Jan. 18, 1966 A. HUET 3,229,489

PROCESS AND APPARATUS FOR BENDING TUBES

Filed July 3, 1962 2 Sheets-Sheet 1

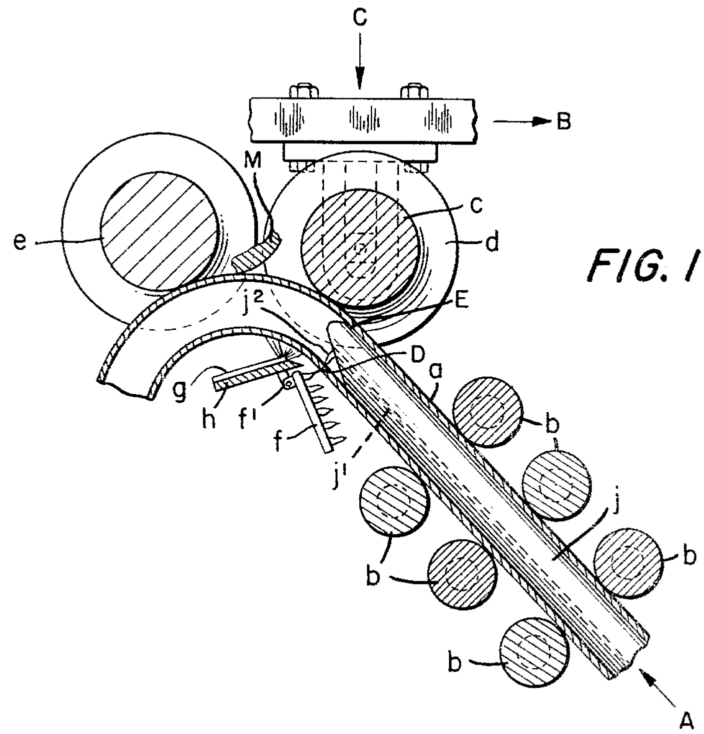


FIG. 1

FIG. 2

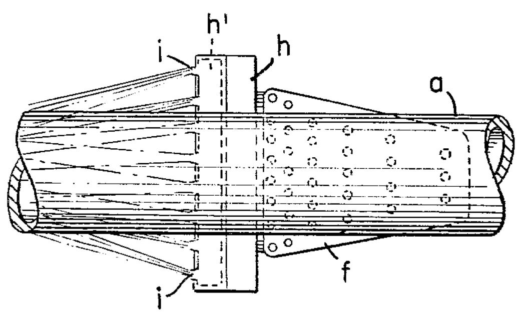
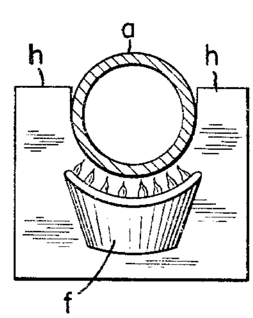


FIG. 3



Jan. 18, 1966 A. HUET 3,229,489

PROCESS AND APPARATUS FOR BENDING TUBES

Filed July 3. 1962 2 Sheets-Sheet 2

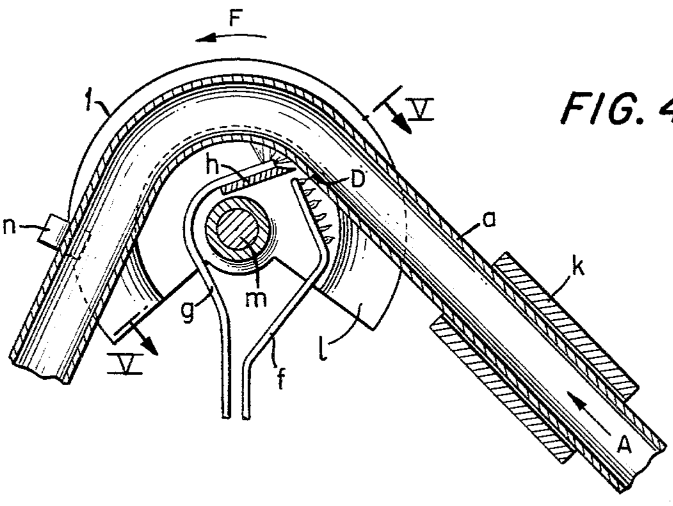


FIG. 4

FIG. 5

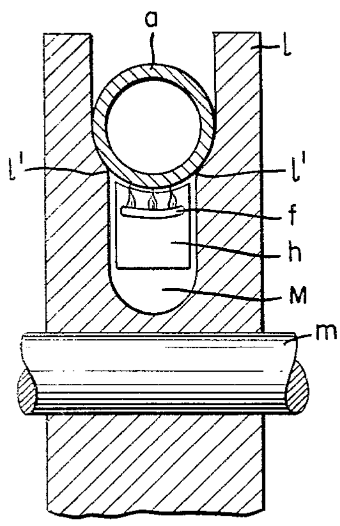
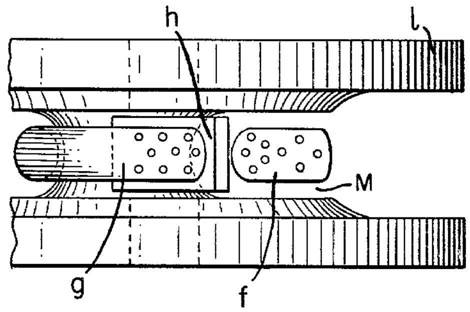


FIG. 6



United States Patent Office 3,229,489
Patented Jan. 18, 1966

3,229,489

PROCESS AND APPARATUS FOR BENDING TUBES

André Huet, 48 Ave. du President Wilson, Paris 16, France

Filed July 3, 1962, Ser. No. 207,243
Claims priority, application France, July 17, 1961, 868,160, Patent 1,302,529
8 Claims. (Cl. 72—128)

This invention relates to the bending of tubes and is particularly concerned with an improved method of and apparatus for bending tubes.

Many processes are current for bending tubes with preliminary heating of the whole periphery of the tube or of a part of it only, at the point where bending is to take place, the tube being then curved over a roller or pressed between dies or acted upon by a single die.

The object of this invention is a process in which a tube is bent by subjecting a narrow band of the tube at the point where bending is going on, to intense local heating, which moves forward as bending proceeds. As soon as a part of the tube has passed the bending device, it is strongly cooled so as to become rigid again. This part of the tube being restored to its normal rigidity then serves as bearing for the following part, which is heated, bent and cooled in its turn, and so on.

In this invention, in the first method, the tube is forced, by rollers moving it forward, for example, against a bearing surface which makes an angle with the direction of motion of the tube, which produces the required bending effect.

This bearing surface which is located at the outside of the bend may consist of one or more deeply-grooved rollers or a curved guide-block; the bottom of the groove in either of these acts on the part of the tube which will be the outside of the bend formed.

The heating devices may be located inside the bend being formed and the cooling devices immediately after them. The heating and cooling devices are preferably separated by a refractory screen which may be arranged to direct the heating and/or cooling media one way or the other. The heater-jets or blowpipes are preferably turned against the direction of motion of the tube.

A round mandrel may be disposed inside the tube to direct the tube, from within, against the throat of the guide roller or die. This mandrel may be hollow, so as to convey means of heating, or cooling, or both, to supplement the action of the similar devices acting outside within the curve. Heating and/or cooling by the mandrel may take the place of heating and/or cooling from outside.

In a variant of the process the tube is drawn through and coiled up on a bending drum the jaws of which support the sides of the tube. The drum may be cut away at the centre and the means of heating and cooling located within it. The radius of this drum determines the radius of the bend produced.

FIG. 1 shows diagrammatically the tube in process of bending against a bearing roller.

FIG. 2 is large scale detail showing the heating and cooling device under the tube, in the process illustrated in FIG. 1.

FIG. 3 is a detail of the same device, showing in elevation the screen between heating and cooling devices.

FIG. 4 shows diagrammatically the second method, by drawing the tube through the bending device.

FIG. 5 is a section on V—V FIG. 4, to a larger scale

FIG. 6 is a larger-scale part-view of the roller in FIG. 4, showing heating and cooling devices located inside the roller or drum.

In the process illustrated in FIGS. 1 to 3, the tube *a* is thrust forward by the rollers *b* in the direction of the arrow A. The tube is thus forced against the roller *c* called the bending roller, which has deep jaws *d* and is mounted to slide on the work table in two directions at right angles (arrows B and C) to any convenient position, at which it is locked during the operation. In this position the bottom of the groove in the roller *c* bears against the outside of the tube *a* and causes it to bend. The radius of the bend in the tube is set by the position of the roller on the table. If required, a second roller *e*, also mounted to slide in two directions at right angles, is placed behind roller *c* to complete the bending and if necessary to reduce the radius of the bend. A straight guide block M FIG. 1, guides the tube from roller *c* to roller *e*.

In this arrangement the bending rollers *c* and *e* act, as can be seen, on the part of the tube which will eventually be the outside of the bend.

The inside of the curve is clear and a curved mounting is fitted at this point, (FIGS. 2 and 3) which is curved to suit the tube and carries oxy-acetylene blowpipes or the like, the flame direction of which is preferably turned against the direction of movement of the tube. The mounting *f* is hinged at f^1 e.g. to the screen *h* so as to swing towards or away from the tube *a* (FIG. 1) so that the strongest heat is at D, FIG. 1, where the bend is being made, and is applied to a relatively narrow band of the tube surface. This band is at right angles of the axis of the tube and embraces about 90° of the perimeter (FIG. 3) but it may embrace 180° or more if the tube is a thick one. In other words, such a band does not necessarily extend around the entire tube, and it may be defined as a narrow portion of tube extending circumferentially of the tube. The ratio of tube thickness to the width of the band D of maximum heating is in general selected to avoid any buckling whatever. The only thing which may occur is a thickening of the tube wall at this point caused by the bending effort exercised by the rollers.

The heating asembly *f* is succeeded by a cooling device *g*. Between these is placed a screen of refractory, or high-melting point metal. In the method shown in FIG. 1 a groove h^1 (FIG. 2) is formed in the screen, to supply the cooling fluid to the jets *i* (FIG. 2) which projects it on to the tube immediately after the band D which has been heated and bent. The cooling device h^1 preferably embraces a larger sector of the tube than the heater *f* (see FIG. 2, where h^1 projects to both sides of the tube). This is to cool the sides of the tube beyond the heated area. The cooling fluid may be compressed air, or preferably CO_2, nitrogen or a neutral gas, and may be humidified if required so as to produce a mist which chills the metal rapidly and completely without the risk of igniting it.

The heating and cooling devices are so mounted as to be adjustable, so that the band D of maximum heating be located at the required spot.

Inside the tube is placed a mandrel *j* the rounded head of which bears on the inside of the tube at the point E FIG. 1, i.e. where the outer wall of the bend is being formed. This mandrel keeps the tube rigid between the rollers *b* which propel it, and the bending roller *c*. The mandrel may be provided with a bore j^1 to convey a gas mixture j^2 to the head of the mandrel so as to heat the zone D opposite the external heater *f* or instead of it. A bore may also be provided inside the mandrel to convey cooling fluid which may be sprayed against the inside of the tube beyond the heating zone D, or even in line with it, to form at that point a thin cold crust which improves the working of the metal in regard to the thickening of the tube wall, preventing any possibility of internal folding. In the same way the tube may be cooled opposite the cooling device *g* or in place of it.

The device acts as follows:

The tube, which may be of steel, is entered between the drive rollers *b* and the mandrel is placed inside it. The end of the tube bears against the bottom of the groove of roller *c*. The heater jets raise the point D to the maximum temperature which may be 1200° C. The tube is bent and as it passes the screen *h*, the cooling device reduces the heated zone to about 600° or 700°. At this temperature the tube regains its rigidity, while, in the case of special steels, it is still above the transformation point. The metal is thickened inside the bend at D during bending, while the bore of the tube at the bend can increase, as there is nothing at the inside of the bend to prevent this.

The deep jaws of the roller *c* and if required, of *e*, by supporting the tube laterally during bending aid the movement of the metal from the inside of the bend towards the bending axis (lower part of FIG. 1) with the result that the thickening of the wall inside the bend is checked while the bore of the tube is increased.

After the tube has passed the cooling zone it may if required be reheated to restore the structure of the metal.

In the variant process shown in FIGS. 4 to 6, the tube is bent by being drawn through the bending assemblying and rolled up on a drum **1** which occupies the inside line of the bend.

The tube is guided by a sleeve *k* fixed to the work table. This may be replaced by bearing rollers. It is caught up by a finger *n* on the drum **1** and the drum revolving in the direction of the arrow F bends the tube. This drum (FIG. 5) has deep jaws which completely embrace the tube, and it is cut away centrally at M (FIG. 5), leaving rounded shoulders l^1 at both sides of the tube. The tube bears on these during bending. The space inside the drum allows the metal of the tube to move towards the roller spindle *m* thus increasing the bore of the finished bend.

Further, the heating and cooling devices *f* and *g* separated by the screen *h* may be located within the drum as in FIG. 4, so that the heat is applied at the point where the bending actually begins.

This point of maximum heating D remains fixed during the whole period of rotation of the rollers and the heating and cooling devices *f* and *g* can therefore be fixed on their mounting within the bending drum. They can however be adjusted at a greater or less distance from the tube in order to regulate temperatures.

In the variant in FIG. 4, a mandrel may be inserted in the tube, which can be arranged to heat and/or cool the latter during bending, from within.

The above device allows of making very small radius bends, even less than the tube diameter, i.e., for a bend of 180°, the distance between the two straight legs of the bent tube may be equal to the tube diameter.

The range of adjustment of the heating and cooling devices makes it possible to bend thin walled tubes e.g. of a wall thickness 1/10 of the diameter.

It is evident that detail modifications can be made without departing from the main principle of the invention.

I claim:

1. Method of bending a steel tube, comprising providing a steel tube of uniform wall thickness, subjecting in each of a number of circumferentially extending narrow

portions of the tube successively to heating while exerting upon said portions a thrust force applied longitudinally of the tube, to cause a thickening of the metal at said portions, each of said portions being left laterally unsupported at least on the outer face surface thereof while said thickening is taking place, with the tube being supported on the outside of the bend.

2. Method of bending a steel tube, comprising, providing a steel tube of substantially uniform wall thickness, subjecting in turns each of a number of circumferentially extending narrow portions of the tube material to a heat while exerting upon said portion a thrust force applied longitudinally of the tube to cause thickening of said portion at its point of maximum temperature, said portion being left laterally unsupported along its outer face during said thickening, with the tube being supported on the outside of the band, said heat being applied concurrently inside and outside the tube.

3. Method of bending a length of tube comprising, providing a tube subjecting in succession each of a number of adjacent circumferentially extending narrow portions of said length of tube to a series of operations which comprises in uninterrupted succession heating said portions with, while applying to said section a thrust force directed longitudinally of the tube to cause a thickening of the metal in each of said portions under the effect of said force, and cooling said portion, each of said operations progressing without interruption from end to end of said length of tube.

4. Method of bending a length of tube which consists in subjecting in turns each of a number of adjacent narrow circumferentially extending portions on said length of tube to a series of operations which comprises in uninterrupted succession the heating of said portion, the thickening of the metal in said portion under the effect of a thrust force applied longitudinally of the tube and the cooling of said portion, said portion being laterally unsupported on its outer face while said thickening is taking place, each of said operations progressing without interruption from end to end of said portion of tube.

5. Method of bending a length of tube of a thickness less than 1/10 of its diameter which consists on subjecting in turns each of a number of adjacent narrow circumferentially extending portions on said length of tube said portion embracing about 90 degrees of the perimeter of the tube to a series of operations which comprises in uninterrupted succession the heating of said portion, the thickening of the metal in said portion under the effect of a thrust force applied longitudinally of the tube and the cooling of said portion, each of said operations progressing without interruption from end to end of said length of tube.

6. Apparatus for bending a tube comprising: means for guiding a portion of said tube along a straight path;

means for directing a portion of said tube along a curved path, said two means being so arranged as to leave a clear space between them;

a heating device located between said two means for softening a narrow portion of tube material extending circumferentially of the tube;

means for impelling the tube out of said guiding means and into contact with said directing means, to produce a bend at said portion and to present an adjacent portion of tube material to said heating device;

a cooling device disposed relative to said heating device in the direction of progression of the tube and disposed for cooling each of said portions after bending;

a screen located between said cooling device and heating device;

said impelling means and said guiding means comprising a series of driving rollers located to advance said tube towards said directing means;

said directing means comprising a plurality of rollers, at least one of said plurality being located externally of said tube on the outer side of the bend, and being adjustable in relation to said impelling rollers.

7. Apparatus according to claim **6** including a mandrel, inserted within the straight part of tube to be bent.

8. Apparatus according to claim **6** wherein said mandrel includes means for heating and for cooling the tube from inside.

References Cited by the Examiner

UNITED STATES PATENTS

682,070	9/1901	Hart	153—45
1,888,891	11/1932	Schmidt	29—157
1,891,338	12/1932	Snell	29—157
1,996,838	4/1935	Snell	29—157
2,221,417	11/1940	Taylor	29—157
2,391,252	12/1945	Louthan	153—46
2,433,055	12/1947	Linden et al.	153—32

FOREIGN PATENTS

151,294	5/1953	Australia.
499,627	6/1930	Germany.

WHITMORE A. WILTZ, *Primary Examiner.*

MICHAEL V. BRINDISI, CHARLES W. LANHAM, *Examiners.*