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[54] **MACHINE AND METHOD FOR EXPANDING SHEET METAL PIPE TO NONCIRCULAR CROSS SECTION**  
20 Claims, 23 Drawing Figs.

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72/392, 29/183.5  
[51] Int. Cl. .... **B21d 39/08**  
[50] Field of Search. .... **72/355,**  
370, 392, 393; 29/183.5

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**ABSTRACT:** A method of expanding or stretching and a machine to expand or stretch sheet metal pipe into flat oval cross section pipe as well as the resulting length of small diameter expanded, noncircular cross section pipe. The machine has a vertical operating wedge reciprocally disposed between inclined expansion track and mandrel assemblies over which sections of initially round pipe are placed. Power components for the machine are under the working parts and are preferably located below ground level. The method of operation results in expansion of a length of sheet metal pipe up to twice the length of the expansion mandrels into flat oval cross section. The pipe is placed over the mandrels and at least one-half its length stretched, the pipe then being reversed with its other end placed over the mandrels, properly located and stretched in coextensive relationship to the other previously stretched portion of the pipe. The wedge is reciprocated by a hydraulic motor (ram), the inclined tracks are guided for lateral displacement at their lower ends and, by cooperating linkage, will be positively slid back into juxtaposition when the wedge is withdrawn to a retracted position.

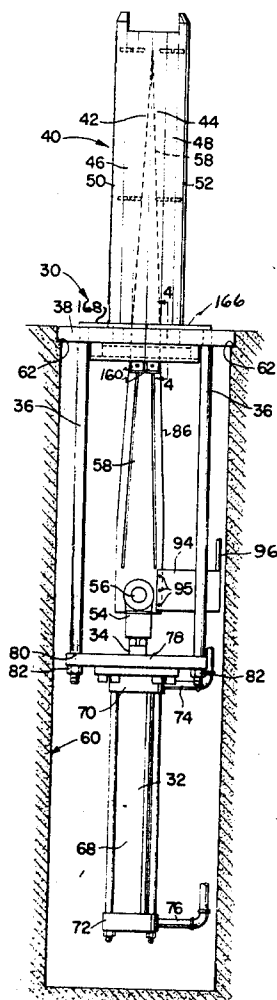


FIG. 1

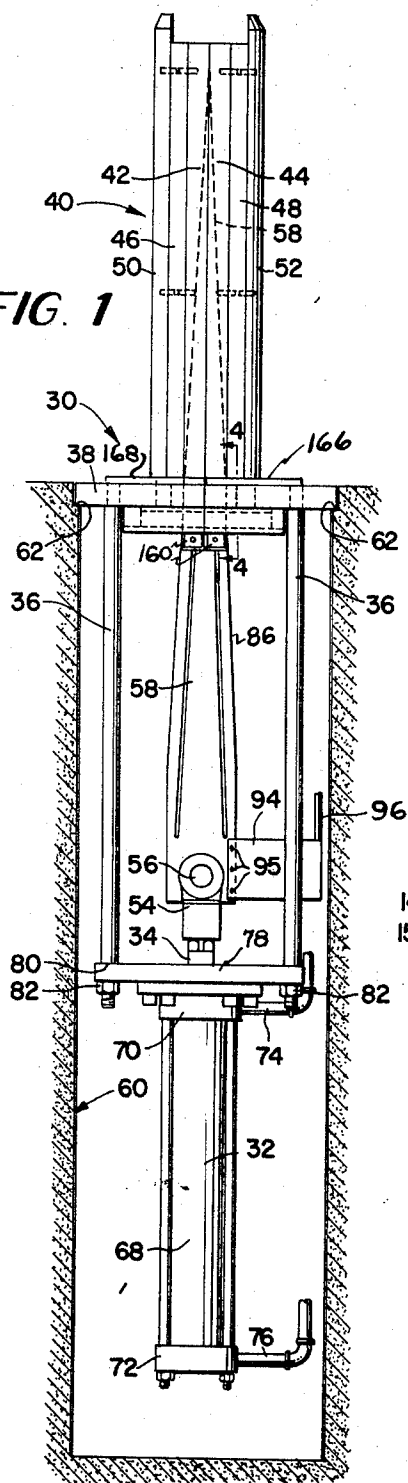
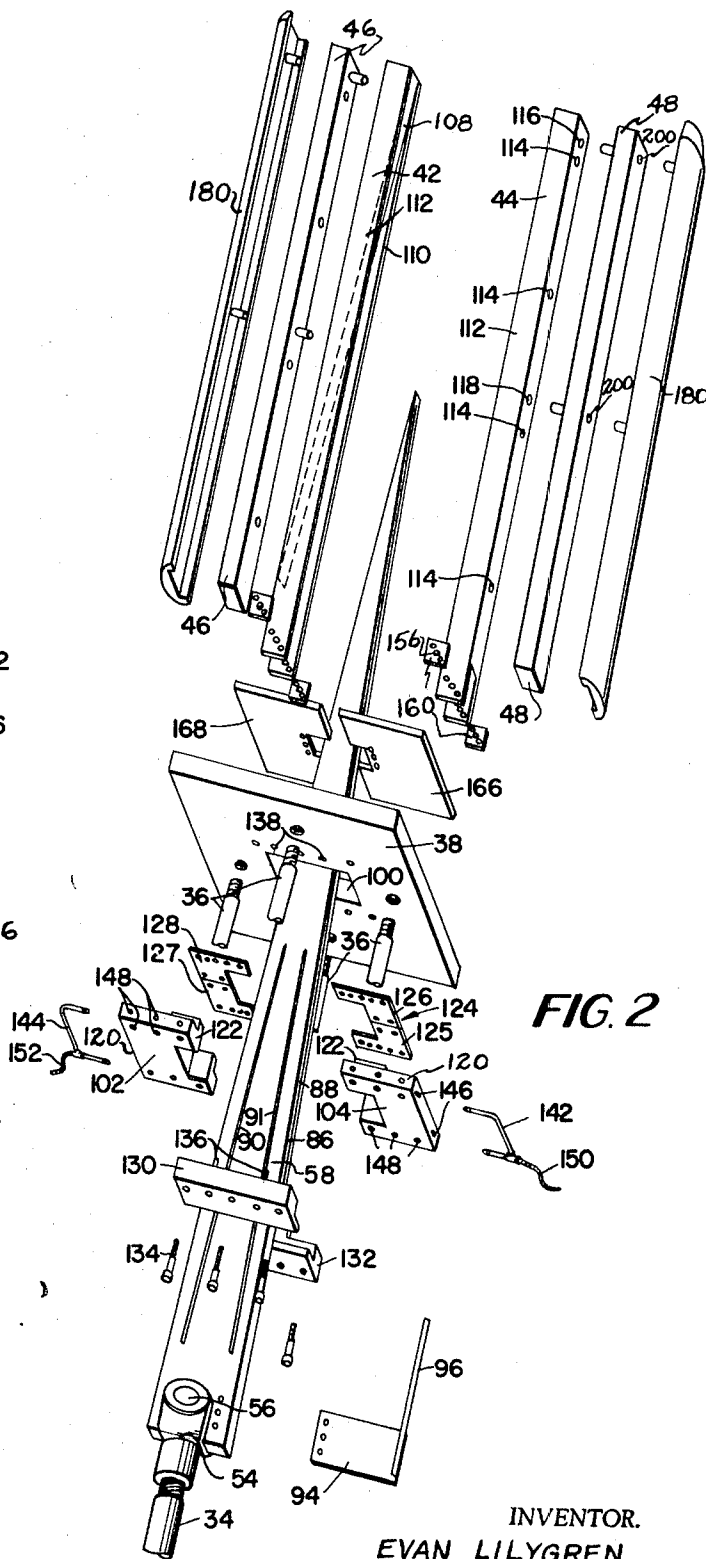


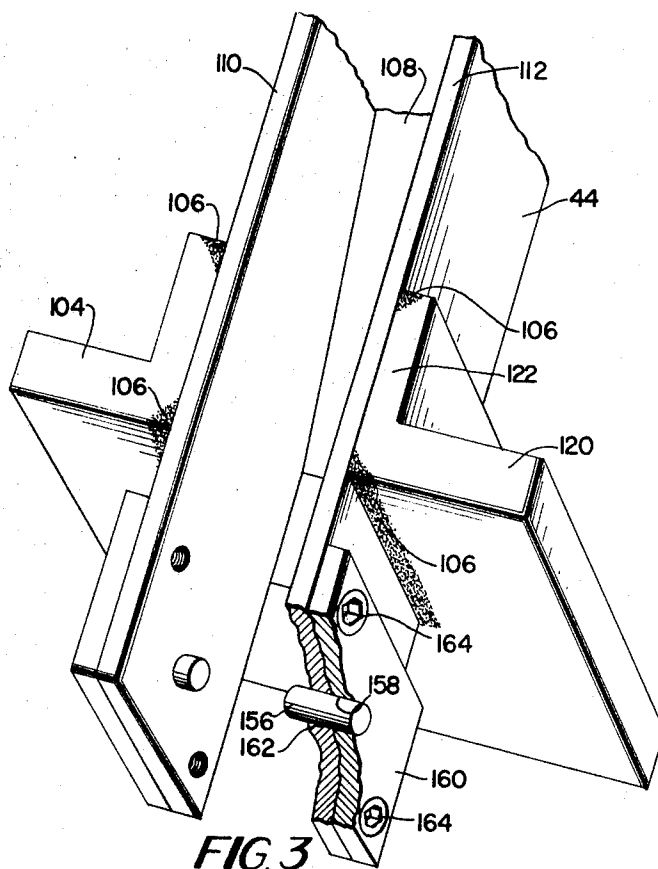
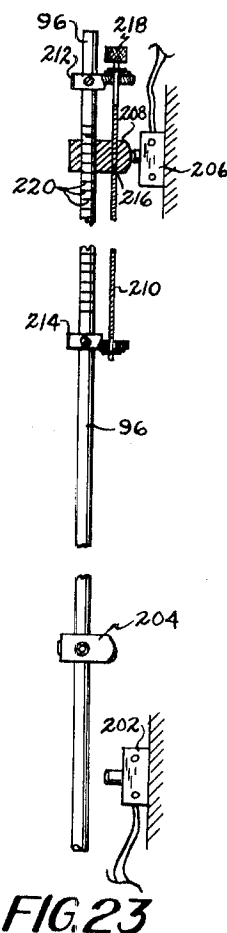
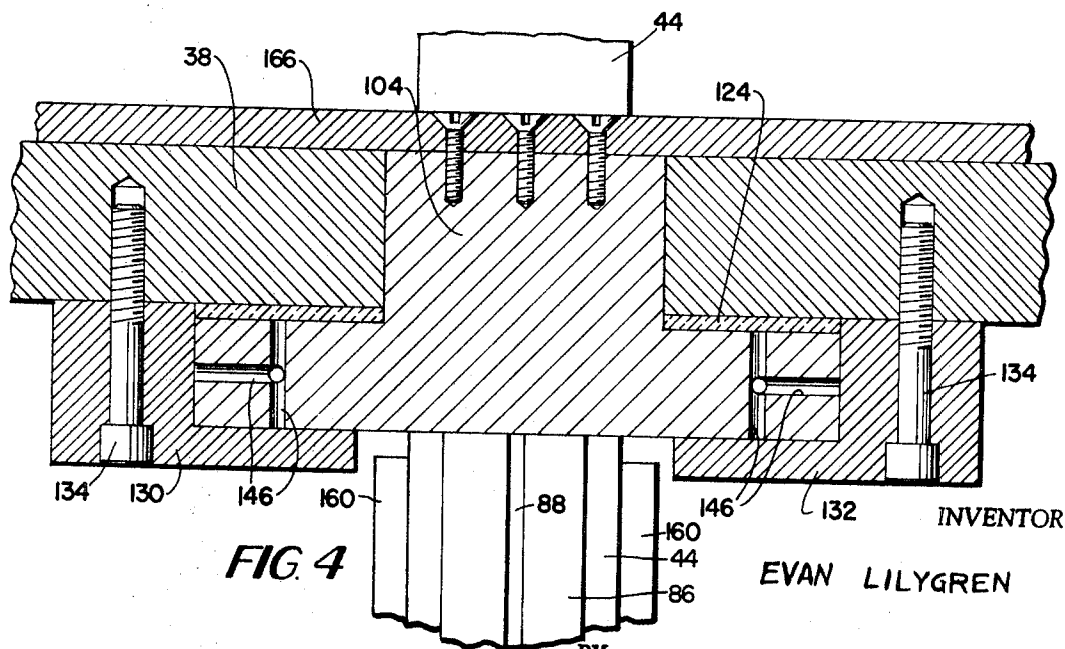
FIG. 2



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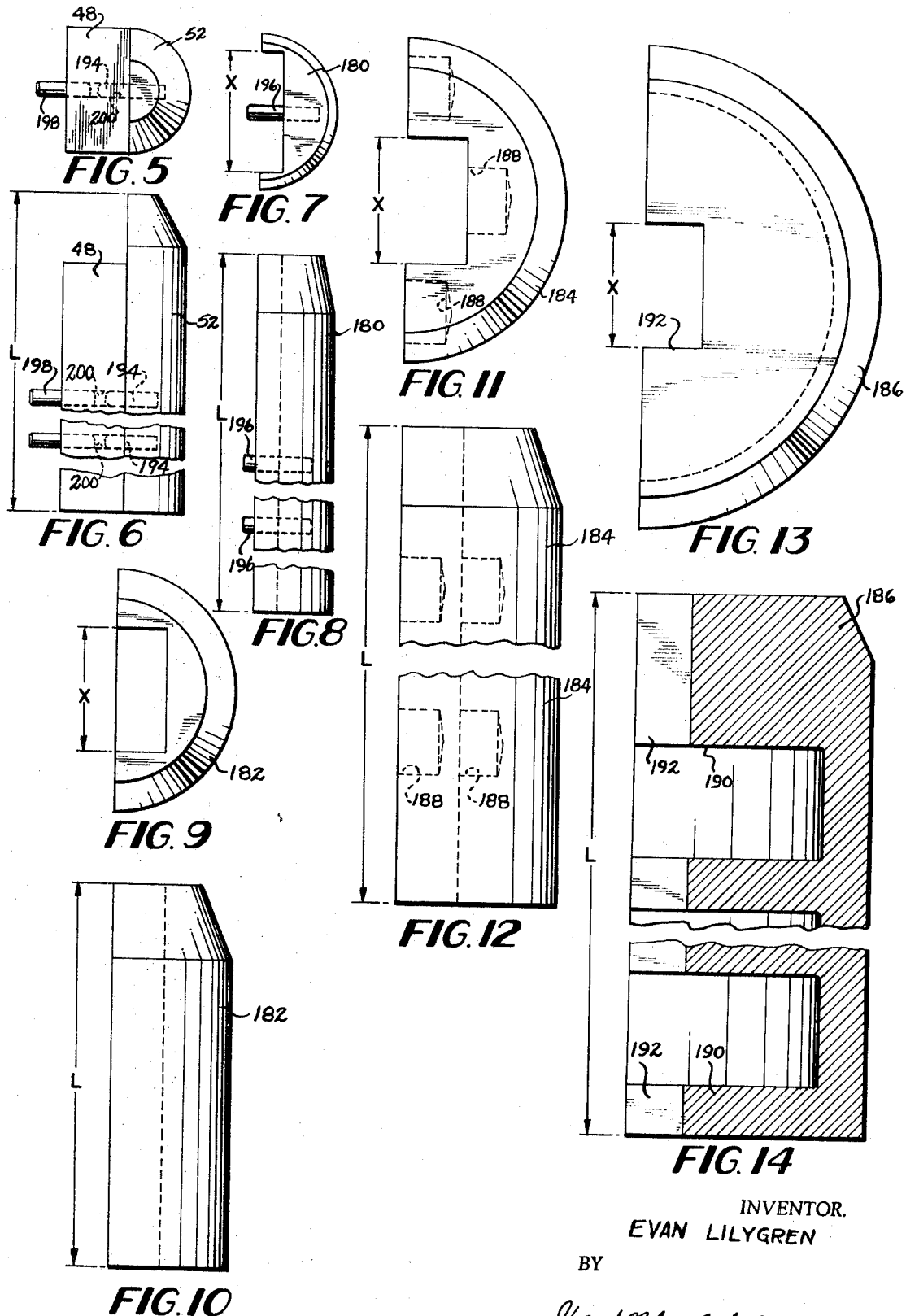
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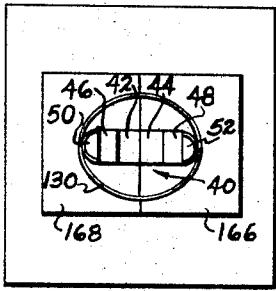


FIG. 15

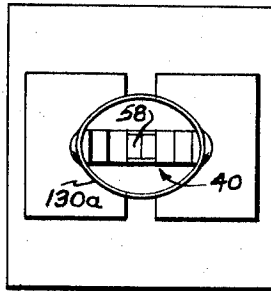


FIG. 17

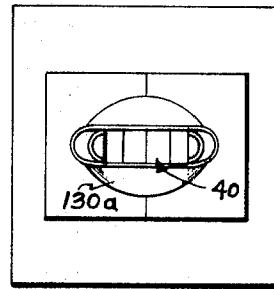


FIG. 19

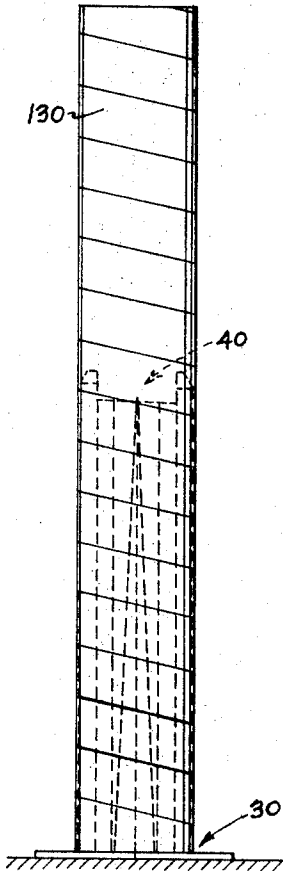


FIG. 16

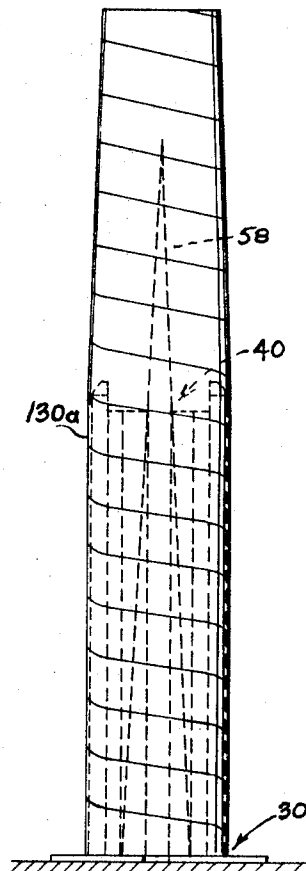


FIG. 18

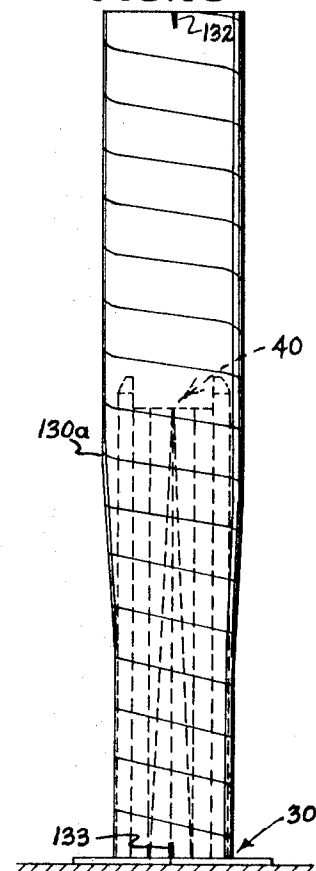


FIG. 20

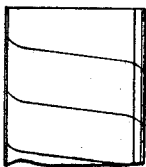
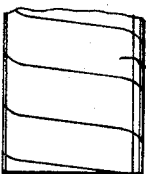


FIG. 22

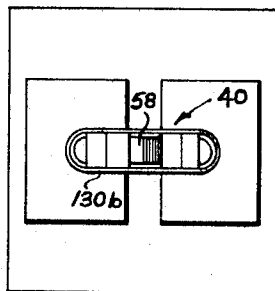


FIG. 21

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# MACHINE AND METHOD FOR EXPANDING SHEET METAL PIPE TO NONCIRCULAR CROSS SECTION

## BACKGROUND OF THE INVENTION

The present invention relates to noncircular cross section, e.g., flat oval ducts or pipes and a machine and method for making flat oval duct. In the past, round pipe or duct has been made into noncircular cross section such as flat oval shape either by squashing of the pipe from the exterior or by slipping the pipe over a larger horizontally disposed expansion assembly of mandrels and wedges or expanding links. All such previously known machines have been massive and the tool components extremely heavy, requiring overhead cranes or dollies for assembly and disassembly. The required strength and hence size of the working components of the prior art expansion machines has effectively placed a minimum limitation on the size of pipe, which can be machine stretched, to an approximately 14-inch diameter pipe. Prior to the present invention, lengths of smaller diameter pipes expanded to noncircular cross section, and more specifically, the resulting smaller diameter pipe with flat oval cross section, has not been available.

The present invention uses a much simpler operating mechanism than is used in the previously known expansion mandrel machines. It avoids the undesirable overhanging cantilever aspect which requires heavy, strong working components, because, in the machine of the present invention, the expansion components are arranged in vertical disposition. Furthermore, by locating the major power component below ground level, the relatively small portions which act as expansion tools require only a minimum amount of space in the work area, the visible working components having the appearance of a group of beams standing on end and projecting several feet above ground level. The controls may be located on a wall or off to one side of the machine away from valuable manufacturing floor space. The various aspects of this invention will be disclosed and described in conjunction with sheet metal spiral pipe, but are also applicable to welded seam and seamless sheet metal pipe.

Accordingly, a primary object of the present invention resides in the provision of short lengths of sheet metal pipe having an original inside diameter less than 14 inches and expanded to a noncircular cross section such as flat oval shape.

A still further object resides in the provision of a novel, simplified wedge actuated pipe expansion machine with the wedge and the stretching mandrel assembly disposed in vertical disposition.

Still another object resides in the provision of a novel expansion machine in accord with the previous object wherein the power components of the machine are located below ground level.

Still another object resides in the provision of a novel flat oval pipe stretch machine including a dual-acting hydraulic ram motor in which the piston rod is connected in line with an expander wedge, the wedge cooperates between two inclined expander tracks, a set of mandrels selected from a multiplicity of sets of stretching mandrels of different sizes to produce the desired size of noncircular cross section pipe, is secured to the expander tracks, the lower ends of the expander tracks are securely maintained in guide ways permitting lateral expansion of the two tracks and supported mandrels, and cooperating linkage between the guide tracks at their lower ends interconnect with the wedge to provide mechanism for returning the guide tracks and mandrels to their initial positions as the wedge is retracted by the hydraulic cylinder. In conjunction with this object, mandrel spacers are provided and are installed singly or in multiple units as desired to enable numerous sizes of expanding noncircular pipe to be made on the basic machine.

A still further object of the present invention resides in providing the novel machine as described in the previous object with the hydraulic piston axis disposed vertically and with all machine components below ground level excepting the

upper end of the wedge, the inclined expanding tracks and the mandrels.

Still another object resides in a novel method of producing a length of sheet metal pipe expanded to a noncircular cross section the length of which can be up to twice as great as the length of the working faces of the expansion mandrels, comprising the steps of placing one end of initially round sheet metal pipe over the mandrels so that at least half of its length will be expanded, expanding that portion of the round pipe, removing and reversing the length of pipe and placing the other end portion in prealigned disposition over the expanding mandrels and expanding the remaining portion of the length of sheet metal pipe. In conjunction with the foregoing method steps, such steps can be utilized with a vertically disposed expanding mandrel assembly whereupon the pipe is positioned vertically over the end of the mandrel preceding each of the two expanding steps.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings showing a preferred structure and embodiment, in which:

FIG. 1 is a side elevation view of the vertical expansion machine according to the present invention;

FIG. 2 is an exploded perspective view illustrating most of the components of the machine excepting the hydraulic ram;

FIG. 3 is an enlarged detail perspective view of the lower end of one of the side rails, a portion of which is broken away to show the retracting pin structure;

FIG. 4 is an enlarged detailed section taken on line 4-4 of FIG. 1 illustrating the manner in which the side rails are maintained in assembly with the top plate;

FIGS. 5 and 6 are top and side views respectively, of the three inch mandrel together with a spacer bar, the separate mandrel and bar being shown spigoted together by dowels as an example of how they are assembled;

FIGS. 7 and 8 are top and side views of one of a set of four inch mandrels;

FIGS. 9 and 10 are top and side views, respectively, of a 6-inch mandrel;

FIGS. 11 and 12 are top and side views, respectively, of an 8-inch mandrel;

FIGS. 13 and 14 are top and side views, respectively, of a twelve inch mandrel, the side view being sectioned;

FIGS. 15 through 22 represent various stages of the method used in expanding a length of spiral pipe which has a greater length than the length of the expansion mandrels, FIGS. 15, 17, 19 and 21 being top views and FIGS. 16, 18 and 20 being side views of the pipe on the machine. FIG. 22 is a side view of the finished flat oval spiral pipe; and

FIG. 23 (located on drawing sheet 2) illustrates a limit switch and switch operator arrangement which enables adjustment of the ram-operating stroke.

## GENERAL DESCRIPTION

The expansion machine 30 for making pipe with flat oval cross section is shown in FIG. 1. Machine 30 includes a hydraulic motor, or ram 32 disposed in vertical arrangement with its piston rod 34 extending from the upper end of the ram. The ram is rigidly supported in a depending fashion by means of truss rods 36 secured to depend from the underside of a top support plate 38. Projecting up through and to a position above the top plate 38 is the expansion assembly 40 which consists of an opposing pair of vertical side rails 42 and 44, associated spacer bars 46 and 48 and a matched pair of expansion mandrels 50 and 52. The side rails 42 and 44 are permanent assembly components whereas the spacer bars 46 and 48 and mandrels 50 and 52 can be changed according to the initial diameter of the round pipe being expanded to flat oval form as well as the desired flat oval shape to which the pipe will be expanded. The spacer bars 46 and 48 can be omitted, or used in any combination with the various sizes of the mandrels, as will be fully described hereinafter.

Each side rail 42 and 44 is an assembly of several components and the two rails are axially maintained relative to the top plate 38 although being permitted to slidably shift in a horizontal direction to an opened and closed condition in accord with operation of ram 32. Connected to the upper end of the piston rod 34 by means of a clevis fitting 54 and a clevis pin 56 is an expansion wedge 58. As depicted in FIG. 1, the ram is retracted, in which condition the two side rails 42 and 44 are disposed in an adjacent or closed relationship. In retracted condition, the lower portion of wedge 58 is below the top plate 38 and the upper portion of the wedge 58 projects up through the top plate and fits between track flanges and against inclined surfaces of tracks on the inner sides of the two side rails 42 and 44.

The machine, consisting of ram 32, truss rods 36, top plate 38, expansion assembly 40 and wedge 58 as an assembly is mounted in a well 60 with ram 32 located near the bottom of the well and the top plate 38 flush with ground or floor level resting on a ledge 62 formed around the upper end of well 60. The top support plate, if desired, may be secured to the upper end of the well 60 although it is not necessary inasmuch as all working stresses are accommodated within the assembled structure of the machine.

The description will be directed to machine components as well as a method for making flat oval length of spiral sheet metal pipe. Nevertheless it is to be understood that the pipe need not be spiral pipe and the expanded noncircular cross section need not be flat oval as the shape will be determined by the contours of the mandrels, e.g., the shape could be rectangular.

#### MACHINE DETAILS

Details of the various machine components and their functional relationship will be described with primary reference to the exploded perspective of FIG. 2.

With the exception of various nuts, bolts, machine screws, the ram and some support structure, essentially all of the components of the machine 30 are shown in FIG. 2. The vertical ram 32 seen in FIG. 1 is a commercially available two-directional piston-cylinder hydraulic motor having a cylinder casing 68, with cylinder heads 70 and 72 at each end and having operating fluid conduits 74 and 76 connected through suitable ports in each of the cylinder heads. The upper cylinder head 70 is secured by machine screws to the underside of a centrally apertured cylinder mounting plate 78. In the exemplary machine, an actual satisfactory production machine, the motor was selected for exerting working forces utilizing 1,500 p.s.i. hydraulic pressure.

Materials of construction described are exemplary and other materials of equivalent strength can be used. The cylinder mounting plate 78 can be made of hot rolled steel and, in the exemplary embodiment, is approximately 1½ inches thick and in cooperation with four stay rods 36 serves to rigidly secure the cylinder assembly to the top support plate 38. Dimensions given in this description are exemplary and of course can vary according to machine size, design and strengths of materials. The stay rods are cold rolled steel bar stock with slightly reduced diameter, threaded upper ends screwed into tapped bores through the top support plate 38. The lower threaded ends of all four stay rods 36, also of slightly reduced diameter to form a shoulder 80 to abut against the cylinder mounting plate 78, pass through close fitting apertures in the cylinder mounting plate. The plate 78 is then rigidly secured to the four stay rods by means of nuts 82.

The upper projecting end of piston rod 34 is threaded to receive the internally threaded shank of clevis 54. Fitted between the forked arms of clevis 54 is the wide lower end of the center expansion wedge 58, a part which is made from steel having a thickness of approximately 2 inches. In the exemplary embodiment, the wedge is 73 inches long with a tapered portion of 62 inches. The wedge has a width of approximately 6½ inches at its lower end. Extending throughout substantially the entire extent of each of the inclined wedge

faces 86 is a shallow lubricant groove 88 which terminates a short distance from the thin wedge end.

Clearly shown in both of FIGS. 1 and 2, each of the two parallel sides of wedge 58 are provided with two nonparallel grooves 90 and 91 which have an angle of convergence the same as that of the wedge faces. The pairs of grooves 90 and 91 are located on the lower half of the wedge and cooperate with guide pins secured to the lower end of the side rails 42 and 44 and, as will be hereinafter described, provide a pin and slot motion transmitting linkage for positive retraction of the guide rails during withdrawal of the center wedge after an expansion stroke has occurred. The grooves 90 and 91 are approximately three-eighths inch wide by one-fourth inch deep.

Secured to the lower end of wedge 58 (see FIG. 1) is a small laterally disposed bracket plate 94 to which is welded a vertical rod 96. The rod 96 can project up through a guide hole in the top plate 38, and because it is directly connected to the wedge, its movement is equal to and thus is a direct indication of wedge movement. By using a pointer on the end of the rod and a fixed vertical scale it will provide a visual indication of the position of the wedge. Also, the rod can carry ram stroke limit cams which coast with appropriate limit switch mechanism connected in a ram control circuit to provide automatic limiting of the working stroke and a return limit position for the ram. As will be more fully described hereinafter, such working stroke limit cam or the associated limit switch can be made adjustable to vary the working stroke in order to precisely control the expansion of the mandrels as desired.

Turning back to FIG. 2, the wedge 58 can be seen projecting through a rectangular opening 100 in the center of the top support plate 38. Opening 100 is dimensioned to permit free unrestricted passage of the wedge throughout its travel between retracted and extended positions and to also accommodate the lower ends of the shiftable side rails 42 and 44 and their end bracket collars 122.

The expansion assembly 40 has as primary components the two side rails 42 and 44 which are shifted laterally away from each other by the center expansion wedge 58 as it moves upward under the force of hydraulic ram 32. Side rails 42 and 44 cannot move vertically because the lower end of each side rail is securely maintained against vertical displacement against the top support plate 38. This is accomplished by guiding and retaining components now to be described in detail.

As mentioned hereinbefore, the two side rails 42 and 44 are part of the permanent machine installation, being provided with means by which various different size mandrels can be readily installed and removed. While FIG. 2 shows the side rails 42 and 44 and their associated side rail end brackets 102 and 104 as separated components, each side rail will have its associated end bracket 102 or 104 welded in place, the weld surface being ground to finish dimensions before the rail is installed in assembly. FIG. 3, a partially broken-away enlarged view of the lower end of side rail 44, shows how its end bracket 104 is rigidly secured to the side rail by the weld areas 106. The side rails as well as their end brackets are made from steel and should be carefully machined to desired size. FIGS. 2 and 3 show an inclined track face on the two side rails. The inclined face 108 (FIG. 3) of side rail 44 and the similar inclined face of side rail 42 have a taper which is machine ground at angle which matches that of the center expansion wedge 58. The track face 108 extends from the location near the lower end of the side rail and terminates at the upper end and is located between two side flanges 110 and 112. The side flanges are spaced apart approximately the same dimension as the width of the expansion wedge 58 with a positive tolerance permitting a free but close sliding fit of the wedge 58 between the two side rail flanges. Several tapped apertures 114, four being illustrated, are provided in the rear wall of the two side rails for grease pressure fittings which can be threaded into such apertures enabling provision for lubricating grease to be injected between the tapered working surfaces of the expansion wedge 58 and the two side rails 42 and 44. The grease fitting apertures or ports 114 through the side rails are aligned

with the oil groove 88 previously described as located in the inclined wedge faces 86 of center expansion wedge 58.

In addition to the grease-fitting ports through the wall of side rails, two dowel pin holes 116 and 118, seen in FIG. 2 on side rail 44 are provided for locating and removably assembling appropriate expansion mandrels and spacer bars on the two side rails. The two dowel holes are dimensioned to provide a matched and accurate sliding spigoted fit of associated dowel pins on the mandrels and spacers, as will be hereinafter described.

Returning to FIG. 3 the side rail end bracket 104 welded to the lower end of side rail 44 has a wide horizontal flange which extends laterally approximately 3 inches on three sides of the side rails, the flange being approximately 1½ inches thick. Such an end bracket is a rigid part of the side rail and cooperates with guide ways fastened to the undersurface of top support plate 38 to rigidly maintain the side rail in vertical disposition, yet it permits the two rails to slide outwardly away from each other under expansion operations. The end bracket 104 has an upstanding collar closely embracing the two sides and back face of the associated side rail 44. When the side rails are placed into the machine assembly, the upper ends will be inserted from under the top support plate 38 through the central hole 100 and the collar 122 will fit with a close sliding fit between the sidewalls of the support plate hole 100.

Best shown in FIG. 2 is a bronze liner oil plate 124, which can be made from two or four pieces such as pieces 125, 126, 127 and 128 of oil-impregnated bronze. This oil plate 124 is relatively thin and is fastened by flat head screws to the top side of the horizontal flanges 120 on the side rail end brackets and provides a bearing surface between the end brackets and the underside of the top support plate 38.

When side rails 42 and 44 have been assembled up through the top plate hole 100 and the side rail end brackets are abutted up against the undersurface of plate 38, a pair of heavy steel side rail angle bracket tracks 130 and 132 are fastened by machine screws 134 to the underside of plate 38. The two tracks 130 and 132 are accurately located on plate 38 by means of locator pins 136 and holes 138 in the plate 38 and maintain the side rail end brackets 102 and 104 against the under surface of plate 38 with a close sliding fit.

Provision is made for lubricating the relatively sliding surfaces between the side rail end brackets 102 and 104 and the guide tracks 130 and 132 and between the oil-impregnated liner plate 124 and the undersurface of support plate 38. To this end, injection-greasing conduit pipes 142 and 144 are secured by appropriate fittings to injection ports such as shown at 146 in the end edges of side rail end bracket 104. The ports 146 open through internal drilled passages to a plurality of openings 148 in the front, back, top and bottom surfaces of the end brackets and thereby permit injection of lubricating grease between all relatively sliding surfaces. Appropriate matched apertures in the bronze liner plate 124 and the upper surface of the end brackets 102 and 104 permit passage of the lubricating grease to the undersurface of the top support plate 38. Flexible conduits 150 and 152 (FIG. 2) are connected to any suitable injection greasing apparatus to enable greasing without disassembling the machine.

After the two side rail assemblies 42 and 44 have been assembled through and to the support plate 38 by their retaining brackets 130 and 132, the center expansion wedge 58 is placed in the assembly by insertion from below up between the two side rails 42 and 44 between their side flanges 110 and 112 as shown by the dotted line in FIG. 1. The truss rods 36, cylinder mounting plate 78 and ram 32 are assembled with piston rod clevis 54 fitted over the lower end of the expansion wedge 58 and clevis pin 56 installed. With the ram retracted, the upper end of expansion wedge 58 will be adjacent the upper ends of the two side rails and the side rails can be slid toward and abutted with each other in the position shown in FIG. 1, and with the components so disposed, the lower end guide pin plates 160 can be fastened on the lower ends of the two side rails 42 and 44 with their guide pins 156 (see FIG. 3)

fitted into the guide grooves 90 and 91 in the parallel side surfaces of wedge 58. The lower ends of both side rails are extensions of the flanged sidewalls 110 and 112 and because the guide rail pins must be added after the side rails and center wedge are assembled, provision is made for removal of the guide pin plates 160.

All four guide pins 156 are identical and, with reference to FIG. 3, each is a steel dowel press fit into a hole 158 in its associated guide pin plate 160. The plate 160 fits against the outer surface of the lower end of a side rail flange and its extended guide pin 156 projects through an accurately located guide pin hole 162 in the lower end of the side rail flange. The guide pin 156 projects slightly less than one-fourth inch from the inner surface of the side rail flange 112 and in assembly will extend into an associated one of the previously described guide grooves 90 and 91 in the side surface of the central wedge 58, the depth of such groove being approximately one-fourth inch deep. There is a free sliding fit of the guide pin 156 in its groove so that none of the expansion force transmitted by the wedge 58 to side rails 42 and 44 will be transmitted through the guide pins which are solely for the purpose of returning the side rails to their abutted position as the central wedge 58 is withdrawn after an expansion stroke. The guide pin plates 160 are fastened on the lower ends of the side rails by countersunk capscrews 164.

When the side rails are assembled to the top support plate 38, the collar portions of the side rail end brackets which fit into the opening 100 in plate 38 have their top surfaces level with the top surface of plate 38. The upper end of the top rear edge of collar 122 has several threaded bores formed therein enabling split cover plate parts 166 and 168 to be secured to the side rail end brackets by screws. The cover plates slide back and forth together with the side rails serving as a protective cover against dirt, dust and other particles which could fall through the clearance between the side rail end brackets and the top plate hole 100. Cover plates are made from steel plate and have a close sliding fit over the upper surface of the top support plate.

The foregoing assembly, together with a suitable hydraulic operating fluid source, hydraulic lines and control components such as valves, solenoid operators for the valves and a control circuit with suitable switches constitute the basic assembly to which is added a selected set of mandrels such as 50 and 52 and, if spacers are needed, one or more spacers such as 46 and 48 shown in FIG. 1.

FIGS. 5-14 illustrate some of the different sizes of mandrels which can be used with the machine to expand round pipe to a flat oval configuration. The smaller size mandrels such as the three inch mandrels 50 and 52 shown in FIGS. 1, 5 and 6, and the 4 inch mandrels 180 shown in FIGS. 2, 7 and 8 as well as the spacer bars 46 and 48, can be suitably machined from aluminum bar stock. The larger mandrels such as the 6-inch mandrel 182 shown in FIGS. 9 and 10, the 8-inch mandrel 184 shown in FIGS. 11 and 12 and the 12-inch mandrel 186 shown in FIGS. 13 and 14, as well as other different sizes can be suitably made from cast aluminum. The mandrel material can of course be steel or iron or some other comparable material.

The larger mandrels, such as 184 and 186, can be cast with suitable lightening recesses such as 188 and 190 to reduce their weight and permit manual handling. Mandrels larger than the 4-inch mandrel are made with a vertical channel recess 192 along the length of its inside face, the channel formed to have a close sliding fit over either an associated one of the side rails 42 or 44 or, if spacers are used, over a spacer such as 46 or 48. When installed, the base of the large mandrels will rest on cover plates 166 and 168.

The smaller mandrels, such as the 3-inch mandrels 50 and 52 and the 4-inch mandrels are provided with short projecting dowels 194 and 196 which peg into either the aforescribed locator holes 116 and 118 in the side rails 42 and 44 to attach and locate the small mandrels on the expansion side rails or, if spacers 46 and 48 are used, into similar locator holes in the spacers.

Spacers 46 and 48 are identical rectangular bars which are pegged to the outer side face of one or both of the side rails to enable increasing the dimension of the major axis of an expanded flat oval pipe. Several spacers, for example, six or more can be included as components for a machine and each spacer has short dowel pins 198 projecting from one side face and locator holes 200 aligned with the pins 198 but opening from the opposite side face. The location of the spacer dowel pins 198 and locator holes 200 match the side rail locator holes 116 and 188 as well as the location of dowel pins 194 and 196 in the smaller mandrels. Thus, one or more spacers 46 and 48 can be pegged together and pegged to the outer side of a side rail. The smaller mandrels 50 and 52 or 180 can in turn be pegged to and located on the installed spacers. Also the channel recesses, such as 192 in the larger mandrels can fit over the outermost spacer, whether one or more spacers are used, to locate the larger mandrels.

The following are examples of how just one set of mandrels and spacers can be used in various combinations. All dimensions are nominal.

Using only the pair of 3-inch mandrels 50 and 52, a 6-inch size circular duct can be expanded to a 3-inch  $\times$  7.7-inch flat oval by using a ram stroke of approximately 6 inches. The ram stroke can be controlled by adjusting the control limit switch engagement position.

Again using only the pair of 3-inch mandrels, a 7-inch size circular duct can be expanded to a 3-inch  $\times$  9.2-inch flat oval duct. In this case the ram stroke will be set to approximately 22 inches.

Still using the pair of 3-inch mandrels 50 and 52 and only one spacer 46 (which can be placed on either side rail) an 8-inch diameter duct can be expanded to a 3-inch  $\times$  10.7-inch flat oval duct. And by using two spacers, a 9-inch diameter duct can be expanded to a 3-inch  $\times$  12.4-inch flat oval duct. The versatility of possible combinations is substantial. The actual stretching of the duct is very minute, only enough to set the sheet metal to the expanded shape. In fact, if the wedge stroke is not accurately controlled the expanding mandrel assembly can burst the pipe.

On sheet 2 of the drawing, FIG. 23 illustrates a simple means by which the ram stroke can be varied. Rod 96, the previously described indicator rod, is secured to the base of wedge 58 (FIG. 1). Limit switch 202, which is secured to fixed structure such as the wall of the well or structure fastened to the truss rods 36, will control the retract limit position of the ram and is operated by an operator cam 204 securely fastened on the indicator rod 96. Limit switch 206, also secured to fixed structure, will control the extended stroke limit position of the ram and is operated by an adjustable operator cam 208 which can slide up and down along a portion of rod 96. This part of rod 96, if desired, can be projected above ground level. The threaded rod 210 journaled for rotation in brackets 212 and 214, fastened at spaced-apart locations on indicator rod 96, passes through and coacts with matched threads in a bore 216 in the shiftable operator cam 208. When threaded rod 210 is rotated via a knurled knob 218 the cam 208 can be shifted up or down on rod 96 to vary the stroke limit position where limit switch 206 is actuated. By using suitable available hydraulic control circuits with electrically operated valves not shown, limit switches 206 and 202 would be included in the valve control circuits to open and close and thereby control application of hydraulic fluid to the motor 32, during its extension or expansion stroke and during the retraction stroke. Index markings 220 on rod 96 can be used to accurately set the adjustable cam 208.

#### METHOD

While the length of pipe which can be expanded by such machines as described is not specifically limited, most ducts are supplied in standard lengths. Based on a 12-foot standard length of duct it was decided that a convenient size of machine would be one to expand 6-foot lengths. Nevertheless, a machine incorporating the invention could be made with a

longer wedge, longer side rails and longer mandrels to make any length of expanded duct within reason. The machine, as built to make 6-foot lengths, uses a 24-inch maximum stroke motor 32 and mandrels which have a length of 40 inches. This results in a machine for which a pit or well 60 of reasonable depth can be dug and by using the following method can expand a six foot length of duct, and the duct can be manually manipulated on and off the machine.

The machine 30 is adjusted for a desired ram stroke and the appropriate mandrels installed, with spacers if necessary. In the disclosed example, which will be described relative to FIGS. 15—22, the 3-inch mandrels 50 and 52 are installed with two spacers 46 and 48 on the side rails 42 and 44. This assembly will expand 9-inch diameter duct to a flat oval shape of 3-inches  $\times$  12.4-inches (approximate values).

First, a 6-foot length of spiral steel pipe 130, which for most purposes can be 24 gauge, is slightly flattened either by hand, machine or by throwing it down hard on the ground.

Second, the pipe 130 is placed vertically over the closed expansion assembly 40 with one end of pipe 130 resting on the cover plate parts 166 and 168 as shown in FIG. 15 and 16.

Third, the expansion wedge 58 is forced up through an approximate full stroke which expands the lower portion of the duct 130 (about 40-inches) into a partially expanded shape identified in FIGS. 17 and 18 as 130a.

Fourth, the wedge 58 is retracted and pulls the expansion assembly together. At this stage the duct 130a can be lifted by hand off of the expansion assembly 40.

Fifth, the partially expanded duct 130a is reversed so the unexpanded end portion is down and that portion placed over the closed expansion assembly 40 as shown in FIGS. 19 and 20. Alignment of the major axis of the already expanded portion of duct 130a with the mandrels is essentially self-accomplished because of the overlap of at least 6 inches of the 40-inch mandrels beyond the 36-inch midpoint of a 6-foot length of duct. In the very large size ducts where major and minor axes of the expanded ducts differ by only an inch or so, longitudinally aligned index marks on the duct such as shown at 132 and 134 can be used and can be aligned with the cover plate separation line. In any event, alignment of the reversed duct 130a in the position shown in FIG. 20 is readily attained.

Sixth, the machine wedge 58 is again operated to expand the assembly 40 and the remaining portion of the duct is shaped to make a completely expanded 6) -foot length of flat oval duct 130b shown in FIG. 21.

Seventh, the wedge 58 is again retracted and the finished flat oval duct 130b (shown in FIG. 22) is vertically removed from the machine.

The basic method can be used on prior art horizontal mandrel machines to expand a length of pipe longer than the mandrels, although such machines will not permit expansion of the smaller duct sizes.

Such expanded flat oval duct made from less than 14-inch nominal diameter pipe has not been possible on previously known machines; but can be made on the aforescribed vertical mandrel machine.

Throughout the specification and claims reference is made to spiral pipe or tubing. Those are terms well known in industry as referring to what is also known as helical lock seam tubing or pipe. The phrase flat oval duct refers to duct which has a cross section with two substantially parallel flat wall portions joined by curved wall portions at each end of the cross section.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What I claim and desire to be secured by Letters Patent is:

1. A method of making noncircular cross section tubing by converting a length of circular cross section sheet metal tubing

into noncircular cross section tubing comprising the steps of: locating the length of tubing upon a shorter length expandible mandrel assembly extending inside one end of the tubing for a distance greater than half the length of the tubing; deforming said more than half the length of the tubing into the desired noncircular cross section by expanding the mandrel assembly uniformly throughout its length; restoring the mandrel assembly from its expanded condition to release the tubing; removing and reversing the length of tubing and locating its nonexpanded end upon the mandrel assembly with the mandrel assembly extending inside the other end of the length of tubing for a distance greater than the nonexpanded portion of the length of the tubing with the previously expanded portion of the tubing properly aligned with the direction in which the mandrel assembly expands; deforming the remaining undeformed portion of the length of tubing by again expanding the mandrel assembly uniformly through out its length; again restoring the mandrel assembly from its expanded condition; and removing the completely deformed length of tubing from the mandrel assembly.

2. A method of making noncircular cross section tubing as claimed in claim 1 wherein the final noncircular cross section is flat oval and wherein the circular cross section tubing initially is selected from standard diameter sheet metal tubing 5 inches and larger.

3. A method of making noncircular cross section tubing as claimed in claim 1, wherein the length of tubing is placed on the mandrel assembly with its elongated axis disposed vertically.

4. A method of making noncircular cross section tubing as claimed in claim 1, wherein the tubing is initially partially flattened from its original circular cross section.

5. A length of internally, expansion deformed, flat oval cross section spiral tubing, having two substantially parallel flat wall portions and curved end wall portions made from helical seam, initially round tubing having an initial diameter less than 14 inches.

6. An expandible mandrel machine for converting sheet metal tubing having an initial diameter which may be as small as 6 inches by cross section expansion into noncircular cross section tubing comprising: a pair of elongated vertically disposed parallel tube former means having a length greater than half the length of the tubing to be converted; and force applying means including a vertically shiftable means disposed between said parallel former means and adapted to apply uniform pressure transverse to the elongate axis of and throughout the length of said parallel former means to move said former means apart while maintaining their parallelism when said shiftable means is shifted in one direction and including means to retract said two parallel former means toward each other.

7. An expandible mandrel machine as defined in claim 6, wherein each of said pair of former means includes a side rail, said side rails having vertically converging track surfaces extending from adjacent their lowermost ends to adjacent their upper ends; and said vertically shiftable means comprises a wedge longer than said side rails having converging side faces complementary to and engaging said facing track surfaces.

8. An expandible mandrel machine as defined in claim 6, wherein means on said former means and means on said vertically shiftable means are interconnected to provide said means for retracting said former means toward each other upon movement of said vertically shiftable means in its said other direction.

9. An expandible mandrel machine as defined in claim 8, wherein said means for retracting said former means comprise pin and slot connections with pins mounted on said former means and convergent slots provided in said vertically shiftable means and into which slots said pins project.

10. An expandible mandrel machine as defined in claim 6, wherein said force applying means includes a dual acting reciprocating piston motor with an upwardly projecting piston rod secured to the lower end of said vertically shiftable means.

11. An expandible mandrel machine as defined in claim 6, including a main support means at the lower end of said former means; and means connecting said former means to said support means in a manner preventing movement of said former means in the direction of movement of said vertically shiftable means and permitting controlled movement of said former means in a predetermined path normal to the direction of movement of said vertically shiftable means.

12. An expandible mandrel machine as defined in claim 11, wherein said support means has a central passage and both of said former means and said vertically shiftable means project from below said support means up through said central passage.

13. An expandible mandrel machine as defined in claim 12, wherein said means which connect said former means to said support means comprises an end bracket means secured to the lower end of each of said pair of former means and disposed against the under surface of said support means, and guide ways secured under said support means in embracing and guiding relationship with said end bracket means to maintain them against the under surface of said support means.

14. An expandible mandrel machine as defined in claim 13, wherein means are provided for injection lubrication of the relatively shiftable surfaces of said brackets, said ways and said support means.

15. An expandible mandrel machine as defined in claim 11, wherein said force applying means includes a vertically reciprocating piston motor and a rigid suspension assembly secures said motor in depending relationship under and to said support means.

16. An expandible mandrel machine as defined in claim 11, including means for variably controlling the length of work stroke of said force-applying means.

17. An expandible mandrel machine as defined in claim 6, wherein each of said pair of former means comprises a vertical side rail engaged on its inner side by said vertically shiftable means, at least one mandrel form member disposed parallel to and at the outer side of each said rail and means interconnecting said form members with their associated side rails.

18. An expandible mandrel machine as defined in claim 17, wherein at least one of the pair of former means comprises more than one interconnected form member, in laterally stacked arrangement, interconnected with each other and the associated side rail.

19. An expandible mandrel machine as defined in claim 17, wherein at least the outermost of said form members have an outer half cylindrical surface the axes of which are disposed vertical and parallel when all form members are interconnected with their associated side rail, and said outermost of said form members on the pair of side rails constitute a matched pair selected from a group of matched pairs of half cylindrical form members, each matched pair having a different diameter corresponding to the inside diameter of the minor axis of a standard size flat oval tubing.

20. An expandible mandrel machine for converting sheet metal tubing by cross section expansion into noncircular cross section tubing comprising: support structure; a pair of elongate parallel tube former means having a length greater than half the length of the tubing to be converted; and force-applying means including a reciprocably shiftable means disposed between said parallel former means and adapted to apply uniform pressure transverse to the elongate axis of and throughout the length of said parallel former means to move said former means apart while maintaining their parallelism when said shiftable means is shifted in one direction and including means to retract said two parallel former means toward each other; each of said pair of former means including a side rail, said side rails being mounted adjacent one of their ends on said support structure and having converging track surfaces extending from adjacent their mounted ends to adjacent their other ends; and said shiftable means comprises a wedge longer than said side rails having converging side faces complementary to and engaging said facing track surfaces.

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,581,548 Dated June 1, 1971

Inventor(s) Evan Lilygren

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 10, change "larger" to --large --.

Column 7, line 10, change "188" to --118--.

Column 8, line 44, delete ")" after --6--.

Column 9, line 17, "through out" should be --throughout--.

Signed and sealed this 4th day of January 1972.

(SEAL)  
Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Acting Commissioner of Patents