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APPARATUS FOR BENDING PIPE

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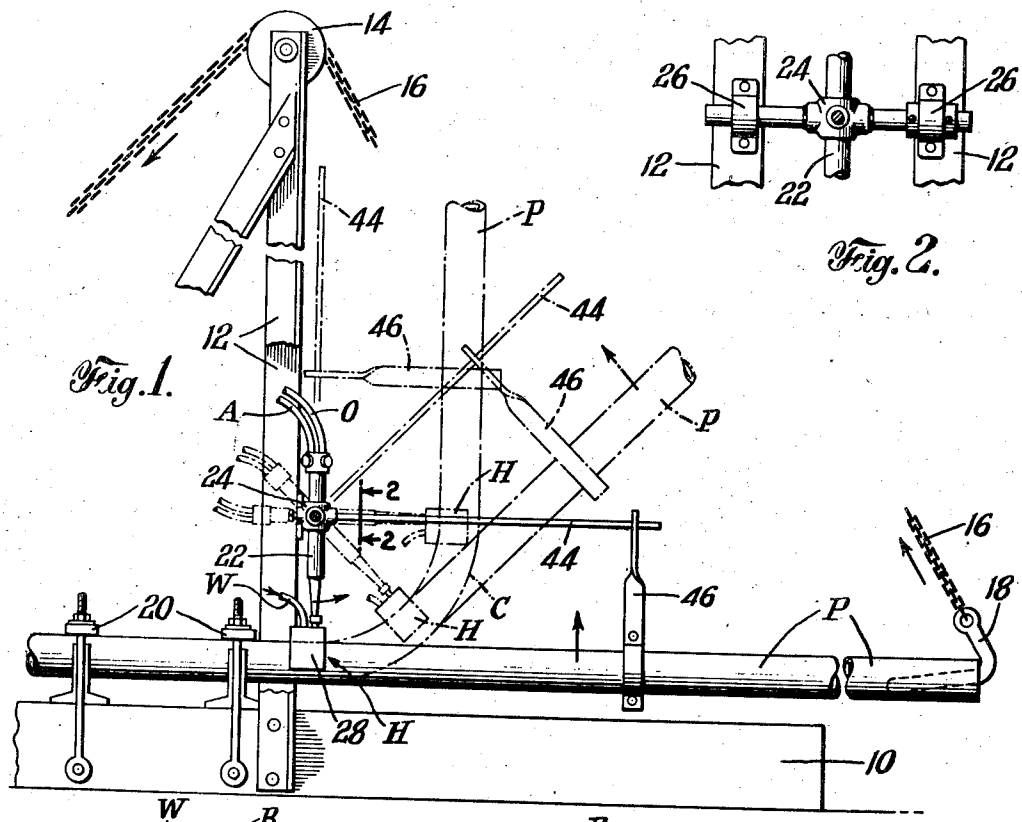


Fig. 1.

Fig. 2.

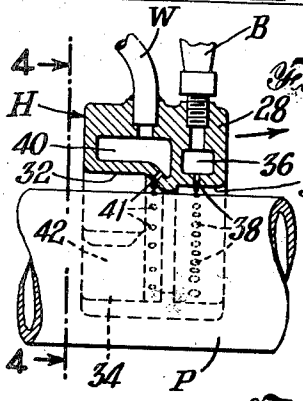


Fig. 3.

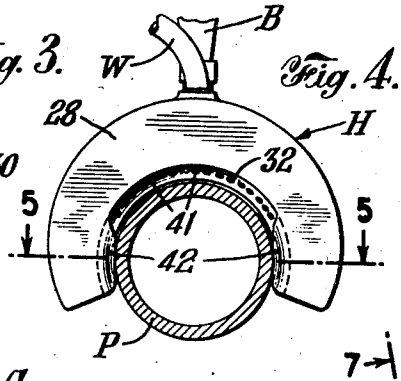


Fig. 4.

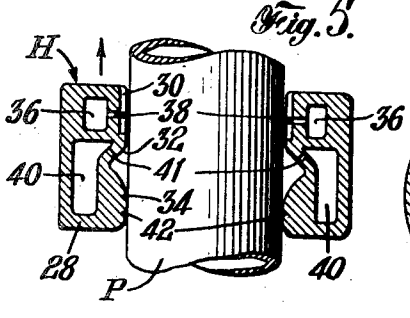


Fig. 5.

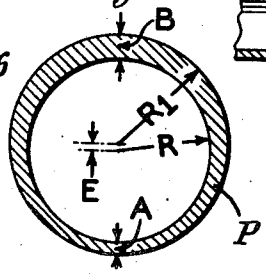


Fig. 7.

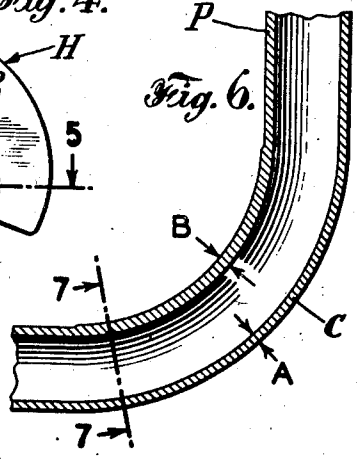


Fig. 6.

INVENTORS
WALTER R. LINDEN
HERBERT H. MOSS
BY
ATTORNEY

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APPARATUS FOR BENDING PIPE

Walter R. Linden, Palisades Park, and Herbert H. Moss, Elizabeth, N. J., assignors to The Linde Air Products Company, a corporation of Ohio

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3 Claims. (Cl. 153—32)

1

This invention relates to pipe bending and more particularly to progressive upset bending of metal pipe.

A method of bending such pipe has been developed, known as "wrinkle" bending, which involves wrinkling the pipe outwardly so that the pipe, with its length shortened slightly on one side by wrinkling, deviates from a true line by the angle resulting from the wrinkle. In practice, flame is used to heat one or more axially spaced bands at right angles to the longitudinal axis of the pipe and extending more than halfway around the circumference of the pipe. The pipe is then bent either by hand or mechanically by slightly buckling such bands. As a rule, wrinkling is used to produce only a slight change in direction of the pipe. When the direction is more pronounced, a series of wrinkles provide a more abrupt bend. Wrinkle bending, has found its greatest use in overland gas and oil piping for curvature of relatively low degree.

Other known methods of bending pipe involve simply bending the pipe while cold or hot. However, the outer wall of "fire" and "cold" bends is definitely and objectionably thinned by the bending operation.

It has also been proposed to bend pipe by progressively flame heating, upsetting and chilling the metal as the bending operation proceeds, but such proposals, due probably to the relatively low temperature obtainable with flames produced by a mixture of air and fuel gas, have not generally been adopted. In some cases the bend must be restored to a round section after the bending operation, especially in the case of large diameter pipe, or expensive and heavy apparatus, not at all suitable for field use, must be used. Also, such proposals involve the combustion of fuel gas and air, or propane and air, as the heating medium. Such fuel gases are not always readily available to cross-country pipe laying gangs. Nor is it feasible in the field to fill a pipe to be bent with a core to maintain a round section.

Factory made bends and fittings are very expensive. As a result, there exists a very great demand for some satisfactory method of progressively bending pipe that can be carried out in the field by ordinary workmen, with light, simple equipment and a readily available source of heat.

The main object of this invention is to overcome disadvantages and difficulties of the prior art and provide a pipe bend that is stronger and more economical. Other objects are to provide an improved process and novel apparatus for bending metal pipe.

2

Such objects are accomplished, according to the invention, by subjecting the pipe to a suitable bending moment in the region to be bent, and then progressively heating, upsetting and chilling the metal in an extremely narrow transverse wall zone in such region, which zone moves axially from one end to the other of the bend as the bending operation proceeds. Such extremely narrow transverse wall zone is obtained, for example, by a flame composed of commercially pure oxygen and fuel gas (which has a temperature of the order of 1500° higher than an air and fuel gas flame) directed radially against the pipe wall with the inner cone of the flame only slightly spaced from the peripheral surface of the pipe. By virtue of its high heat intensity, such oxy-fuel gas flame causes rapid heating of the metal to a temperature slightly below the mushy stage in a very narrow wall zone, and upsetting of the heated metal takes place before the high temperature heat is transmitted to the adjacent metal. Such upsetting rapidly progresses to a value of 125% to 133% or more of the initial wall thickness, and the upset metal is chilled directly after being upset. The oxy-fuel gas heating flame may be produced by a suitable blowpipe head having internal ports or tips which direct a suitable mixture of the oxygen and fuel gas against the pipe, the pipe and head being moved relatively to each other in the direction of the bend, without substantially changing their relative transverse positions.

According to the invention, pipe bending is accomplished by the continuous upsetting of axially small increments of metal, providing the facility of variable bend radii, nominal wall thickness on the outside of the bend, and a reinforced inside wall giving the bend great strength. The invention makes it possible, with simple and readily available materials, to obtain a truly circular pipe bend by progressive and continuous incremental upsetting without thinning the outer wall or damaging the metal affected by the upsetting process. Damage to high strength pipe, if any, can be corrected by subsequent heat treatment by the device of the invention, if desired.

A critical and novel feature of the invention is the employment of at least one row of high-temperature oxy-fuel gas flames which embraces the circumference of the pipe only in the compression zone thereof.

The invention involves a process of bending commercial pipe and tubing by upsetting that portion of the metal lying in the compression area of the flexural diagram for simple bending

by the application of heat of sufficient intensity to quickly change the temperature of a very narrow band of the metal in such portion to a value slightly below the mushy stage, the heat being derived from oxy-acetylene flames having a temperature of the order of 5,600° F. for a 1.5/1 ratio of oxygen to acetylene, progressively applied from the point of bend origin to the opposite or second point of tangency. The heating zone is so disposed as to shift the normal neutral axis of the tubular section to a point sufficiently close to the metal in the region of the outer radius or tension portion of the tubular section so as to minimize the intensity of the tensile stress therein during the bending operation. The result is rapid reorientation of the metal only in the flexural plane normal to the longitudinal axis of the bend.

In the drawing:

Fig. 1 is a fragmentary view in side elevation of apparatus illustrating the invention;

Fig. 2 is a fragmentary view in front elevation taken on line 2—2 of Fig. 1;

Fig. 3 is a fragmentary view mainly in cross-section of the head;

Fig. 4 is a view mainly in rear elevation taken on line 4—4 of Fig. 3;

Fig. 5 is a horizontal sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a longitudinal sectional view of a pipe bent according to the invention; and

Fig. 7 is an enlarged transverse sectional view of the pipe taken on line 7—7 of Fig. 6.

The reorientation of the metal in the plane 7—7 of bending produces two eccentric circles having radii R and R_1 (the centers of which have an eccentricity E) when viewed from the standpoint of the inner and outer walls of the section, as shown in Fig. 7, and of such relation that the thickness of wall "A" is substantially that of the pipe wall before bending at "B," the increase being proportional to the decrease in length of the metal required to be upset to form a specific pipe bend C. Accurate control of upsetting is accomplished by chilling the metal quite close to the zone of upsetting and progressing therewith as the bend is being made, which in effect operates to reestablish the normal temperature structural property of the tubular section close to the plastic zone directly following upset. This operates to constrain the heated metal to the initial circular shape. The present upset method of bending pipe produces a true and uniform bend C possessing a reinforced inner wall B and, in turn, making for a stronger bend in service because of the increased strength in that portion A of the bend subject to tension.

In the illustrated apparatus, which is shown only by way of example, a base 10 is provided with uprights 12 near the top of which is mounted a pulley 14 over which a chain 16 passes. The chain is provided with a hook 18 which is inserted in one end of the pipe P to be bent, and a pulling force is applied to the other end of the chain 16. For this purpose the chain may be wound on a windlass not shown, which may be turned by hand or by a motor. A pair of vises 20 are also mounted on the base 10 for anchoring the main section of the pipe P, as the upward bending force is applied to the free end thereof through the chain 16.

An oxy-acetylene blowpipe 22 is mounted in a fitting 24 which is pivoted to the uprights 12 in suitable bearings 26. Mounted on the blowpipe 22 is a novel head 28 consisting of an oxy-acetylene heating flame section 30, a chilling section 32 and a pipe bearing section 34. The oxy-acetylene heating flame section 30 is provided with an oxy-acetylene distributing passage 36 having a row of ports 38 for discharging a suitable combustible mixture of oxygen and acetylene inwardly of the head to form jets which, when ignited, produce characteristic oxy-acetylene heating flames of very high temperature and intensity. The chilling section 32 of the head 28 is provided with a chilling fluid distribution passage 40, and a row of chilling fluid outlet passages 41 which are arranged in rearwardly inclined relation to the oxy-acetylene gas ports 38, and are adapted to discharge streams of cooling fluid such as water against the pipe P. The chilling water streams are placed as close as possible to the oxy-acetylene flames. The pipe bearing section 34 of the head 28 is provided with diametrically opposed pipe bearing surfaces 42 which are adapted to slidably engage and prevent the pipe wall from collapsing or expanding laterally during the bending operation. For pipes of small diameter the bearings 42 may be omitted, but they may be desirable in some cases for pipes of large diameter. Also, roller or ball bearings may be used, if desired.

Commercially pure oxygen and fuel gas, in this case acetylene, are supplied to the blowpipe 22 through suitable flexible conduits O and A; and water is supplied to the head 28 through a suitable flexible hose W.

In order to correlate movement of the head 28 with the bending of the pipe P, the fitting 24 in which the blowpipe 22 is mounted, is provided with an arm 44, the outer end portion of which passes through an opening in a bracket 46 which is secured to the pipe P in substantially parallel relation to the longitudinal axis of the blowpipe 22, the longitudinal axis of the arm 44 being substantially parallel to that of the pipe P before being bent.

In operation, with the parts in the full line position shown in Fig. 1, oxygen and acetylene are supplied to the blowpipe 22 in which they are mixed and the resulting oxy-acetylene jets from the ports 38 are ignited. The oxy-acetylene flames are applied to the pipe P in an extremely narrow band which extends about ¾ of the way around the circumference of the pipe. The chain 16 is then tensioned to apply a suitable bending force to the free end of the pipe P, and water is supplied to the head H through hose W. The oxy-acetylene flames quickly heat an axially narrow zone of metal in the wall of the pipe P until such metal becomes sufficiently soft or plastic or reaches a forging temperature such that the metal is upset by the bending force in the compression area of the flexural diagram.

The head 28 is thereupon automatically advanced in the direction of the bend, as the bend progresses, by the bending movement of the pipe itself, acting through clamp 46, arm 44 and blowpipe 22. As the incremental zone of upset metal advances, the upset metal is chilled immediately after being upset, by streams of water from the ports 41 in the head 28. The bearings 42 engage opposite sides of the pipe P as the head 28 advances during the formation of the bend, and prevent undue collapse or lateral expansion of the pipe P. The bearings 42 also act to guide the head with respect to the pipe.

As a result, a bend C is produced as shown in Figs. 6 and 7. The wall thickness of the bend C is uniform in any longitudinal plane through the pipe wall throughout the length of the bend.

Because the metal in the outside of the bend at A is not heated or stretched, its thickness remains substantially equal to that of the original pipe, while the thickness of the metal on the inside of the bend at B is increased.

The heating may be accomplished with manually operated blowpipes using a combination of oxygen and fuel gas such as acetylene to provide concentrated heat of high intensity or preferably, as illustrated, by a multi-flame oxy-fuel gas heating head providing a substantially uniform and very narrow heat band that extends at least half-way but not all the way around the pipe. While good results may be obtained with a single row of oxy-fuel gas flames of uniform size, still better results may be obtained by oxy-fuel gas flames the size or heating value of which increases toward the neutral axis of the bend, the average width of the plastic heat band or zone being of the order of the wall thickness of the pipe.

The invention extends the advantages of wrinkle bending to those of progressive upset pipe bending, while overcoming disadvantages and difficulties of the prior art. Pipe laying crews usually have on hand oxygen and acetylene or other fuel gas supplies as well as simple apparatus which may be adapted for carrying out the invention in the field. Pipe of any diameter may be bent according to the invention, without filling it with sand or using a core or mandrel to maintain its round shape. Pipe may be bent very rapidly, i. e. in a matter of minutes, by even unskilled workmen. The bending is automatic, and results in uniformly satisfactory bends, and in addition is quite inexpensive, being as cheap or cheaper than wrinkle bending or other methods of bending.

The wall thickness is uniform from one end of the bend to the other, with an increase in strength over that of the same pipe prior to bending. The bend needs no reforming after the bending operation. The radius of curvature of the bend may be greater than, equal to or less than the diameter of the pipe. The invention is not generally applicable to ordinary cast iron pipe, because of the well-known physical and metallurgical characteristics of cast iron. It also is not generally applicable to wrought iron pipe, because the act of upsetting might affect the layers or striations of iron and slag-like material therein which give wrought iron etc. well-known properties.

The proposals of the prior art will not work except in a shop having machinery for re-rounding flattened pipe. The reason for flattening is found in their use of a low temperature heat source involving air (as distinguished from commercially pure oxygen) and fuel gas. Such a heat source covers a relatively wide area axially of the pipe. If the heated area is wide with respect to the wall thickness, when force is applied a wrinkle will occur. If the pipe is heated in a wide band all the way round, then flattening or ovaling on the far side together with thinning of that wall will take place at the same time as the upsetting and thickening of the near wall. Such combination takes the place of the wrinkle, which would occur under the first named condition.

By use of a very high temperature local heat, such as that obtained by the combustion of a mixture of commercially pure oxygen and a fuel gas such as acetylene, applied partially around a pipe, and to a very narrow band or localized area (the area of this primary heat is probably that which lies directly in the intense zone i. e., immediately beyond the tip of the inner cone, the other heat might be termed the secondary zone) an upset will occur if sufficient force is so directed as to cause such an upset. Such upset will continuously occur, if the force remains while the area first heated and then cooled moves progressively along. The result will be a smooth and continuous bend with all the upset or thickened metal on the inner side of the pipe bend, while the outer side, remaining cold, will still be in a similar physical condition as at the start. Mechanically, the pipe will remain as round as at the start. It is immaterial whether the pipe moves or the heating element moves. The relationship of speed of traverse to heat input to pipe is important. The force to cause upsetting need be no more than the weight of the pipe itself, under some circumstances.

The crux of the matter lies in the high temperature and intensity and nature of an oxygen and fuel gas flame and its extremely localized or narrow heat zone. These qualities make the continuous bend of the present invention a practical possibility for the average general shop and the field. The inventive concept includes the proper application of the extremely high temperature heat of a mixture of commercially pure oxygen and suitable fuel gas and its extremely narrow and high heat zone.

The equipment, even for field work, can be very simple. For example, a single 20 foot joint of pipe might be suspended say 6 or 8 feet above ground and held securely at one end. Beneath this there may be set up a track and some simple means of traversing. To this is attached, pointing directly upward, a U headed blowpipe equipped with quench. The blowpipe is set at proper distance from the pipe and at the place where the bend is to occur. The blowpipe is lit, the pipe heats, the quench is turned on and the machine starts, at that speed which is satisfactory. The weight of the pipe either singly or aided by additional weights, will supply enough upsetting force, if the relation of machine speed to the localized, high temperature heat band is correct.

While a 1.5/1 mixture of oxygen and acetylene is good because such mixture produces an intense flame having a temperature of the order of 5600° F., other mixtures of oxygen (as distinguished from air) and other fuel gas such as hydrogen, natural gas, and manufactured gas may be used. For example, a 0.5/1 mixture of oxygen and hydrogen produces a flame temperature of about 4980° F.; a 1.2/1 mixture of oxygen and natural gas (90° methane and 10° ethane), a flame temperature of about 5300° F.; and a 0.5/1 mixture of oxygen and "city" gas, about 4920° F. Mixtures of air and such gases, however, produce flame temperatures of between 1500° F. and 2000° F. lower than mixtures of the same gases and commercially pure oxygen. Since the critical range of steel is about 1350° F.–1600° F., the oxy-fuel gas flame results in a marked improvement over the prior art employing air-fuel gas flames.

While an oxy-fuel gas flame, i. e., a flame produced by a suitable mixture of commercially pure oxygen and acetylene has proved to be successful in carrying out the invention, the principles thereof might be carried out by other suitable heating mediums, such as the electric arc surrounded by air or helium, and high-frequency induction heating, which concentrate the heat applied to the pipe in a very narrow band the

width of which is of the order of the thickness of the wall of the pipe.

What is claimed is:

1. Pipe bending apparatus including a blowpipe having a head provided with fuel gas outlets, means supporting said blowpipe for tilting movement, and means acting to tilt said blowpipe comprising a member connected to said supporting means, and a member connected to the pipe and slidably engaging the first member so as to form a parallelogram with the blowpipe and the pipe.

2. Pipe bending apparatus including a pipe heating head, means supporting said head for tilting movement, and means for tilting said head comprising a member connected to said supporting means, and a member connected to the pipe and slidably engaging the first member.

3. Pipe bending apparatus including a pipe heating head, means for supporting said head for

tilting movement, and means for tilting said head comprising members including an arm connected to said head and a bracket connected to the pipe, the effective length of which arm changes as the head is tilted with the bending of the pipe.

WALTER R. LINDEN.
HERBERT H. MOSS.

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