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METHOD AND MEANS FOR COLD TREATING METAL TUBING

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Fig. 1.

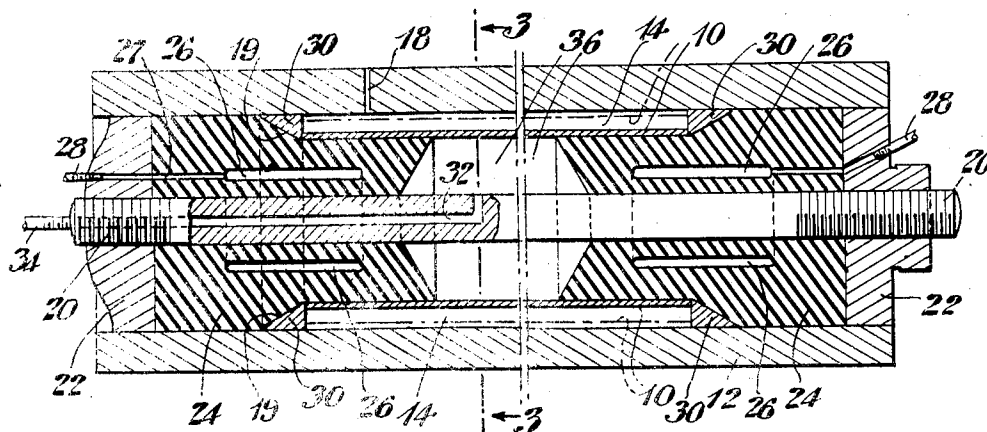


Fig. 2.

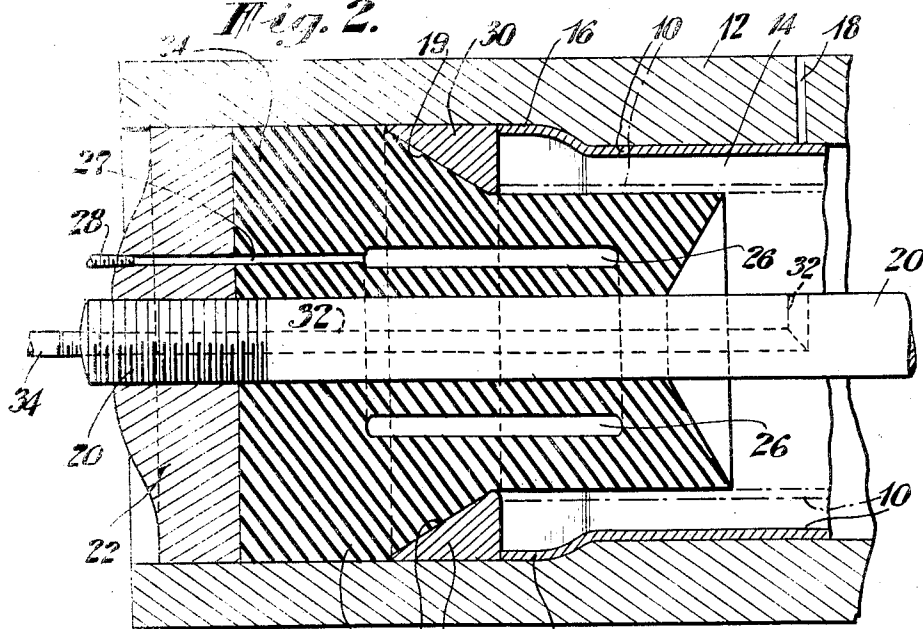
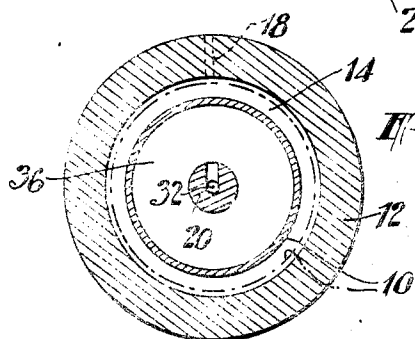


Fig. 3.



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METHOD AND MEANS FOR COLD TREATING
METAL TUBINGJames P. Fisher, Bartlesville, Okla., assignor to
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8 Claims. (Cl. 113—44)

This invention relates to the cold-treating of metal tubing, and more particularly to an improved method of and means for expanding a large pipe section in a direction transversely of its longitudinal axis.

In the construction of oil and gas pipe lines over long distances from the oil and gas producing regions to the centers of population and industry, great expense is involved not only because of the distances over which the oil and gas must be transported, but also because of the large quantities of expensive materials used in building such pipe lines. The cost per unit capacity of the pipes used to construct such pipe lines is a large item, and the primary object of the present invention is to provide a method of and means for increasing the carrying capacity of pipe sections without any materially adverse effect on the ultimate strength or molecular arrangement of the material composing the pipe sections.

Steel pipe or tubing as at present manufactured normally embodies much more metal in its walls and has walls of much greater average thickness than service requirements demand. The reason for the presence of this large amount of excess metal in the pipe is that present-day methods for manufacturing pipe are of such a character that the pipe produced is normally far from truly symmetrical in dimensions and wall thickness and normally carries flaws and internal stresses in its structure. The presence of such flaws and internal stresses weakens the pipe section as a whole, and the pipe normally fails when placed under pressure, or due to corrosion, at the locus of such flaw or point of internal strain. In other words, pipe sections of the type at present available for use in the construction of oil and gas pipe lines are not normally as strong as they should be, having regard to the amount of metal in the walls thereof.

Another object of the present invention is to provide method and means whereby steel or other metal pipe sections may be rendered stronger, more symmetrical in dimensions and wall thickness, and of maximum carrying capacity and strength per unit average wall thickness.

It has previously been proposed to increase the carrying capacity and to reduce the wall thickness of metal pipe by expanding the circumferential dimensions of the pipe and thereby simultaneously reducing the average wall thickness. The methods in use for effecting such expansion, however, have not proved altogether satisfactory, in particular for the production of large pipe

for use in relatively high-pressure fluid transportation service, because such methods have almost without exception involved subjecting the pipe metal to temperatures above red heat or the use of piercing machines and expanding mandrels developing severe frictional stress between such expanding medium and the walls of the pipe undergoing expansion. Such frictional stress develops corresponding internal strain in the pipe structure and lack of symmetry and flaws in the metal composing the walls of the expanded product of the treatment, which cannot all be corrected and ironed out even by an expensive subsequent annealing treatment.

Another object of the present invention is to provide method and means whereby metal tubing may be expanded to a capacity comparable with its wall thickness and at the same time improved both as to symmetry and dimensions, and in its physical structure and properties.

With the above objects in view, the present invention contemplates method and means whereby controlled hydraulic pressure is employed in expanding large steel or similar metal pipe sections in a manner such that no new heat is required and no friction strains and flaws are developed in the metal, and any old weaknesses in the original metal pipe or defects in dimensions are ironed out, yielding a substantially uniform product of improved capacity and symmetry and microscopic structure without substantial sacrifice of strength.

More specifically, the present invention contemplates subjecting a large metal pipe section to uniformly controlled hydraulic internal pressure throughout its entire length, the pressure employed being sufficient to uniformly stress each unit section of the pipe wall beyond the elastic limit of the metal but well below its yield point; to thereby cause a uniform readjustment and actual realignment of the atomic structure of the metal and expansion of the pipe to a predetermined new and permanent uniformly symmetrical dimension and shape. By this treatment, the elastic limit and the percentage of elongation of the metal comprising the pipe walls are somewhat increased, and flaws originally present in the pipe are ironed out and the mass of metal comprising the pipe walls is symmetrically disposed and rearranged around the longitudinal axis of the pipe.

With these and other objects and features in view, the invention consists in the improved method of and apparatus for treating tubing

hereinafter described and more particularly defined in the accompanying claims.

The apparatus of the present invention is represented in its preferred form in the accompanying drawing, in which:

Fig. 1 shows in longitudinal section, the preferred mechanism for cold-expanding tubing, with a tube to be expanded therein, embodying the principles of this invention;

Fig. 2 is an enlarged view of a modified form of the mechanism showing a recession or shoulder in the interior of the die to give one end of the tubing to be stretched a bell or flared shape; and

Fig. 3 is a cross-sectional view of the mechanism shown in Fig. 1 on a line 3—3.

Similar reference numerals refer to similar parts in the drawing.

The preferred mechanism contains, as shown by Fig. 1 of the attached drawing, a tube 10 inserted therein to be cold-expanded; and consists of a die 12 of high grade tensile steel sufficiently strong to withstand heavy pressures exerted against the interior of the tube during the process of expanding. The die is a long cylindrical block having a length greater than that of the tube to be expanded therein. The interior of the die comprises a bore 14 running longitudinally throughout its entire length and has a diameter corresponding throughout to the desired outside diameter of the tube after it has been expanded.

In one part of the wall of the die directly over a portion within which the tube is to be expanded, is an air relief hole 18 passing through the entire thickness of the die wall from its outer surface to the bore. One or more of these relief holes may be provided in the die at certain intervals of the length of the die. The air relief hole allows for the escape of air from the bore of the die during the hydraulic expansion of the tube and also serves to permit water to escape, thereby indicating any flaws or defects present in the tube while being expanded.

Extending longitudinally of the die is a pipe-clamp or vise mechanism consisting of a movable shaft 20, clamp headers or jaws 22, resilient members such as rubber gaskets 24 having annular hollow cores 26 each with connection 27 leading through the header 22 into a fitting 28 in communication with a source of pressure fluid located outside the die, and of metal rings 30. The pipe-clamp mechanism has the double function of holding the tube to be expanded in place in the bore of the die during its expansion to prevent warping or bending, and of forming a sealed closure preventing the escape of the pressure fluid used in expanding the tube 10.

The shaft 20, a circular rod made of high grade tensile steel, is equal to or greater in length than the die 12 and is threaded at either end for properly mounting the clamp jaws or headers 22. One end of the shaft 20 need not be threaded but may have a clamp header permanently mounted thereon in order to facilitate insertion of the clamp during the expanding operation. Along the axis of the shaft at one end is a bored passage-way 32 opened out through a fitting 34, through which water or other fluid expanding medium is introduced under pressure into the interior 36 of tube 10.

The clamp headers 22 are steel rings or disks of high tensile strength, with a diameter forming a close fit between the circumference of the header and the circumference of the bore of the die thus forming a closed chamber within which the hydraulic expansion of the tube

is effected. The clamp headers may have the shapes as shown by the drawing or any other desirable shape. The side of each clamp header facing the tube to be expanded is straight, whereas the other side may be slightly bulged to make it stronger and resistant to any outward warping of the clamp header that might occur during the hydraulic pressure expanding of the tube if thinner headers were used. The type of header shown at the right side of Fig. 1 having a squared outer section is preferred to facilitate easy disconnection after the pressure expanding operation.

The gaskets 24 are mounted adjacent the inner sides of the headers. That part of the length of the gasket lying adjacent the inside of the clamp header 22 has a diameter with a dimension to fit snugly into the die, whereas another portion contains a part 19 slightly tapering for resting thereon the tapered edge of the metal ring 30; while the remaining portion of the gasket is of diameter to fit the interior of the end portions of the tube 10 prior to expansion. During the cold-expanding of the tube each rubber gasket 24 at the ends of the shaft 20 forms a closure between the adjacent clamp header 22 and the tube to prevent the escape of any water during the process of cold-expanding the tube. Inside each rubber gasket is the annular hollow core 26 into which water may be forced through the passage 27 and the fittings 28. The core 26 extends into that part of the gasket fitting into the tube 10 to facilitate sealing and expanding the end portions of the tube.

The cross-section of metal ring gasket 30 is substantially that of a right-angle triangle with the longer side rounded against the shouldered portion of the rubber gasket at 19, while the side adjacent the end of the tube 10 is smooth and extends at right angles to the longitudinal axis of the pipe and die, thus permitting free movement of the tube ends radially outward while being expanded without frictional strain or buckling. This ring 30 is made of high grade steel and is used not only as a protection for the rubber gasket against damage by the ends of the tube during its cold expansion, but also as a wedge between the interior wall of the die and the gasket to help seal the ends of the die when hydraulic pressure is applied against the interior of the tube.

As a modification (not shown) of the above mechanism the clamp shaft 20 may be eliminated and the end portions of the inner walls of the bore of the die threaded. The clamp headers 22, having their circumferences threaded, may with their accessories then be screwed into the die to any desired extent depending upon the length of the pipe to be inserted in the die.

As another modification, instead of the bore of the die being uniformly dimensioned throughout its length, one end of the bore may be flared along its circumference as shown at 16, Fig. 2. If the interior of the die is flared at one end as shown, tube sections will be obtained after expansion with one end bell-shaped to allow for better joining of the tube when built into oil or gas lines. The clamp header and gasket at this end of the die will be larger in diameter than the clamp header at the other end because of the shouldered portion.

One mode of operating the mechanism for cold-expanding pipe is as follows: One of the clamp headers 22, mounted on one end of the shaft 20, with a rubber gasket 24 and a metal ring 30 in

place, is inserted at one end of the die with the rod 20 extending through the die. When this end of the clamping mechanism has been set in position in the die, the metal tube 10 is inserted through the open end of the die until its forward end fits over the forward part of the rubber gasket 24 already in position in the die. The other clamp header, with the rubber gasket and metal ring attached, is then screwed onto the shaft 20 until the forward part of the gasket fits into the tube 10. The headers are then drawn together to hold the tube in a tightly clamped position preventing longitudinal expansion.

Water or other pressure fluid is then forced into the hollow cores 26 of the cylindrical expandible gaskets through the passage 27 and the fitting 28. The water expands the rubber gaskets, thereby pressing the gasket against the inner walls of the tube 10 and the inner walls of the die, and the metal ring 30 against the inner walls of the die, thus sealing off the interior of the pipe 10. Water or other fluid under pressure is then forced into the interior 36 of the tube 10 through fitting 34 and passage 32 extending along the axis of the shaft 20. Gradually increasing hydraulic pressure is applied against the interior of the tube until the stress exerted on the metal walls of the tube exceeds the elastic limit, the diameter of the walls is uniformly increased and the outside diameter expands to that of the interior of the die. Each metal ring 30 has a smoothly polished side bearing against the end of the tube 10, thus allowing for the smooth unobstructed movement of the tube end outwardly while being expanded.

If a tube with flared ends is desired, the same method of operation is performed in the modified apparatus shown in Fig. 2. The expanded tube is easily taken out of the die at its larger end shown. The invention contemplates applying uniformly controlled hydraulic pressures of sufficient intensity against the walls of metal tubes so that the diameter of such tubes can be increased at least 10% over their original diameter without any adverse effect on the molecular arrangement of the tube structure.

Pressure applied in the hollow core 26 is equal to that applied against the interior of the tube 10 during the expanding operation and is sufficient to keep the ends of the tube and the die watertight and at the same time to expand the ends of the tube uniformly with the other parts.

The tube as a result of this treatment will have been stressed beyond its elastic limit in order to expand it against the inner wall of the die. On removing the hydraulic pressure the tube material, while having a permanent deformation, shrinks away from the interior of the die an amount proportional to the strain at the elastic limit of the tube. This shrinkage is sufficient to allow for the easy removal of the expanded tube from the die upon completion of operation.

A pressure gage (not shown) may be used as a means for determining when the expansion operation is completed. The gage is connected to the hydraulic fitting 34, and as water is introduced through the passage into the interior 36 of the tube 10, the pressure on the gage will quickly rise as soon as the interior has been filled with water. After raising the pressure to a point at which the pipe yields under stress above its elastic limit, the indicator will move only slowly or remain stationary, while the tube is undergoing expansion and permanent deformation. When the tube expands to the dimensions of the die, the pressure gage will again show a

decided and sudden increase due to the resistance of the die wall to further expansion of the tube. This sudden increase in pressure on the gage is an indication to the operator that the expanding operation is completed, whereupon the pressure is released.

The expansion of the tube having been completed, one end of the clamping mechanism is loosened and the same expanding operation is performed with the next tubing.

As an example of one application of the process of this invention, a steel tube containing 0.2 carbon and of $\frac{1}{4}$ " wall thickness with an outside wall diameter of 25" having an elastic limit of 28,000 pounds per square inch was uniformly expanded to 26" outside diameter. The elastic limit of such expanded steel tube was found to be 45,000 pounds per square inch, despite the smaller wall thickness.

The finished tube will have undergone during the treatment a hydraulic pressure test and will still possess a definite and certain safety factor relative to the working pressure and to the elastic limit of the material. The fluid working pressure on steel tubes of 10-20 inch or larger diameter used in long distance gas and oil transmission lines for conveyance of gas and oil under pressure, is often from 400 to 1000 pounds per square inch. It is obvious that gas and oil may be conveyed through tubes improved by this process under higher working pressures on account of the increased elastic limit and ultimate strength of the tube. Furthermore, economy of tube foot area is attained in the construction of gas and oil lines from tubes improved by the process of the present invention, since the diameter of such tubes is increased and allows for carrying more gas or oil than the tubes would carry if they were not expanded.

Having thus described the invention, what is claimed as new is:

1. Apparatus for cold-expanding metal tubes by hydrostatic pressure, which comprises a die with an internal bore corresponding in shape and dimensions to the desired external shape and dimensions of a tube to be expanded, clamp headers mountable at each end of the bore of said die to retain the tube to be expanded in position, resilient gaskets adapted for partial insertion into each end of the tube to be expanded between the tube ends and the clamp headers, and annular gaskets disposed between said resilient gaskets and the ends of the tube to be expanded having smooth bearing faces extending transversely between the ends of the tube and the inner wall of the die.

2. Apparatus for cold-expanding metal tubes, comprising a tubular die containing an air relief hole through its wall and having an inside diameter and dimensions equal to the desired external diameter and dimensions of the tube after expansion, adjustably mounted clamp headers adapted to hold between them within the die the tube to be expanded, and resilient sealing members with hollow cores adapted to form a tight closure within said die between each header and the adjacent end of the tube to be expanded, the core of each resilient member communicating with a source of pressure fluid.

3. Apparatus for cold-expanding metal tubes, comprising a die having an internal bore of shape and dimensions corresponding with the desired external shape and dimensions of a tube coaxially retained within said die, a pair of clamp headers adjustable longitudinally of the die

adapted to serve as end closures for the die, and as clamps for holding the tube to be expanded in a longitudinally fixed position, resilient sealing gaskets adapted to form a tight closure between each header and the adjacent tube and, a metal gasket mounted intermediate each end of the tube and adjacent header and having a smooth face abutting against the end of the tube and extending at right angles between the end wall of the tube and the wall of the die, and means for applying hydrostatic pressure against the tube in said die.

4. In apparatus for cold-expanding metal tubes, the combination with a die having an internal bore of shape and dimensions corresponding to the desired external shape and dimensions of a tube after expansion, of a tube-clamping mechanism longitudinally disposed within said die and containing adjustably mounted clamp headers at each end thereof, each of said headers having cooperatively connected thereto a resilient gasket, and annular metal gaskets at each end of the tube to be expanded having an external diameter corresponding to the bore of the die and an internal diameter less than the diameter of the tube and having a face mountable in abutting relation to the end of the tube and adapted to form a smooth bearing surface extending transversely between the die wall and the ends of the tube.

5. Apparatus for cold-expanding metal tubes, comprising a die having an internal bore of shape and dimensions equal to the finished shape and dimensions of a tube coaxially centered in said die and to be expanded therein, a tube-clamping mechanism longitudinally adjustable in said die comprising headers mountable in the die at each end of said tube, each header having cooperatively attached thereto on its inner side a resilient gasket with a hollow annular core opened to an exterior pressure fluid supply and adapted to form a tight closure at each end of said die to prevent escape of pressure fluid from the tube retained in said die during its expansion, said resilient gasket being adapted for partial insertion into the end of the tube retained in said die, and a metal gasket encircling each of said resilient members having one side contiguous with the inner wall of said die and a smooth-faced side at right angles to the wall of the die and abutting the ends of the tube.

6. In mechanism for cold-expanding metal tubing, a tubular die of high tensile strength with a diameter corresponding with the desired external diameter of a tube to be radially expanded therein, a threaded clamp shaft longitudinally disposed and adapted for insertion coaxially

through the interior of a tube retained and to be expanded in said die, said shaft having a passage opened along its axis for introducing a liquid under pressure into the interior of said tubing, a pair of clamp headers each mounted on one end of said shaft and comprising adjustably spaced end closures for said die, resilient gaskets of adjustable diameter adapted for partial insertion into each end of said tube, said resilient gaskets containing hollow annular chambers therein extending throughout a substantial portion thereof and adapted to receive pressure fluid for expanding said gaskets, and a trilateral annular metal gasket having one side encircling each said resilient gasket, another side bearing against the inner walls of the die, and a third smooth-faced side extending at right angles to and abutting each end of the tube retained in said die.

7. In apparatus for cold expanding metal tubing, a die with an internal bore of shape and dimensions corresponding to the desired external shape and dimensions of a tube to be expanded, clamping means adapted for holding said tube longitudinally fixed in a coaxially centered position within and originally spaced from the side walls of said die, and a pair of resilient sealing members adapted to cooperate with the clamping means in supporting and sealing the respective ends of the tube to be expanded, and in permitting radial expansion thereof, and metal rings adapted for mounting between the members and the tube, each ring having a smooth faced side abutting the adjacent end of the tube retained in said die and extending at right angles inwardly from the die walls.

8. The method of cold-expanding a metal tube uniformly throughout its length in a direction at right angles to its axis, comprising placing said tube within a die having internal shape and dimensions corresponding with the desired outside dimensions and shape of said tube after expansion, clamping said tube in coaxially centered position within said die and spaced from the lateral walls thereof, forming an expandible seal between the interior of said tube and the ends of the die, introducing fluid under pressure into the interior of the tube and into the expandible seal so that the pressure in said seal corresponds with the pressure in the interior of the tube, building up such pressures to a point at which the walls of said tube are stressed beyond their elastic limit and assume new dimensions and shape, releasing the hydraulic pressure thus built up in the tube and freeing and separating the expanded tube from the die.

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