June 11, 1940.

J. E. GRAY ET AL

2,203,868

APPARATUS FOR MAKING WROUGHT METAL T'S

Filed June 26, 1939

4 Sheets-Sheet 1

FIG. 1.

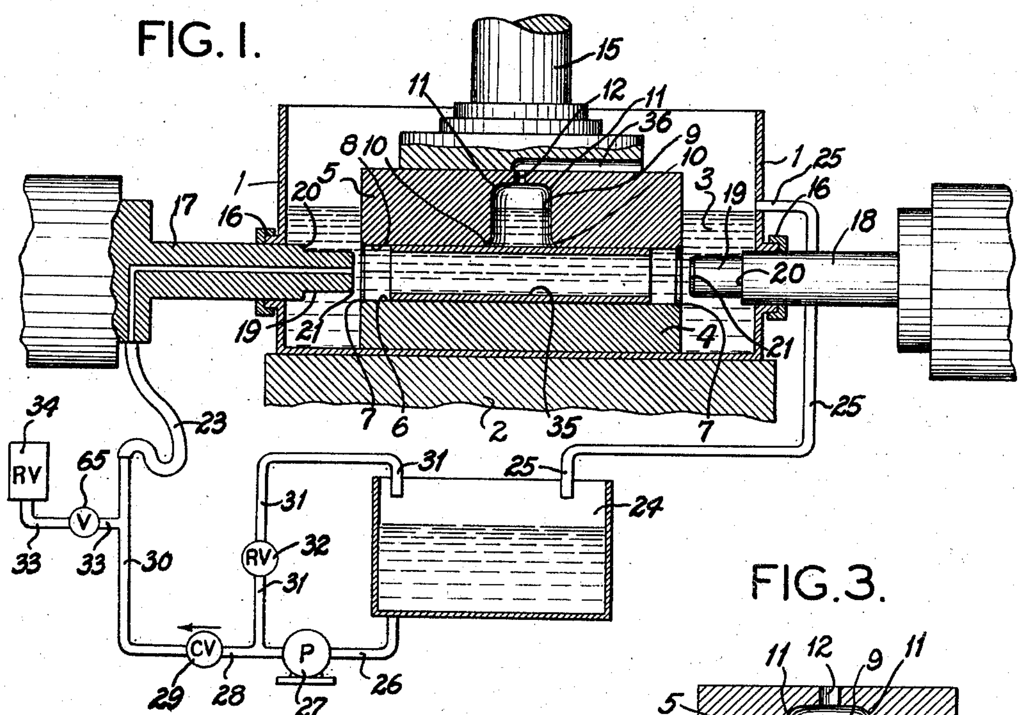

FIG. 3.

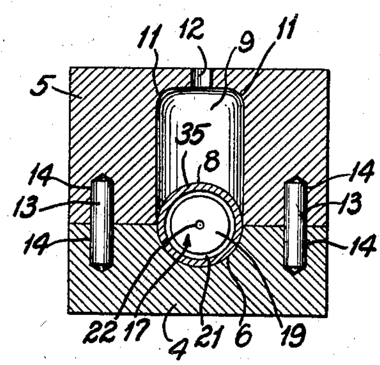

FIG. 2.

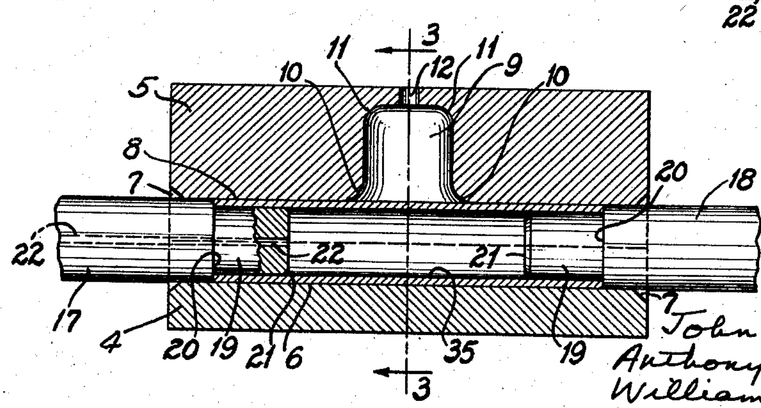

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FIG.4.

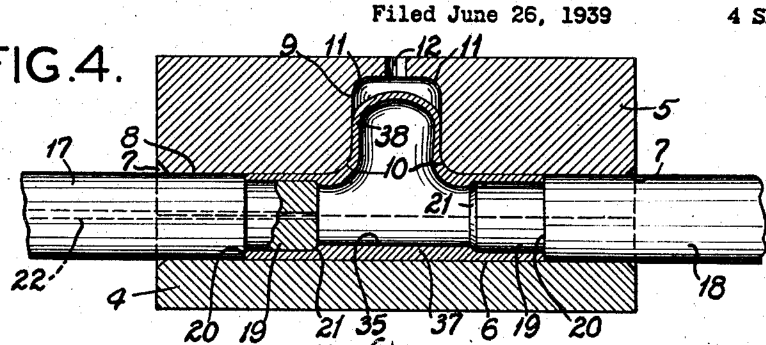


FIG.5.

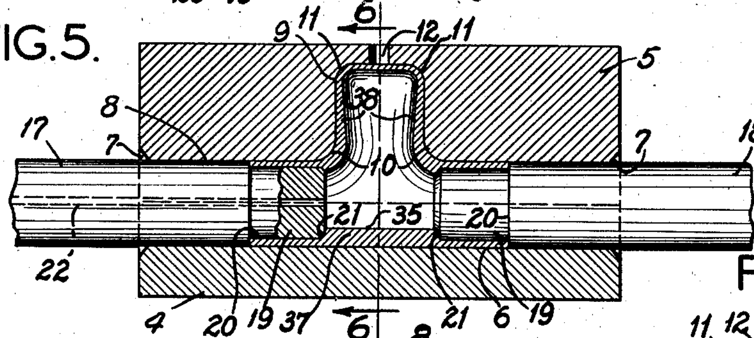


FIG.6.

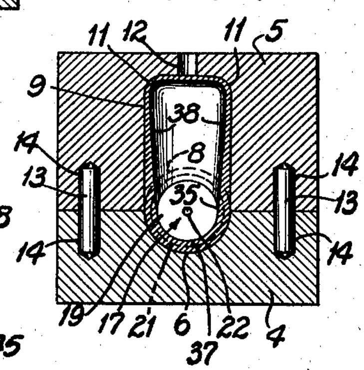
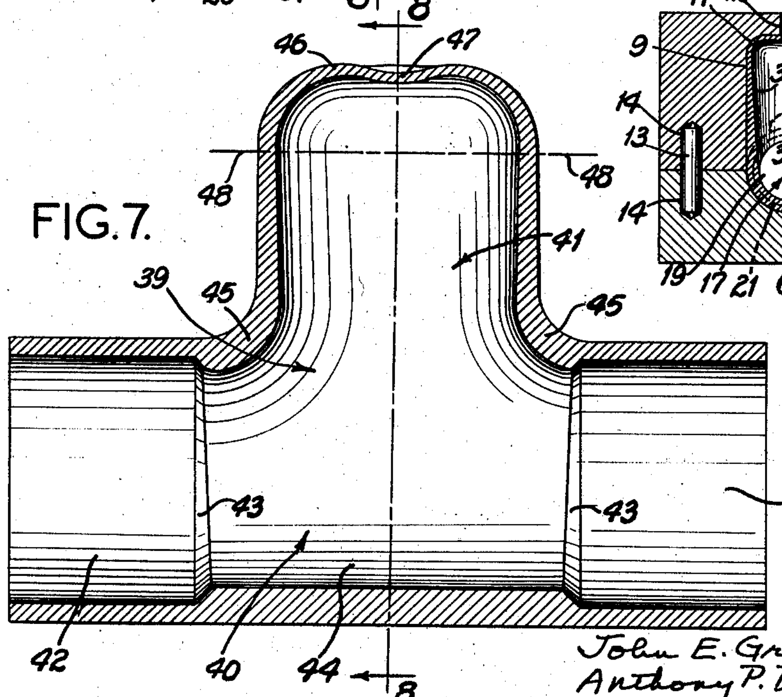


FIG.7.



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APPARATUS FOR MAKING WROUGHT METAL T'S

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FIG.8.

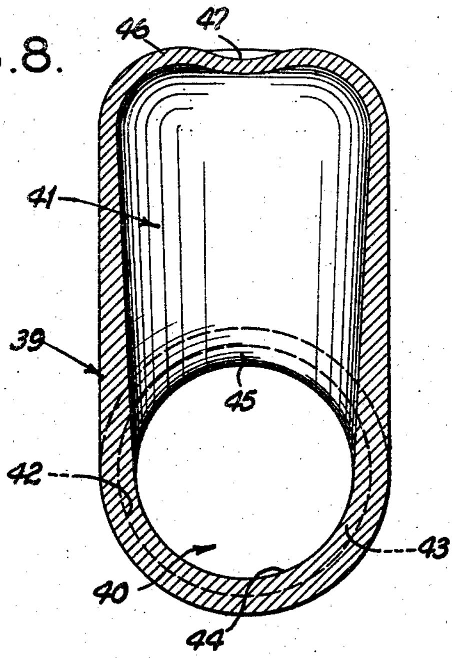

FIG.9.

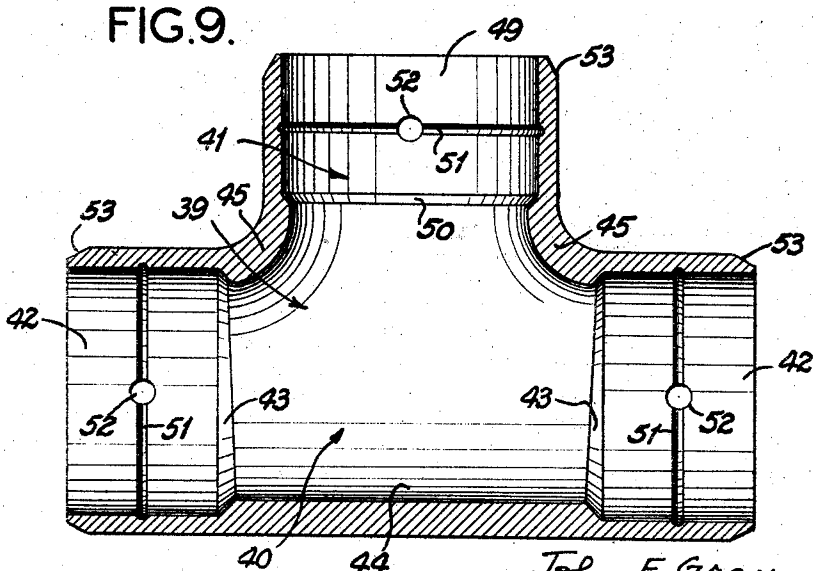

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FIG. 10.

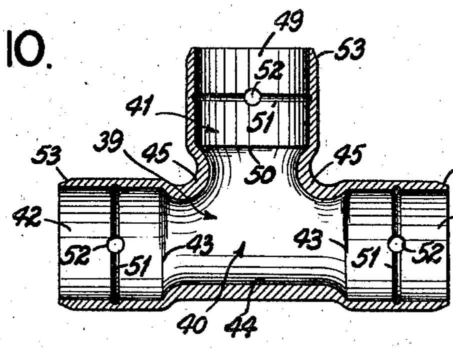


FIG. 11.

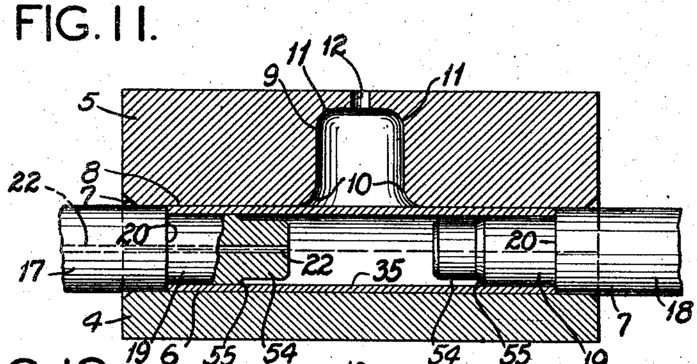


FIG. 12.

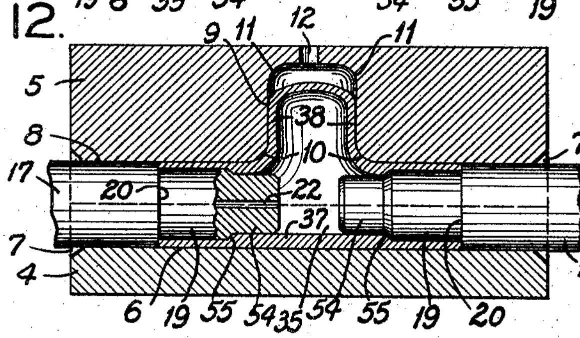
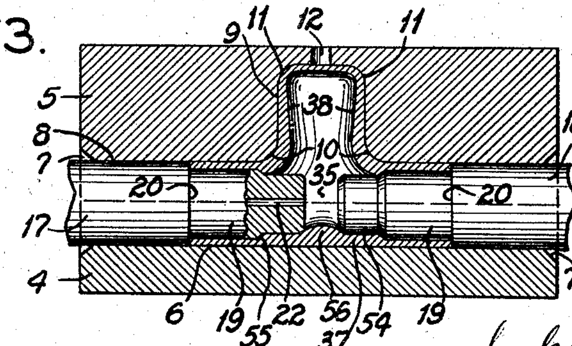


FIG. 13.



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Patented June 11, 1940 2,203,868

UNITED STATES PATENT OFFICE

2,203,868

APPARATUS FOR MAKING WROUGHT METAL T'S

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Application June 26, 1939, Serial No. 281,084

3 Claims. (Cl. 113—44)

This invention relates to wrought metal fittings having branches, such as T's, crosses, and the like, and the method of and apparatus for manufacturing such branch fittings, and, with regard to certain more specific features, to seamless branch fittings produced by a cold hydraulic drawing and upsetting operation from tubular blanks. It is to be understood that the term T is herein employed in a generic sense to designate fittings of the type or class having branches or laterals, and is intended to include such variations as those fittings commonly known as crosses, and those fittings commonly known as reduction T's, in which the several outlets or sockets for pipe connections are of different size, since the process of the invention is equally applicable to the formation of these variations of the T type of fitting.

One of the principal objects of this invention is the provision of apparatus for forming seamless metal T's more economically than by previous known methods.

Other objects of the invention are the provision of apparatus for manufacturing T's of the class described which, while subjecting a tubular blank to tremendous forces causing it to upset by plastic deformation to a blank of approximately T-shape, controls the application of said forces in such manner that rupture of the blank is avoided, and which, in the course of the upsetting operations, employs both endwise mechanical pressure applied to both ends of the tubular blank and coordinated internal hydraulic pressure within the tubular blank, the hydraulic pressure, however, being carefully controlled so that it does not exceed certain limiting values at various stages of the upsetting operation; the provision of a method and apparatus of the class described which is particularly designed for rapid operations upon a sequence of tubular blanks, and in which little individual personal attention needs be given to any one blank; the provision of a method and apparatus of the class described which, in the course of the upsetting operation on the tubular blank, causes a substantial flow of metal from certain regions of the blank into certain other regions of the blank, thereby to increase the thickness and therefore the strength of these latter regions; and the provision of a method and apparatus of the class described which is relatively simple and economical.

Another and more specific object is the provision of apparatus which requires no specially formed tubular blanks, but which is particularly adapted to use tubular blanks made from standard commercial copper tubing, and requiring no special treatment or pre-forming except the cutting of proper lengths from long lengths of the tubing.

Other objects of the invention are the provision of an improved form of wrought metal seamless T fitting produced from a seamless tubular blank; the provision of a T of improved strength in certain regions, such as the saddle region of the T by virtue of the wall thickness varying from point to point throughout the T, thicker portions being provided at such regions as are subjected to the greatest strain when the T is placed in ordinary use.

Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, and features of construction and operation, which will be exemplified in the articles and methods hereinafter described, and illustrated in the accompanying drawings in connection with the formation of a T, the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which are illustrated several of various possible embodiments of the invention,

Fig. 1 is a view, partly in section and partly diagrammatic, of apparatus used in carrying out the present invention;

Fig. 2 is an enlarged axial section showing a tubular blank in position in a pair of dies for an upsetting operation;

Fig. 3 is a cross section taken substantially along line 3—3 of Fig. 2;

Fig. 4 is a view similar to Fig. 2, illustrating an intermediate stage in the formation of the tubular blank into a T.

Fig. 5 is a view similar to Figs. 2 and 4, illustrating a final stage in the forming operation;

Fig. 6 is a cross section taken substantially along line 6—6 of Fig. 5;

Fig. 7 is an enlarged longitudinal section of the partially finished T as it is removed from the dies, after the completion of the forming stage indicated in Fig. 5;

Fig. 8 is a cross section taken substantially along line 8—8 of Fig. 7;

Fig. 9 is an axial section of a completed T made in accordance with the present invention;

Fig. 10 is an axial section of an alternative form of completed T made in accordance with the present invention; and

Figs. 11, 12, and 13 are longitudinal or axial sections respectively similar to Figs. 2, 4, and 5, illustrating an alternative embodiment of the method of the present invention.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

The present invention is concerned with the manufacture of T's, adapted for use as pipe fittings or the like, from tubular blanks by plastic deformation of the metal by upsetting and drawing operations. The present invention finds its chief utility in connection with metals such as copper and its alloys; in fact, wrought copper is the metal for which the method of the present invention is principally designed. However, the invention likewise applies to other metals that are capable of being worked plastically in the manner hereinafter set forth; and while the invention will hereinafter be described principally with respect to copper as the metal, it is to be understood that it will likewise apply to other metals.

The cold plastic deformation, by upsetting or hydraulic drawing, of tubular blanks into T shapes is not broadly new. Nor is the upsetting of the tubular blank by combined mechanical pressure and internal hydraulic pressure in itself broadly new. In the present invention, however, a correlation of pressure applied mechanically, endwise to the ends of the tubular blank, and a carefully controlled internal hydraulic pressure, is brought about in such a manner that, for the first time, a satisfactory T may be produced by this general class of operations.

The present invention produces a T cheaply which not only satisfactorily meets all of the requirements for a satisfactory pipe fitting, but likewise presents many additional advantages hereinafter to be pointed out in greater detail.

The apparatus of the present invention will first be described, attention being particularly invited to Fig. 1.

Numeral 1 indicates a vat or tank, which is supported on a base 2 of suitable rigidity. The vat 1 is filled to a predetermined level with a liquid 3, which may well be water. However, certain oils which have a low coefficient of compressibility are preferable under certain conditions.

Numeral 4 indicates the lower half of a split die arrangement, the upper half of which is indicated at numeral 5. The lower die half 4 comprises a rectangular block of metal, such as steel, across the top face of which is positioned a semi-circular groove or impression 6 (see also Fig. 3). The ends of the groove 6 are preferably somewhat flared outwardly, as indicated at numeral 7, at the point at which they meet the end faces of the block 4. The block 4 normally rests on the bottom of the tank 1, with its groove 6 upwardly facing.

The upper half 5 of the split die is likewise a rectangular block, albeit somewhat thicker than the block 4. In its lower face it carries a semi-circular groove or depression 8 which matches with the groove 6 in the block 4, in order to provide a cylindrical hole through the length of the composite die. At a mid-position in the length of the block 5, a cylindrical hole 9 extends upwardly from the groove 8 to a point just short of the top of the block 5. This hole 9 constitutes the negative imprint of the neck of the T that is to be formed. Its diameter is determined by the desired diameter of the neck of the T to be formed, and will be assumed, for present purposes, to be equal to the diameter of the run of the T, that is to say, equal to the diameter of the hole formed by matching grooves 6 and 8.

The line of juncture between the hole 9 and the groove 8 is carefully rounded off as indicated at numeral 10, at a substantial radius of rounding, such as the order of one-third of the radius of the hole itself. This is an important point in connection with the proper, smooth flow of metal later in the upsetting operation. Likewise, the inner end of the hole 9 is rounded, or filleted, as indicated at numeral 11, at a substantial radius of curvature. A small vent hole 12 connects the upper end of the hole 9 with the top face of the block 5.

Referring momentarily to Fig. 3, it will be seen that tapered end pins 13, which fit into suitable holes 14 in the blocks 4 and 5, are provided, in order, when said blocks 4 and 5 are brought together, that the grooves 6 and 8 will accurately match to form a truly cylindrical hole through the die assembly.

For maximum facility in operation, the upper half 5 of the split die construction is mounted on the lower end of a vertically moving hydraulic ram 15 (see Fig. 1). A groove or channel 36 is provided to connect the end of hole 12 in the upper die half 5 to the outside. The hydraulic ram 15, exteriorly actuated by means customary in this art, holds the split die construction together when expansion operations are conducted therein, with sufficient force so that the die halves will not separate.

Aligned axially with the cylindrical hole provided by the matched die halves there are provided, in the opposite walls of the tank 1, a pair of gasketed bushings 16, through which operate hydraulic rams or plungers 17 and 18. The plungers 17 and 18 are exteriorly actuated by suitable well known means, such as hydraulic pistons, to move toward each other, inwardly into the die, at the same controlled speeds. Throughout the majority of their lengths, the rams 17 and 18 have an external diameter just sufficiently less than the internal diameter of the cylindrical hole through the assembled die, to permit of their sliding therein. At the inner extremities of each of the rams 17 and 18, however, portions 19 of reduced diameter are provided and sharp shoulders 20 connect these portions 19 to the remainder of the rams. The extreme ends of the rams are preferably slightly tapered, or beveled, as indicated at numeral 21.

A fluid passage 22 runs through the ram 17, and opens at the inner end face thereof. A stout flexible hose or conduit 23 makes an external connection to the passage 22.

In general, the ram 18 is solid, and is not provided with a fluid passage analogous to fluid passage 22 in ram 17, but it is within the scope of the present invention to provide a similar fluid passage 22 in the ram 18.

Numeral 24 indicates an overflow tank or sump that is usually mounted at some position beneath the tank 1. An overflow pipe 25 is arranged to maintain the pre-established liquid level in the tank 1, and to conduct any overflow liquid to the tank 24.

Numeral 26 indicates a conduit that leads from the bottom of tank 24 to a high pressure pump 27. A conduit 28 leads from the pump 27 to a check valve 29. The check valve 29 opens in such direction as to permit liquid to pass away from the pump 27, but not back towards the pump 27, in conduit 28. A conduit 30 connects the opposite side of check valve 29 to the flexible conduit 23, and thus to the passage 22 in ram 17.

A by-pass conduit 31, in which is provided a suitably adjusted release valve 32, leads from the conduit 28 back to the overflow tank 24. Branching off from the conduit 30 is a conduit 33, which leads to a suitable relief valve 34. A manually operative valve 65 is also provided in the line 33. The relief valve 34 is of a high pressure type, and may well be apparatus of the type known as liquid intensifiers.

The apparatus as thus described is used to manufacture T's in the following manner:

In order to accurately describe the present invention, it will be presumed that it is desired to make a wrought copper T for use with two-inch outside diameter pipes. In other words, each of the pipe-receiving sockets of the T is to be capable of receiving a suitable length of two-inch pipe.

For such a T, we take a tubular copper blank about ten inches long, with an outside diameter of about 2.25 inches, and a wall thickness of about 0.135 inch. The copper of this tube should be in a fairly soft condition, although it need not be completely annealed. The tubular blank is straight and open at both ends, and is preferably cut from a length of standard commercial copper tubing.

The ends of the tubular blank are squared off, preferably as square as possible with ordinary cutting machinery, and the ends are preferably freed of burrs and like irregularities. Beyond this no special pre-forming is necessary to prepare it for use in the present method.

The tubular blank, as thus prepared, is now positioned in the groove 6 of the lower die half 4, it being presumed that the upper die half 5 has been drawn away from the lower die half 4 by means of the plunger 15.

The tubular blank, from this time on, is indicated in the drawings by numeral 35. Since the tubular blank 35 is thus initially immersed entirely below the liquid level 3 in the tank 1, in the course of its being positioned in the groove 6, it is completely filled with liquid. It is advisable that this filling with liquid be complete, and that no air be permitted to remain in the blank.

When the blank 35 is placed in the groove 6, it is preferably centered as closely as can be done by eye. Accurate centering is not needed, however, at this time.

The plunger 15 is now operated to bring the upper die half 5 down into conjunction with the lower die half 4. When the juxtaposition of these two die halves is had, it will be seen that the tubular blank 35 is completely enclosed in the cylindrical hole through the assembled die. The external diameter of the blank 35 is equal to, or just slightly less than, the internal diameter of said cylindrical hole.

Fig. 1 illustrates the various elements at this stage of operation.

The pump 27 is now brought into operation, if it is not already operating. This pump 27 is of such a character that it is able to produce, at its outlet, a fluid pressure somewhat in excess of the order of 4000 pounds per square inch, for the size T here concerned. However, it will be seen that the liquid conduit system is such that, as long as the end of passage 22 at ram 17 is open, and not confined, the pump merely forces liquid through the conduit 28, check valve 29, conduits 30 and 23, and the passage 22, into the tank 1. The overflow conduit 25 conducts all liquid above the pre-established level back to the overflow tank 24.

The rams 17 and 18 are now brought into operation. Both rams are advanced inwardly at the same rate, and at a rate such that, if they were not obstructed, they would meet, end to end, precisely at the central axis of the hole 9 of the upper die block 5.

Soon the ends 19 of reduced diameter on the rams 17 and 18 enter the ends of the cylindrical hole through the die, and almost immediately thereafter enter the respective ends of the tubular blank 35. The diameters of these end portions 19 are preferably equal to, or slightly less than, the internal diameter of blank 35, so that the fit between said end portions 19 and the blank 35 is a relatively tight one.

If the blank 35 is not accurately centered in the die, it will be seen that the advancing rams now quickly center it.

Soon the shoulders 20 at the end of the reduced diameter portions 19 of the rams 17 and 18 come up flush with and abut the squared ends of the tubular blank 35. This condition is indicated in Fig. 2. Since liquid has been flowing out the end of passage 22 in all of the intervening time, there is an assurance that the entire interior of the tubular blank 35 will be filled with liquid. Just before a sealing joint is obtained between the ends of the tubular blank and the shoulders 20 of the rams 17 and 18, the liquid pressure within the blank 35 will begin to build up. At the instant a sealing pressure is effected, the internal hydraulic pressure is controlled by the setting of relief valve 32.

The rams 17 and 18 continue to advance towards each other. In so doing, the shoulders 20 force the end of the tubular blank 35 inwardly. This inward motion of the ends of the blank causes upsetting of the metal of the blank. The flow of metal is all toward the center of the die because the thickness of the annular space between the reduced diameter ends of the rams and the side walls of the die is equal approximately only to the original thickness of the wall of the blank. Subsequently, the metal of the central portion of the blank tends to increase in thickness, as indicated at numeral 37 in Fig. 4, with a resultant decrease in internal volume of the blank.

Meanwhile, the pressure of the liquid within the blank will increase. This is because of the volume of the interior of the blank is continually decreasing, by reason of the inward displacement of the ends of the blank, and no outflow of liquid back through the passage 22 is permitted because of the action of the said check valve 29 (it is to be understood that the relief valve 34 is set to operate only at a relatively high pressure).

The result is that the increased-thickness, central portion 37 of the blank 35 is forced to expand or flow into the hole 9 of the die block 5, forming an incipient T neck 38 (Fig. 4). During this expanding, the liquid trapped in the hole 9 outside the blank 35 is vented through the hole 12 and passage 36. The flow of metal is smooth and even around the curved line of juncture 10, instead of at a sharp right angle such as would exist were the line of juncture 10 not curved.

The combined effect of the internal liquid pressure and the mechanical force of the rams on the ends of the blank is to cause a smooth flow of metal into the incipient neck 38. The metal which flows into the incipient neck 38 is drawn from the central portion 37, which, for reasons heretofore explained, is of increased thickness.

If the plastic deformation were permitted to go on without venting or relieving the liquid pressure within the blank by means of relief valve 34, said liquid pressure would quickly increase to such a value that a rupturing or fracturing of the blank would take place. For this reason, the relief valve 34 is set at a predetermined high pressure level, so that the liquid pressure within the blank will never exceed this value. By so controlling the liquid pressure within the blank, rupture is not only avoided, but the drawing of the metal into the incipient neck of the T takes place in an orderly manner, so that it is correlated with the amount of excess metal provided by the flow of metal caused by the mechanical pressure of the rams 17 and 18 on the ends of the blank 35.

By so correlating the maximum internal pressure of the liquid in the blank 35, the expanding operations may be carried on with satisfaction until the incipient neck 38 completely fills the hole 9 in the die half 5, as indicated in Fig. 5. Fig. 5 thus indicates a maximum inward movement of the rams 17 and 18. When this point is reached, the direction of movement of the rams 17 and 18 is reversed, and they are withdrawn from the die assembly. Thereafter, the plunger 15 is operated in an upward direction so as to remove the die half 5 from the die half 4, and the roughly formed T is then freed from the upper die half 5 by applying a suitable instrument through the hole 12. This instrument application may be performed automatically by having a suitable knock-out plunger slidably moving inside the plunger 15.

Fig. 7 is an enlarged view of crude T as it comes from the forming operation. Said T is now designated by numeral 39. It includes a run portion 40 and an unfinished neck or side outlet portion 41. The run 40 internally terminates as socket portions 42, the wall-thicknesses of which are substantially equal to the wall-thickness of the original tubular blank. Each socket 42 is inwardly terminated by a sloping shoulder 43, produced by the bevelled ends 21 of the rams 17 and 18. The portion 44 of the run 40 between the sockets 42 is of greater wall-thickness (frequently as much as 0.27 inch in the stated example) than the sockets 42. The neck 41 may be in overall length somewhat longer than either of the socket portions 42; it connects smoothly, along a curved line of juncture 45, with the run 40. The end 46 of the neck 41 is presently closed off by a web of metal, which may be slightly dented, as indicated at numeral 47, as a result of the application of the knockout tool during its removal from the die. The wall thickness of the neck diminishes from a maximum thickness, say, of twice the original wall-thickness of the tubular blank, along the line of juncture 45, to a minimum thickness not greatly less than the original wall-thickness of the tubular blank near the end of said neck (not including the web 46, which is usually considerably thinner).

The entire T is characterized by the smooth, unbroken, seamless surfaces of its interior. No buckles, ridges, or waves are discernible if the method has been carried out proficiently. The excessive thickness of the portion 44 of the T, and along the line of juncture 45, provides added strength and reinforcement at just those parts of the T which, in service, are subjected to the greatest strains.

The operations required to complete the manufacture of the T are few and simple. First, the web 46 is cut off, say along a line 48 (Fig. 7). Then a drill or other suitable tool is applied to the neck 41 in order to provide it with a socket 49 (Fig. 9) inwardly terminated by a shoulder 50. The shoulder 50 is substantially as wide as the shoulders 43 bottoming sockets 42. But the line of juncture 45 remains with its original strengthening excess thickness.

The ends of the run 40 are now cut off to make the socket portions 42 equal in axial length to the socket portion 49. A drill or reamer may be applied to the walls of the sockets 42 to bring them to smooth, true cylindricity, but ordinarily this is not necessary, as the rams 17 and 18 have left these sockets in sufficiently true cylindricity for joint-making purposes.

Not only is the metal-thickness distribution of the finished T in optimum arrangement, but likewise the metal hardness; all as a result of the method by which the T has been formed. The metal of the finished T is discernibly harder in the portions 44 and 45 than in the socket portions 42, 42, and 49. A maximum hardness is ordinarily found in a region of the run of the T diametrically opposite the neck portion 41. This hardness distribution likewise adds to the strength of the finished T.

As an alternative finishing procedure, the rough T, subsequent to the cutting off of the web 46, may be expanded or belled outwardly to provide expanded sockets 42, 42, and 49 (Fig. 10) of relatively greater internal diameter, instead of the drilled sockets of Fig. 9. This procedure is frequently more satisfactory with smaller T's of lesser wall-thickness.

It will be obvious that different diameter T's will require different sets of pressures. In general, the smaller the diameter, the greater will be the pressures required. For example, if a T is formed from a copper blank with an outside diameter approximately ⅞″ and a wall-thickness approximately .065″, the initial pressure controlled by relief valve 32 will be on the order of 4,000 to 6,000 pounds per square inch, and the maximum pressure controlled by relief valve 34 will be on the order of 8,000 to 10,000 pounds per square inch; if the T is made from a copper blank having an outside diameter of 2¼″ and a wall-thickness of approximately .125″, valve 32 will be set to open at pressures on the order of 3,000 to 4,000 pounds per square inch, and relief valve 34 will be set to open at pressures on the order of 6,000 to 8,000 pounds per square inch.

From the specific dimensions and pressures given, those skilled in the art will readily be able to work out suitable values for other sizes and types of T's.

Figs. 11, 12, and 13 illustrate a variation in the method of the present invention whereby, during the upsetting of the tubular blank, even more metal is caused to flow around to the incipient neck portion of the T, resulting in the production of even greater wall-thicknesses in the final neck portion. For this variation, the same apparatus is used as in Fig. 1, with the exception that each of the rams 17 and 18 is provided, at its inner end, with an extension 54 of even more reduced diameter than the respective extensions 19, and with tapered shoulders 55 connecting these extensions 54 with said extensions 19. The extensions 54 serve to provide a limiting means for the increase in thickness of the walls of the blank located adjacent thereto during the upsetting (see Figs. 12 and 13), and thus force metal that would otherwise build up in excess of the limit thickness to flow principally into the incipient neck, albeit partly into a ridge or bead **56** (Fig. 13) intermediate the ends of the rams. If this ridge or bead **56** is objectionable in the finished T, it may easily be bored out.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions and processes without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. Apparatus for upsetting tubular blanks into T fittings comprising a tank, means establishing a liquid level in said tank, a forming die having a longitudinal passage, open at each end, for receiving and forming said blank, said die being positioned in said tank below said liquid level, a pair of rams axially aligned with said passage and movably positioned to enter said passage from the opposite ends thereof, at least one of said rams having a liquid passage extending to the end face thereof which enters said die, and means supplying liquid under pressure to said last-named passage.

2. Apparatus for upsetting tubular blanks into T fittings comprising a tank, means establishing a liquid level in said tank, a forming die having a longitudinal passage, open at each end, for receiving and forming said blank, said die being positioned in said tank below said liquid level, a pair of rams axially aligned with said passage and movably positioned to enter said passage from the opposite ends thereof, at least one of said rams having a liquid passage extending to the end face thereof which enters said die, a source of liquid under pressure, a liquid conduit connecting said source and said last-named passage, check-valve means in said conduit preventing liquid therein from flowing toward said source, and pressure release means connected to said conduit to limit the liquid pressure in said die and said last-named passage.

3. Apparatus as set forth in claim 2, in which the fluid source includes an overflow tank receiving overflow liquid from the first-mentioned tank, and a pump withdrawing liquid from said overflow tank and delivering it to said conduit.

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