

Sept. 27, 1932.

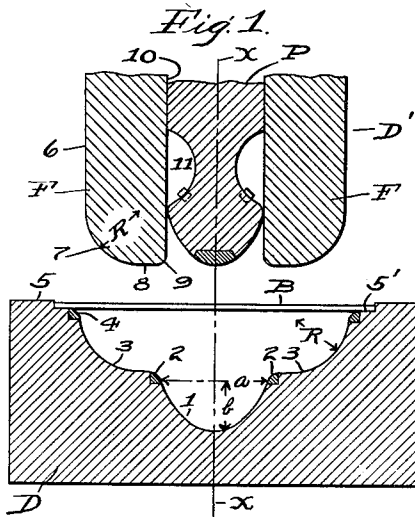
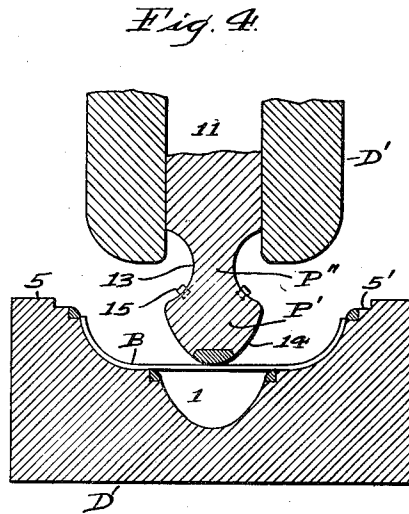
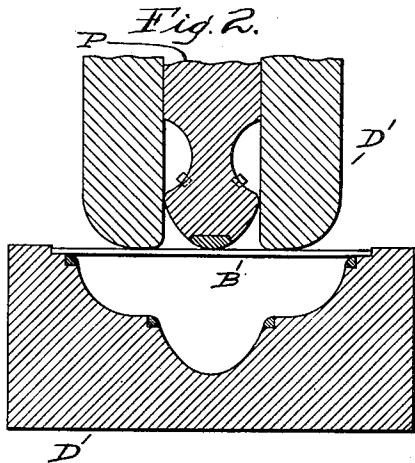
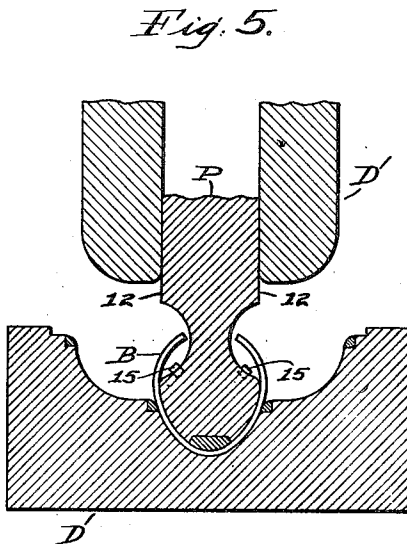
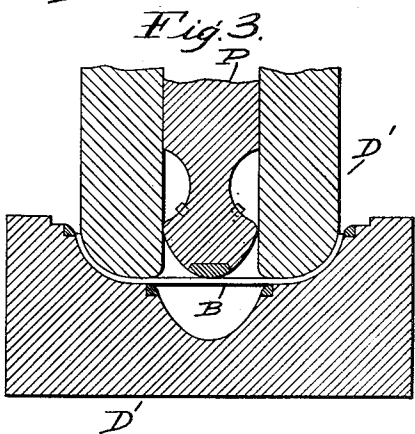
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1,879,078

METHOD OF AND MEANS FOR FORMING TUBULAR ARTICLES

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4 Sheets-Sheet 1



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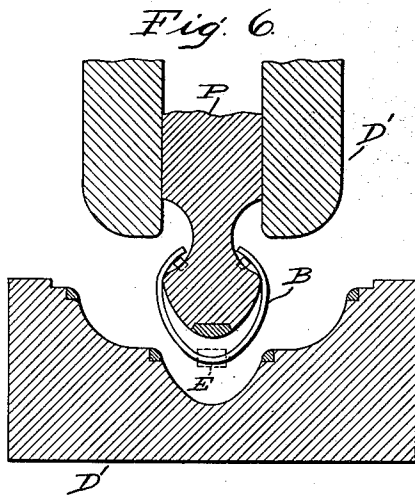
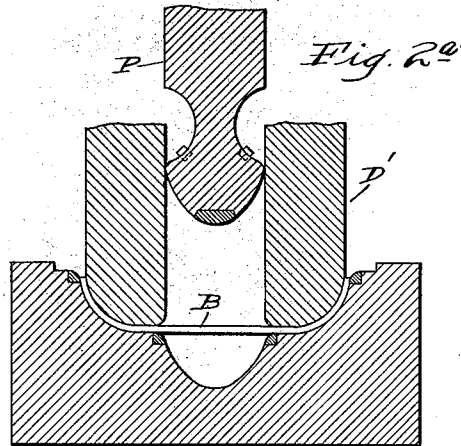
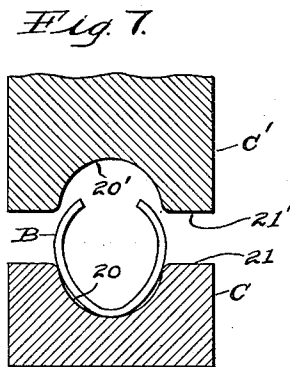
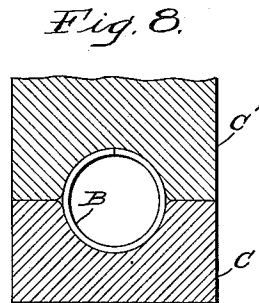
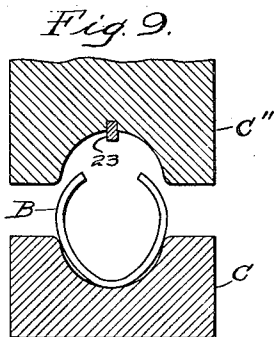
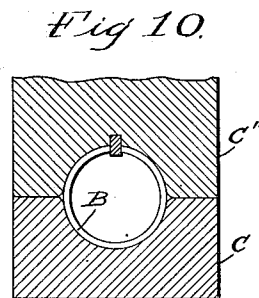
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METHOD OF AND MEANS FOR FORMING TUBULAR ARTICLES

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4 Sheets-Sheet 2



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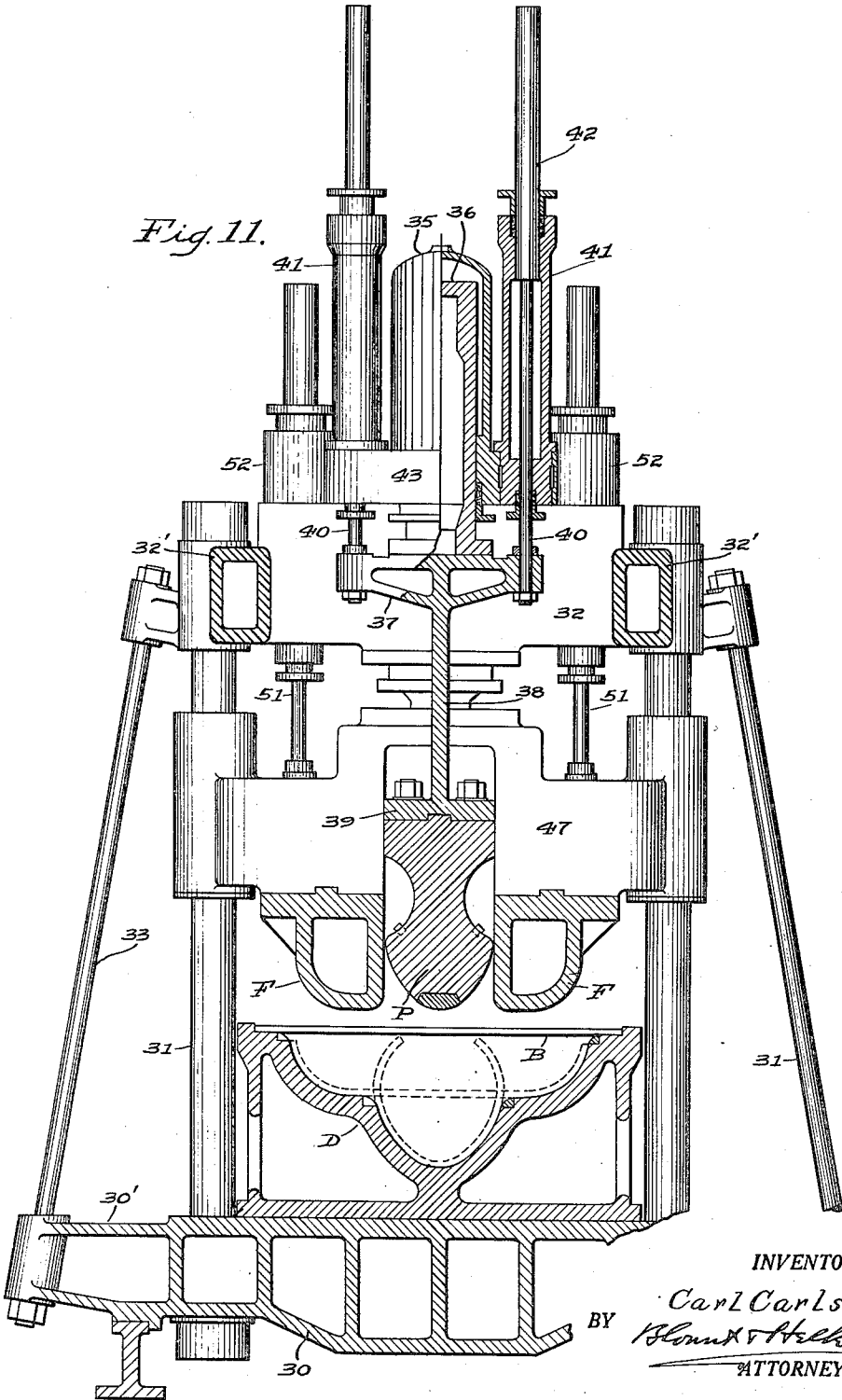
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METHOD OF AND MEANS FOR FORMING TUBULAR ARTICLES

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4 Sheets-Sheet 3



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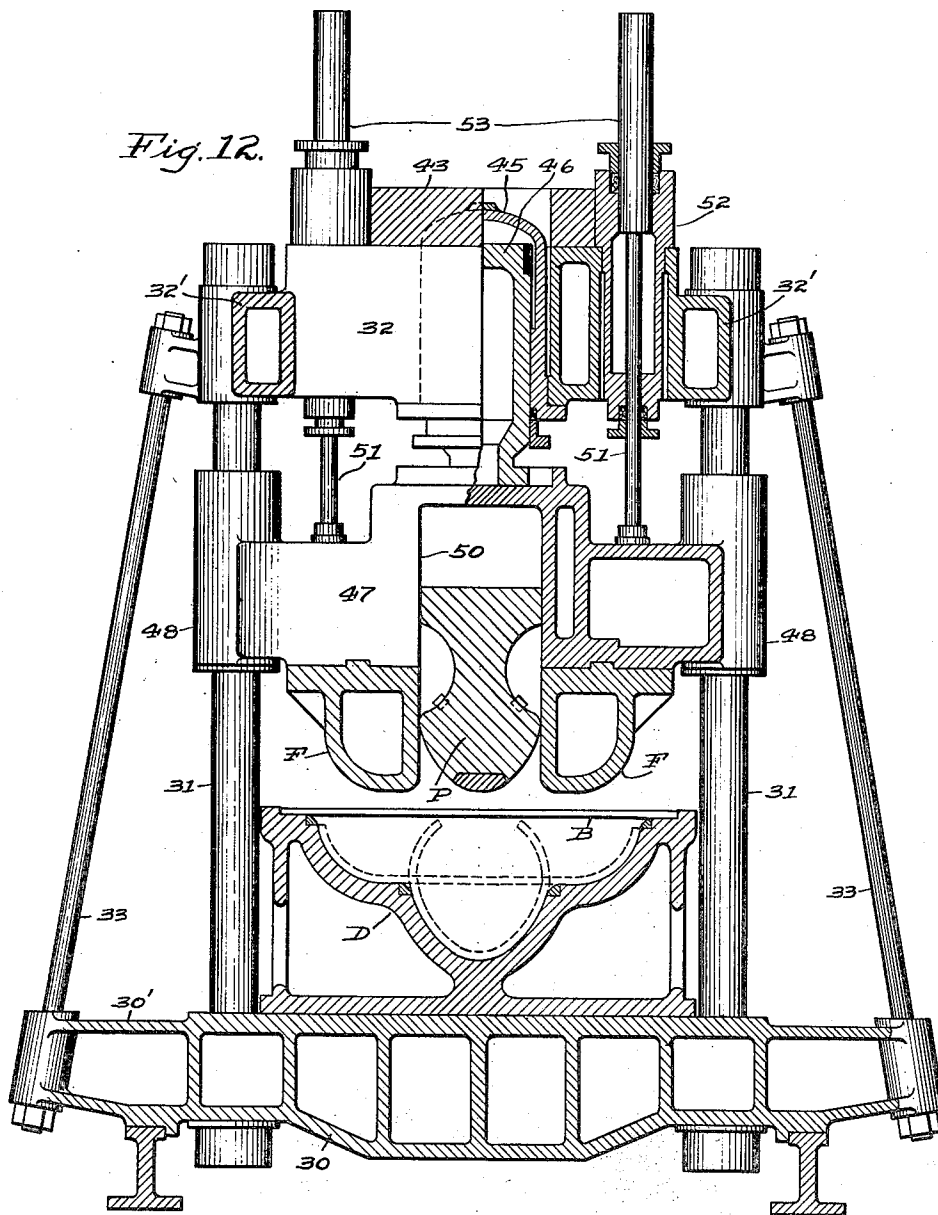
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METHOD OF AND MEANS FOR FORMING TUBULAR ARTICLES

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS FOR FORMING TUBULAR ARTICLES

Application filed April 4, 1930. Serial No. 441,452.

The present invention, while relating to the formation of tubular articles in general, is more particularly adapted for the reduction of flat, elongated blanks to cylindrical cross section preparatory to welding the longitudinal seam thus formed between the adjacent side edges of the blanks to produce a metallic pipe, and in certain aspects may be regarded as an improvement upon the invention disclosed in my pending application for U. S. Letters Patent Serial No. 344,979, filed March 7, 1929, in that, by the practice of the present invention, more truly cylindrical blanks may be formed under certain conditions of operation and with certain classes of material than by my said earlier invention.

In accordance with the present invention, the flat elongated blank is brought to a predetermined and partially completed state by suitable manipulation of a single set of dies of peculiar form and is then transferred to another set for the performance of the final shaping and closing operation, the present method thus differing to some extent from my said earlier method in which the blank was completely reduced to the desired form by suitable manipulation of a single set of dies. While the practice of the present invention thus requires the employment of two sets of dies actuated preferably by separate presses, the disadvantages attendant upon the use of a mandrel as a base or foundation upon which to form up the blank are entirely avoided, while the perfection and accuracy of the finished blank produced by the method and the speed with which it can be practiced make it highly advantageous for the commercial manufacture of blanks designed to be subsequently welded into pipe or for other purposes.

A principal object of my invention, therefore, is to provide a novel method of reducing a flat blank and more particularly one of elongated shape to cylindrical cross sectional form by a series of successive operations, the major portion of which and, in fact, all, save the final shaping and closing operation, are performed in a single set of dies.

A further object of the invention is to provide a set of dies of novel character adapted to form or shape the blank preparatory to the said final operation and which are so constructed and arranged that after the blank has been initially inserted in the dies it may be brought to a condition suitable for said operation by manipulation of the relatively movable members of the dies and without removal therefrom.

My invention further includes other objects, advantages, steps and novel features of operation and of design, construction and arrangement hereinafter more particularly pointed out or which will be apparent to those skilled in the art from the following description of certain ways of performing the said method by means of my said improved dies and a closing die of usual form.

As hitherto stated, the invention may be advantageously employed for forming cylindrical pipe blanks designed to be welded along the longitudinal seam formed at the abutting or substantially abutting side edges of the blank to thereby produce a completed pipe, and for convenience of description I shall therefore refer to the practice of the invention for that purpose, it being understood however, that the invention may be employed with equal facility in the formation of hollow tubular articles other than pipe blanks from flat sheets or plates.

In the performance of the invention I provide, as hitherto stated, a set of dies comprising a single female member and a compound male member embodying relatively movable parts or elements, both the female and male members of the set being of sufficient length to receive the blank which, of course, usually substantially corresponds in length to the pipe which is to be formed. Thus, if the latter is to be ten feet in length, the dies should have a length at least as great, although it will of course be obvious that the dies may be longer than the blank on which they are to operate.

In the accompanying drawings, Figs. 1 to 6 inclusive consecutively illustrate one series of operations requisite for reducing the blank in accordance with the present method to a condition suitable for the final shaping and

closing operation by means of a set of dies constructed in accordance with my invention and as shown in said figures, and Figs. 7 and 8 illustrate the said final operation on the blank as well as the closing dies utilized for that purpose. In Fig. 2^a I have illustrated another way of operating my improved dies during one of the steps incident to the forming of the blank, while in Figs. 9 and 10 I have shown a slightly modified form of closing die designed to leave an open seam in the blank as well as the manner of its use. I have also shown in Figs. 11 and 12 a form of press which may preferably be used for the actuation of my improved dies, although by no means essential to their use, as other forms of presses may be employed if preferred, Fig. 11 being designed to more particularly illustrate those parts of the press which are effective to operate the central plunger of the male die, and Fig. 12 those parts thereof which are effective to operate the side formers of the male die, all as will hereinafter more fully appear during the description of the press as shown in said figures, in both of which the blank is illustrated in initial position in full lines and in certain other positions in dotted lines. Throughout the drawings the same characters of reference are used to designate the same parts.

I shall first refer more particularly to the conformation and construction of the dies shown in Figs. 1 to 6 inclusive, and then to the series of operations incident to their use in forming up the blanks preparatory to the final closing operation, and for this purpose reference may first be had to Fig. 1. Thus, in the said figure, I have shown the female die D in the form of a longitudinally extending block of suitable length hollowed out so as to provide a channel 1 symmetrically disposed with respect to the central, vertical, longitudinal plane X—X of the die as a whole. Measured horizontally or across its mouth, this channel approximates the finished outside diameter of the desired tubular blank or, in other words, the distance *a* approximates that diameter while the depth of the channel or distance *b* approximates one-half that amount; in cross section, however, the channel, instead of being semi-cylindrical or substantially so, is of generally semi-elliptical shape as clearly shown in the drawings. This channel terminates on each side of the plane X—X in a shoulder 2 which is slightly rounded or filleted off outwardly, and from each of these shoulders the die is outwardly cut back horizontally for a short distance to then merge upwardly into a surface 3 of a radius R substantially corresponding to the radius of the other surface of the desired tubular blank. At its upper extremity each surface 3 is rounded or filleted outwardly at 4 to merge into the upper surface 5 of the die which is desirably countersunk as at 5' to a

width approximating that of the flat blank B which is to be formed up and to a depth such that when the blank is disposed on the die as shown in Fig. 1, it will rest in the countersink and be retained in position thereby. It will be apparent that this countersinking of the female die is desirable in that it assures each of the blanks being symmetrically positioned thereon preparatory to the forming-up operation and thereafter remaining in proper relation with the die during the initial steps thereof.

The male member of the die, generally designated as D', comprises a plurality of parts, namely, a central plunger P and side formers F—F between which the plunger is disposed and vertically movable. These formers may be either integral with each other or else constructed separately, but in any case are arranged to move unitarily throughout the series of operations incident to forming up the blank, the cross sectional profiles of both side formers being substantially similar though, of course, the formers are oppositely disposed. Thus, and beginning at the lower end of the outer vertical side face 6 of either former, the surface thereof is carried inwardly on a radius R to form a surface 7 which merges into a horizontal surface 8, which at its inner end is preferably rounded off as at 9, and intersects the inner vertical face 10 which forms one wall of the slot 11 between the formers and in which the plunger P is adapted to move.

The upper part of the plunger P has vertical side faces 12 respectively adapted to engage the adjacent faces 10—10 of the formers and form a sliding fit therewith, while above its lower extremity or head P' the plunger is oppositely inwardly cut out on each of its side faces as at 13 so as to provide a relatively thin neck P'' connecting the head P' with the body of the plunger. Beneath these cut-out portions the head P' conforms generally in transverse section to the channel 1 and is adapted to enter the same so as to force a portion of the blank B thereinto and cause it to conform thereto as hereinafter more fully explained. The oppositely inwardly and downwardly curved side surfaces 14 of the plunger head thus meet at its lower extremity or apex.

As the wear adjacent the shoulders 2 and surfaces 4 of the female die and in the vicinity of the apex of the plunger head is particularly heavy, small inserts of highly wear-resistant metal are desirably placed adjacent these points as shown and welded or otherwise permanently secured in position. Additionally, to facilitate the longitudinal stripping of the blank from the plunger preparatory to the final closing operation hereinafter described, small longitudinally spaced rollers 15 are preferably mounted on the plunger so as to project slightly above the surfaces

13 for revolution on axes substantially parallel to the planes of said surfaces at the points where the rollers intersect them; these rollers are longitudinally spaced throughout the length of the plunger at suitable intervals and serve to take the weight of the blank just prior to and during the stripping operation.

The closing dies shown in Figs. 7 and 8 require but little description, consisting as they preferably do of longitudinally extending blocks C, C' respectively provided with a longitudinally extending channel 20, 20' of substantially semi-circular cross section and of a radius corresponding to that of the outer surface of the desired tubular blank. Preferably, the corners formed at the intersection of the channels and the surfaces 21, 21' of the blocks in which they are cut are slightly rounded off as clearly shown in said figures.

The series of operations incident to the reduction of a flat, elongated, preferably rectangular blank B to tubular form and as illustrated in the figures to which reference has hitherto been made will now be described:

With the formers and plunger elevated above the die D, the blank B is first laid in the countersink 5' in the upper surface of the latter so as to extend symmetrically across the opening in the die as shown in Fig. 1. In the ordinary operation of the dies, the male die D' is then moved downward toward the blank, with the plunger and formers moving as a unit, until they contact the upper surface of the blank as shown in Fig. 2 and thereafter force the blank downwardly into the female die until the blank conforms to the curved surfaces 3—3, thus preventing further downward movement of the die D' as a unit, the relative position of the parts at this point being shown in Fig. 3. Thereupon, the side formers F—F are retracted upwardly while the plunger P remains in contact with the center of the blank, thus holding the latter in the die D as shown in Fig. 4 and, when the formers have been sufficiently retracted to clear the latter, the plunger is forced downwardly still further so as to carry the center part of the blank into the channel 1 and cause the blank to conform thereto; during this operation the previously curved side portions of the blank curl or turn symmetrically oppositely inward toward the plunger, the extremities of their edges entering the cut-out portions 11 on the sides thereof and approaching the surfaces 13 until they finally attain the positions shown in Fig 5. It will be observed that during this operation the shoulders 2 of the die D in effect form fulcrums about which or rather against which the adjacent portions of the blanks turn and slide as the central part of the blank moves down in the channel 1 until final position is attained. The plunger P is now retracted upwardly until the inwardly oppositely turned edges of the blank are engaged by the rollers

15 or by the surfaces 13 if the rollers are not employed, so that further upward movement of the latter is operative to lift the blank out of the channel as shown in Fig. 6; it will be noted that the blank is now supported solely from the plunger and in large measure depends below and is out of contact therewith. By the operation of any suitable mechanism such as a longitudinally movable ejector E, typically indicated in dotted lines and operable lengthwise of the dies from a point adjacent one end thereof, the blank is now stripped from the plunger by a movement of longitudinal translation, the rollers 15 assisting in this operation by reducing the friction which would otherwise be present if the edges of the blank were resting directly on the surfaces 13.

To facilitate production and avoid the necessity of manually or otherwise moving the blank about the plant, the press in which the closing dies C, C' are disposed is preferably so arranged with relation to the press containing the dies D, D' that the blanks will pass directly from the latter to the closing dies during the stripping operation, so that at the conclusion thereof the blank will be disposed in the lower closing die C substantially as shown in Fig. 7. Thereupon, the closing dies are brought together so as to close the juxtaposed edges of the blank against each other and reduce it to the final tubular form as shown in Fig. 8, those parts of the blank which have been formed in the channel 1 during the preceding operation being, during the closing movement of the closing dies, swelled out in the lower die C so as to conform to the contour of its channel as the upper portions of the blank are brought together and caused to conform to the corresponding channel in the upper die C'. The finished tubular blank is now removed from the closing dies in any convenient way for subjection to the subsequent welding or other operations forming no part of the present invention.

In cases in which it is desired to produce a blank having an open as distinguished from a closed or substantially closed seam between the juxtaposed edges, an upper closing die C'' may be provided having at the center of its channel a longitudinally extending inwardly projecting web or fin 23, as shown in Figs. 9 and 10, against which the edges of the blank are brought into abutting engagement when the dies are closed, thus spacing the edges of the finished blank apart for a distance corresponding to the thickness of the web. Therefore, in accordance with the present invention, it is possible by the employment of closing dies either devoid of or provided with webs or fins 23 of suitable thickness, to produce tubular blanks having their edges either in abutting or substantially

abutting engagement or spaced apart for any desired distance within reasonable limits.

Hitherto, in referring to the ordinary manner of operating the dies in the performance of the method, I have stated that the male die D' is moved toward the blank after the latter is positioned on the female die with the plunger and formers moving as a unit until they contact with the upper surface of the blank as shown in Fig. 2. An alternative method of operation and one which under certain conditions may desirably be employed, is indicated in Fig. 2*; in this method the plunger is maintained in or substantially in its initial or raised position while the side formers are moved down relatively to the plunger until they contact the blank and while the side portions thereof are being brought into conformation with the surfaces 3—3. The plunger is then moved down into contact with the blank so as to steady it in the female die and the side formers next raised so as to bring the parts into the position shown in Fig. 4, after which the plunger is again moved down so as to form the center portion of the blank in the ordinary manner.

While, as hitherto stated, my improved dies may be actuated by a press of any suitable form, I have shown in Figs. 11 and 12 a type of press which is eminently satisfactory for the purpose and which, under most conditions, I prefer to utilize. This press to which brief reference will now be made, is of course sufficiently long to accommodate the dies and thus comprises a longitudinally extending base 30 suitably supported on the floor or other rigid surface. Suitably secured on the base and extending longitudinally thereof is the female die D, the body of which in these figures is shown as partially hollow instead of solid to thereby minimize its weight. Above the female die are disposed and supported as hereinafter described the side formers F—F and plunger P which together constitute the male die D' hitherto described, the formers in these figures being shown as hollow instead of solid to similarly effect a saving of weight.

Preferably adjacent each end of the base and, where the press is comparatively long at intervals therebetween, are disposed mechanisms for supporting and actuating the plunger and side formers, these mechanisms being preferably all of similar construction and comprising means for independently raising and lowering the plunger and other means for independently raising and lowering the side formers as a unit, all of said means being of such construction and arrangement as to permit the requisite relative movement between the formers and the plunger. One of these mechanisms is illustrated in Figs. 11 and 12 and a description thereof will therefore suffice for all of the

others, as many of said mechanisms being employed as are dictated by the length of the press and other conditions such as the thickness and character of the blanks being operated on and the like.

Fig. 11 is designed more particularly to illustrate that portion of the mechanism which directly controls the plunger P and is a transverse section of the press, with certain parts shown in elevation, on the plane of the actuating cylinders of said mechanism with those parts of the mechanism which serve to actuate the side formers appearing in the background, while Fig. 12, which is designed to illustrate more particularly the mechanism controlling the side formers, is also a transverse section of the press on the plane of the side former actuating cylinders but showing certain parts in end elevation as they would appear if the plunger actuating mechanism were removed.

As shown, the plunger and side former actuating mechanisms as a whole comprise a pair of standards 31 rising from and on opposite sides of the frame and a similar pair spaced longitudinally therefrom for a suitable distance. Adjacent the upper end of these standards is secured a frame comprising heads 32 which extend transversely between each pair of standards and which are tied together longitudinally by hollow members 32' on each side, the center of the frame being open; braces 33 are also arranged between the heads and lugs 30' extending laterally from the base so that a very rigid structure is presented.

Disposed preferably midway between the transversely extending heads 32 and coincident with the center line of the press is the main plunger actuating cylinder 35 containing a piston 36 extending vertically and secured at its lower end to a cross head 37 from which depends a web 38 having a foot 39 to the lower face of which the plunger P is bolted or otherwise secured. This cross head is connected at each end with a piston rod 40 extending upwardly in a superjacent cylinder 41 having a piston 42. The main cylinder 35 is mounted on or integrally formed with a longitudinally extending supporting base 43, the extremities of which rest upon and are secured to the heads 32 and thereby effect the requisite support of the main cylinder and auxiliary cylinders 41 which are also carried by the base on opposite sides of the main cylinder.

The frame also supports the main former actuating cylinder 45 which is desirably seated in a bore in one of the transversely extending heads as shown in Fig. 12 and is fitted with a piston 46 secured at its lower end to a yoke 47 provided on its ends with sleeves 48 which embrace the adjacent standards 31 and are slidable thereon. This yoke is provided at its center with a suitable slot 50 for

the reception of the plunger P and to its lower face on each side of the plunger are bolted or otherwise secured the side formers F—F, the yoke being preferably cored out to decrease its weight. On both sides piston rods 51 extend upwardly into superjacent cylinders 52, also carried by the head on opposite sides of the main cylinder, and each provided with a piston 53, suitable means (not shown) being provided for controlling the admission and exhaust of a suitable fluid to the several cylinders thereby to actuate their respective pistons when and as required.

When the male and female dies are thus assembled with actuating mechanism of the character disclosed, it will be apparent that admission of fluid to the main cylinder 35 is effective to move the plunger down relatively to the yoke 47 and side formers, while admission of fluid to the cylinders 41 is operative to raise the yoke with consequent discharge of the fluid from the main cylinder 35. In a generally similar manner, admission of fluid to the main cylinder 45 is operative to move the yoke and side formers downwardly relatively to the plunger, while admission of fluid to the cylinders 52 is effective to raise the said parts. Thus, by suitably controlling the flow of fluid to the various cylinders, the plunger and side formers can be raised or lowered together as a unit, or either can be moved relatively to the other when and as required to properly operate the dies as hereinbefore more particularly explained.

It will of course be understood that as many of the said actuating mechanisms as desired may be disposed at longitudinally spaced intervals along the base of the press; thus, on a press twenty feet in length, a pair of said mechanisms disposed adjacent each end of the base will ordinarily be found sufficient, while in a press forty feet in length four of the said mechanisms may be disposed at equal intervals, although the exact number utilized is of course a matter of choice, the control means for the several mechanisms being preferably so arranged as to operate all of them in unison and desirable from a single control station.

It will be understood that the present invention contemplates both the formation of tubular blanks in which the juxtaposed edges are in abutting or substantially abutting engagement as well as blanks in which the said edges are separated by a gap or space and, consequently, that terms such as tubular, cylindrical or the like as herein employed for convenience of description, are to be understood as including both of said forms and whether of truly circular or slightly elliptical cross section. Moreover, it will of course be appreciated that for the satisfactory performance of the invention, the flat blank must be of proper width to form a tube of the proper diameter when ultimately reduced to

the desired cross sectional form and that when a tube having an open instead of a closed seam is desired, due allowance must be made therefor by proportionately decreasing the width of the blank.

While I have herein described with considerable particularity both the specific shape of a preferred embodiment of my improved dies as well as the series of operations therewith which I prefer to employ in the practical performance of my method of forming tubular articles, I do not thereby desire or intend to confine myself solely thereto, as slight variations may be made if desired in the conformation of the dies as well as modifications in the series of operations incident to their use, without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim and desire to protect by Letters Patent of the United States:

1. The method of producing a hollow tubular article which comprises the steps of disposing a flat blank in a die, and then, by manipulation of the members of the die and without removing the blank therefrom, first simultaneously bending the longitudinal edge portions of the blank away from the plane thereof, and next bending the center portion of the blank oppositely from said plane and thereby causing the edge portions of the blank to move oppositely inward toward each other, then removing the blank from said die to another die, and finally by manipulation of said last mentioned die closing the longitudinal edges of the blank into proximity with each other.

2. The method of producing a hollow tubular article which comprises the steps of disposing a flat blank in a die having male and female members, the male member comprising relatively movable parts, and then by manipulation of the die while maintaining the blank therein first simultaneously bending the longitudinal edge portions of the blank symmetrically away from the center portion thereof in the same direction from its plane while maintaining said center portion flat and then bending said center portion in the opposite direction from said plane and symmetrically with respect to said previously bent edge portions while permitting the latter to approach each other above the center portion, then transferring the blank to another die, and finally applying pressure to the blank by means of said last mentioned die to cause the juxtaposed edges thereof to move together and the blank to assume a substantially circular cross sectional contour.

3. The method of producing a hollow tubular article which comprises the steps of disposing a flat blank in a die having relatively movable members and then by manipulation of said members first bending the edge por-

tions of the blank symmetrically upwardly from the center portion thereof, then relieving the bending pressure on said edge portions and bending the center portion of the blank in the opposite direction while permitting the previously bent edge portions to approach each other oppositely while said center portion is being bent, then lifting the blank from one of said members by means of the other member, removing the blank from said member by a longitudinal movement of translation, disposing the blank in another die, and finally by manipulation thereof closing the edges of the blank together and causing it to assume a substantially circular contour.

4. The method of producing a hollow tubular article which comprises the steps of disposing a flat blank in a die having relatively movable members and then by manipulation of said members first bending the edge portions of the blank symmetrically upwardly from the center portion thereof, then relieving the bending pressure on said edge portions and bending the center portion of the blank in the opposite direction to a partially elliptical cross sectional contour while permitting the previously bent edge portions to approach each other oppositely while said center portion is being bent, then lifting the blank from one of said members by means of the other member while supporting the blank solely on said last mentioned member, removing the blank from said member by a longitudinal movement of translation, disposing the blank in another die, and finally by manipulation thereof closing the edges of the blank together.

5. The method of reducing an elongated flat blank to hollow tubular form by progressive operations in two sets of dies, one of said sets having a member comprising relatively movable parts, which includes the steps of first positioning the blank in said last mentioned die and then, by manipulation of the members thereof and while maintaining the blank therein, first bending the longitudinal edge portions of the blank symmetrically upward with respect to the center portion of the blank while maintaining said center portion flat, then relieving the bending pressure on the edge portions and next bending the center portion in the opposite direction symmetrically with respect to the previously bent edge portions whereby the latter are caused to approach each other oppositely inwardly, then transferring the bent blank to the other set of dies, and finally reducing the blank to the desired cross sectional form by a single closing movement of said dies.

6. In a method of producing a hollow tubular article from an elongated flat blank having parallel side edges, the steps of disposing the blank in a die comprising male and female parts, the male part having relatively movable members, then, by manipula-

tion of said members, first bending the longitudinal edge portions of the blank upwardly from the plane thereof, and then, while maintaining the blank in the die, relieving the bending pressure on said edge portions and bending the center portion downwardly from said plane to thereby cause said edge portions to move oppositely inward toward each other.

7. The method of forming a substantially tubular article which includes the steps of disposing a flat blank in a die comprising a female member and a male member having relatively movable parts, bending certain portions of the blank through the medium of one of said parts, then bending another portion of the blank through the medium of another of said parts, then removing the blank from the die, transferring it to another die, and forming it therein to final shape.

8. The method of forming a substantially tubular article which comprises the steps of disposing a flat blank in a die having a female member and a male member comprising relatively movable parts, bending certain portions of the blank by means of one of said parts and then, while maintaining the blank in the die, bending another portion thereof by means of the other of said parts, said last mentioned operation bringing the edges of the blank a distance apart not greater than the smallest through dimension of the finished article, and then bringing the blank to final form in another die.

9. The method of forming a substantially tubular article which comprises the steps of disposing a flat blank in a die having a female member and a male member comprising relatively movable parts, bending certain portions of the blank, then, by manipulation of the male member, retaining the blank in the die while bending another portion thereof, said last mentioned operation bringing the edges of the blank in closer proximity than the diameter of the finished tube, and then removing the blank to another die and there bringing it to final shape.

10. The method of forming a substantially tubular article which comprises the steps of disposing a flat blank in a die having a female member and a male member comprising relatively movable parts, bending certain portions of the blank, then, by manipulation of the male member, retaining the blank in the die and bending another portion thereof, then removing the bent blank to another die and therein forming it to final shape.

11. A die adapted for employment in reducing a flat blank to hollow tubular form comprising a female member having a central longitudinally extending channel and oppositely outwardly curving surfaces disposed on opposite sides of said channel, and a male member comprising separate relatively movable elements, one of said elements having curved surfaces substantially conforming to

said curved surfaces of the female member and the other element comprising a head adapted to enter the channel in the female member and inwardly oppositely curving surfaces above the head.

12. A die adapted for employment in reducing a flat blank to hollow tubular form comprising a female member having a central longitudinally extending channel, the cross section of which substantially conforms to a partial ellipse, and oppositely outwardly curving surfaces disposed on opposite sides of said channel, and a male member comprising separate relatively movable elements, one of said elements having curved surfaces substantially conforming to the curved surfaces of the female member and the other element comprising a head adapted to enter said channel and of substantially similar cross sectional contour thereto, a body portion spaced from the head and a neck of less thickness than the head connecting the latter with the body portion.

13. A die adapted for employment in reducing a flat blank to hollow tubular form comprising a female member having a central longitudinally extending channel symmetrically curved oppositely from its center, a generally outwardly curving surface disposed on each side of said channel and a rounded shoulder interposed between each of said surfaces and the channel, and a male member comprising side formers respectively having curved surfaces substantially conforming to the said curved surfaces of the female member and a central plunger disposed between and relatively movable with respect to the side formers, said plunger comprising a head adapted to enter said channel and generally conforming thereto, a body, and a neck of reduced thickness connecting the head and the body.

14. A die adapted for employment in reducing a flat blank to hollow tubular form comprising a female member having a central longitudinally extending channel symmetrically curved oppositely from its center, a generally outwardly curving surface disposed on each side of said channel and a rounded shoulder interposed between each of said surfaces and the channel, and a male member comprising side formers respectively having curved surfaces substantially conforming to the said curved surfaces of the female member and a central plunger disposed between and relatively movable with respect to the side formers, said plunger comprising a head adapted to enter said channel and generally conforming thereto, a body, and a neck of reduced thickness connecting the head and the body, the side surfaces of the neck being oppositely inwardly curved above the head.

15. A die adapted for employment in reducing a flat blank to hollow tubular form

comprising a female member having a central longitudinally extending channel symmetrically curved oppositely from its center and a generally outwardly curving surface disposed on each side of said channel, and a male member comprising relatively movable elements, one of said elements having curved surfaces substantially conforming to the said curved surfaces of the female member and the other element comprising a body slidable in the first element, a head spaced from the body, a neck of reduced thickness connecting the body and the head and anti-friction means carried by the head on opposite sides of the neck adjacent the point of juncture of the latter with the head.

16. A die adapted for employment in reducing a flat blank to hollow tubular form comprising a female member having a central longitudinally extending channel symmetrically curved oppositely from its center and a generally outwardly curving surface disposed on each side of said channel, and a male member comprising relatively movable elements, one of said elements having curved surfaces substantially conforming to the said curved surfaces of the female member and the other element comprising a body slidable in the first element, a head spaced from the body, a neck of reduced thickness connecting the body and the head and a plurality of longitudinally spaced rollers carried by the head on opposite sides of the neck and adjacent its point of juncture therewith, the surfaces of the rollers extending above the adjacent surfaces of the element.

In witness whereof I have hereunto set my hand this 29 day of March, 1930.

CARL CARLSEN.

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