United States Patent

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[54] **TUBE FLATTENING AND BENDING MACHINE**
12 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **72/385,** 72/DIG. 16
[51] **Int. Cl.** **B21d 13/02**
[50] **Field of Search** ..... 72/305, 383, 385, 399, DIG. 16

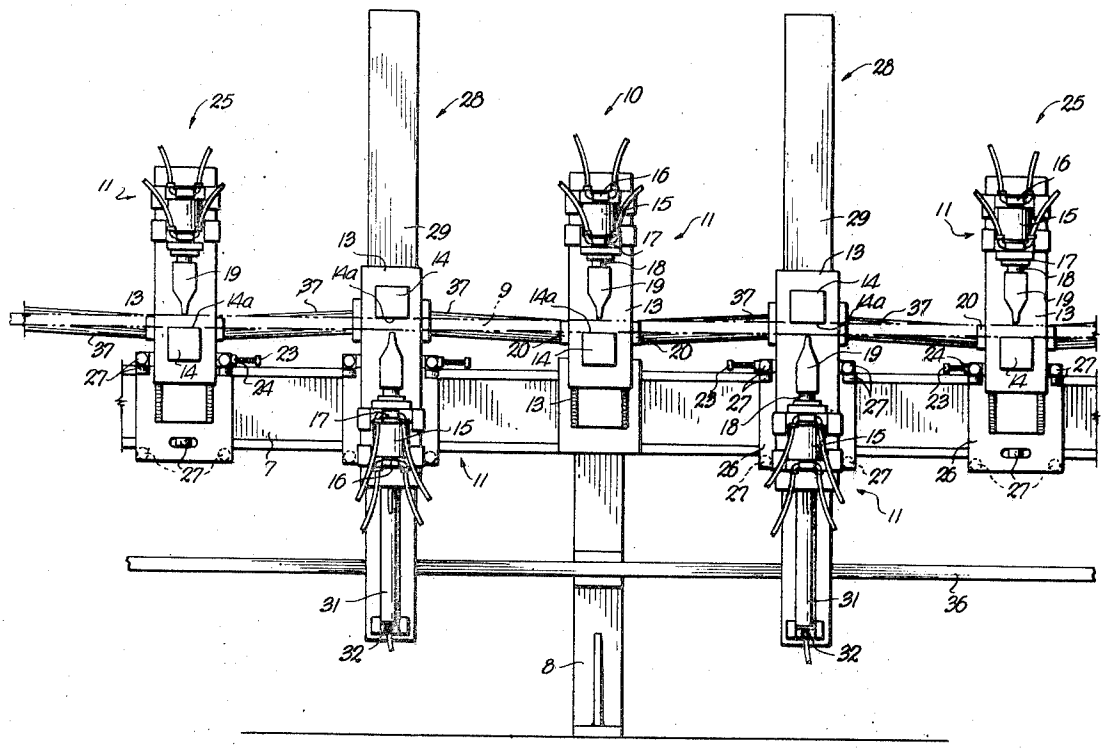
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ABSTRACT: A machine for flattening portions of a straight length of tubing and for bending the tubing into a zigzag shape. Movable outboard stations are mounted by rollers on a rail extending to each side of an immovable central station. Associated with each station is an anvil and hammer assembly to hold, to flatten and to grip a portion of the tubing. A hydraulic cylinder is mounted on alternate outboard stations to move the anvil and hammer assembly in an upwardly direction from the rail, thereby bending the tubing into a zigzag shape.



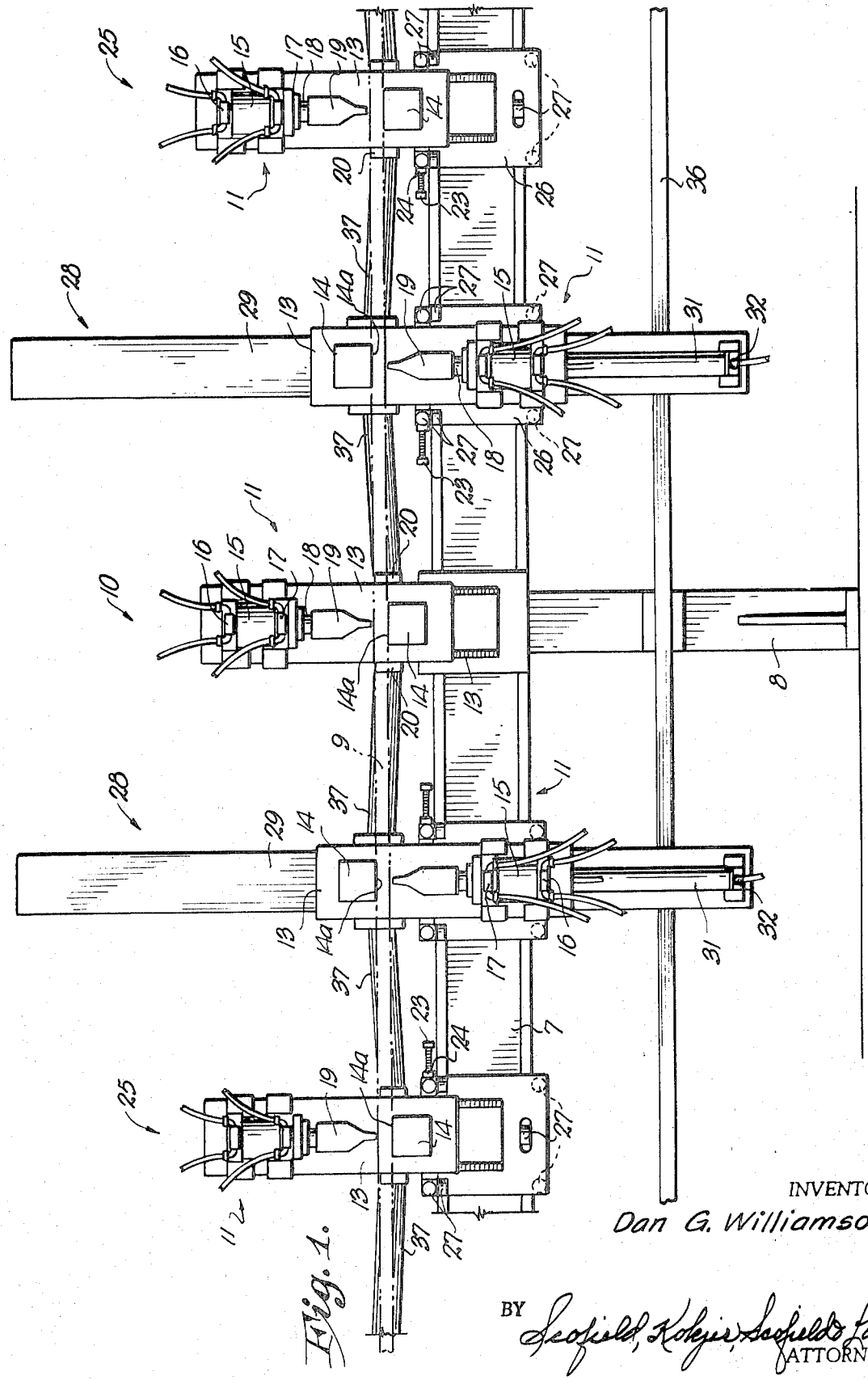
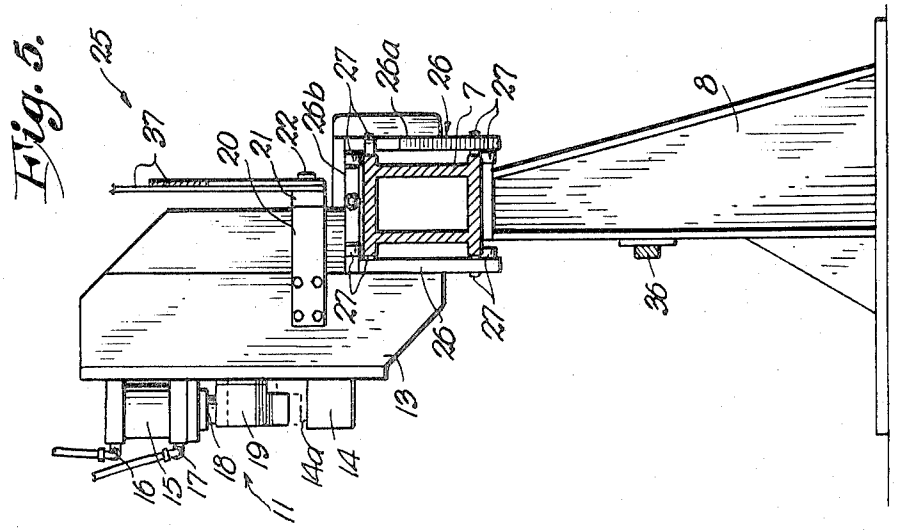


Fig. 1.

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Fig. 5.



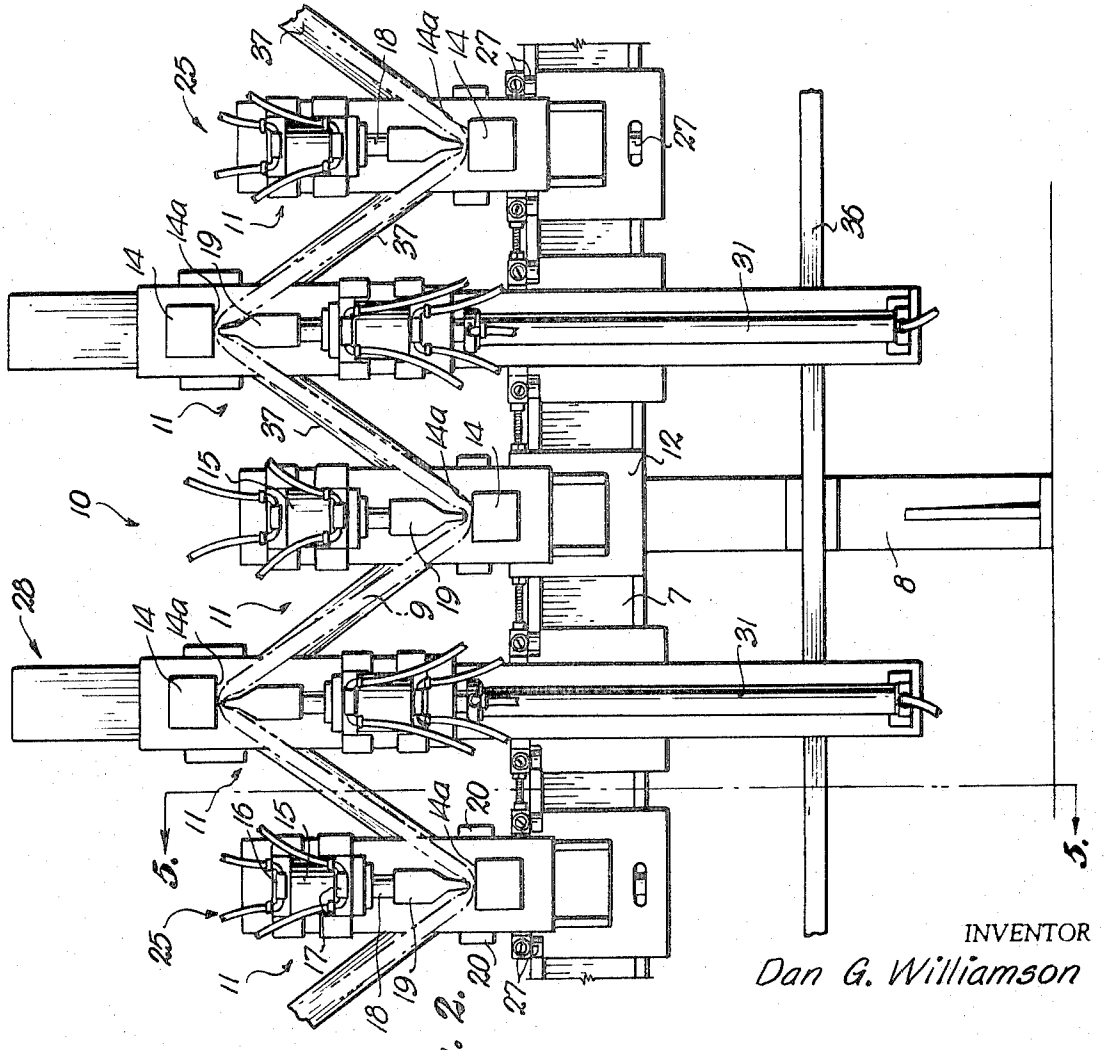


Fig. 2.

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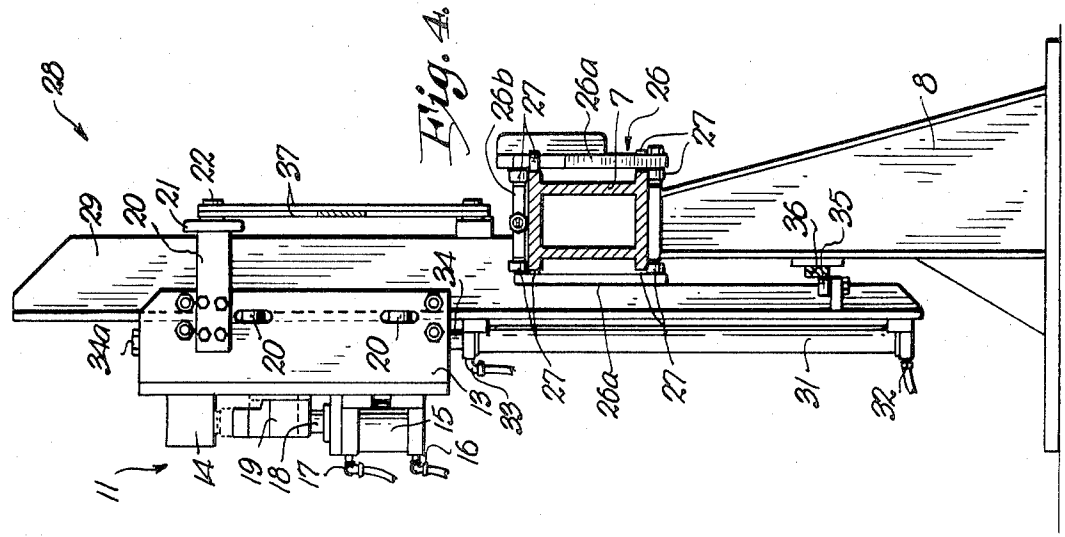


Fig. 4.

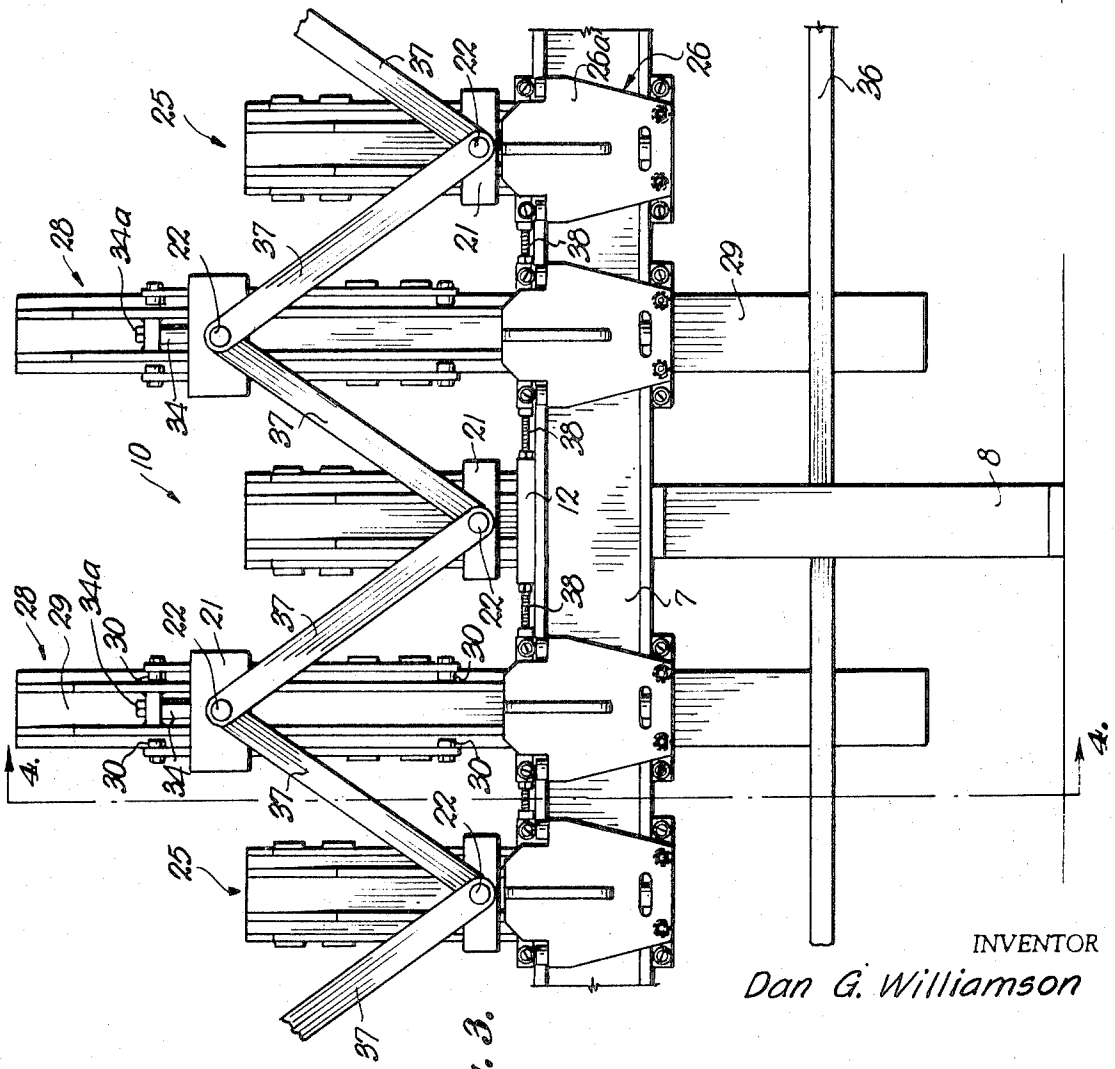


Fig. 3.

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TUBE FLATTENING AND BENDING MACHINE

BACKGROUND OF THE INVENTION

The art of bending a straight length of tubing into a zigzag shape, known in trade as a web, has long practiced. One useful application of this product is construction of a truss structure such as a bar joist which is formed by rigidly attaching straight members known as chords to the apices of the zigzag web member.

Many machines have been devised to bend tubing into a zigzag shape. To my knowledge, these bending machines can be classified into one of three broad categories.

Perhaps the oldest type of bending machine is one which makes successive bends to a straight length of tubing as it is fed to the bending apparatus of the machine. For high-production requirements of identical web members, this method of bending is much too slow.

A second type of bending machine has a plurality of bending devices which accommodates the entire straight length of tubing. Successive bends, beginning at one end of the tubing, are made one at a time by mechanically drawing successive bending devices toward the opposite end of the tubing which is held stationary by the machine. Likewise, this method of bending is slow.

The final type of bending machine is similar to the previous type except all bends are made simultaneously. Although much faster in production, this machine is physically limited by the great speed of the end bending device traveling toward the stationary holding device at the opposite end.

Of the tube-bending machines of which I am presently aware, all function to bend tubing in such a manner that the resulting apices of the zigzag web can be described either as a sharp kink caused by collapsing the wall of the tubing, or as a smoothly rounded bend. In either case, however, the apices have an unsuitable surface on which to affix chords should the zigzag web be used for construction of a bar joist or similar structure.

SUMMARY OF THE INVENTION

One of the primary objects of the present invention is to provide a tube-bending machine operable to form a zigzag web member having flattened portions of tubing at its apices, thereby providing a suitable surface on which other members can be affixed. An additional object is to provide a machine in which the contour and configuration of the flattened portions of tubing can easily be varied.

Another object of the invention is to provide a tube-bending machine which accommodates the entire length of a straight piece of tubing and in which, during the bending operation, the ends of the tubing are displaced toward the center of the length of tubing rather than one end of the tubing being moved toward the opposite, stationary end of the tubing. This feature greatly reduces the speed at which machine members holding the ends of the tubing must travel, and thus yielding a prominent safety advantage as well as decreasing wear on moving members. Likewise, web members of greater length than those formed by previous machines can now be formed.

Another object of the invention is to provide a tube-bending machine in which the number of bends in the zigzag web member can be easily increased or decreased.

Still another object of the invention is to provide a tube-bending machine in which the height of the zigzag web member to be formed can be easily adjusted and changed.

A further object of the invention is to provide a tube-bending machine which is highly reliable and safe for high-speed production of zigzag members and which is economical to manufacture, maintain and operate.

Other and further objects of the invention will appear in the course of the following description thereof.

DETAILED DESCRIPTION

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, and in which like reference numerals indicate like parts in the various views:

FIG. 1 is a front elevational view of the components of a tube flattening and bending machine constructed in accordance with a preferred embodiment of the invention, the movable components positioned to receive a straight length of tubing and the break lines indicating interrupted length;

FIG. 2 is a front elevational view of the machine of FIG. 1 in the condition it is in after having performed its flattening and bending functions upon the tubing;

FIG. 3 is a rear elevational view of the machine in the FIG. 2 configuration;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3 in the direction of the arrows; and

FIG. 5 is a sectional view taken along line 5—5 of FIG. 2 in the direction of the arrows.

Referring to the drawings, the basic support structure of the whole machine comprises a horizontal rail 7 which is shown supported by a floor anchored column 8. The rail 7 is of sufficient length to accommodate a straight length of tubing 9 (shown in broken lines) from which a zigzag web member is to be formed. Rail 7 is a box-beamlike structure, having generally the appearance in cross section of the Roman numeral II, as best seen in FIGS. 4 and 5. The rail may be made as long as required. Although a single column 8 is shown for purposes of illustration, additional columns 8 normally are provided at appropriate intervals along the length of rail 7 for necessary support.

Referring particularly to FIG. 1, an immovable central station 10 is located approximately midway along the length dimension of rail 7. Station 10 comprises an upper anvil and hammer assembly, generally designated as numeral 11 and an inverted L-shaped base 12 which is rigidly affixed on the top and front faces of rail 7.

The anvil and hammer assembly is carried by a support member 13 which, in the preferred embodiment, is an elongated boxlike structure which extends above the top rail 7 and is located forwardly of the front side thereof. Support 13 is rigidly attached to the top and front faces of base 12 and has the general configuration shown in FIG. 5, which, as will be seen, shows a movable station rather than a fixed station.

The anvil of anvil and hammer assembly 11 is indicated at 14. It is removably mounted (by bolts or other conventional fasteners) on the front face of support member 13 slightly above rail 7, and comprises a block with a flat upper anvil surface 14a.

Also mounted on the front face of support member 13 but at its uppermost end is a double-acting hydraulic cylinder 15 into two internal chambers. Connection 16 provided access to chamber behind the internal piston and connection 17 provides access to the chamber in front of the internal piston. The piston is fitted with an extrusion 18, which projects externally from hydraulic cylinder 15 and downwardly toward anvil 14.

A hammer 19 is removably mounted on the end of the extension 18. The separated distance between the tube-engaging surface of anvil 14 is preferably just slightly greater than the outside diameter of the tubing to be handled by the machine. In the preferred device, the working end of the hammer is shaped much like the blade of a screwdriver with a flat lower end. Attached to and extending rearwardly from the opposite side faces of support member 13 are support bars 20. As can best be seen in FIG. 3, a cross member 21 is attached to and extends between and is supported by the ends of bars 20. A horizontal pivot pin 22 is connected to the crossmember 21 and the axis of pin 22 coincides with the horizontal centerline running from front to rear of the tube-engaging surface 14a of its associated anvil 14.

Disposed on rail 7 and spaced at intervals therealong outboard stations 25 which are similar in basic structure to station 10 but differ therefrom in that they are supported for movement along the rail. The anvil and the hammer assemblies 11 associated with stations 25 have members 13 through 22 identically corresponding to those members previously

discussed with respect to station 10 and therefore are designated by like reference numerals.

The distinguishing structural difference between stations 25 and station 10 is the manner of connecting the anvil and hammer assemblies 11 to rail 7.

As best viewed in FIG. 5, the assembly support member 13 of each station 25 is attached to an inverted U-shaped frame 26 disposed across rail 7 and having the side legs 26*a*, 26*a* and bight 26*b*. A plurality of guide rollers 27 are connected to the frame 26 and engage the top, side and bottom surfaces of each face of rail 7. The rollers permit the movable station to ride freely along the rail and at the same time stabilize the station in a fixed orientation with respect to the long axis of the rail.

Disposed on rail 7 on each side of the stationary central station 10 between station 10 and moveable stations 25 are second movable outboard stations 28, which are similar in several aspects to stations 25 and station 10. The anvil and hammer assemblies associated with stations 28 have members 14 through 22 corresponding to those members previously discussed with respect to stations 25 and station 10 except that the entire anvil and hammer assembly 11 is rotated 180° about a centerline running from front to rear and bisecting the distance between the tube-engaging surface of anvil 14 and hammer 19. Being so positioned, hydraulic cylinder 15 is disposed on the lowermost end and anvil 14 is disposed on the uppermost end of support member 13 as viewed in FIG. 1.

Rather than being rigidly attached to a frame 26 as in station 25, support member 13 is supported for up and down movement along a vertical beam 29 by a plurality of rollers 30, best viewed in FIG. 4. Beam 30 is rigidly attached to the inverted U-shaped frame 26 which has associated rail-engaging rollers 27, as earlier described with respect to stations 25. The beam 30 has vertically running flanges with which the rollers 30 cooperate.

Mounted on the lower portion of the front face of beam 30 and extending inwardly through the hollow support member 13 is an elongate double-acting hydraulic cylinder 31. A movable internal piston (not shown) divides hydraulic cylinder 31 into two internal chambers. Connection 32 provides access to the chamber below the internal piston and connection 33 provided access to the chamber in front of the internal piston. Attached to the piston in an extension 34 which projects upwardly from the cylinder to connect to the uppermost end of support member 13 as at 34*a*.

The upright beam 29 has a lower portion 29*a* which parallels cylinder 31 and to which the cylinder is connected. Located on the rear face of such lower portion is a roller 35 which engages a horizontal bar or track 36 which is attached to columns 8 beneath rail 7. As can best be seen in FIG. 3, station 10 is connected to stations 28, and the latter to stations 25 by connecting links which extend between the respective stations and have their ends pivoted to the pins 22 on the back side of each station. As earlier mentioned, each station has a pivot pin 22 extending rearwardly from crossmember 21 of the anvil and hammer assembly 11.

As will subsequently be seen, the distance to which stations may approach one another during inward travel toward the midpoint of the rail, which is the location of the stationary central station 10, is controlled by limit stops attached to the stations. These are preferably on the form of threaded studs 38, one for each station, which extend to one side of the station in position to engage the next inboard section when the distance between them has closed sufficiently. Locknuts 39 are provided on the studs. The limit distance between stations can be changed by threading the studs in or out, as necessary.

The tube flattening and bending machine is utilized to form a zigzag web member in the manner to be described.

With the stations in the condition illustrated in FIG. 1, a straight length of tubing 9 is placed between the anvils 14 and hammers 19 of stations 10, 25, and 28, the latter having, of course, first been positioned in the spaced away position with respect to the anvils. To do this, pressurized fluid is introduced onto the chamber behind the internal piston of hydraulic cylinder 15 through connection 17 by a suitable means, such as a conventional hydraulic pump and two-way valve (not shown), which influences connecting rod 18 and hammer 19 away from anvil 14. When the tube is in place, the flow is reversed to impel the hammer toward the anvils. This action collapses tubing wall and flattens a limited portion of the tubing at each station to the contour and dimensions of the tube-engaging surface of hammer 19.

Although it is not essential to the flattening operation, it is desirable that the connections 16 and 17 of each station be respectively connected in series by flexible hoses to common lines of a conventional two-way hydraulic circuit. This allows substantially simultaneously flattening of the portions of tubing between anvil 14 and hammer 19 of each station.

Once flattening is completed, and while maintaining flattening pressure, pressurized fluid is introduced into the chamber behind the internal piston of the hydraulic cylinders 31 through connections 32 through a two-way hydraulic circuit (not shown) independent of the flattening hydraulic circuit. This causes the piston extensions 34 to move in an upwardly direction and, since the extensions carry the anvil and hammer assemblies 11, of station 28, the anvil and hammer assemblies move upwardly on rollers 29 along beam 30. Although it is not essential to the bending operation, it is desirable that the connection 32 of each station 28 be connected in series or in parallel by flexible hoses to the two-way hydraulic circuit. This allows substantially simultaneous bending to occur and thereby increases the production speed.

Firmly held between anvil 14 and hammer 19, the flattened portion of tubing 9 also travels in an upwardly direction along beam 29 and initiates the bending of the tubing. At the same time, the station connecting links 37 are displaced upwardly at station 28, causing them to pivot about pins 22, and exerting forces operating to pull neighboring stations together. Since the central station 10 is rigidly affixed to rail 7, all outboard stations are pulled inwardly toward station 10 and they will continue to move until the limit stops 38 are engaged all along the line. The condition of the machine at this time is illustrated in FIGS. 2 and 3.

Pressure on the fluid in hydraulic cylinders 15 is now released, and pressurized fluid is introduced into the chamber in front of the internal piston of hydraulic cylinder 15 through connection 17, which forces the fluid behind the internal piston out through connection 16 and also forces connecting rod 18 and hammer 19 to return to their original position. At this point, the anvils 14 and hammers 19 no longer grip the tubing and the zigzag member can be manually removed from the machine.

Next, the pressure on the fluid in hydraulic cylinders 31 is released and pressurized fluid is introduced into the chamber in front of the internal piston of hydraulic cylinder 31 through connection 33, which forces the fluid behind the internal piston out through connection 32 and also forces anvil and hammer assembly 11 downwardly along beam 29 to its original position as viewed in FIG. 1.

The number of bends in zigzag web members subsequently to be formed can be easily increased or decreased. This is accomplished by adding or deleting additional outboard stations at either end of rail 7. Extra outboard stations can be removed from rail 7 simply by rolling said stations off the end of the rail. Alternatively, extra stations can be stored at the ends of rail 7 if these areas of the rail are not needed to form a zigzag web member. All connections needed to add an outboard station are exceedingly simple. A station connecting arm 37 and suitable hose to the hydraulic cylinders is all that is required.

Likewise, the height and angle of the zigzag web member to be formed can be easily adjusted and changed. This is accomplished by loosening locking nuts 24 on each station, adjusting bolts 23 to a desired length and then retightening locking nuts 24, or by substituting link members 37 of different length, or both.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove

set forth, together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A tube-bending machine operable to form a straight length of tubing into a ZigZag web member having flattened sections of tubing at its apices; said machine comprising:

a normally fixed central station;

a rail member extending on both sides of said central station, said rail member of sufficient length to accommodate said straight length of tubing from which said web member is to be formed;

a plurality of movable outboard stations mounted on said rail member with at least one on each side of said central station;

a tube flattening and gripping assembly associated with each said station, each of said assemblies having tube-engaging surfaces and operable to flatten and to grip a section of said tubing;

first power means for operating said assemblies to flatten and to grip a section of said tubing;

bending means associated with at least one movable outboard station on each side of said central station, said bending means operable to move said flattening and gripping assemblies of said one movable outboard station on each side of said central station in a direction substantially perpendicular to the lengthwise direction of said rail member;

second power means for operating said bending means of said one movable outboard station on each side of said central station; and

link means for connecting successive stations, said link means operable to cause said movable outboard stations to move toward said central station as said second power means operates said bending means.

2. The machine as in claim 1, wherein a plurality of said movable outboard stations are alternately disposed on said rail members away from said central station such that an outboard station having bending means is followed by an outboard station having no bending means and an outboard station having no bending means is followed by an outboard station having bending means.

3. The machine as in claim 1, wherein said movable outboard stations are mounted on said rail members by rollers to permit movement of said outboard stations along the lengthwise direction of said rail members.

4. The machine as in claim 1, wherein each of said assemblies includes:

an anvil having a tube flattening and gripping surface;

a hydraulic cylinder;

a reciprocable piston associated with said hydraulic cylinder; and

a hammer opposed to said anvil having a tube flattening and gripping surface connected to said piston of said hydraulic cylinder.

5. The machine as in claim 4, wherein said tube flattening and gripping surface of said anvil conforms to said tube flattening and gripping surface of said hammer to impart the contour and dimensions of the latter surface to the flattened section of said tubing when said activating means operates said assembly.

6. The machine as in claim 4, said anvil and hammer removably mounted on said assembly.

7. The machine as in claim 1, each of said bending means including a hydraulic cylinder and a piston associated with said hydraulic cylinder connected to said assembly.

8. The machine as in claim 1, said first means capable of substantially simultaneously operating said assemblies to flatten and to grip sections of said tubing.

9. The machine as in claim 1, said second power means capable of substantially simultaneously operating said bending means of said movable outboard stations.

10. The machine as in claim 1, said link means for connecting successive stations including link member extending between said successive stations one end of said member pivotally connected to one of said stations and the other end of said member pivotally connected to the other of said stations.

11. The machine as in claim 1, wherein stop means prevent successive stations from moving closer to each other than a preselected distance when said second power means operates said bending means.

12. The machine as in claim 11, said stop means including adjustable bolt means, at least one of which is connected to each of said stations, said bolt means having a station engaging surface to prevent successive stations from moving closer to each other than a preselected distance when said second power means operates said bending means.

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