May 16, 1961 A. GRESSE 2,983,995

BENDING PROCESS

Filed April 16, 1956

Fig.1

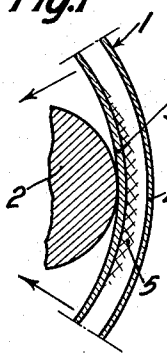


Fig.2

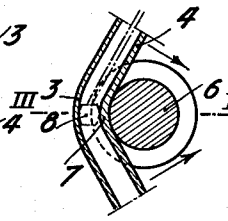


Fig.3

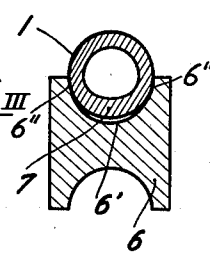


Fig.4

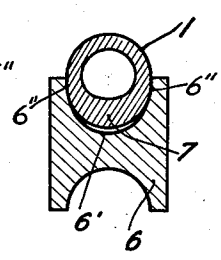


Fig.5

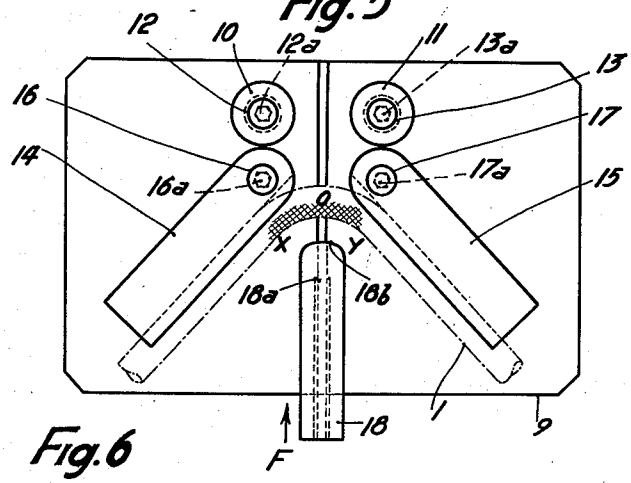


Fig.6

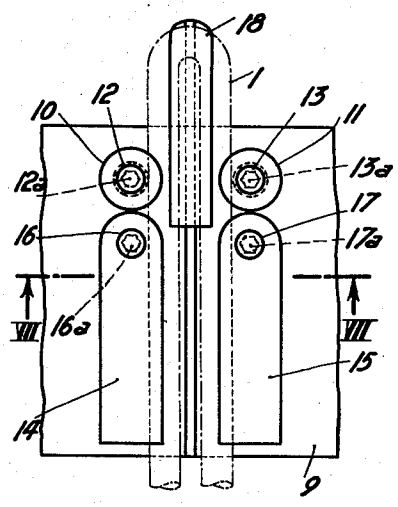
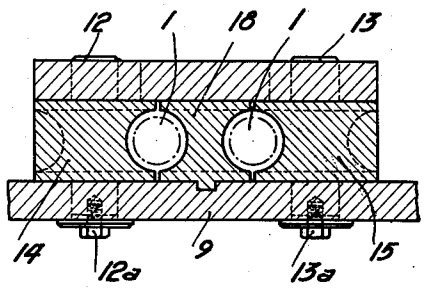


Fig.7



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BENDING PROCESS

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8 Claims. (Cl. 29—157.6)

The present invention relates to a method of bending metal tubes and it is more especially concerned with bending such tubes "to a short radius," the thickness of the tubes being relatively large. By the expression "bending to a short radius," there is meant the bending of a metal tube having the following characteristics:

$$e \geqslant d/12$$
$$r \leqslant 1.75d$$
$$a \leqslant 90°$$
$$e' \geqslant (e - 0.5 \text{ mm.})$$

where d is the external diameter of the tube in mm, e is the thickness of the tube wall in mm., r the theoretical radius in mm. of the finished bend, a the final angle in degrees included between the two limbs of the bend, e' being the thickness in mm. of the extrados wall of the bend.

It is known that bending operations of this kind applied to relatively thick tubes—which is the case for example in the manufacture of tubular coils—tend to reduce the thickness of the wall on the outside of the bend and to compress and increase the thickness of the wall on the inner side of the bend in the zone in which the tube is worked, from which there results on the one hand a reduction of the internal diameter of the tube, which may in certain cases be such as to cause a weakening of the wall of the tube, and especially a reduction in the internal diameter of the tube, even extending to the complete closure of the bore.

The present invention is proposed to remedy these drawbacks, and it has for its object a sure method which does not produce either cracking or folding or striction or physical deterioration of the metal of which the tube is constituted at the point at which it is bent, and which reduces the differences between the elongation and the compression of the opposite walls of the tube.

The method of bending a metal tube in accordance with the present invention consists in subjecting such a tube to a first operation of moderate bending in the opposite sense to the final bending of the elbowed tube to be produced, then bending the said tube at the point of the said first bending operation and in the opposite direction to the said first bending operation, preferably at the same time displacing, towards the internal face of the bend thus formed, the extra thickness of the compressed wall of the said bend, then bringing up to a high temperature a part of the internal face of the said bend, and then bringing towards each other the two arms of the said bend and continuing this latter operation whilst applying a pressure on the internal face of the elbow along the bisecting line of the angle of the said elbow and in the plane of the said bisecting line, in such manner as to pass the bent tube into a gauge, the last operation being continued if desired until the two arms of the said tube thus bent are parallel.

The first operation of moderate bending is preferably carried out in the hot state.

The external wall of the bend or elbow is preferably cooled during the above mentioned last bending operation.

The present invention will be explained in more detail below, reference being made to the attached drawings which illustrate one form of embodiment of the application of the method, and in which:

Fig. 1 is a diagrammatic view showing the first stage of the method of bending in accordance with the present invention.

Fig. 2 is an identical view of the second stage.

Figs. 3 and 4 are views in cross-section, taken along the line III—III of Fig. 2, at the beginning and at the end of the second stage of the bending operation, respectively.

Figs. 5 and 6 are plan views showing the beginning and the end of the process of bending.

Fig. 7 is a view in cross-section taken along the line VII—VII of Fig. 6.

In Fig. 1 of the drawings, there is shown a tube designated generally by the reference No. 1, which is subjected to a first bending operation of slight extent in the opposite direction to the final bending of the elbow desired. The tube **1** is bent over a supporting former **2**; it can be seen that the compressed part of the wall becomes thickened at **3**, whilst the drawn-out portion **4** of the wall of the tube becomes thinner. The zone **5** is preferably heated so as to facilitate the carrying out of this operation.

This first operation is followed by a second manipulation which consists in partly bending the tube **1** to an angle of about 110 or 120° by supporting the drawn-out zone **4** of Fig. 1 on the bending sheave **6**, the part **3** which was previously compressed being then located on the outside. Thus, this bending carried out in the opposite sense to the first bending operation, applies to the walls of the tube **1** an effect opposite in sense to the first: the extrados **3** tends to become thinner, whilst the intrados **4** tends to become thicker at **7**. It is also possible to provide an internal olive shaped mandrel or bending oval **8**, held fixed by any known means, not shown in detail in the drawings, instead of carrying out this operation with either filled or empty tubes. In the case of thick tubes, it is preferable to make the profile of the groove of the bending sheave **6** oval by hollowing out the bottom of the said groove. Thus, the increased thickness **7** (Fig. 2) of the intrados **4** is displaced towards the exterior of the tube and is received in the hollowed-out portion formed in the sheave, whilst the walls of the tube are supported by the buttress flanks of this groove. There is shown in Fig. 3 the sheave **6** which has been oval at **6'** and in the groove of which is placed the tube **1** which is supported by the sides **6** of this groove.

In Fig. 4, there is shown the relative position of the roller and the tube; the intrados has penetrated partly into the hollowed-out portion **6'**, and the thickened portion **7** has been forced into the hollowed portion **6'**.

The bend thus obtained is then heated by applying very rapid heat to the part **7** over a limited region (shaded at *xoy* in Fig. 5). The elbow is then placed on a frame **9** on which two rollers **10**, **11** are rotatably mounted on shafts **12**, **13** and are retained by bolts **12***a*, **13***a*, and two arms **14**, **15** are pivotally mounted on pivots **16**, **17** and held in position by bolts **16***a*, **17***a*. On this frame, there is also mounted a punch **18** which can be displaced in any known manner (not shown in the drawings) along the bisecting line of the elbow.

The elbow having been arranged in this way, the arms **14**, **15** are first manipulated by bringing them closer to each other as they pivot on their axes, while at the same time the punch moves forward in the direction of the arrow F. When the angle of the elbow has reduced to

a certain value, for example of the order of about 60°, the punch has come in contact with the tube and applies a thrust to it, directed towards the top of the figure. This punch has the shape of a fork, of which the distances from the bottom 18*a* to the extremities of the arms 18*b*, and the distance apart of the said arms are chosen to correspond to the external diameter of the tube being worked so as to prevent it being crushed. The combined action of the arms **14**, **15** and the punch forces the tube **1** upwards and obliges it to pass between the rollers **10**, **11**; the two limbs of the hairpin bend thus obtained are parallel to each other, the heating having the object of assisting the molecular flow.

If so desired, the operation may be continued or the punch may be freed in the direction opposite to that of the arrow F in order to withdraw the short-bend tube thus obtained.

In the same way, all subsequent operations of forming in a die and like operations may be effected without thereby departing from the scope of the present invention.

The device described above is only one example of the embodiment of the method. All the operations of the method in accordance with the present invention can be carried out on a single machine with the object of making the process automatic, using tools designed in accordance with the nature of the metal of the tubes to be treated.

The operations of bringing the tube arms closer together may be accompanied by a simultaneous application of cooling to the elbow by any known means which are not shown on the drawing.

It will be understood that the application of the method in accordance with the present invention may only comprise a part of the operations described, such as for example the operations of bending and folding, or those of forming bending and folding, or those of bending, folding and die-forming.

What I claim is:

1. A method of bending a tube of deformable metal to a short radius, as hereinbefore defined, said method comprising the steps of carrying out a first bending operation through a small angle in a direction opposite to that of the ultimate bend of the elbowed tube to be produced, so as to thicken the outer wall of said ultimate bend effecting a second bending operation on the said tube in the same plane as said first operation, and in a direction opposite to that of said first bending operation, thereby slightly reducing the thickness of said thickened outer wall, causing the thickened portion of the inner compressed wall of the bend, formed by said second operation, to be displaced toward the inner side of the elbow thus formed by providing a space to receive the displaced metal, heating to a high temperature a zone of the inner face of said elbow, forcing toward each other the straight extremities of said elbowed tube until a certain angle of elbow is reached, subsequently applying a local pressure to the inner face of said elbow in the plane of the angle formed by said elbowed tube and along the bisector thereof, and effecting the final bending operation by forcing said elbowed tube between at least two gauging members.

2. A method as claimed in claim 1, in which said final bending operation is continued until the said straight extremities of the elbowed tube are substantially parallel to each other.

3. A method as claimed in claim 1, in which the said first bending operation of moderate extent is carried out with said tube in the hot state.

4. A method as claimed in claim 1, in which the extra-thickness of the compressed wall of said tube, formed during said second bending operation, displaced towards the inner side of the said elbow by virtue of an ovality formed in the bottom of the circular groove in the bending sheave which receives and forms the said tube.

5. A method as claimed in claim 1, in which said local pressure applied to the inner face of the said elbow is created by means of a forked punch actuated by suitable means, the forks and body extremity of said punch being adapted to fit the external wall of the said tube.

6. A method as claimed in claim 1, in which said final bending operation consists in forcing said elbowed tube between a plurality of rollers rotatably mounted on a base-plate, the said rollers having circular grooves formed in their peripheral faces.

7. A method in accordance with claim 1, and comprising the steps of: inwardly bending the straight extremities of said elbowed tube by a pair of arms each pivotally mounted at one of its extremities on a base-plate and shaped to accommodate the outer walls of the said straight extremities along their length, forcing the elbowed portion by said local pressure between the pivoted ends of said sleeves before being engaged between the said gauging members, and bringing the straight extremities of said elbowed tube towards each other by force applied to said sleeves during the final bending and gauging operation.

8. A method as claimed in claim 1, and comprising the further step of cooling the external surface of said elbow eration.

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