Oct. 24, 1944. C. A. ORR ET AL 2,361,318

TUBE PRODUCT

Original Filed Nov. 21, 1938 3 Sheets-Sheet 1

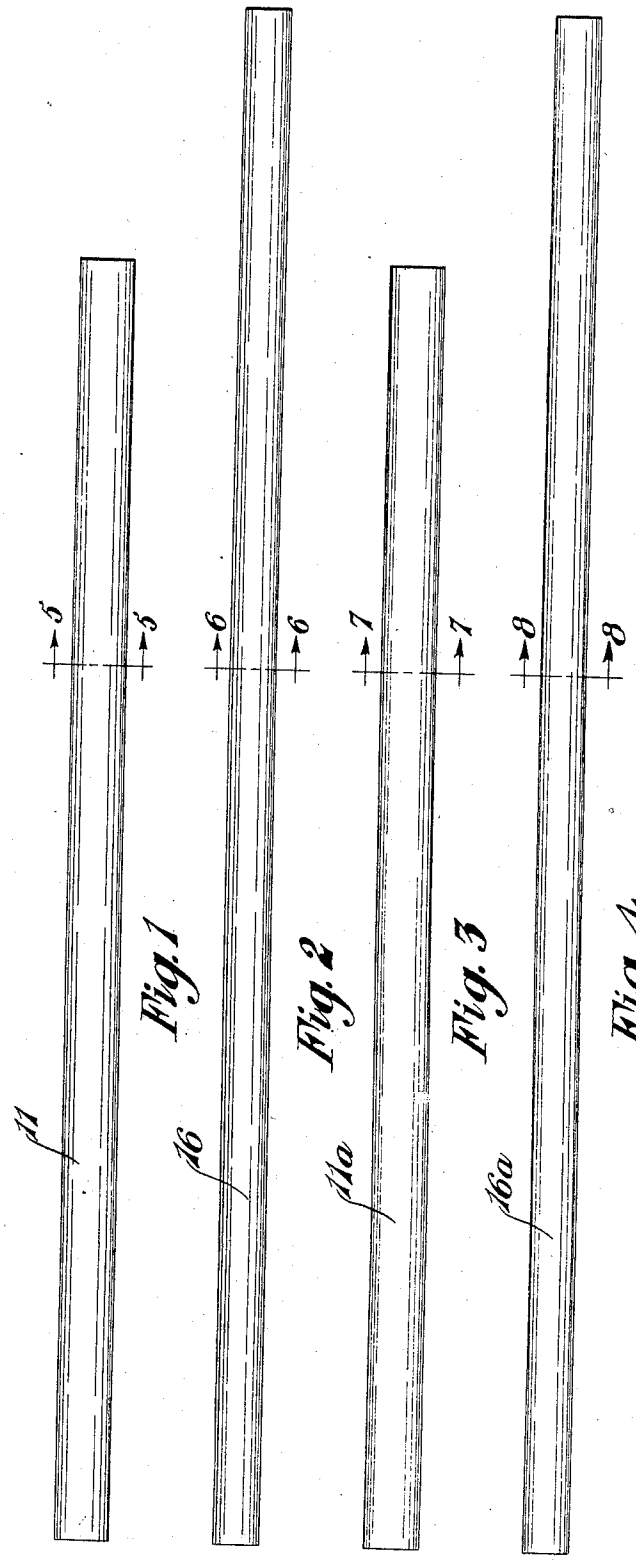


Fig. 1

Fig. 2

Fig. 3

Fig. 4

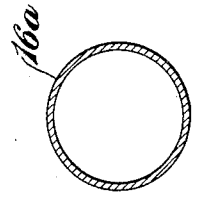


Fig. 8

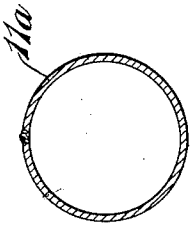


Fig. 7

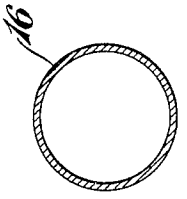


Fig. 6

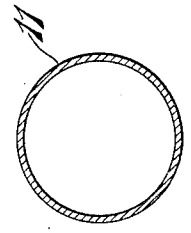


Fig. 5

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TUBE PRODUCT

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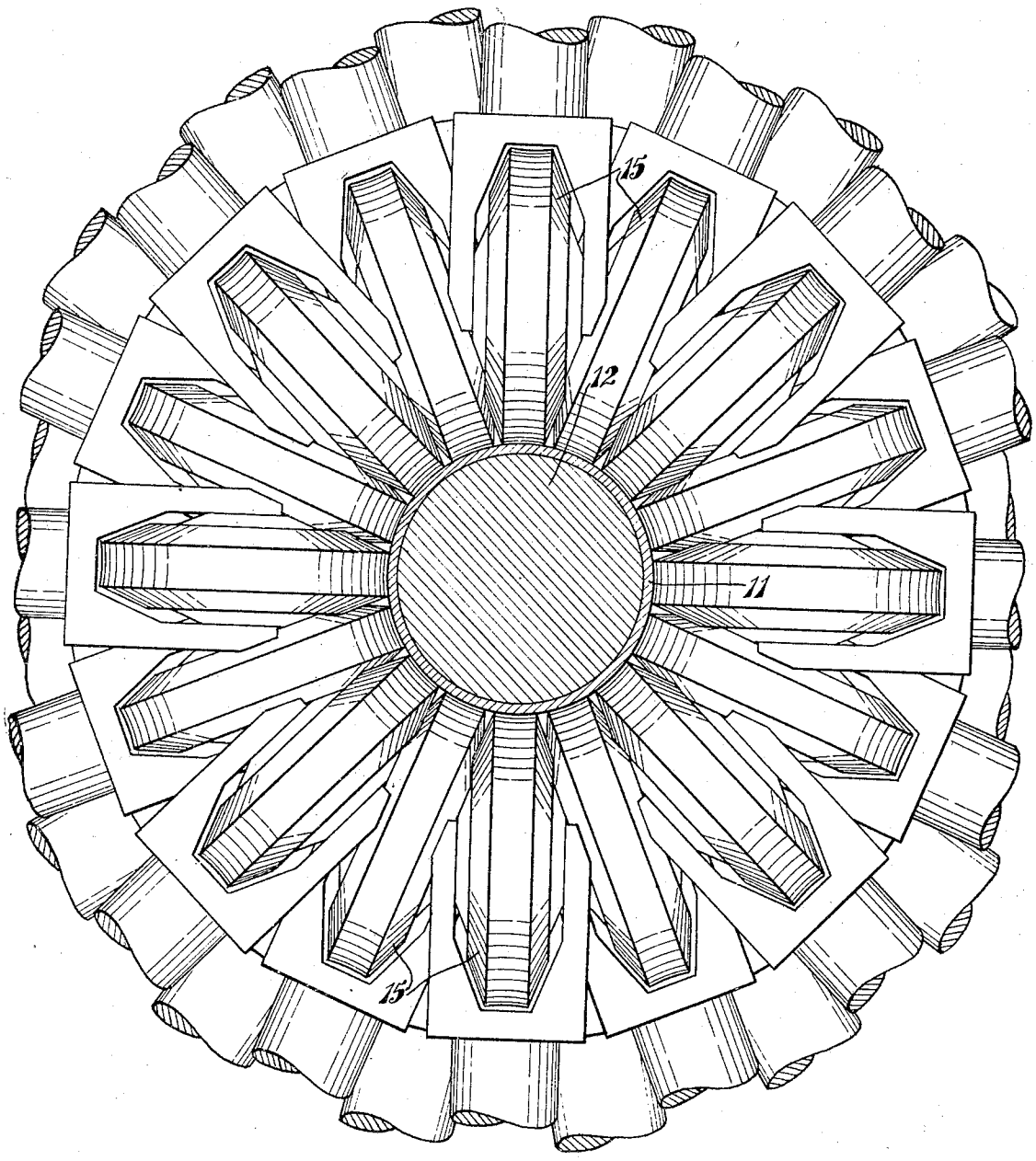


Fig. 9

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TUBE PRODUCT

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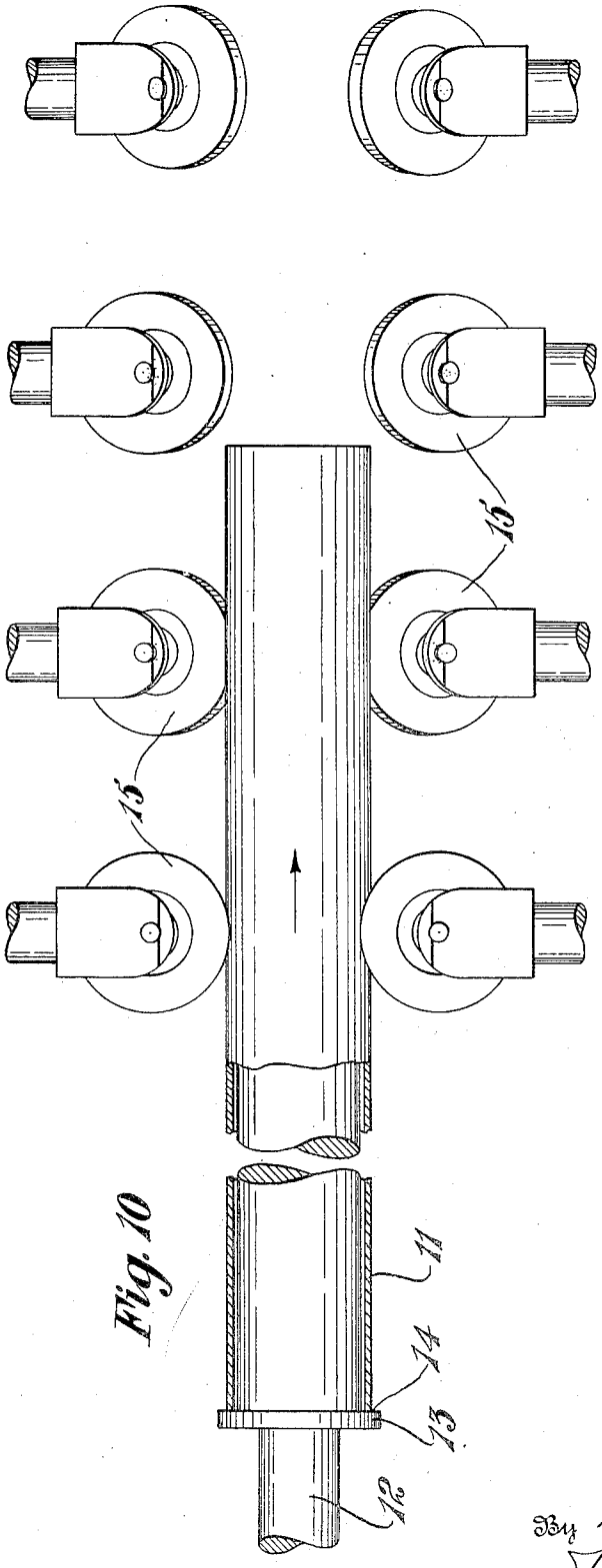


Fig. 10

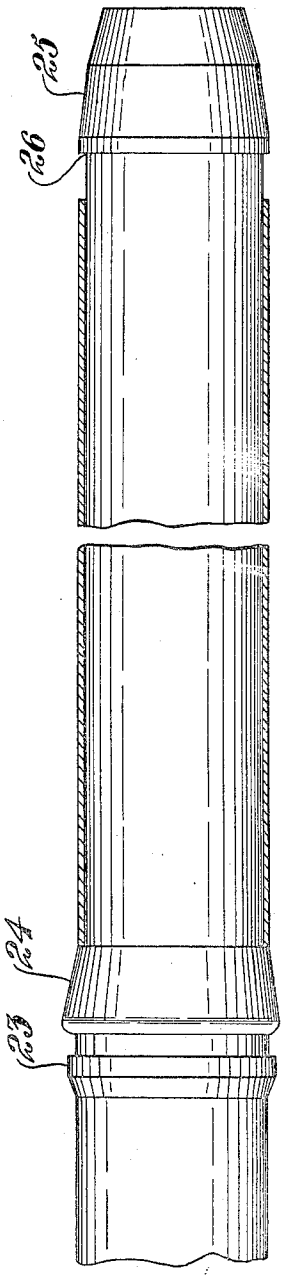


Fig. 11

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UNITED STATES PATENT OFFICE

2,361,318

TUBE PRODUCT

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Original application November 21, 1938, Serial No. 241,580, now Patent No. 2,275,801, dated March 10, 1942. Divided and this application October 9, 1941, Serial No. 414,322

3 Claims. (Cl. 138—47)

The invention relates to tubes, pipes, poles, shafts and the like; and particularly to seamless steel tubes and to a method of cold rolling the same. However, the method and product improvements hereinafter described are equally applicable to the manufacture of welded tubes, pipes, poles, shafts and the like made from metal sheets, strips, stripsheets and the like. This application is a division of our application entitled Manufacture of tubes, Serial No. 241,580, filed November 21, 1938, Patent No. 2,275,801, dated March 10, 1942.

The use of steel pipes or tubes having relatively large diameters and relatively thin walls for many purposes, such as for water pipes and for oil well casings, is largely determined by the physical properties of the steel. These physical properties may be changed for any given pipe size and wall thickness to increase the strength thereof by changing the analysis of the steel. However, a change in the steel analysis is sometimes undesirable, because of the prohibitive cost of using expensive alloying elements; and because of the diminished weldability of the special analysis steel selected, as welding is frequently required in connection with the installation of such tubes.

The strength of a steel tube of any given analysis and diameter may be increased by increasing the wall thickness thereof; but such a change is objectionable due to the cost or weight of the increased amount of metal present therein.

In numerous instances it has been proposed to change the physical properties of a tube by squeezing or pressing a tube while cold between two semi-cylindrical dies to slightly decrease the diameter of the tube. Such a cold pressing operation may increase the yield point of the tube wall in compression in a circumferential direction to a considerable extent but it only slightly increases the yield point of the metal in tension in a longitudinal direction; and in any event the resulting yield point in tension in a longitudinal direction is less than the resulting yield point in compression in the circumferential direction.

Moreover, such a cold pressing operation may increase variations in wall thickness, may increase out-of-round imperfections, and, due to the very nature of such a pressing operation in acting radially at some places and tangentially at other places upon a tube wall, does not uniformly alter the physical properties.

Over eighty years ago it was proposed to hot roll seamless tubes by pointing a tube blank and passing the same on a mandrel through a series of radially acting and separately mechanically adjusted rolls for reducing the diameter and thickness of the tube blank. In such process the mandrel engages the pointed end of the tube blank to pull the same through the rolls. The seamless tube so treated is finally drawn through a suitable die to size the same and provide a smooth finish.

Such a process is primarily a hot rolling process; and would be impractical for a number of reasons if used as a cold rolling process. Initially, a pointing of the tube blank is required, which not only increases expense, but decreases yield. Moreover, the mandrel, in engaging the pointed tube end, places the tube walls under longitudinal tension as the rolls are working the tube wall metal against the mandrel, so that grain distortion may result.

Moreover, while the yield point in tension in a longitudinal direction may be increased somewhat by such a cold working operation, no appreciable change will occur in the yield point in compression in a circumferential direction. Finally, it is practically impossible to uniformly load a plurality of mechanically adjusted radially acting rolls, so that such a cold working of the tube wall would not be uniform and the wall thickness therefore could not be accurately controlled.

It has likewise been proposed to cold work seamless tubes for reducing the diameter and thickness of the tube walls by passing the same through a series of upper and lower, concaved, half-round, driven rolls. However, it is substantially impossible to drive such rolls and load them uniformly; and by their very nature concaved rolls exert unequal pressures upon the tube walls, so that the resulting product is not evenly and uniformly worked and the wall thickness and uniformity thereof cannot be accurately controlled.

Such an operation may increase the yield point in tension in a longitudinal direction to some extent, but it has little or no effect upon the yield point in compression in a circumferential

direction. In such an operation, the tube wall is not under longitudinal tension or compression throughout its length while being worked, although a small zone of the same may be under longitudinal tension while being worked radially due to the action of the driven rolls in advancing the material therethrough.

The prior Riemenschneider Patent No. 1,984,083 outlines the manufacture of straight and true cylindrical or tapered tubes from tubes of irregularly varying diameter. The procedure there, however, includes a cold rolling operation by rolls acting radially against a mandrel on which a tube is pulled through the rolls. Again, in such an operation, the material being worked is under longitudinal tension, while the radially acting rolls are working the metal.

Seamless tubes, have also been cold worked by a cold drawing operation, which again involves placing the material under longitudinal tension while it passes through the draw die, so that the yield point in tension is exceeded before the drawing-in action occurs.

For these and other reasons, whenever the wall thicknesses or diameters of seamless tubes have been increased or decreased to any appreciable extent, the same has usually been accomplished by a hot working operation; and substantially all cold working operations on seamless or electric welded pipes or tubes have been merely for the purpose of shaping, sizing or straightening the tubes. Such cold working operations, as previously pointed out, may raise the yield point in tension in a longitudinal direction, but do not appreciably affect the yield point in compression in a circumferential direction.

In the prior art cold pressing operation referred to, while the yield point in compression in a circumferential direction is raised, the resulting yield point in tension in a longitudinal direction is less than the yield point in compression in a circumferential direction.

Finally, except when using the method shown in the Riemenschneider Patent No. 1,984,083, and possibly when using a cold drawing operation, the prior art methods of cold working a pipe or tube do not uniformly work the material due to the impossibility of uniformly loading driven rolls, or of uniformly loading a plurality of mechanically controlled radially acting rolls, or of uniformly loading dies which act radially at some places and tangentially at other places on the metal being worked; and in the excepted instances, the metal being worked is maintained under longitudinal tension.

Accordingly, it is an object of the present invention to provide a method of cold working tubes, particularly seamless tubes, to provide a strong thin walled steel tube of relatively large diameter that has good welding characteristics.

Moreover, it is an object of the present invention to provide a method of cold working tubes, particularly seamless tubes, by performing a cold working operation while the tube walls being worked are maintained under longitudinal compression.

Likewise, it is an object of the present invention to provide a method of cold working tubes, particularly seamless tubes, by using radially acting rolls which may be uniformly loaded to provide a balanced working pressure against a mandrel, so that the thickness, and the uniformity of thickness, of the tube walls being worked may be controlled or improved; and so that the strength of the tube walls will be uniform throughout in a longitudinal direction and also uniform throughout in a transverse direction.

Likewise, it is an object of the present invention to provide a method of cold working steel tubes, particularly seamless steel tubes, by materially elongating the tube walls and reducing the diameter thereof with or without a wall thickness reduction and without grain distortion.

Likewise, it is an object of the present invention to provide a new method of cold working tubes, and particularly seamless tubes, by which the yield point in compression in a circumferential direction is substantially increased, by which the yield point in tension in a longitudinal direction is also substantially increased, and by which the yield point in tension in a longitudinal direction is increased to a point substantially greater than the yield point in compression in a circumferential direction.

Moreover, it is an object of the present invention to provide for the manufacture of a steel tube, particularly a seamless tube, which is cold worked, to materially increase the yield point in tension in a longitudinal direction and the yield point in compression in a circumferential direction; to decrease extreme variations in wall thickness; and to decrease the cost of making strong, large diameter tubes without loss of yield; whereby such tubes may be made available for use in places and for purposes from which they have heretofore been excluded.

And finally, it is an object of the present invention to overcome the difficulties encountered in the prior art of cold working pipes or tubes; to simplify the manufacture of the same; to provide an improved cold rolled tube product; and generally to obtain the desiderata referred to hereinabove.

The foregoing and other objects may be obtained by the tube products, constructions, parts, arrangements, improvements, methods, processes and operations which comprise the present invention, the nature of which is set forth below in general statements.

Some of the features and operations of the improved method are illustrated in the accompanying drawings, showing more or less conventionally or diagrammatically, details of apparatus by which they may be performed; and the invention is particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the method improvements of the present invention may be described in general terms as including in the manufacture of cold worked steel tubes, the steps of cold rolling the tube on a mandrel, uniformly loading the rolls so that balanced working pressures are exerted by the rolls during the cold rolling operation, and during each pass maintaining the unworked portion of the tube walls and especially the portion being worked under longitudinal compression while the cold rolling operation is being performed; whereby the tube will be materially elongated and reduced in diameter.

The nature of the improved tube products of the present invention may be described in general terms as including a steel tube, the metal of which has been cold worked, to raise its yield point in compression in a circumferential direction 40 per cent or more, to raise its yield point in tension in a longitudinal direction 30 per cent or more, and to have a substantially greater yield point in tension in a longitudinal direction than

the yield point in compression in the circumferential direction.

In the drawings,

Figure 1 is a side view of a seamless tube prior to being cold worked by the improved method;

Fig. 2 is a similar view of a seamless tube after being cold worked by the improved method;

Fig. 3 is a similar view of an electric welded tube prior to being cold worked by the improved method;

Fig. 4 is a similar view of the tube shown in Fig. 3 after being cold worked by the improved method;

Figs. 5, 6, 7 and 8 are enlarged sections taken respectively on the lines 5—5, 6—6, 7—7 and 8—8, Figs. 1, 2, 3 and 4;

Fig. 9 is a diagrammatic cross section of the cold rolling apparatus;

Fig. 10 is a diagrammatic longitudinal section of the apparatus shown in Fig. 9; and

Fig. 11 is a diagrammatic view of a modified form of mandrel.

Similar numerals refer to similar parts throughout several figures of the drawings.

A seamless cylindrical steel tube is indicated at 11 in Figs. 1 and 5 and the same may be a usual seamless tube product of almost any diameter say beyond 3 inches in outside diameter and having almost any desired wall thickness ranging from approximately 1⅛ inch to ¾ of an inch or even more.

The tube 11 may be placed on the cylindrical mandrel 12 of a machine generally of the type shown in the Frahm Patent No. 1,605,828, or the Riemenschneider Patent No. 1,984,083 for being cold worked thereon, the mandrel being somewhat smaller in diameter than the tube. Such a machine must, however, have certain modifications in order to accomplish the objects and carry out the method to produce the product of the present invention.

The mandrel 12 must be provided with a collar 13 or other enlarged means against which an end of the tube 11 may be abutted as at 14. With this arrangement, as the mandrel is moved in the direction of the arrow of Fig. 10, the cold roller swaging dies 15, roll, swage and cold work the tube against the mandrel 12 to elongate the tube and decrease its diameter.

While the radial working of the tube metal by the rolls 15 is being performed, the tube wall is maintained under longitudinal compression between the bite of the rolls 15 and the shoulder 14 because the mandrel shoulder 14 is engaged against the left hand end of the tube 11 for pushing the tube through the rolls.

The tube 11 may be pushed through the rolls 15 any number of times or passes, say from 1 to 10 or more passes, but preferably 2 or 3 passes, depending upon the reduction in diameter to be accomplished by the cold rolling operation and the amount it may be desired to change the thickness of the tube wall.

Due to the fact that the radially acting rolls 15 are each hydraulically controlled by a fluid cylinder, all of which roll cylinders are connected with a suitable single source of fluid pressure such as water, oil, compressed air or the like, the rolls 15 are all uniformly loaded and exert a uniform or balanced working pressure during the cold working operation so that the cold working of the metal of the tube wall between the rolls 15 and mandrel 12 is uniform throughout.

As a result, any thickening or thinning of the tube wall is uniformly accomplished and if the tube wall of the initial tube 11 has the usual variations in thickness present in seamless tubes, the range of the extreme variations is materially diminished by the uniform cold working of the metal while the metal is under longitudinal compression between the bite of the rolls 15 and the pushing or advancing shoulder 14.

As previously stated, this cold working of the metal in the tube wall elongates the tube 11 to a considerable extent, such as is indicated by the finished cold rolled tube 16 shown in Figs. 2 and 6; and while the first pass of the tube through the rolls 15 may thicken the tube wall somewhat due to the decrease in diameter thereof, subsequent passes cause further elongation of and thinning of the tube wall. Thus, the wall of the cold rolled tube 16 may be thicker or thinner than that of the initial tube 11, as desired.

In Figs. 3 and 7, a welded tube made of sheet metal is shown at 11a, which may be treated in a manner similar to the treatment of the seamless tube 11 to produce a cold rolled welded tube product 16a illustrated in Figs. 4 and 8.

In Fig. 10, the mandrel is shown as only being capable of moving in one direction for performing a cold rolling operation; but the mandrel construction may be modified, as shown in Fig. 11, to include a stop or abutment shoulder 23 having a stripper stop or abutment ring 24 whereby the cold rolled tube may be stripped from the mandrel. A plug 25 is also provided at the other end of the mandrel having an abutment shoulder 26 whereby the mandrel may be moved back and forth through rolls 15 to perform a cold rolling operation in each direction of movement. Obviously, the stops 24 and 26 must be located further apart than the resultant length of the finished tube 16.

Examples of products made by treating them in accordance with the improved method are as follows:

Example 1

Seamless steel tubes having an analysis of .32 carbon, .75 manganese, .019 phosphorus, .036 sulphur and .24 silicon, and having a minimum tensile strength of 75,000 pounds per square inch (average actual tested tensile strength of 88,770 pounds per square inch), having a nominal outside diameter of 11¾ inches (actual measured average O. D. 11.803''), having a nominal gauge of .375 inch (actual measured average gauge .394''), having an average yield point in tension in a longitudinal direction of 62,470 pounds per square inch, and an average yield point in compression in a circumferential direction of 51,360 pounds per square inch, with an average elongation in 2 inches of approximately 30 per cent, were cold rolled in accordance with the improved method from 2 to 10 passes on a $10\frac{7}{16}$'' diameter mandrel.

The resulting cold rolled tubes had an average resulting outside diameter of 11.433 inches, an actual average gauge of .426 inch, an average tensile strength of 94,520 pounds per square inch, an average yield point in tension in a longitudinal direction of 83,040 pounds per square inch, and an average yield point in compression in a circumferential direction of 76,780 pounds per square inch, with an average elongation in 2 inches of about 25 per cent.

Thus, the longitudinal tensile yield point was increased approximately 33 per cent, while the transverse compressive yield point was increased about 49½ per cent with the resulting longitudi-

nal tensile yield point considerably above the resulting transverse compressive yield point; and the ultimate tensile strength was raised nearly 7 per cent.

Ductility and resistance to impact were somewhat reduced, as would be expected, while the residual stress as measured by a split ring test, was improved by being diminished; and extreme variations in gauge were likewise improved by being diminished about 50 per cent. In this Example 1 the average reduction in diameter was about 3.97%.

Example 2

Seamless steel tubes having an analysis of 0.28 carbon, 1.08 manganese, 0.18 phosphorus, 0.32 sulphur, 0.17 silicon and having a minimum tensile strength of 75,000 pounds per square inch (actual average tested tensile strength of 90,420 pounds per square inch), having a nominal outside diameter of 11¾ inches (actual measured average O. D. 11.812 inches), having a nominal gauge of .330 inch (actual measured average gauge .320 inch), having an average yield point in tension in a longitudinal direction of 63,190 pounds per square inch, and an average yield point in compression in a circumferential direction of 55,680 pounds per square inch, with an average elongation in 2 inches of approximately 32½%, were cold rolled in accordance with the improved method some 9 passes on a $10\frac{7}{16}$" diameter mandrel.

The resulting cold rolled tubes had an average resulting outside diameter of 11.193 inches, an actual average gauge of .340 inch, an average tensile strength of 100,680 pounds per square inch, an average yield point in tension in a longitudinal direction of 91,650, and an average yield point in compression in a circumferential direction of 83,300 pounds per square inch, with an average elongation in 2 inches of about 25%.

Thus, the longitudinal tensile yield point was increased about 45%, while the transverse compressive yield point was increased about 51% with the resulting longitudinal tensile yield point considerably above the resulting transverse compressive yield point, and the ultimate tensile strength was raised about 11%. Ductility and resistance to impact were somewhat reduced, as would be expected, while the residual stress as measured by a split ring test, was improved by being diminished slightly; and the extreme variations in gauge were likewise improved by being diminished about 50%. In this Example 2, the average reduction in diameter was about 5.23%.

In both Examples 1 and 2, the tubes were elongated from 4 to 8 inches in a 40 foot length.

Example 3

Electric welded pipes having an analysis of 0.05 carbon, 0.31 manganese, 0.014 phosphorus and 0.031 sulphur, having a minimum tensile strength of about 45,000 pounds per square inch, having a nominal outside diameter of 11 inches, having a nominal gauge of .134 inch, and having an average yield point in tension in a longitudinal direction of approxmately 32,000 pounds per square inch and a yield point in compression of approximately 32,000 pounds per square inch, were cold rolled in accordance with the improved method from 6 to 10 passes on a $10\frac{7}{16}$" diameter mandrel.

The resulting cold rolled tubes had an average resulting outside diameter of 10.765 inches, an actual average gauge of .135 inch, an average tensile strength of 55,000 pounds per square inch, an average yield point in tension in a longitudinal direction of 52,880 pounds per square inch, and an average yield point in compression in a circumferential direction of about 50,000 pounds per square inch, with an average elongation in 2 inches of approximately 28%.

Thus, the tensile yield point was increased approximately 65%, while the transverse compresive yield point was increased about 56% with the resulting longitudinal tensile yield point above the resulting transverse compressive yield point; and the ultimate strength was raised about 22%.

Accordingly, by using the improved method of cold rolling metal tubes, particularly seamless tubes, a strong thin walled steel tube of relatively large diameter having good welding characteristics may be made; a tube having a uniform strength in a longitudinal direction and also a uniform strength in a transverse direction may be made; the thickness of the tube wall, and the uniformity of the thickness thereof, may be controlled or improved; the yield point in tension in a longitudinal direction may be substantially increased, and the yield point in compression in a circumferential direction may also be substantially increased; and the manufacture of such tubes and the product thereof may be generally improved.

Moreover, the amount that the longitudinal tensile yield point is raised may be controlled by the amount of cold rolling performd; and the amount that the transverse compressive yield point is raised may be controlled by the amount that the diameter of the tube is reduced.

Having now described the features of the invention, the operation and use of the preferred method, the characteristics of the improved product obtained, and the advantages and results occurring in the use of the method and in the product; the new and useful parts, elements, combinations, constructions, methods and steps and the reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.

We claim:

1. A cold rolled steel tube, the material of which has a yield point in compression in a circumferential direction not less than 50,000 pounds per square inch, the yield point in compression in a circumferential direction being increased 40 per cent or more over the amount thereof prior to cold working, the yield point in tension in a longitudinal direction being increased 30 per cent or more over the amount thereof prior to cold working, and the yield point in tension in a longitudinal direction being substantially greater than the yield point in compression in a circumferential direction.

2. A cold rolled steel tube, the material of which has a yield point in compression in a circumferential direction not less than 50,000 pounds per square inch, the yield point in compression in a circumferential direction being increased 40 per cent or more over the amount thereof prior to cold working, the yield point in tension in a longitudinal direction being increased 30 per cent or more over the amount thereof prior to cold working, the yield point in tension in a longitudinal direction being substantially greater than the yield point in compression in a circumferential direction, and the tube having a uniform strength in a longitudinal direction and a uniform strength in a transverse direction.

3. A thin walled cold rolled steel tube of relatively large diameter having good welding characteristics, the material of which has a yield point in compression in a circumferential direction not less than 50,000 pounds per square inch, the yield point in compression in a circumferential direction being increased 40 per cent or more over the amount thereof prior to cold working, the yield point in tension in a longitudinal direction being increased 30 per cent or more over the amount thereof prior to cold working, the yield point in tension in a longitudinal direction being substantially greater than the yield point in compression in a circumferential direction, the tube having a uniform strength in a longitudinal direction and a uniform strength in a transverse direction, and extreme variations in gauge of the thin walled tube being about 50 per cent less than the amount thereof prior to cold working.

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