thickened by upsetting to points lying within the spring seats 8 and 9 as may be seen in Fig. 3. The outer ends of the arms 2 and 3 are reduced in diameter externally and are formed into the shape of tubular conical 45 sockets as indicated at 12 and 13, the walls being brought to a maximum thickness at the inner ends of the sockets as indicated at 14 and 15. The sockets 12 and 13 receive the shanks 16 and 17 of the knuckle pieces 4 50 and 5.

The sockets are reamed out and the shanks 16 and 17 machined and pressed into the ends of the tube (that is, forced into the socket) and are then secured by circumferential welds ⁵⁵ as at 18 and 19 to the knuckle pieces, shoulders being provided on the knuckle pieces adjacent the ends of the tube to provide a V-shaped groove which is filled with the welding metal. The shanks 16 and 17 are pinned to the

60 ends of the tubes preferably by welded pins as shown in Fig. 4 although tapered or riv-eted pins may be employed if desired. The welding is accomplished by drilling a recess at each side through the socket and into the body of the shank and then producing by

plugs 20 and 21, which at the same time are fused to both the body of the shank and the walls of the socket. Thereby, the circumferential or hoop strength of the socket is not 70 impaired and it is not necessary to drill away the body of the shank to an extent which would materially weaken the same. The pins 20 and 21 are placed principally on a neutral axis of the axle so that the beam strength 75 of the axle is not materially impaired. The welded pins 20 and 21 are highly advantageous in taking the torque reaction of the wheels upon the arms of the axle.

The inner welding line of the plug to the 80 shank lies below the dividing line between shank and socket so that the weld is not in shear but the body of the plug such as 20 or 21 is in shear at said dividing line. The strength of such riveted plugs or pins 20 and 35 21 in shear is very high with the result that excellent connection can thus be made. The shanks are pressed into the ends of the arms when the shaft of the axle is straight (that is, as shown in Fig. 1) and the taper between 00 the parts facilitates a very close mechanical fit.

The spring pads 8 and 9 which are shown more in detail in Figs. 18 and 19 are preferably made of pressed sheet metal or plate 25 stock and comprise a flat platform portion 23 upon which the lower leaf of the leaf spring 24 rests.

A pair of wings 25 and 26 integral with the platform portion 23 are formed into a 100 cylindrical shape to fit the outer cylindrical surface of the axle, the ends of the platform portion 23 extending outwardly, preferably beyond the diameter of the tube so as to form the corners 26 in which the U-bolts 27 and 103 28 are adapted to lie. The U-bolts are connected together by yokes 29 and 30, the yokes being just long enough to permit the leaf spring to lie between the sides of the shanks of the bolts and the seats or saddles 25-25, 110 extending around the circumference of the tube less than half way so that the said seats or saddles 25-25 are embraced between the shafts of the U-bolts 27 and 28. This pro-115 vides a light and compact spring seat. These curved wings which form the saddles or seats 25-25 are then welded along their edges to the tubular member 1 and with such welding the seats form rigid support against which 120 the U-bolts may draw to secure a very firm grip upon the axle. The platform portion 23 is provided with a hole 32 at the center for the reception of a pin or stud in the center of the spring. 125

In attaching the spring seat, the axle and clips or seats 8 and 9 are held in a jig while the edges 33 are fastened by hand welding and then the circumferential welds along the edges 35 of the saddles or seats 25 are ma- 130

by hand.

The extended welds along the edges provide a secure attachment between the spring ⁵ seat and the axle.

In Fig. 6, we have shown a modified form of spring seat in which the spring seat is formed of a forging. In this case, since the bottom is a solid cylindrical surface, extended wings

- 10 or seats are not required and the weld 37 at each side does not interfere with the location of the bolt as shown in Fig. 6, so that the cylindrical seat can be more extensive and can extend over a wider are of the surface of
- 15the tube. The weld 37 forms a fillet in the corner between the side wall of the seat member 38 so that it need not interfere with the shank of the U-bolts such as 27 and 28.
- As shown in Figs. 6 and 6A, such forged 20 spring seat may be provided with an arm 40 forming a shackle 39 for attaching the strap of a shock absorber or rebound check, such shackle having an eye 41 or being otherwise formed to receive the end of a strap or of a
- 25cable which may be employed for this purpose. If a two way shock absorber is to be employed the arm 40 may bear a pin or the like connection for the shock absorber.
- In the process of manufacture of the axle, the blank 10 shown in Fig. 8 is a piece of seamless steel tubing and while in the particular axle which we have built a diameter of $21_{4}^{\prime\prime\prime}$ and wall thickness of $\frac{1}{16}^{\prime\prime\prime}$ have been employed, it is to be understood that these dimensions are article.
- mensions are optional. The end of the tube is first swaged down as by rolling to taper the outer end as indi-cated at 45 in Fig. 9. This results in a slight
- elongation of the blank and a slight thick-40 ening of the walls of the outer end which later forms the arms 2 and 3. This rolling down is preferably accomplished at each end either simultaneously or individually and is
- 45 preferably done hot. The tube is then brought to a proper forging heat and is upset to thicken the walls to a point within the place where the spring seat, such as a 8 or 9, is later attached.
- At the same time, or by subsequent opera-50tion, the upsetting of the outer end to form the socket 12 is accomplished, the inside diameter being held to a definite shape by a mandrel formed in two parts and dividing at the point of maximum wall thickness as indi-55 cated at 14 in Fig. 10.

The sockets 12 and 13 are then reamed out to an accurate diameter and the shanks such as 16 and 17 of the knuckle pieces 4 and 5 are accurately machined and pressed in with

60 a press fit into the sockets 12 and 13, these parts being carefully held in alignment and the shaft or body of the tube being straight as indicated in Fig. 1. Then the circumferential welds 18--18 are formed, this opera- Further pressure overcomes the resistance

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chine welded. Obviously, this could be done although it may be done by hand. Then the pockets for receiving the welds 20 and 21 are drilled and the said welds are made between the shank and the walls of the socket. The drilling of the pockets may occur before 70 the circumferential welds 18 and 19 are made so that the two welding operations may be accomplished at substantially the same time.

This leaves the axle in the shape shown in Fig. 1 and it is now ready for forming. The axle is then heated preferably throughout its entire length or it may be heated only at the point where it is to be bent, that is, just outside of the place where the spring seat will 80 later be fastened. Then it is placed in the press shown in Fig. 16 and laid in the die 47 which has a groove to receive the axle as shown in Fig. 1. The lower die 47 has a spring follower plate 48 which is adapted to 85 be held in position by suitable follower springs indicated at 49. This spring follower plate 48 is provided with a seat for receiving the shaft or body of the axle and to hold the same with sufficient rigidity that the upper die member 50 in engaging the body of the 90 axle secures a firm grip upon the same. Then the uper die member 50 forces the axle down to bend the axle into the shape shown in Fig. 2.

The lower die member 47 is preferably ⁹⁵ mounted upon a plunger member 51, which plunger member may be connected to a hydraulic piston in a cylinder 52 and subjected to a predetermined hydraulic pressure in a connected accumulator, 53, subject to air pressure of a predetermined value. This holds the lower die member 47 in elevated position with a predetermined force which is sufficient in cooperation with the upper die member 50 to form the body of the axle to 105 the desired shape.

A box or chamber 54 surrounds the plunger and this box or chamber contains a bath of quenching liquid 55 which may be water or oil, or the like, the level of which is below the top of the lower die member 47 when the latter is in elevated position.

The upper die member 50 is preferably mounted on a hydraulic plunger 56 having an operating cylinder 57 capable of exerting a pressure in excess of the predetermined pressure, sustaining the lower die member. The operation is as follows:

The lower die member 47 being elevated as shown in Fig. 16 and the axle member being placed in the lower die member, hydraulic pressure is admitted to the upper end of the piston connected to the plunger 56 eausing the plunger to travel downwardly 125 and carry the upper die member 50 into engagement with the body of the axle, depressing the follower plate 48 and forcing the axle to conform to the shape of the die. tion preferably being performed by machine of the plunger 51 and both dies are then thrust 130

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down into the bath 55 with the axle held of frusto-conical or frusto-pyramidal rebetween them in such position that it is incapable of warping during cooling and the disposed about the periphery of the shank, axle is thereby quenched and at the same time and by an upsetting operation similar to that ⁵ held to the desired shape. The pressure is then released upon the upper side of the pis-ton of the plunger 56 and the pressure on the lower side of the plunger 51 causes the same to be raised to its upper limit, and then ¹⁰ the pressure applied to the lower side of the piston connected to the plunger 56 causes the die member 50 to be raised to clear the lower die and the contained axle. The axle is then removed and thereafter the spring 15 seats 8 and 9 are attached by welding as previously described to provide the completed axle shown in Fig. 2.

In Fig. 7, we have shown a modified form of the axle of the Elliott type where the forked 20 knuckle piece 58 is provided. The arm 2 is thereby shortened but the formation of the maximum strength against bending in any socket 12, the peripheral weld 18 and the pin welds 20 and 21 may be formed in the same ²⁵ manner and the spring seat 8 attached, all as previously described. The forked knuckle piece may then be drilled and finished just as the reverse Elliott axle shown in Fig. 2 may be drilled and machined to finish the axle.

In Figs. 11 to 14 inclusive, we have shown 30 the manner of attaching the knuckle piece and the end of the arm by pressing or forging operation to interlock the shank 60 of the knuckle piece 61. In this case, after the operation of forming the tapered socket 12 35 of Fig. 10, the end of the arm is upset in a die to produce the protuberances 63-63 upon the outside walls of the socket. The inside walls are tapered as in Fig. 10, the sockets being, however, shortened by such operation, 40 to provide the increased metal for the pro-tuberances 63. The shank 60 is provided with parallel corrugations or grooves across the top and bottom of the shank as indicated at 64, the shank otherwise being machined 45 and being pressed into the socket. The next operation is a pressing or forging of these protuberances 63 into the recesses 64 on the inside wall of the socket. That is to say, the outside wall of the socket is brought to a 50 circular form tapered outside.

The excess metal which was contained in the protuberances 63 which formed ridges of lunar shape upon the top and bottom of the socket are thereby forged into the pockets 55 or corrugations 64 as indicated at 65 in Fig. This disposal of the metal on top and 12. bottom places it in a position where it has maximum value for increasing the moment of inertia in bending. The operation of forc-ing the metal inwardly may be performed in 60 a suitable two part die engaging top and bottom of the outside of the socket.

Instead of grooves such as 64 across the top and bottom, the shank 66 of the knuckle 65

cesses 68 formed therein and these may be shown in Fig. 11 metal may be provided on 70 the outside of the socket which is then forced into such recesses 68-68 to provide the interlocking projections 69-69 connecting the socket and the shank 66 firmly together. The outer margins of the sockets and 75 the shanks may be welded if desired but if properly forged this is not necessary.

An advantage of the welded form is that the inside of the body is completely closed off from the outside so that moisture can-80 not get into the inside and corrode the axle.

Tests made upon this axle indicate its superioriy in performance as against axles of the prior art. The tubular shape of the body of the axle is highly desirable because of 85 direction and also because of its high torsional strength.

The bent ends or arms 23, which are con-90 nected to the wheels, form crank arms which particularly under the action of heavy braking of the vehicles tends to twist the axle with respect to the spring. The welding of the seats 8 and 9 to the body of the axle pro-95 vides a hold which is highly resistant to such torsional stresses as well as to other stresses which are incidental to the use of the axle.

The method of forming the axle disclosed 100 in this application forms the subject matter of our copending divisional application, Serial No. 409,094 filed Nov. 22, 1929 (Case 2); and the spring seat per se disclosed herein forms the subject matter of our divisional 105 application, Serial No. 409,095, filed Nov. 22, 1929 (Case 3); and the method of and means for heat-treating the axle disclosed herein forms the subject matter of our copending divisional application, Serial No. 409,096, 110 filed Nov. 22, 1929 (Case 4), to which divisional applications reference is here made for those details.

We do not intend to be limited to the details shown and described.

We claim:

1. An axle comprising a thin walled central body portion and end portions having thicker walls which taper inwardly and terminate in small diameter free ends, said end 120 portions being formed into upwardly extending arms, the walls of said arms being thickest at points disposed inwardly from the free ends thereof and being shaped from said points outwardly therefrom to form sockets 125 which open into the free ends of the arms, said sockets being tapered and having maximum cross sectional area at the free ends of the arms, knuckle pieces comprising solid tapered shanks fitted in said sockets and extendpiece 67 shown in Fig. 15 may have a series ing to the points of maximum thickness of 130

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said arms, and heads butted against the ends of the arms, and fusion welds joining said knuckle pieces to said arms.

2. An axle comprising a thin walled body ⁵ portion, a thicker walled arcuate portion at end of said body portion, a spring pad mounted on said arcuate portion, an externally tapered arm extending from the free end of said arcuate portion, the walls of said arm being

- 10 thickest at its midsection and tapering towards its ends, said tapering walls forming a frusto-conical socket having its base at the free end of the arm, a knuckle piece, a shoulder on said knuckle piece butted against the
- ¹⁵ free end of the arm, a frusto-conical solid shank formed integral with said knuckle piece and fitted within said socket, said shank extending to the thick walled midsection of the arm, a pair of fusion welds extending
- 20 through the arm walls and into said shank to key the shank against rotation in the socket, and a circumferential fusion weld joining said shoulder to the free end of said arm.
- 3. An axle comprising a thin walled body
 ²⁵ portion, a thicker walled arcuate portion at end of said body portion, a spring pad mounted on said arcuate portion, an externally tapered arm extending from the free end of said arcuate portion, the walls of said arm
 ³⁰ being thickest at its midsection and tapering
- towards its ends, said tapering walls forming a frusto-conical socket having a base at the free end of the arm, a knuckle piece, a frustoconical solid shank formed integral therewith, a shoulder at the junction of said shank and knuckle piece disposed at an acute angle to the axis of the shank, said shank being registered with said socket with the shoulder butted against the end of said arm, said shank 40 artspring to the thick walled midsection of
- ⁴⁰ extending to the thick walled midsection of the arm, a pair of fusion welds extending through the arm walls and into said shank to key the shank against rotation in the socket, and a circumferential fusion weld joining
 ⁴⁵ said shoulder to the free end of said arm.

4. An axle comprising a thin walled cylindrical body portion, arms upturned from the ends of said portion, the outer surface of said arms tapering inwardly so that the free ends
⁵⁰ thereof are of smaller circumference, the inner surface of said arms tapering inwardly from the junction of the arms and the body portions to define thick wall sections located medially of the arms, said inner surface tapering outwardly from said thick wall section to define tapered sockets opening inwardly from the free ends of the arms and to define

thin wall sections at the free ends of the arms, knuckle pieces having shanks registering with said sockets, said shanks being tapered to permit tight mechanical fits with the sockets and to facilitate locating the knuckle pieces at a definite distance apart, and fusion welds for fixedly securing said knuckle pieces to said

65 arms.

5. An axle comprising a thin walled cylindrical central portion, arms upturned from the ends of said portion, said arms being tapered to small diameter free ends, there being 70 sockets opening into the free ends of said arms, said sockets being tapered, knuckle pieces registered with the free ends of said arms, tapered shanks formed integrally with said knuckle pieces and registered with said sockets, said arms and shanks containing a 75 plurality of drill holes extending through the arms and into the shanks, plugs fused into said holes, and circumferential fusion welds joining the ends of the arms and the knuckle 80 pieces.

In witness whereof, we hereunto subscribe our names this 29 day of April 1929.

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