

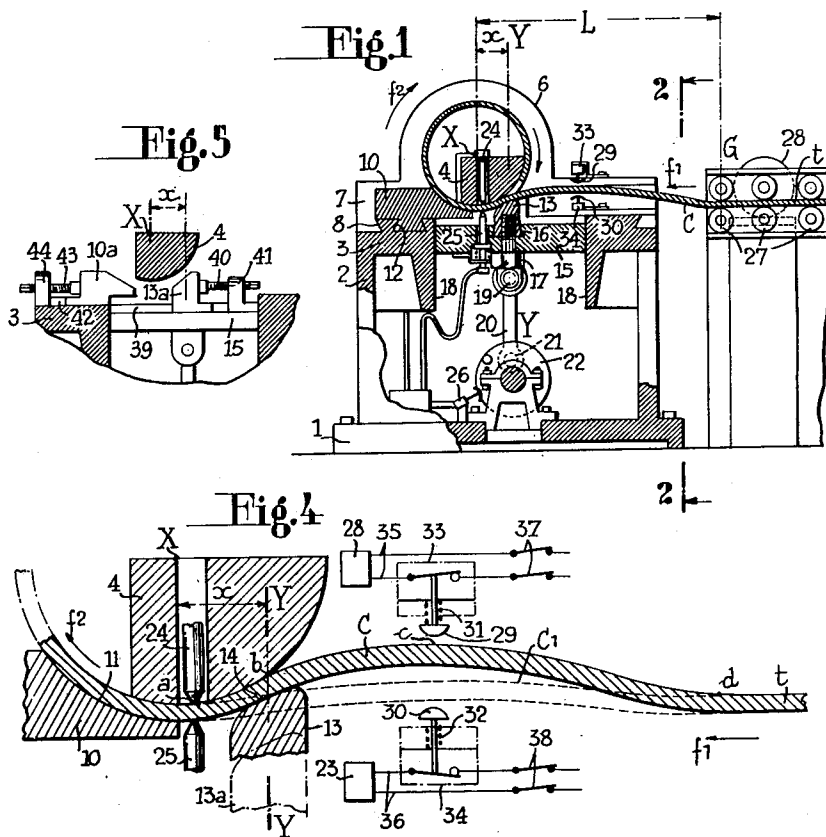
Feb. 6, 1962

F. H. MONTIGNOT
SHEET-BENDING METHOD AND MACHINE FOR THE
PRODUCTION OF TUBULAR ELEMENTS

3,019,834

Filed Jan. 28, 1959

2 Sheets-Sheet 1

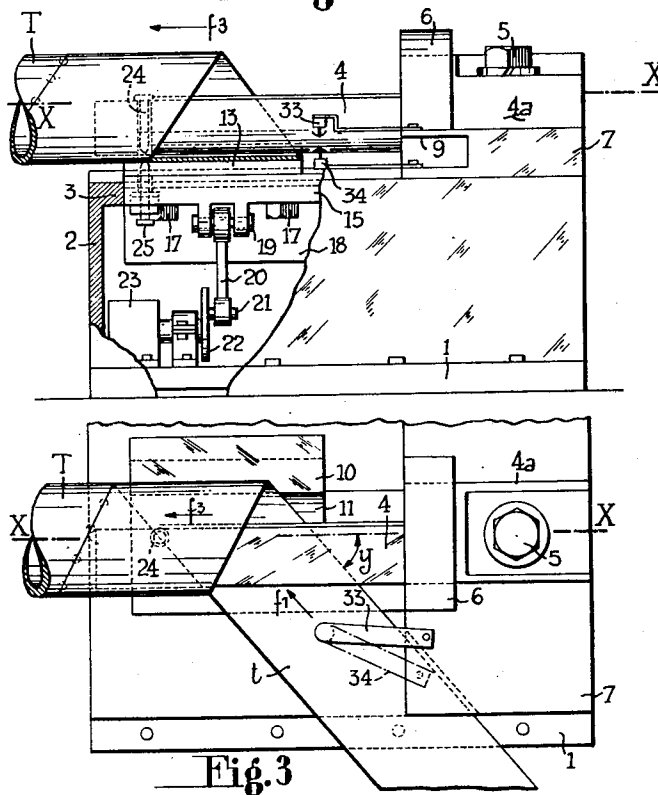


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SHEET-BENDING METHOD AND MACHINE FOR THE PRODUCTION OF TUBULAR ELEMENTS

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The present invention relates to methods and machines for bending metal sheets or plates for the production of tubular elements, and more particularly to methods and machines whereby said elements are produced by the application of a plane metal sheet on an anvil or like former by a punch imparting successive blows.

An object of the invention is to provide a method of bending a sheet in the form of a tubular element, said method being improved in such manner as to coil and produce said tubular element without any special device for driving said element and without any oscillation of the latter about its axis which remains fixed, thereby increasing the precision and regularity of production and prolonging the life of the tool equipment.

In said improved method, which is of the type in which the sheet to be bent is coiled round a former, said sheet is fed to said former in a continuous manner so that a certain length of sheet is freely located in space before reaching the former, and there are applied successively on said sheet discontinuous bending blows so as to bend a portion of said sheet permanently at each blow by applying it against the former on a part of its face on the side of the former adjacent the point from which the sheet is fed, so as to create at the same time in said free length of sheet in the region of the latter located between the point where it is temporarily stopped from moving due to its application against the former and the point from which it is fed and owing to the continuous supply of the sheet, an elastic bend whose convexity is directed toward the former, the potential energy stored in said elastic bend automatically causing as soon as the force exerted ceases, a substantial straightening of said bend and a peripheral advance round the former of the permanently bent portion of the sheet.

In one form of the invention, the sheet is bent against a fixed anvil by successive blows applied to the sheet by a punch on the portion of the sheet situated immediately on the input side of the anvil, that is, on the side of the latter nearest the point from which the sheet is continuously fed.

Another object of the invention is to provide a bending machine for bending in accordance with the foregoing method, said machine having a fixed former and a feed device for feeding said sheet to the machine in a continuous manner, the feed device being located at a distance from the former which is equal to said free length of the sheet and a bending device being provided for exerting discontinuous successive bending forces on said sheet along an axis which is offset relative to the axis of the former on the side thereof adjacent the point from which said sheet is fed.

Further features and advantages of the invention will be apparent from the ensuing description, with reference to the accompanying drawing, to which the invention is in no way restricted.

In the drawing:

FIG. 1 is a side elevational view, partly in section and partially broken away, of a machine according to the invention;

FIG. 2 is an elevational view, partly in section on line 2—2 of FIG. 1;

FIG. 3 is a plan view corresponding to FIG. 2;

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FIG. 4 is an enlarged diagram illustrating the method of the invention, and

FIG. 5 is a partial view, similar to FIG. 1, of a modification of the machine of the invention.

In the embodiment shown in the drawing, the machine is adapted to coil or bend in a helical manner a metal sheet *t* continuously fed by a feeding device *G* so as to produce a tubular element *T* whose helical coils are subsequently welded.

Said machine comprises a stand 1, uprights 2 and a table 3. The latter carries one end 4a of a fixed former having an effective cylindrical outer face having an axis X—X and a radius of curvature substantially equal to the inside radius of the tubular element *T* to be produced.

The cross-sectional shape of said former or anvil 4 is in the form of sector whose peripheral contour is part-circular, as seen in FIGS. 1 and 4, thereby reducing surface contact with the tubular element *T* and in consequence friction.

To permit the machine to produce tubular elements or tubes having any diameter, the end 4a is constituted preferably by an interchangeable support block of constant shape and size irrespective of the radius of curvature of the effective face of the anvil 4 and said block 4a is detachably secured to the table 3 by a dovetail arrangement (not shown) and a bolt 5. The attachment of the block 4a to the table 3 is furthermore reinforced by an inverted U-shaped strap 6 provided with a foot 7 fixed to the table by a dovetail arrangement 8 (FIG. 1). The foot 7 is provided with an aperture 9 (FIG. 2) for passage therethrough of the sheet *t* when the latter is fed to the machine, and on the side of the foot 7 corresponding to the effective face of the anvil 4 the foot does not extend beyond the support block 4a so as not to obstruct the region where the sheet *t* starts to coil round the anvil.

The table 3 also carries on the opposite side of the anvil to the device feeding the sheet to the anvil a guide block 10 whose effective face 11 (FIG. 4) is part-cylindrical and has an axis X—X and a radius of curvature equal to the outside radius of the tube *T* to be produced. The block 10 is fixed to the table 3 by a dovetail arrangement 12 (FIG. 1).

In the region where the sheet *t* starts to coil round the anvil 4 there is mounted a punch 13 whose effective face 14 (FIG. 4) is convex and whose stroke axis Y—Y is offset relative to the axis X—X of the anvil a distance *x* toward the region from which the sheet *t* is fed. The two axes are orthogonal.

The punch 13 is mounted on a plate 15 by a dovetail arrangement 16 and bolts 17 (FIG. 1). The plate is vertically slidable between two slideways 18 provided on the table 3 and is pivotably connected at 19 to a link and crank arrangement 20, 21, 22 driven by a motor-speed reducer unit 23.

Further, a spot-welding device having electrodes 24 and 25 is mounted on the anvil and the punch and the electric circuit actuating said device is adapted to supply alternating current to said electrodes in each operative stroke of the punch, said electric supply circuit being controlled by a contactor 26 (FIG. 1) actuated by the link and crank arrangement so that a spot weld is formed for each blow of the punch.

The lateral feed device *G* which continuously feeds positively and guides the sheet *t*, is so adapted that the sheet is free in space over a certain length *L* which is about 50 cm. for a 2 mm. thick steel sheet (FIG. 1) between the point at which the sheet leaves said device and the point at which it is tangent to the anvil 4. Said feed device comprises rollers 27 (FIG. 1) some of which are driving rollers since they are connected to a motor-speed reducer unit 28. Although for reasons of clearness the

feed device G is shown in FIG. 1 to have rollers parallel with the axis X—X, in actual fact said device G, which is orientatable, is so disposed that the direction f_1 of feed of the sheet t toward the anvil 4 forms an acute angle y with the axis X—X (FIG. 3).

Fixed in opposed relation to one another on the foot 7 are two plungers 29 and 30 which are located above and below the sheet t respectively, in the region between the feed device G and the bending device. Said plungers control the opening, in opposition to the action of closing return springs 31 and 32, of switches 33 and 34 respectively inserted in the electric supply circuits 35 and 36 of the motor-speed reducer units 28 and 23. Said switches are connected in series with hand control switches 37 and 38. The setting of the plungers 29 and 30 will be explained hereinafter.

The machine operates in the following manner:

Initially, the motor-speed reducer units 23 and 28 are inoperative and the unit 28 is first started up by closing the switch 37. This unit drives the driving rollers of the device G continuously and the sheet t is positively fed tangentially to the anvil 4 in the direction of arrow f_1 until the end transverse edge of the sheet is engaged between the effective face 11 of the guide block 10 and the anvil 4. At this moment, the motor-speed reducer unit 23 is started up so as to impart to the punch 13 an alternating rectilinear motion on the axis Y—Y while the sheet t is continued to be positively fed in a continuous manner. Thus the length of the sheet t between the anvil 4 and the point where it leaves the feed device G is caused to exceed said distance L, since it does not yet issue from the bending device of the machine at the same rate as its feed to the anvil and is therefore elastically deformed by a warping C whose deflection is about 5 cm. for a 2 mm. thick sheet. When the punch 13 strikes the sheet t it applies it against the anvil 4 as shown in FIG. 4 and permanently deforms it at ab , whereas it elastically upwardly displaces at bcd the excess sheet not yet engaged between the anvil and the punch. This excess sheet is therefore buckled or warped along the bend C whose convex face $abcd$ is directed toward the anvil 4 and whose radius of curvature is greater than that of the effective face of the anvil, so that the deformation of the sheet along this bend is only temporary. When the punch once more descends to the position 13a shown in dot-dash line (FIG. 4), the temporary bend C tends to straighten under the effect of elasticity, as shown in C_1 and forces the portion of sheet just bent at ab to advance between the anvil 4 and the guide block 10 and coil round the anvil.

This procedure is repeated for each stroke of the punch and in this way the sheet is permanently bent little by little.

Owing to this arrangement, the bend C tends to apply the sheet against the anvil, which favours the permanent bending. Further, owing to its elastically straightening out, the bend C supplies the energy for coiling the sheet round the anvil. This bend is also a sheet accumulator and a connecting means between the continuous feed device G and the discontinuous bending device (4—13). This bend C permits the motor-speed reducer unit 28 of the feed device G to operate in a simple manner independently of the motor-speed reducer unit 23 driving the punch, without any synchronisation therebetween.

As each coil of sheet is being formed after application of the sheet t against the anvil 4, this coil taking up position adjacent the previously-formed coil, both adjacent coils are welded together by a series of spaced spot welds, each spot weld being produced simultaneously with the operative stroke of the punch 13 toward the anvil 4 owing to the action of the electrodes 24 and 25, whose current supply is controlled by the device driving the punch through the medium of the contactor 26. The tube T is thereby produced.

Owing to the inclination of the coils relative to the

axis X—X corresponding to the angle y , the tube T, which is subjected to the thrust of the sheet t under elastic stress in the bend C, undergoes an intermittent helical movement and, without any special driving device, progresses longitudinally along the axis X—X in a discontinuous manner as new coils are formed. If the blows of the punch are repeated very quickly (for example 300 blows per minute) and the sheet is fed to the anvil slowly (for example 10 mm. per blow), the movement of the tube out of the machine is substantially continuous, which permits application of any continuous welding devices for performing the final welding of the tube.

Owing to the combination of the guide block 10 and the anvil 4, the coils do not have a tendency to uncoil themselves or to increase in diameter in a more or less controllable manner, which occurs when a sheet elastically straightens itself out and increases its radius of curvature when it is once more released after having been subjected to a bending force. In the present invention, the sheet is trapped between the anvil 4 and the guide block 10 and is made to conserve the radius of curvature that the punch imparted thereto when it applied the sheet against the anvil. Thus the coils have a constant diameter which is controlled with great accuracy and the formed tube T undergoes its helical movement while its axis remains fixed in a precise manner, which facilitates the subsequent finishing and handling operations on said machine. Further, the machine functions in an improved manner, since it is only subjected to the vibration—of hardly any effect on the machine—emanating from the sheet as it rises and tends to straighten out in the bend C within a predetermined constant length.

Furthermore, owing to the fact that the spot welding is carried out on the part of the tube which is already permanently bent, the spot welds are not subsequently subjected to any stress, which permits welding in a rather superficial and therefore rapid manner, thereby accelerating the rate of the blows of the punch and increasing the production capacity of the machine.

Finally, the safety contactor (29—33) located over the region in which the sheet t is fed to the machine so as to act as means limiting the maximum amplitude of the band C, is adapted to open the supply circuit of the motor-speed reducer unit 28 when, for any reason, the rate of coiling the sheet t round the anvil 4 becomes less than that of its feed toward the machine and the surplus length of sheet becomes excessive and the amplitude of the bend C exaggerated. In this event, without the contactor (29—33) there would be a danger that the deformation of the sheet in the bend be permanent, which must be avoided.

Similarly, the safety contactor (30—34) located below the sheet t and acting as means limiting the minimum amplitude of the bend C, is adapted to open the supply circuit of the motor-speed reducer unit 23 if for any reason the rate of feed of the sheet becomes less than that of its coiling round the anvil 4. In this way, the deflection of the bend cannot diminish to a point at which the resulting increased tension of the sheet is capable of opposing its application against the anvil under the effect of the punch.

In both cases, the supply current of the circuit for the units 28 and 23 is re-established as soon as the bend C leaves the abutments 29 and 30.

In a modification shown in FIG. 5, the offset x between the anvil 4 and the working axis Y—Y of the punch is adjustable. To this end, the punch 13a is movable along the plate 15 in a direction perpendicular to the axis X—X owing to provision of a dovetail arrangement 39 and an adjusting screw 40 co-acting with a nut 41 mounted on the plate 15.

Further, the guide block 10a has a plane or slightly convex effective face and is capable of being shifted in a direction perpendicular to the axis X—X by means of a dovetail arrangement 42 provided on the table 3 and an

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adjusting screw 43 coacting with a nut 44 mounted on the table 3. By means of this arrangement, the same punch and the same guide block can always be used, even when the diameter and/or the thickness of the pipe to be produced vary. It is merely necessary to move the punch and the guide block away from the anvil when the diameter and/or the thickness of the pipe increase, and to move them toward the anvil in the opposite case.

Although specific embodiments of the invention have been described, many modifications and changes may be made therein without departing from the scope of the invention as defined in the appended claims.

Thus, instead of arranging that the device G be orientatable for the purpose of varying the angle γ between the feed direction f_1 of the sheet and the axis X—X, the device G could be fixed in position and the machine be made orientatable about a pivot connected to the stand of the machine.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. A method of bending a sheet about a cylindrical portion of a fixed form, comprising: continuously positively feeding the sheet in the direction toward said form, maintaining the sheet free of restriction over a determinable length prior to its reaching said cylindrical portion of the form, applying to the free length of the sheet a discontinuous force substantially perpendicular to said sheet for permanently bending a portion of said sheet by applying the latter against the cylindrical portion of the form, said portion facing the direction from which the sheet is fed, and creating simultaneously in said free length of sheet, upstream of the sheet portion which is being permanently bent and which is temporarily stopped due to its being applied against the form, due to the continuous positive feed of the sheet toward said form, an elastic bend whose convexity is directed oppositely to that of said sheet portion, then terminating the bending force so that the potential energy stored in said elastic bend automatically and simultaneously causes the expansion of said elastic bend and an advance with respect to said form of the permanently bent sheet portion, and guiding said bent sheet portion during its advance about the fixed form on the downstream side thereof opposite the direction of feed of the sheet with respect to the form.

2. In a machine for bending a metal sheet, in combination: a fixed form, at least a part of the surface of which is cylindrical, a feed device for continuously positively feeding the sheet to be bent in the direction toward said form and spaced a determinable distance from said form so that a corresponding length of the sheet is freely located in space between said form and said feed device, pushing means offset with respect to the form on the side of said form facing the feed device to exert on said free length of sheet upstream of said form discontinuous successive bending forces substantially perpendicular to said length of sheet, and a device for guiding the sheet which is bent around the fixed form by said pushing means, said guide device, being located on the downstream side of the form facing away from the feed device.

3. A method of forming a helical sheet winding by bending said sheet about a fixed anvil having a cylindrical surface, said method comprising continuously feeding the sheet to be bent to said anvil along an oblique direction relative to the generatrices of said cylindrical surface and in such a manner that a certain length of sheet is freely located in space before reaching said cylindrical surface;

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applying successive and discontinuous blows on the portion of the sheet located immediately above the anvil in said free length so as to apply said portion, upon application of each blow, against said anvil on a portion, facing the side from which the sheet is fed, of the cylindrical surface of said anvil, while forming an elastic bend in said sheet immediately above said portion of the sheet applied against the anvil, in such a manner that the elastic bend automatically causes, by its expansion after application of the blow, the peripheral advance of the permanently bent portion of the sheet relative to the anvil, and guiding said bent portion of the sheet around said anvil on the side opposite the feeding of the sheet relative to the fixed anvil.

4. A machine for helically winding a metal sheet, comprising in combination: a stand; an anvil having a fixed axis carried by said stand and having an at least partially cylindrical surface; a feed device for continuously feeding the sheet to be bent to said anvil, said feed device being located at a determinable distance from the anvil so as to leave a determinable length of sheet freely located in space between said anvil and said feed device, and being disposed in such a manner that the sheet reaches the anvil along a direction which is oblique to the generatrices of the cylindrical surface; a bending device carried by said stand for applying on the free length of sheet discontinuous successive forces perpendicular to said free length for permanently bending the free part of sheet adjacent said cylindrical surface of the anvil and elastically bending the rest of said free part of the sheet adjacent the feed device, said device comprising a punch provided with a convex working end and movable along an axis which is orthogonal to the axis of the anvil and offset relative to said anvil axis toward the side of the feed device, guide means for guiding said punch along its axis on said stand, and a mechanism for imparting to said punch a reciprocating movement along said punch axis; and a guide block for guiding the portion of sheet bent by said bending device round the cylindrical surface of the anvil, said block being supported by said stand concentrically to said cylindrical surface on the side opposite the feed device relative to the anvil and defining with the latter a narrow passage concentric to said cylindrical surface of the anvil.

5. A machine as claimed in claim 4, wherein said punch is movable transversely of its axis on said guiding means, and comprising an adjusting device connecting said punch to said guiding means for adjusting the position of said punch transversely on said guiding means and, thus, with respect to the anvil.

6. A machine as claimed in claim 4, wherein said guide block for the bent sheet is movable relative to said anvil, comprising an adjusting device which connects said guide block to said stand for displacing said guide on said stand relative to said anvil.

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