Oct. 9, 1962 G. J. J. VUILLIEN 3,057,394

SHEET BENDING MACHINE FOR PRODUCING TUBULAR ELEMENTS AND PLANT INCLUDING APPLICATION OF SAID MACHINE

Filed May 2, 1960 3 Sheets-Sheet 1

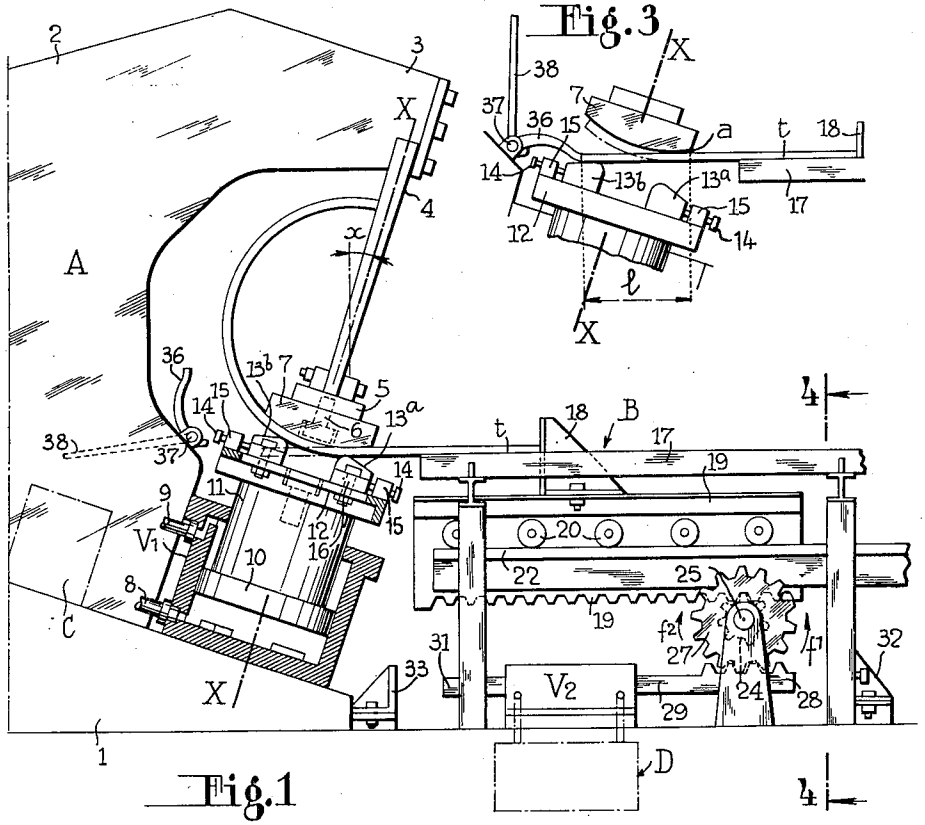


Fig.1

Fig.3

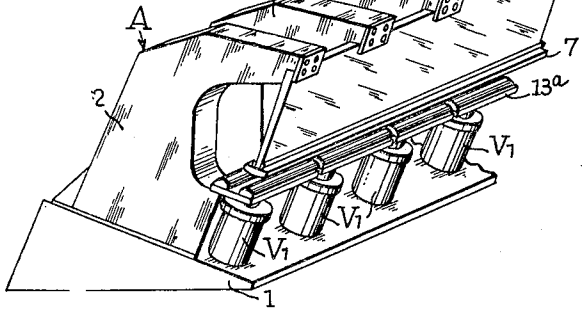


Fig.2



Fig.9

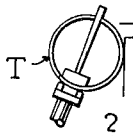


Fig.12

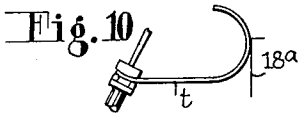


Fig.10



Fig.7



Fig.11

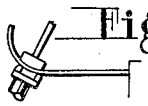


Fig.8

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SHEET BENDING MACHINE FOR PRODUCING TUBULAR ELEMENTS AND PLANT INCLUDING APPLICATION OF SAID MACHINE

Filed May 2, 1960 3 Sheets-Sheet 2

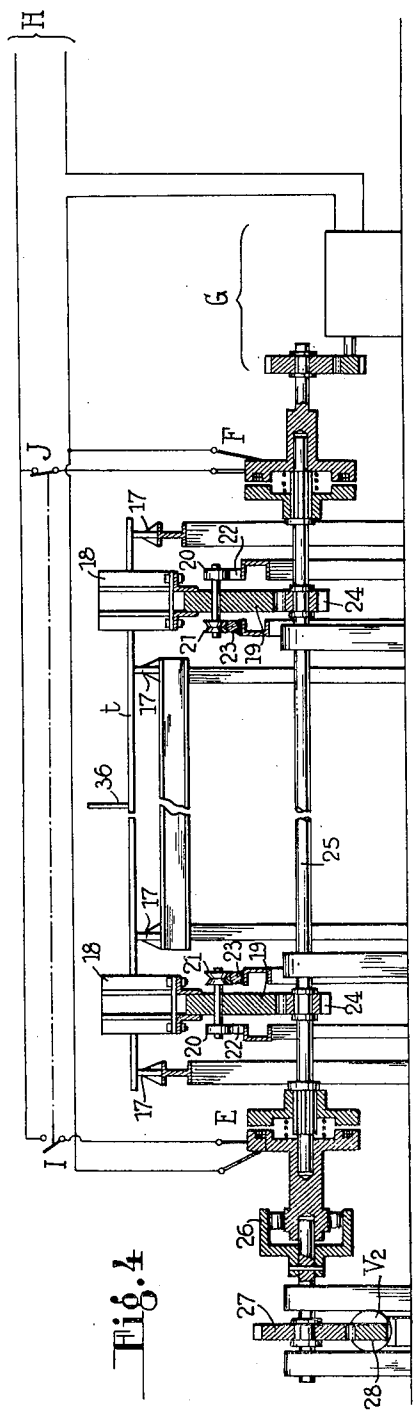


Fig. 4

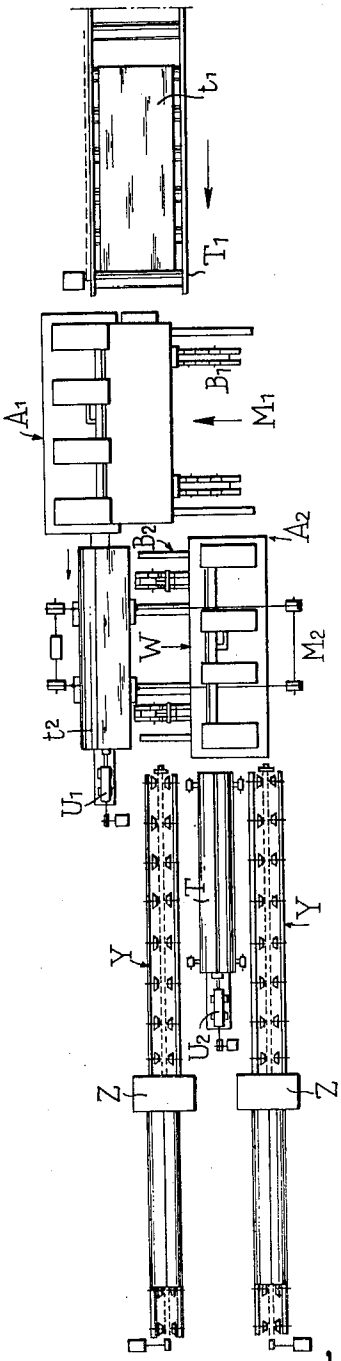


Fig. 13

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SHEET BENDING MACHINE FOR PRODUCING TUBULAR ELEMENTS AND PLANT INCLUDING APPLICATION OF SAID MACHINE

Filed May 2, 1960 3 Sheets-Sheet 3

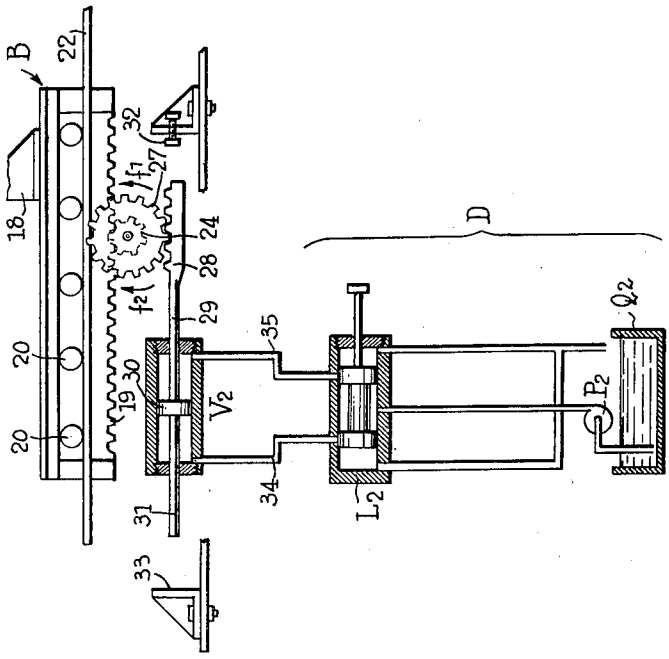


Fig. 6

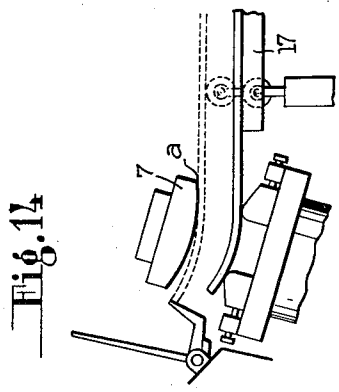


Fig. 14

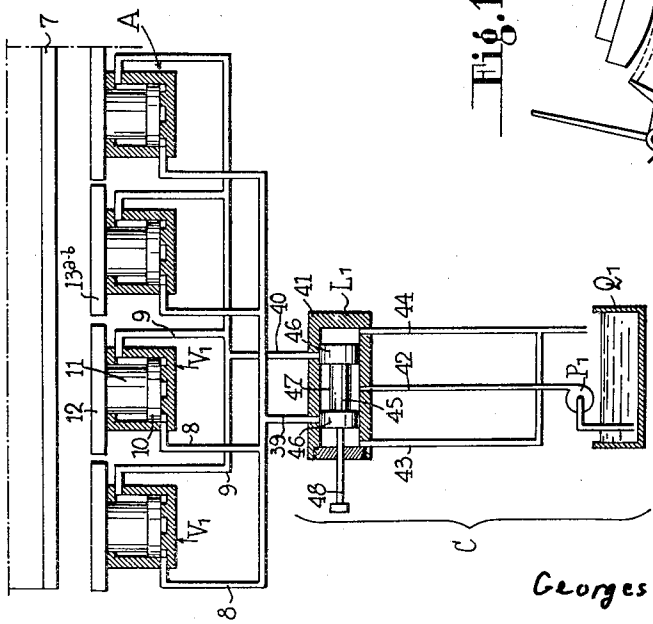


Fig. 5

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SHEET BENDING MACHINE FOR PRODUCING TUBULAR ELEMENTS AND PLANT INCLUDING APPLICATION OF SAID MACHINE

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Filed May 2, 1960, Ser. No. 26,088
Claims priority, application France May 6, 1959
2 Claims. (Cl. 153—48)

The present invention relates to sheet metal bending machines for producing tubular elements and more particularly to hydraulic machines in which these elements are formed from a flat rectangular sheet of metal whose dimensions correspond to those of the tubular element to obtain by applying this sheet against an anvil in a direction parallel with its longitudinal edges by means of a suitable tool operating by successive blows.

Known machines or hydraulic presses comprise a lower anvil whose length corresponds to that of the tube to obtain and which could have a concave curvature and a bending device which is disposed above the anvil and has a punch whose length corresponds to that of the tube to obtain and is vertically movable. The anvil and the bending actuating means are carried by a bolster device. The lower and upper bolsters are rigidly braced, for example by four uprights, the assembly constituting a closed press frame or cage. The stiffening arrangements for the anvil and above all the single bending device of great length (about several metres) make the machine particularly heavy owing to the reinforcement of the upper bolster and the corresponding proportions of the lower bolster.

When these machines are designed to produce tubes of large diameter and great thickness, they take up a great amount of space particularly in height not only due to the necessary bending force and consequently the size of the raws, but also due to the size of the maximum diameter of the tubes to form. The great height of the frame requires a reinforceing thereof in width, whence increased weight and overall size. The dimensions of these machines therefore become prohibitive.

The object of the invention is to provide a hydraulic bending machine improved in such manner as to permit without excessively dimensions the production of thick, very large diameter tubular elements.

This machine mainly comprises a multiple press having on a single stand, a number of elementary presses whose swan-neck shaped frames are in alignment in a direction perpendicular to a fixed direction in which the metal sheet is fed, a single anvil rigidly suspended from the upper parts of said frames by a single flat plate which almost completely closes the opening of said swan-neck shaped frames and constitutes an axial plane of symmetry of said anvil whose operative face is, in the same way as said plane, transverse to the direction in which the metal sheets are fed and is downwardly directed, the stand carrying in front of each frame a hydraulic actuating device actuating an individual bending device, the hydraulic devices and the bending devices pertaining to the different elementary presses being in alignment parallel with said plane of symmetry, that is, transversely of the longitudinal direction in which the metal sheets are fed.

Owing to this arrangement and particularly to the multiplicity of the press frames and the movable bending devices pertaining to the various elementary presses constituting the multiple press and owing to the mounting of these bending devices at the foot of the press frames, the surprising result is obtained that the machine according to the invention has, for a given power, much smaller dimensions than those of known machines and particularly as concerns its one height which is reduced by about one half. Further, this arrangement permits feeding the metal sheets in a horizontal plane which facilitates the handling of the sheets, whereas in known machines the sheets are fed in a plane downwardly inclined toward the striking plane.

Another object of the invention is to provide a plant for continuously producing tubular elements, which are welded along a longitudinal joint, this plant comprising two bending machines of the above-mentioned improved type, each one bending one half of each metal sheet.

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

In the drawings:

FIG. 1 is a diagrammatic side elevational view, with parts cut away, of a machine according to the invention, having presses, shown in their bending position, and a feed device;

FIG. 2 is a partial perspective view of the machine showing a number of its elementary presses combined with the single common anvil;

FIG. 3 is a partial side elevational view of one of the elementary presses in its inoperative position at the moment of arrival of the sheet to bend;

FIG. 4 is a vertical longitudinal sectional view, taken along line 4—4 of FIG. 2, of the sheet feed device;

FIG. 5 is a diagrammatic sectional view of the hydraulic press actuating device;

FIG. 6 is a view similar to FIG. 5 of the hydraulic device actuating the sheet feed device;

FIGS. 7 to 12 are diagrams showing different stages in the production of a tubular element;

FIG. 13 is a diagrammatic plan view of a complete plant for producing tubes comprising two bending machines according to the invention, and

FIG. 14 is a diagrammatic view similar to FIG. 3 of a modification of the feed device feeding metal sheets whose longitudinal edges have been previously bent or formed up.

I. DESCRIPTION OF THE BENDING MACHINE (FIGS. 1 TO 6)

In the illustrated embodiment, the machine is adapted to bend a metal sheet t along parallel generatrices so as to impart thereto a closed curve shape in the form of a tube and thereby bring together the opposite ends which are parallel with these generatrices and must be subsequently welded together.

This machine comprises mainly (FIG. 1): a multiple press A, its sheet feed device B feeding the sheets in a longitudinal direction from right to left as viewed in FIG. 1, parallel with the plane of the latter, a hydraulic actuating device C actuating the multiple press A, and a hydraulic actuating device D actuating the sheet feed device B. Each of these parts will be described in turn.

(a) Multiple Press A (FIGS. 1, 2 and 5)

It mainly comprises a number of elementary presses in transverse alignment over a distance which corresponds to the length of the tubes to produce; for example there are eight presses, only four of which are shown in FIGS. 2 and 5. These presses are mounted on a common stand **1** having an inclined face.

Each press comprises a frame **2** which has a V- or swan-neck shape. The frames are fixed to the stand **1**. Fixed to the ends of the heads **3** of the frames **2** is a plate **4** which is common to all the presses. This plate is relatively thin and in the form of a solid having an even resistance, its thickness decreasing downwardly. It almost completely closes the opening of the swan-neck shape of the frames in a plane X—X (FIG. 2) which is inclined at an angle x to the vertical and downwardly approaches the frames **2**. The angle x approximately corresponds to half the angle subtended by the arc of the bend produced in the metal sheet at each stroke of the press. The lower edge of this plate **4** rigidly supports a shoe **5** under which is detachably secured by screws **6** an interchangeable single anvil **7** which is thus rigidly suspended by the plate **4** from the heads **3** of the frame **2**.

This anvil **7** has a lower operative face in the form of a sector of a cylinder whose radius corresponds to half the diameter of the tubes to be obtained and is symmetrical relative to the plane X—X.

Each press furthermore comprises a hydraulic ram or jack V_1, fixed to the stand **1** under the anvil **7**. The axis of operation of each ram V_1, is in the plane of symmetry X—X and is therefore in the extension of the plate **4**.

Each ram V_1 is capable of being fed with oil under pressure by the device C either by way of a pipe S connected to its lower part or by way of a pipe S connected to its upper part and it includes a double-acting piston **10** supporting a slide **11** terminating in a flat slideway or guide **12** perpendicular to the plane X—X.

Mounted on the slideway **12** is a pair of punches **13a** and **13b** which have a convex operative face and are symmetrical relative to the plane X—X and whose spacing is adjustable by shifting them on the slideway **12**. In the direction parallel with the plane X—X each punch has a length corresponding to the length of the tube to be formed divided by the number of presses. The punches of the different presses located on the same side of the plane X—X are in alignment. A very small gap is provided between the punches of adjacent presses. Each punch is adjusted separately by means of two screws **14** screw-threadedly engaged in nuts **15** fixed to the slideway **12**. After adjustment, the punches are blocked in position on the slideway **12** by means of clamping bolts **16**.

To enable the machine to produce tubes of different diameters the appropriate anvil **7** is mounted and the punches **13a** and **13b** are so set at the suitable distance apart relative to the plane X—X in accordance with the desired diameter that the maximum distance between the punches **13a** and the plane X—X is no greater than that between the generator a of the anvil and the plane X—X.

(b) Metal Sheet Feed Device B (FIGS. 1 and 4)

This device B comprises a feed table feeding the metal sheet t and constituted by parallel horizontal supports **17** which are perpendicular to the generatrices of the sector of a cylinder constituted by the anvil **7**. The sheet of metal t—whose length corresponds to that of the tube to be produced and whose width corresponds to the circular perimeter of a cross-section of this tube—is placed on these horizontal supports **17** and the end of the sheet remote from the machine is subjected to a thrust in the direction of the press from two thrust members or abutments **18** spaced apart a distance a little less than the length of the sheet t. Each of the members **18** is adjustably secured to a rack **19** provided with rollers **20** and **21** rolling along runways **22** and **25** parallel with the horizontal supports **17**.

Each of the two racks **19** is meshed with a gear **24** carried by a shaft **25** whose axis is perpendicular to the racks **19**. This shaft is driven in rotation by either of two electromagnetic clutches E and F, either in step by step manner in the direction of arrow f^1 (corresponding to the advance of the racks toward the machine) by a ram or jack V_2 (FIG. 1), or continuously in the opposite direction of arrow f^2 (corresponding to withdrawal of the racks **19**) by a motor and speed reducer unit C.

To this end, one end of the shaft **25** is provided with fluting along which is slidable the secondary clutch plate of the electromagnetic clutch E whose primary plate is connected to a free wheel **26**. The latter drives the primary plate of the clutch E only in the direction of arrow f^1 corresponding to advance of the racks **19** toward the machine. The free-wheel **26** is itself driven in rotation by a gear **27** meshed with a rack **28** which is parallel with the racks **19** and fixed to one end of a rod **29** of the piston **30** of the ram V_2 (FIG. 6). This piston has another rod **31** in opposed relation to the rod **29**. The travel of the piston **30** corresponds to the length of the arc formed in the metal sheet at each stroke of the press and is limited at one end by an adjustable abutment **32**, against which the rack **28** stops, and at the other end by a fixed abutment **33** which stops the rod **31**. Connected to the ends of the cylinder of the ram are pipes **34** and **35** connected to the hydraulic actuating device D. The other end of the shaft **25** is provided with fluting along which is slidable the secondary plate of the electromagnetic clutch F whose primary plate is driven in rotation by the motor and speed reducer unit G.

The clutch F and this unit are supplied with power in series by an electric circuit H to which the clutch E is branch connected. The supply of power to this clutch E is controlled by a switch I and that of the clutch F by a switch J. These switches are mechanically interconnected in such manner that when one of them is open the other is closed.

The purely mechanical part of the sheet feed device is completed by an abutment **36** (FIGS. 1, 3 and 4) for the leading or forward edge of the metal sheet t engaged in the machine. This abutment is disposed substantially mid-way between the racks **19** so as to be in the middle of the leading edge of the metal sheet and is, in the presently-described embodiment, constituted by one arm **36** of a bell crank pivotably mounted at **37** on one of the press frames **2**. The other arm **38** of this bell crank acts as a counterweight and is for example actuated manually and acts as means for shifting the abutment **36**. The latter is capable of assuming two positions. In one of these positions (shown in FIG. 3) this abutment stops further advance of the leading edge of the metal sheet before bending, and in the other position (shown in FIG. 1) the abutment **36** is retracted to permit the punches **13b** to press the sheet against the anvil **7**.

(c) Hydraulic Device C Actuating the Press A (FIG. 5)

The pipes **8** communicating with the lower part of each of the rams V_1 and the pipes **9** communicating with the upper part are branch connected respectively to a single pipe **39** and a pipe **40** connected to a single distributor L_1 for the whole of the machine. This distributor comprises a tubular body **41** closed at both ends. The pipes **39** and **40** are connected to this body **41** on each side of the middle of the latter. A supply pipe **42** supplying liquid under pressure from a pump P_1 communicates with the middle of the body **41** mid-way between the apertures of the pipes **39** and **40** connected to the rams V_1 whereas pipes **43**—**44** dicharging the liquid

into a tank Q_1 are connected to the ends of the body **41** so that the apertures of the pipes **39** and **40** are midway between, on the one hand, the pipes **42** and **43** and, on the other, the pipes **42** and **44**.

Slidable within the body **41** is a slide valve **45** having two flanges **46** separated by an annular recess **47** The slide valve **45** is extended at one end by an actuating rod **48**.

The slide valve **45** is for example actuated manually and is capable of occupying three positions:

A middle position shown in FIG 5, in which the pipes connected to the rams V_1 are closed and the pipes **43** and **44** shut off from the pipe **42** by the flanges **46**. The pistons **10** of the rams V_1 are then held in their inoperative positions;

An extreme left position, in which the liquid under pressure is admitted under the pistons **10** of the rams V_1 which are in their raising stage;

An extreme right position, in which the pressure is admitted above the pistons; the rams V_1 are then in their descending stage.

(d) Hydraulic Device D Actuating the Metal Sheet Feed Device (FIG. 6)

This device is similar to the device C and comprises similar means designated by similar reference characters carrying the index number 2: the distributor L_2 to which are connected the pipes **34** and **35** communicating with the ram V_2, pump P_2 and tank Q_2.

Supplying liquid under pressure to the pipe **35** produces the displacement of the piston **30** and the rack **28** toward the left, as viewed in FIG. 6, that is, in the direction causing the racks **19** to move away from the presses.

Supplying liquid under pressure to the pipe **34** produces the displacement of the piston **30** and the rack **28** toward the right as viewed in FIG. 6, that is, in the direction corresponding to the advance of the metal sheet *t* toward the machine.

II. OPERATION OF THE MACHINE

Operation of the sheet feed device B will first be described and then that of the presses, followed by description of the formation of a tube.

(a) Movement of the Feed Device B

Initially, the switch I is closed and the switch J consequently open. As the slide valve of the distributor L_2 is shifted toward the shift, the liquid under pressure reaches the left end of the piston **30** of the ram V_2 and shifts it and the rack **28** toward the right (FIG. 6), resulting in a driving of the gear **27** in the direction of arrow f^1. In this direction of rotation the freewheel **26** (FIG. 4) in turn drives the primary plate of the clutch E and the shaft **25** owing to excitation of this electromagnetic clutch. Therefore the gears **24**, in rotating in the direction of arrow f^1, drive the racks **19** and the abutments **18** toward the machine (advance). When the rack **28** has reached the end of its travel toward the right (stopped by the adjustable abutment **32**), the slide valve of the distributor L_2 is displaced toward the right, which results in supply of liquid under pressure to the right end of the piston **30** of the ram V_2 and a consequent return of the rack **28**. During this return, the gear **27** rotates in the direction of arrow f^2, but owing to the freewheel **26** the gears **24** are not driven and the racks **19** and abutments **18** remain stationary. The piston **30** of the ram V_2 moves rearwardly until its rod **31** is stopped by the fixed abutment **33**.

(b) Movement of the Punches 13^a, 13^b of Each Elementary Press

The punches are made to rise when the slide valve of the distributor L_1 (FIG. 5) is shifted toward left when when the ram V_2 is at the end of its advance or forward travel. Simultaneously, the slide valve of the distributor L_2 (FIG. 6) is pulled to the right. When the punches 13^a, 13^b travel they remain there during the time necessary for maintaining the bending force of the punches applied to the metal sheet to ensure a permanent deformation of the latter. Thereafter, the slide valve of the distributor L_1 is shifted toward the right. The direction of flow of the liquid under pressure in the rams V_1 is then reversed. The liquid under pressure arrives in the upper part of the ram V_1 and is discharged in the lower part. The punches descend. When all the punches have reached the extreme lower end of their travel, the slide valve of the distributor L_2 is shifted toward the left, which causes the metal sheet to advance.

(c) Formation of a Tube (FIGS. 1 and 7 to 12)

A tube T (FIG. 12) is formed in two stages; a first stage for bending the rectangular flat sheet of metal *t* into a semi-cylinder, starting with the leading edge (FIGS. 7 to 9), and a second stage for bending the sheet into a second semi-cylinder, starting with the edge of the sheet opposed to the leading edge of the first stage, the two semi-cylinders being interconnected along a median generatrix of the sheet, and the longitudinal edges of the latter being joined to form the lips or edges of a longitudinal joint which is subsequently welded.

(1) *First stage.*—A rectangular flat sheet of metal *t* suitably cut to size is placed on the horizontal supports **17** of the feed table in such manner that its rear longitudinal edge is substantially in contact with the abutments **18** of the racks **19** in the initial position of their forward travel. The abutment arm **36** is lowered by the operator who starts up the feed device. As the switch I is closed, the abutments **18** urge the sheet *t* and cause it to slide along the table, until the ram V_2 reaches the end of its forward travel. At this movement, the leading edge of the sheet *t* encounters the abutment **36** (FIG. 3) which ensures that the rear edge of this sheet is in perfect contact with the two abutments **18** thereby making certain that the leading and rear edges of the sheet are perfectly parallel with the generatrices of the anvil **7**.

The slide valve **45** of the distributor L_1 is then pulled to the left to cause the punches 13^a and 13^b to rise. In the course of this upward travel, the punch 13^b in front of which is disposed the abutment **36** raises the latter and causes it to be completely rearwardly retracted owing to the effect of the counterweight or actuating arm **38**. At the same time, the punches 13^b nearest the frames **2** exert a bending force on the sheet *t* which bears against the generatrix *a* of the anvil the most removed from the frames **2** (FIG. 3). The bending force is therefore exerted with a leverage equal to the length *l* of the segment of sheet engaged under the anvil **7**. At the end of the upward travel of the punches, the punches 13^a remote from the frames **2** in turn apply the sheet against the anvil **7** and prevent the sheet from moving away from the generatrix *a* on the anvil. To ensure a permanent curved deformation of the sheet at a radius of curvature corresponding to that of the anvil **7**, the punches are maintained a certain period of time in the extreme upper position of their travel, whereafter they are caused to descend simultaneously. When all the punches are in their extreme lower position of their travel, the abutments **18** once more displace the sheet through the same distance. The punches thereafter rise and bend a further segment of the sheet, the new bend being connected to the previously formed bend.

Advance of the sheet and the striking of the press succeed one another alternately until the leading edge of the sheet wound the anvil **7** reaches the plate **4**. A half-tube has then been formed. The machine and its sheet feed device are then stopped. Closure of the switch J causes the racks **19** and the abutments **18** to return to their initial position. The bent sheet is withdrawn from the machine in a direction parallel with the plane X—X by means of

tongs or a clamp pulled by a carriage. The first stage has thus finished.

(2) *Second stage (Figs. 10 to 12).*—After having been withdrawn from the machine, the sheet is grasped by a handling machine not shown in the drawings (for example lifting apparatus, carriage or conveyor) and returned to the supports **17** of the table, the previously bent part being disposed adjacent abutments **18**[a] which are mounted in place of the abutments **18**. The abutments **18**[a] are higher than the abutments **18** so as to bear against the generatrix of the bent part of the sheet remote from the machine. These abutments **18**[a] are fixed to the racks **19** in front of the position of the abutments **18** at a distance equal to the length of the sheet bent in the course of the first stage.

After these adjustments, the second tube forming stage proceeds as the first stage. When the tube has been formed, it is extracted from the machine and conveyed to the welding machines.

It will be observed that the leverage of length *l* for bending the metal sheet is twice as long as that of known presses having a vertical axis in which the sheet bears against that generatrix of the anvil which is on the vertical working axis and is folded on each side of this median generatrix. Consequently owing to this leverage and the inclination of angle *x* of the axial working plane, the necessary bending force is half that required in known presses. Furthermore, the inclination of the axial working plane X—X permits the sheet to be fed on a horizontal plane, which facilitates handling.

Owing to the multiplicity and the independence of the bending devices and owing to the possibility of a slight staggering in the rising of the different bending devices (those which are fed by the longest pipes **8** being behind those fed by the shortest pipes **8**), the power required for the rams V_1 is less than in the case of a single bending device actuated by a plurality of rams in which arrangement the rams in advance are retarded by the late rams. Loss of energy is thus avoided.

III. PLANT SHOWN IN FIG. 13

If it is desired to produce tubes in a continuous manner, two machines and sheet handling devices could be combined, for example as shown in FIG. 13.

In this arrangement, the flat rectangular metal sheets *t*, suitably cut to size, are brought by a conveyor T_1 having driving rollers to the table of the sheet feed device B_1, of a first machine M_1 having a multiple press A_1. The first stage in the production of the tube shown diagrammatically in FIGS. 7 to 9 is carried out on this machine.

Once bent, the sheet is withdrawn at t_2, in a longitudinal direction relative to the machine M_1 by a tong extractor U_1, carried by a carriage drawn along for example by a cable. At t_2 the bent sheet is received by a transporting carriage W which carries it in a transverse direction to the feed device B_2 of a second machine M_2 having a multiple press A_2 similar to the machine M_1. The direction of transfer is such that it is the unbent edge remote from the feed device B_1 which is fed forwardly by the device B_2 of the machine M_2. The feed device B_2 is similar to the feed device B_1 except that the thrust abutments for the sheet are higher so as to bear not against the rear edge but against the rear generatrix of the bent part, and these abutments are capable of retracting upon passage of the sheet and standing up again in the known manner. The formed tube T is thereafter extracted from the machine M_2 by an extractor U_2 and then transferred to one of two longitudinal conveyors having support rollers and a driving chain Y. The chosen conveyor conveys the tube to one of two welding stations Z for the purpose of welding the longitudinal edges. The production cycle ceases at this station. In the arrangement shown in FIG. 13, two conveyors Y are shown since the working rate of the machines M_1 and M_2 has been assumed to be twice that of the welding machines Z. It will be understood more conveyors such as the conveyor Y could be used or only one conveyor.

IV. MODIFICATION SHOWN IN FIG. 14

The metal sheets *t* instead of being fed to the machines M_1 and M_2 in a completely flat state could be fed thereto after their edges have been formed or bent over, these sheets being previously conveyed by the first conveyor T_1 between two pairs of forming rolls having the required profile of known type located on each side of this conveyor. In this case it is necessary to provide a greater height between the lower generatrix *a* of the anvil and the level of the feed table **17** so as to permit the folded edge of the sheet to engage under the anvil. The feed table must therefore be lower. It is also necessary to provide support rollers, for example mounted at the end of piston rods of vertical rams or jacks to raise the sheet from the table **17** and bring it in contact with the generatrix *a* of the anvil once the sheet is engaged under the anvil. The prior folding of the edges of the sheet has the advantage of imparting a better finished appearance to the tubes, but does not modify the tube forming principle.

Although a specific embodiment of the invention has 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 the hydraulic devices actuating the punches and feeding the sheets could be automatically controlled by electric control means.

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

1. In a machine for bending metal sheets, in which: an automatic sheet feed device feeds the sheets in a longitudinal direction, the sheets moving in a fixed horizontal feed plane: a multiple press comprising a plurality of adjacent elementary presses having: a single stand; as many frames as there are elementary presses, each of said frames being fixed to the stand parallel with the longitudinal direction of the sheets' feed and having a swan-neck shape terminating in an upper head so orientated as to face said longitudinal direction, and all the frames being in alignment in a direction perpendicular to said longitudinal direction; a single transverse thin plate rigidly fixed to the heads of the frames and almost completely closing the apertures constituted by said swan-neck shaped frames, said plate having a transverse plane of symmetry which is downwardly inclined relative to the vertical toward the interior of the swan-neck of the frames, and being limited by a lower transverse edge, a single anvil rigidly fixed to the lower edge of said plate below which it is situated, said anvil having an operative face which is downwardly directed and is symmetrical relative to said transverse plane of symmetry; and for each elementary press, a hydraulic actuating device fixed to said stand in front of each frame and an individual bending device operatively connected to said actuating device so that the latter moves the bending device toward the anvil so as to bend the metal sheet, said actuating and bending devices having a same longitudinal axis which is situated in said transverse inclined plane of symmetry.

2. In a multiple press for bending metal sheets in a longitudinal direction for producing tubular elements:

(*a*) a horizontal feed plane table for feeding metal sheets to be bent;

(*b*) a plurality of C-shaped parallel aligned frames having apertures;

(*c*) a single thin transverse plate rigidly secured to the top of said frames in a downwardly inclined position with respect to the vertical, said thin inclined transverse plate almost completely closing the apertures of said C-shaped frames;

(*d*) a single convex upper anvil rigidly secured to the lower edge of said thin inclined transverse plate and

having an inclined plane of symmetry common with said thin inclined transverse plate;

(*e*) said single anvil having a convex curvature tangent to the feeding plane of metal sheets on a generatrix located on the same side as said horizontal feed plane table with respect to said thin inclined transverse plate;

(*f*) and a plurality of lower bending dies.

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