APPLICATION ACCEPTED AND AMENDMENTS ALLOWED 27.11.90

606956

FORM 1
REGULATION 9

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952–1973

APPLICATION FOR A PATENT

We THE BABCOCK & WILCOX COMPANY

of 1010 Common Street, New Orleans, LOUISIANA 70160, U.S.A.

hereby apply for the grant of a Patent for an invention entitled:

COLD DRAWING TECHNIQUE AND APPARATUS FOR FORMING INTERNALLY GROOVED TUBES

which is described in the accompanying complete specification. This Application is a Convention Application and is based on the Application(s) numbered: 064,048 for a Patent or similar protection made in U.S.A. on 19 June 1987.

Our address for service is:

GRIFFITH HASSEL & FRAZER
71 YORK STREET
SYDNEY N.S.W. 2000
AUSTRALIA

DATED this 16th day of June, 1988.

14 5 : 00

THE BABCOCK & WILCOX COMPANY

By their Patent Attorneys

GRIFFITH HASSEL & FRAZER

TO: THE COMMISSIONER OF PATENTS
COMMONWEALTH OF AUSTRALIA

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5000359 16/06/88

CASE 4779

ASSIGNEE – APPLICANT

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

DECLARATION IN SUPPORT OF AN APPLICATION FOR A PATENT

In support of an Application made by:
THE BABCOCK & WILCOX COMPANY

for a patent for an invention entitled:
COLD DRAWING TECHNIQUE AND APPARATUS FOR FORMING INTERNALLY GROOVED TUBES

I, Robert J. Edwards

of, THE BABCOCK & WILCOX COMPANY , 1010 Common Street, New Orleans, LOUISIANA 70160, U.S.A.
do solemnly and sincerely declare as follows:

1. I am authorised by the above mentioned applicant for the patent to make this Declaration on its behalf.

2. The name and address of each actual inventor of the invention is as follows:

Dean Lowell Mayer

of Rt # 1, Box 847, Fremont, INDIANA 46737, U.S.A.

and the fact(s) upon which the applicant is entitled to make this application are as follows:

The applicant is the assignee of the said invention from the actual inventor.

3. The basic application(s) as defined by Section 141 of the Act was (were) made as follows:

Country U.S.A. on 19 June 1987
in the name(s) Dean Lowell Mayer

4. The basic application(s) referred to in the preceding paragraph of this Declaration was (were) the first application(s) made in a Convention country in respect of the invention the subject of this application.

Declared at New Orleans, LA. U.S.A. this 29th day of June 1988.

Signed: THE BABCOCK & WILCOX COMPANY
Robert J. Edwards

Position: Chief Patent Counsel

GRIFFITH HASSEL & FRAZER, SYDNEY, AUSTRALIA

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(12) PATENT ABRIDGMENT (11) Document No. AU-B-17776/88
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 606956

(54) Title
COLD DRAWING TECHNIQUE AND APPARATUS FOR FORMING INTERNALLY GROOVED TUBES

International Patent Classification(s)
(51)[4] B21C 001/24 B21C 003/16

(21) Application No. : 17776/88 (22) Application Date : 16.06.88

(30) Priority Data

(31) Number	(32) Date	(33) Country
064048	19.06.87	US UNITED STATES OF AMERICA

(43) Publication Date : 22.12.88

(44) Publication Date of Accepted Application : 21.02.91

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(56) Prior Art Documents
US 4646548
US 4313328
DE 3016135

(57) Claim

1. A method of cold drawing an elongate tube shell in a single continuous draw pass to form a cold finished tube having an internal surface with a plurality of longitudinally extending grooves which comprises: longitudinally drawing the tube shell along a mandrel, sinking the tube shell to reduce the diameter of the internal surface of the tube shell to a dimension below the minor diameter of the grooves to be formed, then progressively enlarging the reduced internal surface of the tube shell, and next longitudinally retarding the longitudinal movement of a portion of the reduced internal surface of the tube shell at a plurality of circumferentially spaced intervals to effect formation of the grooves while concurrently, with the formation of the the grooves, reducing the outer diameter of the tube shell by at least 9% and reducing the wall thickness of the tube shell by at least 20% along the same portion of the reduced internal surface of the tube shell.

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PATENTS ACT 1952 Form 10

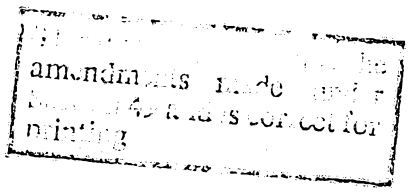
COMPLETE SPECIFICATION

FOR OFFICE USE

Short Title:

Int. Cl:

Application Number:
Lodged:



Complete Specification–Lodged:
Accepted:
Lapsed:
Published:

Priority:

Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: THE BABCOCK & WILCOX COMPANY

Address of Applicant: 1010 Common Street, New Orleans,
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Complete Specification for the invention entitled:

COLD DRAWING TECHNIQUE AND APPARATUS
FOR FORMING INTERNALLY GROOVED TUBES

The following statement is a full description of this invention, including the best method of performing it known to me/us:–

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COLD DRAWING TECHNIQUE AND APPARATUS FOR FORMING INTERNALLY GROOVED TUBES

BACKGROUND OF THE INVENTION

This invention relates to the manufacture of internally grooved tubes and, more particularly, to an improved method of cold drawing tubes for forming continuous shallow grooves, narrowly spaced apart in either an axial or spiral orientation, on the inside surface of the tubes, and an apparatus therefor.

Known methods have been utilized to place grooves on the internal surfaces of tubes for different purposes. Such methods include machining, broaching, informing, extruding and drawing techniques.

Various grooving techniques are described in patent disclosures.

Hackett (U.S. Patent No. 2,392,797), for example, discloses a technique for imparting rifling, fluting, ridging or the like to an internal tubular surface, particularly for a gun barrel or liner, through the use of a die and a mandrel arrangement including a mandrel having a surface configuration which is converse to that to be imparted to the tube. The die compresses the tube onto the mandrel, by relative axial movement of the tube and the die, as the tube moves through the die.

In Harvey, et al (U.S. Patent No. 2,852,835), an apparatus is disclosed wherein metallic tubing is drawn through an annulus formed by a stationary die and a cooperating rotatable rifling mandrel for simultaneously sizing the tubing and forming spiral projections on the interior surface of the tubing. The die includes a tapered frusto-conical lead-in portion followed by a cylindrical

portion which gradually reduces the outside diameter of the tube to the desired final outside diameter. The initial contact of the internal surface of the tube on a portion of the rifling mandrel and the contact of the outer surface of the tube with the tapered lead-in portion of die occur concurrently. Hence, the spaced portions of the inside surface of the tube are radially forced into the grooves of the rifling mandrel simultaneously with a portion of the outer surface diameter reduction. No specific type of groove geometry is disclosed although the patent indicates that the technique is useful for the production of rifled aluminum barrels and the like.

Drawing techniques similar to that of Harvey, et al (U.S. Patent No. 2,852,835) are shown by Nakamura, et al (U.S. Patent No. 3,830,087), Koch, et al (U.S. Patent Nos. 3,289,451 and 3,088,494), Hill (U.S.Patent No. 3,292,408), House (U.S. Patent No. 3,487,673), Sirois (U.S. Patent No. 3,744,290), Stump (U.S. Patent No. 4,161,112), and Tatsumi (U.S. Patent No. 4,373,366). Grover, (U.S. Patent No. 3,865,184) and Runyan, et al (U.S. Patent No. 3,753,364), for example, both teach a horizontally disposed heat pipe as well as a method and apparatus for fabricating the heat pipe. Grover (U.S. Patent No. 3,865,184) is primarily directed towards the actual heat pipe apparatus itself, describing, in detail, the very particular structure desired. Runyan, et al (U.S. Patent No. 3,753,364) is primarily directed to a method and apparatus for producing capillary grooves on the inside tube surface of the heat pipe. The disclosed method and apparatus provide a means for fabricating a spiraled capillary groove by cutting the metal from the wall of the tube and raising and folding the cut metal over to provide a groove having a narrow opening for maximum capillary action.

The cutting tool has a curved planar edge formed by the intersection of a planar surface and a cylindrical surface. The grooves produced thereby may have dimensions of a peak to trough depth on the order to 0.014 inches (0.3556 mm) and a spacing on the order of 0.007 inches (0.1778 mm) with the opening of the grooves narrower than the width of the grooves to provide optimum capillary action. The use of separate annular grooves of the same geometry is also disclosed. The method of placing the grooves in this inner tube wall surface is one of cutting with a cutting tool, and not a cold-drawing process.

When the metal for the inner surface of a tube shell is forced radially into grooves of a mandrel, there is a tendency for the metal to elongate along the longitudinal direction of the groove rather than radially filling the groove. This problem is exasperated as groove depth increases, as spacing between the grooves decreases, as drawing speed increases and, as well, in the case of hard metal workpieces.

In practice, no cold drawing method is known to the inventor which has been succesfully demonstrated as capable of making continuous shallow grooves in a hard metal such as steel, for example, continuous grooves having a depth of 0.020 inches (0.508 mm) with 0.040 inches (1.016 mm) between the grooves. More particularly, no cold drawing method is known to the inventor which is capable of rapidly making, in hard material, shallow continuous grooves that exhibit a uniform spiral along the length of the tube. Such grooves have particular application to heat pipes which use capillary grooves to transfer condensate from a condenser to an evaporator as the tubes exhibit increased heat transfer due to the extended surface and, accordingly, would be optimum

"wicks" when used in thermosyphon-type heat pipe applications.

Summary of the Invention

In a first aspect the present invention provides a method of cold drawing an elongate tube shell in a single continuous draw pass to form a cold finished tube having an internal surface with a plurality of longitudinally extending grooves which comprises: longitudinally drawing the tube shell along a mandrel, sinking the tube shell to reduce the diameter of the internal surface of the tube shell to a dimension below the minor diameter of the grooves to be formed, then progressively enlarging the reduced internal surface of the tube shell, and next longitudinally retarding the longitudinal movement of a portion of the reduced internal surface of the tube shell at a plurality of circumferentially spaced intervals to effect formation of the grooves while concurrently, with the formation of the the grooves, reducing the outer diameter of the tube shell by at least 9% and reducing the wall thickness of the tube shell by at least 20% along the same portion of the reduced internal surface of the tube shell.

In a second aspect, the present invention provides a method of cold drawing an elongated tube shell in a single continuous draw pass to form a cold finished tube having an internal surface with a plurality of longitudinally extending grooves, which comprises:

longitudinally drawing the tube shell concentrically over a mandrel to and through a die bore of the type having a cylindrical bore and a tapering lead-in portion forming a continuation of the bore, the mandrel including a substantially cylindrical grooved plug concentrically within the cylindrical bore, a cylindrical bearing section having a diamenter of smaller dimension than the minor diameter of the grooved plug, and a generally conical bearing section interconnecting the cylindrical bearing section to the grooved plug, the cylindrical bearing section being diposed

partly within the tapering lead-in portion and the cylindrical bore, and where the grooved plug includes a surface with a plurality of longitudinally extending grooves having a groove surface finish of approximately 3 microinches and which are circumferentially spaced about the surface; and sinking the tube shell about the cylindrical bearing section to an internal diameter of a dimension less than the diameter of the grooved plug at the base of the grooves, the outer diameter of the tube shell being reduced by at least 9% and the wall thickness of the tube shell being reduced by at least 20% during the drawing process to facilitate formation of the grooves in the tube shell.

In a further aspect, the present invention provides an apparatus for cold drawing an elongate tube shell to form a cold finish tube having an internal surface with a plurality of longitudinally extending grooves, the apparatus being of the type with a die having a die land circumscribing a cylindrical bore and a generally conical approach zone circumscribing a tapering lead-in portion forming a continuation of the bore, and a mandrel coaxially disposed within the bore and spaced from the surfaces of the die to define a spacing through which the tube shell is to be drawn, the mandrel including a substantially cylindrical grooved plug having a groove surface finish of approximately 3 microinches concentrically disposed with the cylindrical bore, a cylindrical bearing section having a diameter of smaller dimension than the minor diameter of the grooved plug, and a generally conical bearing section interconnecting the cylindrical bearing section to the grooved plug, the cylindrical bearing section being disposed partly within the tapering lead-in portion and the cylindrical bore, the die land and the mandrel being further arranged such that during the cold drawing of an elongate tube shell and while the grooves are being formed on the internal surface of the elongate tube shell, the outer diameter of the tube shell is reduced by at least 9% and the wall thickness of the tube shell is reduced by at least 20%.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view, partly in section, showing a tube shell being drawn relative to a die and mandrel in accordance with the principles of the invention; and

Fig. 2 is a partial view, similar to Fig. 1, showing the die and mandrel of another embodiment of the invention.

DETAILED DESCRIPTION

Fig. 1 illustrates a hollow tube shell 10 being drawn from right to left in the direction of the arrow through a conventional die 11 by pulling means (not shown) such as are well known in the art. The tube shell 10 has substantially cylindrical smooth internal and exernal surfaces prior to being drawn through the die 11.

The die 11 has a die opening including a tapering lead-in portion within a generaly conical approach zone 12, a cylindrical bore within a cylindrical die land 13, and an expanding portion defined within a countersunk exit zone 14. The lead-in portion and expanding portion form a continuation of the bore at the fore and aft sides of the die 11.

An internal mandrel 20, preferably of hard or hard-surfaced material such as tungsten carbide, is co-axially inserted within the bore and spaced from the surfaces of the die to define an annular restraining spacing through which the tube shell 10 is to be drawn, as shown, to effectuate reduction and grooving of the internal surface of the tube shell 10. The mandrel 20 is composed of three working segments -- a grooving plug 21 that has a working surface comprising a plurality of spiraled or axial grooves 22, a generally conical bearing section 23, and a cylindrical

bearing section 24. The generally conical bearing section 23 is connected at its larger end to the grooving plug 21 and at its smaller end to the cylindrical bearing section 24. The cylindrical bearing section 24, at its end opposite the generally conical bearing section 23, is connected to a larger diameter cylindrical rod 25.

The mandrel 20 is oriented within the die 11 such that the cylindrical bearing section 24 extends coaxially of the die opening from within the generally conical approach zone 12 to within the cylindrical die land 13, and both the surface of the zone 12 and the die land 13 are concentrically disposed thereabout.

As the tube shell 10 is drawn through the die, the outer surface of the shell 10 first contacts the generally conical approach zone 12. The surface of the generally conical approach zone 12 thereby sinks the tube shell 10 about mandrel 20 at the smaller diameter mandrel section, i.e. cylindrical bearing section 24.

As shown in Fig. 1, reduction of the diameter of the outer surface of tube shell 10 commences in the generally conical approach zone 12 on a portion of the tube shell 10 which encircles the cylindrical bearing section 24, "before" the grooving occurs.

As shown in Fig. 1, the diameter of the inner tube wall surface of the tube shell 10 is sunk or reduced to a diameter that is equal to or smaller than the mandrel diameter at the bottom of the grooves 22 of the grooving plug 21. This placement overcomes the problem of the inner tube wall surface metal taking the easier path of elongating longitudinally rather than filling the grooves 22. In effect, this forms grooves in the inner tube wall surface with the projections or lands of the grooving plug 21 rather

than attempting to force the inner tube wall surface into the grooves 22 of the grooving plug 21.

The sunk or reduced inner surface of the tube shell 10 is then drawn into contact with and expanded over the generally conical bearing section 23 of the mandrel 20 and lead into the grooves 22 of the grooving plug 21. The projections or lands of the grooved surface of the grooving plug 21 retard the longitudinal movement of the reduced internal surface of the sunk tube shell at a plurality of circumferentially spaced intervals, thereby causing axial flow of the inner tube wall surface material into the grooves 22 of the surface of the grooving plug 21 to effect formation of a tube having a plurality of longitudinally extending grooves on the internal surface thereof.

The mandrel 20 is allowed to rotate, if it is desirable to facilitate the formation of grooves having a spiral orientation on the inside surface of the tube shell 10.

Sinking of the internal diameter of the tube shell 10 prior to contacting the groove lead-in portion (generally conical bearing section 23) to a dimension in which the internal diameter is no larger than the diameter at the bottom of the mandrel grooves 22 has been found to be critical. If this is not done, the tube material elongates longitudinally rather than entirely filling the grooves 22 radially.

The generally conical lead-in or bearing section 23 to the flat grooving surface of the grooving plug 21 is required to assure that sufficient tube material is longitudinally fed to the grooves 22. The groove finish of the mandrel grooving plug 21 must be relatively smooth to allow proper material flow. Excessive roughness causes

misshapen and cratered tops on the leads placed in the tube shell 10; a surface finish of approximately 3 microinches has been shown to be effective, and it is estimated that a 30 microinch or better finish is required.

During the grooving operation, the outside diameter is sunk by at least 9% and the tube wall thickness is reduced by at least 20%. These minimum reductions are required to yield sufficient axial force to cause the tube material to flow into the grooves 22 rather than over the lands. The tube shell 10 should be annealed prior to cold drawing, to allow sufficient tube material ductility to cause proper flow.

In Fig. 2, the reference numerals (one hundred numbers displaced from the embodiment of Fig. 1) are used to designate parts which are similar to those on the embodiment of Fig. 1. The embodiment of Fig. 2 differs from that of Fig. 1 in that the approach zone 112 and bearing section 123, while still conical, are curved convexly (as shown) or concavely (not shown).

A preferred embodiment of the present invention has been shown to be capable of providing grooved tubes at rates of draw in excess of 34 feet per minute, using the special grooving mandrel, a standard tube drawbench and normal equipment to prepare tubes for drawing. Variable groove spiral geometries can be made; 9" to 20" lead spirals have been successfully made with groove fineness from 24 per inch to above 35 per inch.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of cold drawing an elongate tube shell in a single continuous draw pass to form a cold finished tube having an internal surface with a plurality of longitudinally extending grooves which comprises: longitudinally drawing the tube shell along a mandrel, sinking the tube shell to reduce the diameter of the internal surface of the tube shell to a dimension below the minor diameter of the grooves to be formed, then progressively enlarging the reduced internal surface of the tube shell, and next longitudinally retarding the longitudinal movement of a portion of the reduced internal surface of the tube shell at a plurality of circumferentially spaced intervals to effect formation of the grooves while concurrently, with the formation of the the grooves, reducing the outer diameter of the tube shell by at least 9% and reducing the wall thickness of the tube shell by at least 20% along the same portion of the reduced internal surface of the tube shell.

2. A method of cold drawing, as set forth in claim 1, further comprising the step of providing a freely rotating mandrel and spirally grooved plug to uniformly spiral the grooves along the length of tube.

3. A method of cold drawing, as set forth in claim 2, further comprising the step of annealing the tube shell prior to cold drawing.

4. A method of cold drawing, as set forth in claim 2, wherein the spirally grooved plug has a groove surface finish of approximately 3 microinches.

5. A method of cold drawing an elongated tube shell in a single continuous draw pass to form a cold finished tube having an internal surface with a plurality of longitudinally extending grooves, which comprises: longitudinally drawing the tube shell concentrically over

a mandrel to and through a die bore of the type having a cylindrical bore and a tapering lead-in portion forming a continuation of the bore, the mandrel including a substantially cylindrical grooved plug concentrically within the cylindrical bore, a cylindrical bearing section having a diamenter of smaller dimension than the minor diameter of the grooved plug, and a generally conical bearing section interconnecting the cylindrical bearing section to the grooved plug, the cylindrical bearing section being disposed partly within the tapering lead-in portion and the cylindrical bore, and where the grooved plug includes a surface with a plurality of longitudinally extending grooves having a groove surface finish of approximately 3 microinches and which are circumferentially spaced about the surface; and sinking the tube shell about the cylindrical bearing section to an internal diameter of a dimension less than the diameter of the grooved plug at the base of the grooves, the outer diameter of the tube shell being reduced by at least 9% and the wall thickness of the tube shell being reduced by at least 20% during the drawing process to facilitate formation of the grooves in the tube shell.

6. An apparatus for cold drawing an elongate tube shell to form a cold finish tube having an internal surface with a plurality of longitudinally extending grooves, the apparatus being of the type with a die having a die land circumscribing a cylindrical bore and a generally conical approach zone circumscribing a tapering lead-in portion forming a continuation of the bore, and a mandrel coaxially disposed within the bore and spaced from the surfaces of the die to define a spacing through which the tube shell is to be drawn, the mandrel including a substantially cylindrical grooved plug having a groove surface finish of approximately 3 microinches concentrically disposed with the cylindrical bore, a cylindrical bearing section having a diameter of smaller dimension than the minor diameter of the grooved

plug, and a generally conical bearing section interconnecting the cylindrical bearing section to the grooved plug, the cylindrical bearing section being disposed partly within the tapering lead-in portion and the cylindrical bore, the die land and the mandrel being further arranged such that during the cold drawing of an elongate tube shell and while the grooves are being formed on the internal surface of the elongate tube shell, the outer diameter of the tube shell is reduced by at least 9% and the wall thickness of the tube shell is reduced by at least 20%.

7. A method of cold drawing an elongate tube shell substantially as hereinbefore described with reference to the accompanying drawings.

8. An Apparatus for cold drawing an elongate tube shell substantially as hereinbefore described with reference to the accompanying drawings.

DATED this 16th day of November 1990

THE BABCOCK & WILCOX COMPANY
By their Patent Attorneys
GRIFFITH HACK & CO.

FIG. 1

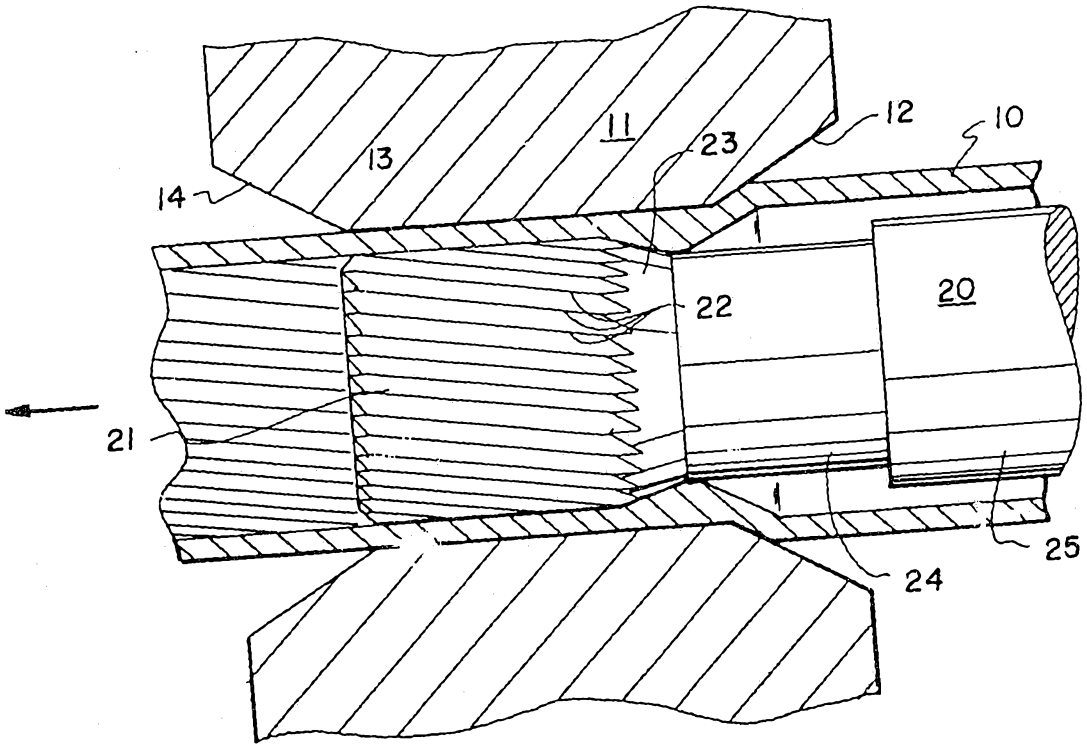

FIG. 2