May 30, 1939. K. BUTCHER 2,160,720

METHOD AND APPARATUS FOR FORMING PIPES

Filed Nov. 3, 1936 5 Sheets-Sheet 1

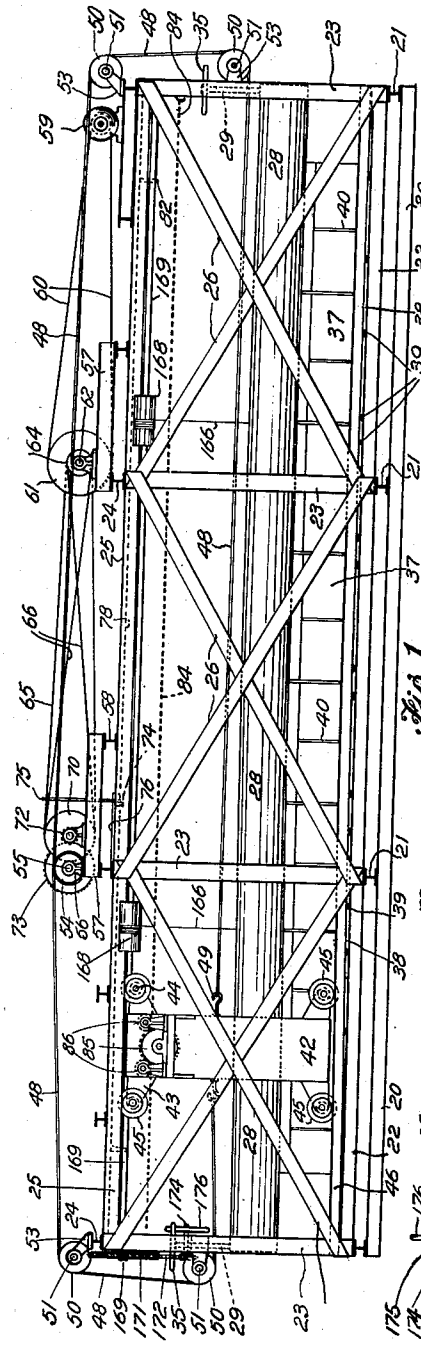


Fig. 1.

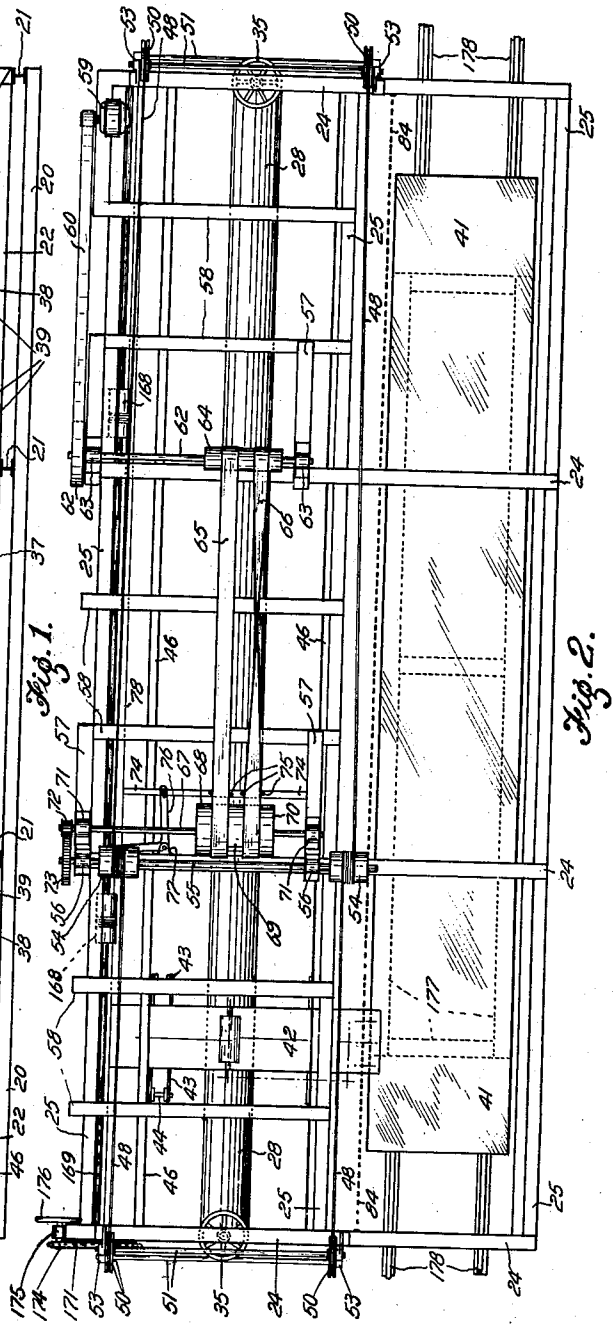


Fig. 2.

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May 30, 1939. K. BUTCHER 2,160,720

METHOD AND APPARATUS FOR FORMING PIPES

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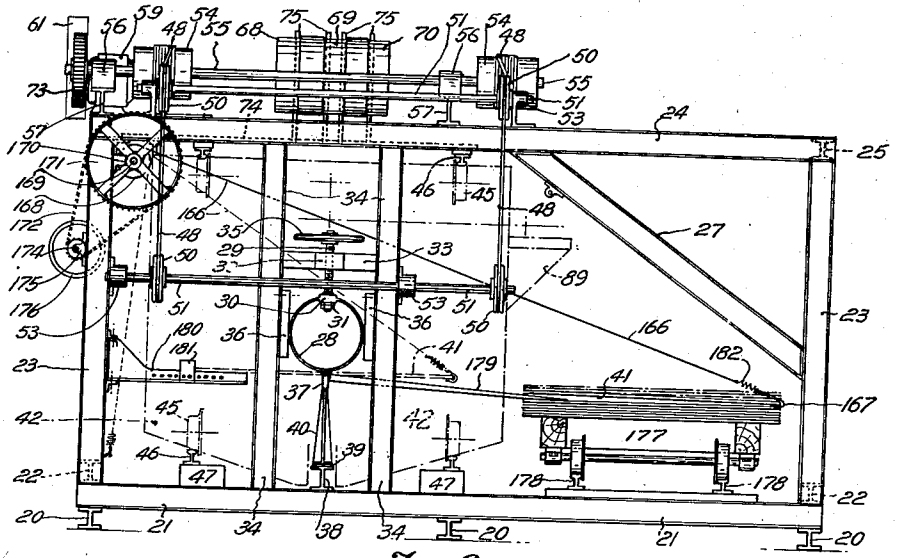


Fig. 3.

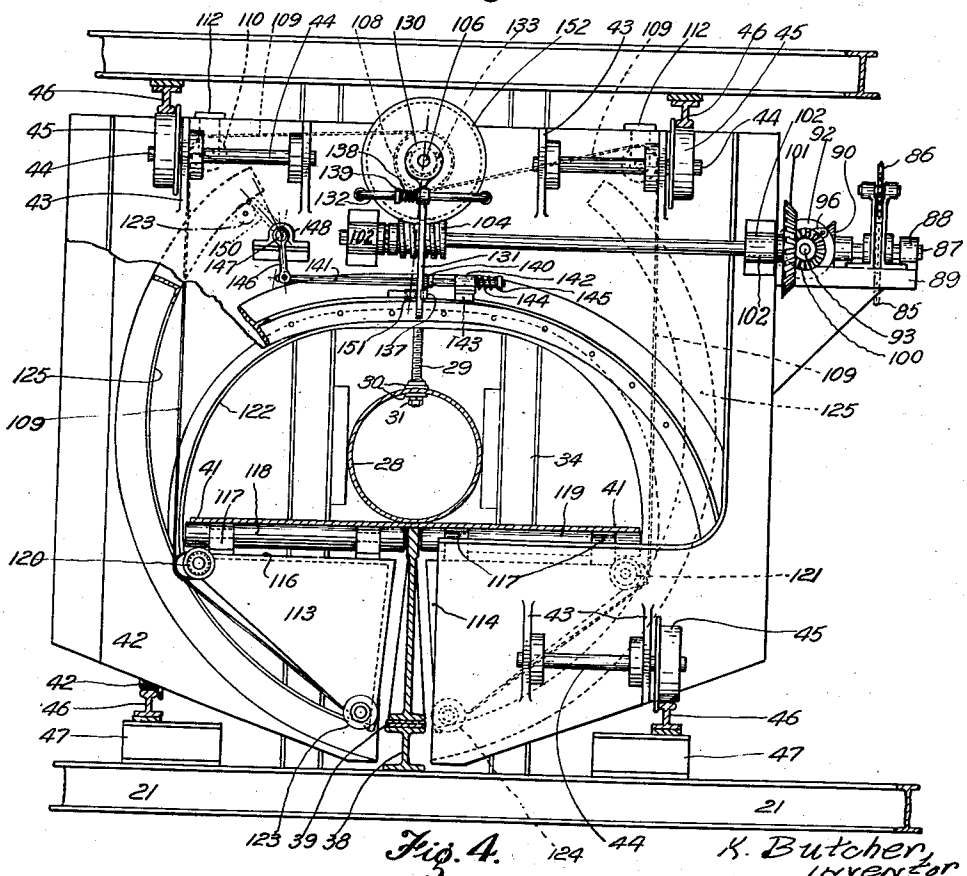


Fig. 4.

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ATTYS.

May 30, 1939. K. BUTCHER 2,160,720

METHOD AND APPARATUS FOR FORMING PIPES

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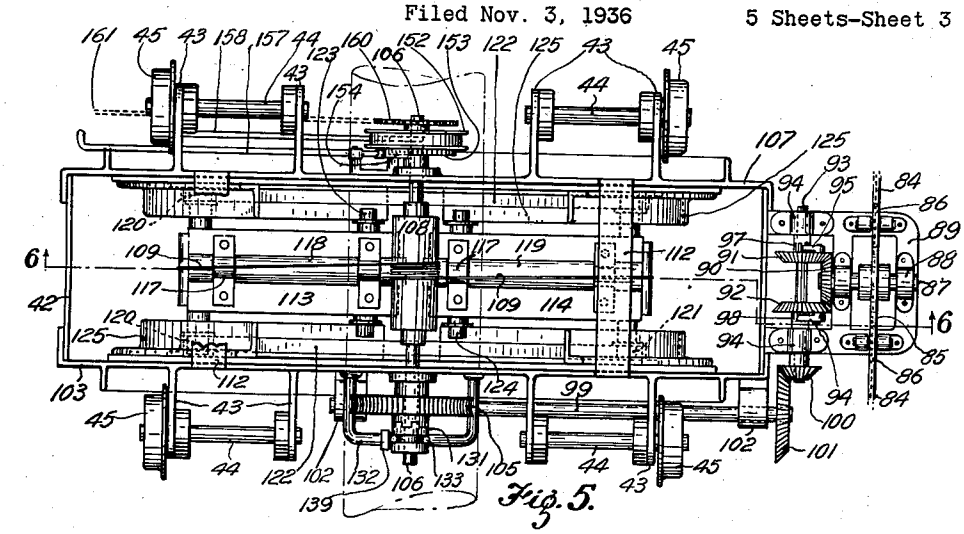


Fig. 5.

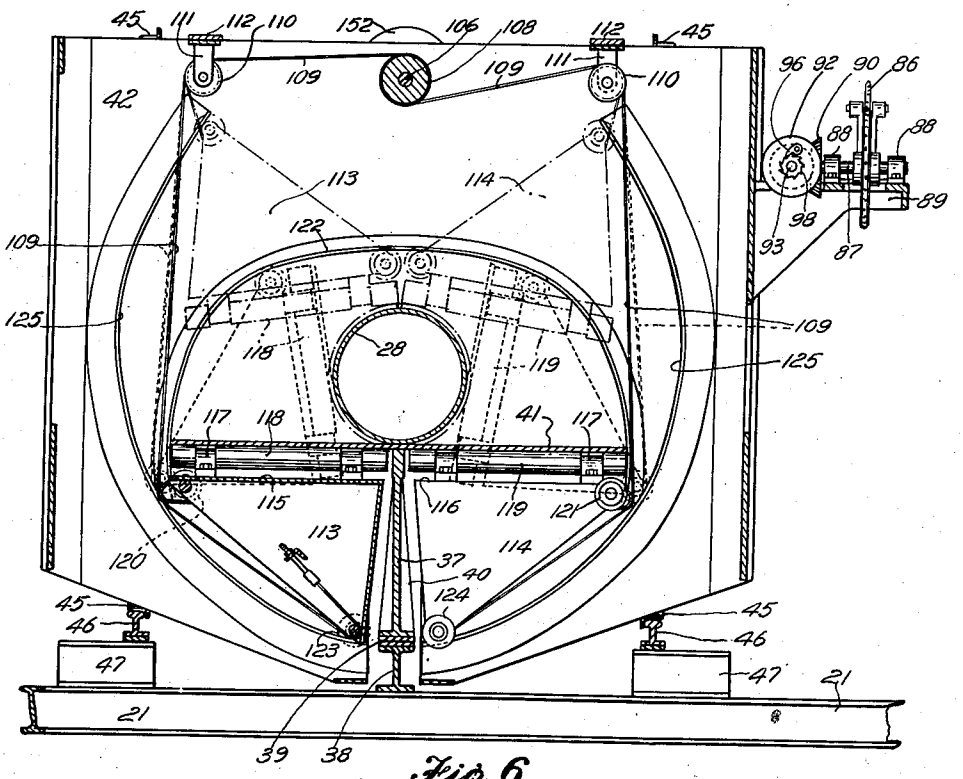


Fig. 6.

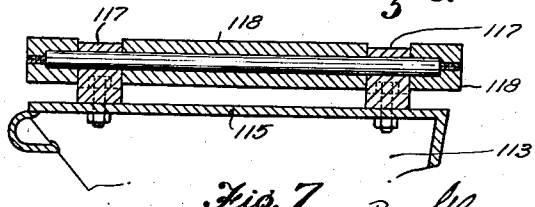


Fig. 7.

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May 30, 1939. K. BUTCHER 2,160,720

METHOD AND APPARATUS FOR FORMING PIPES

Filed Nov. 3, 1936 5 Sheets-Sheet 4

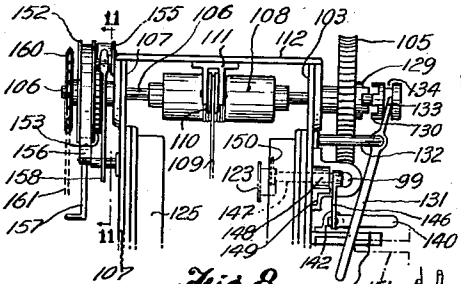


Fig. 8.

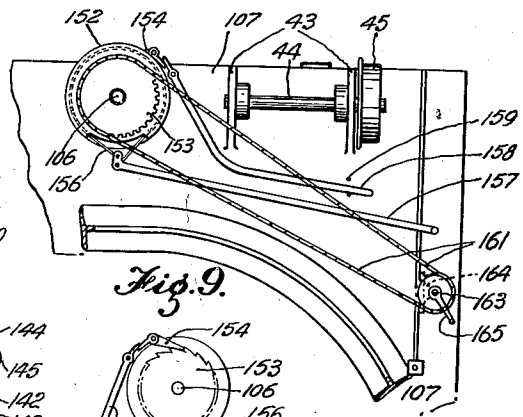


Fig. 9.

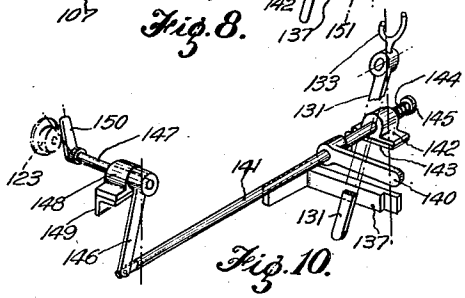


Fig. 10.

Fig. 11.

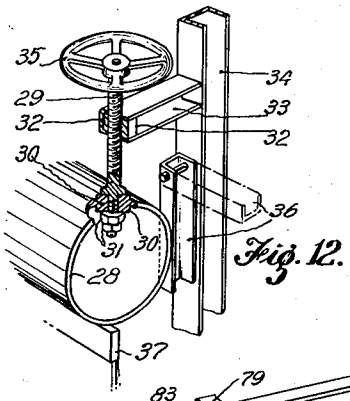


Fig. 12.

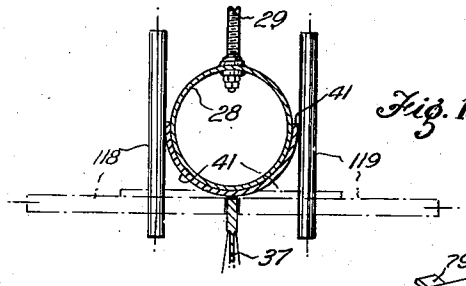


Fig. 13.

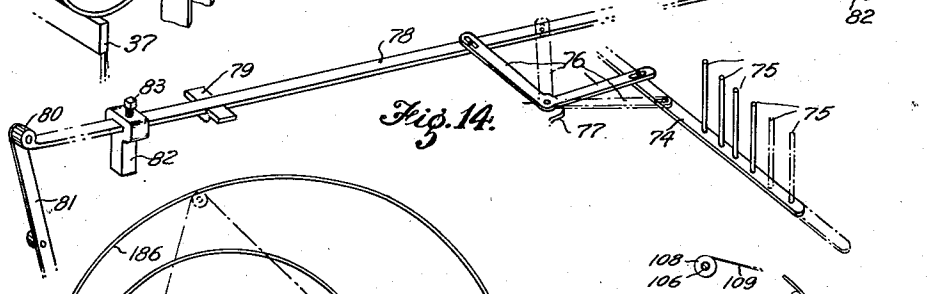


Fig. 14.

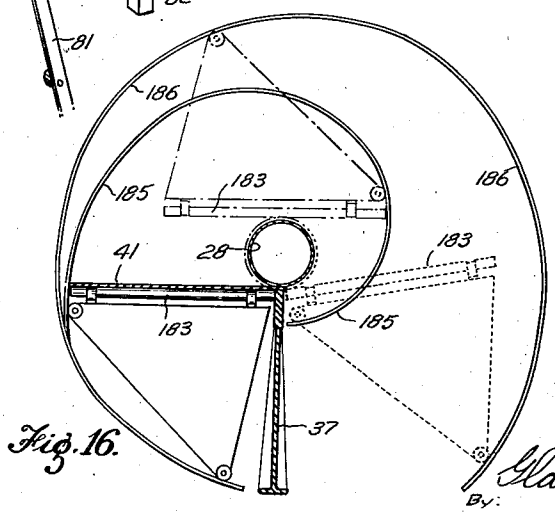


Fig. 16.

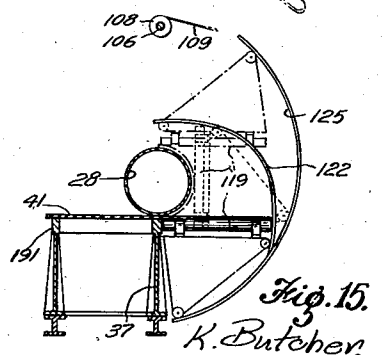


Fig. 15.

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METHOD AND APPARATUS FOR FORMING PIPES

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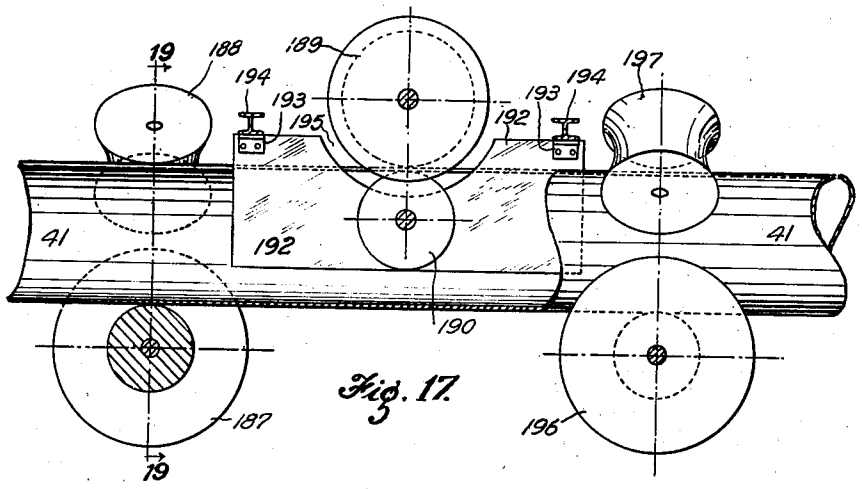


Fig. 17.

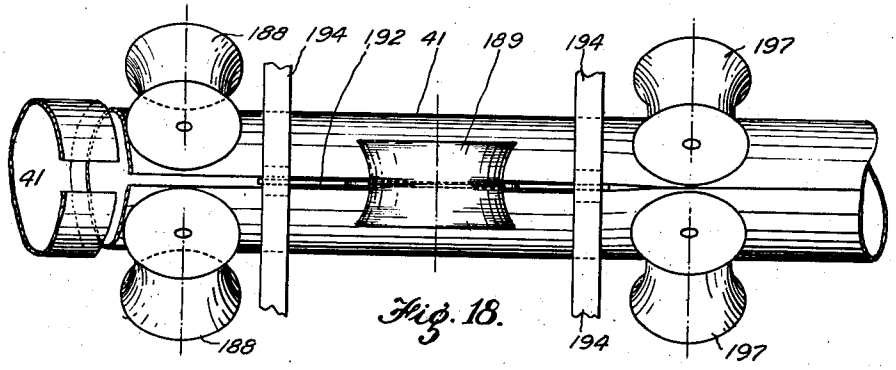


Fig. 18.

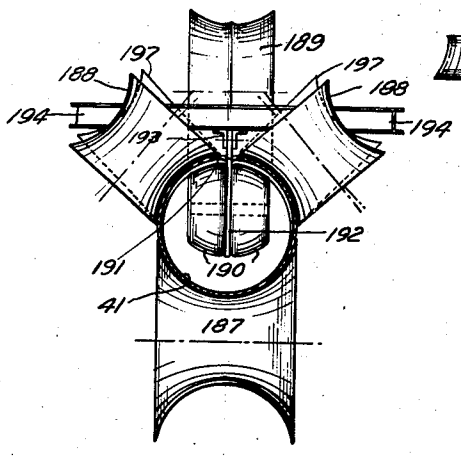


Fig. 19.

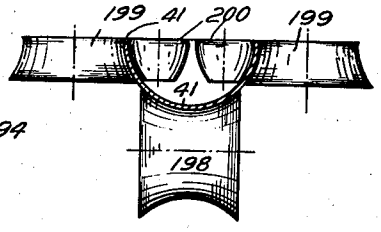


Fig. 20.

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Patented May 30, 1939 2,160,720

UNITED STATES PATENT OFFICE

2,160,720

METHOD AND APPARATUS FOR FORMING PIPES

Kearney Butcher, Essendon, Victoria, Australia

Application November 3, 1936, Serial No. 109,053
In Australia November 28, 1935

16 Claims. (Cl. 153—39)

This invention relates to improvements in the manufacture of metal pipes or pipe sections and refers especially to the manufacture of iron pipes by bending sheet iron around a cylindrical mandrel.

In the description and claims of this specification the terms "pipe sections" and "sections of pipe" are to be understood as referred to the sections of pipe that would be produced by division of a pipe longitudinally and not transversely.

Hitherto it has been found difficult to manufacture metal pipes by bending long lengths of sheet metal around a mandrel, and an object of this invention is to provide an improved method of and apparatus for achieving this result.

This invention also comprehends the manufacture of longitudinal sections of pipe by bending around a mandrel a metal sheet of width equal to a half, third or other fraction of the circumference of the mandrel, and then forming a complete pipe by welding the sections together along the edges. By these means I may construct much larger pipes than would otherwise be possible on a particular apparatus.

A method of forming metal pipes or pipe sections according to this invention comprises bending a metal sheet around a mandrel by disposing the metal sheet between a forming member or members and the mandrel, reciprocating the forming member or members along the sheet, and progressively turning the forming member or members about the mandrel.

Apparatus according to this invention may comprise a mandrel, a forming member or members disposed transversely of and adjacent to the mandrel, means for reciprocating the forming member or members longitudinally of the mandrel, and means for progressively turning the forming member or members about the mandrel.

More particularly the invention may comprise apparatus for forming metal pipes or pipe sections which comprises a mandrel, an anvil extending longitudinally of the mandrel and adapted to hold the centre of a metal sheet against the mandrel, a carriage arranged to reciprocate longitudinally of the mandrel, means for imparting the reciprocating motion to the carriage, roller carriers carried on the carriage, forming rollers rotatably mounted on the roller carriers and disposed transversely of the mandel on opposite sides of the anvil, and means associated wth the carriage for progressively turning the roller carriers in opposite directions about the mandrel.

My invention also comprehends the employment of two or more carriages each of which is arranged to operate over a portion of the length of the metal sheet, and these carriages may move independently along the sheet or may be connected together so as to reciprocate in unison.

According to a feature of this invention, the forming members or rollers throughout their motion maintain the metal sheet against the mandrel substantially along the line at which the said sheet is being bent. In addition, the forming members or rollers are preferably in contact with the unbent portion of the sheet.

According to another feature of the invention, the operation of the apparatus may be either continuous or intermittent, that is, the motions of the forming members or rollers along and about the mandrel may be effected either simultaneously or alternately.

A further feature of the invention resides in rendering certain parts of the apparatus removable so that they may be interchanged for other parts of different sizes when it is desired to form pipes of different diameters.

According to a further feature of this invention, a slight camber is imparted to the pipe in the forming operation, the said camber being in the opposite direction to the camber produced by the welding operation and of such magnitude that the finished pipe will be substantially free from camber.

In a modified form of the invention one half of the metal sheet may be bent around the mandrel by a forming member or members, and the position of the sheet may then be reversed and the other half of the sheet may then be bent around the mandrel by a repetition of the movement of the forming member or members.

In a further form of the invention one side edge of the metal sheet may be securely held against the mandrel and a forming member or members may be disposed against the sheet and then turned around the mandrel until the sheet is bent therearound.

In the preferred form of my invention, an embodiment of which is described below in detail, I employ forming members so arranged as to bend the two halves of a metal sheet simultaneously around opposite sides of the mandrel, whereby side stresses created by the bending of the sheet are equalised.

My invention also comprehends closing and seaming mechanism through which the metal sheet is passed after it has been formed and prior to welding of the seam.

In the accompanying drawings, a preferred

form of the invention is illustrated, and in these drawings:

Figure 1 is a view in side elevation of an apparatus for manufacturing metal pipes constructed in accordance with this invention.

Figure 2 is a view in plan of the apparatus shown in Figure 1.

Figure 3 is a view in end elevation, drawn to a larger scale, of the apparatus shown in Figure 1.

Figure 4 is a view in front elevation of the carriage which is indicated in broken lines in Figure 3. Certain parts of the carriage are broken away in this figure for convenience of illustration.

Figure 5 is a plan view of the carriage illustrated in Figure 4.

Figure 6 is a view in sectional elevation on the line 6—6 of Figure 5. The dotted lines and the chain-dotted lines represent different positions assumed by the roller carriers during the operation of the apparatus.

Figure 7 is an enlarged sectional view of one of the forming rollers and its associated parts.

Figure 8 is a view in side elevation of the upper portion of the carriage illustrated in Figures 4, 5, and 6.

Figure 9 is a view in rear elevation of the mechanism illustrated in Figure 8.

Figure 10 is a perspective view illustrating the clutch operating mechanism shown in Figure 8.

Figure 11 is a view in sectional elevation on the line 11—11 of Figure 8.

Figure 12 is a perspective view of the rear end of the mandrel showing the manner in which it is supported.

Figure 13 is a diagrammatic view in sectional end elevation showing the manner in which a half section of pipe may be formed by the apparatus, the chain-dotted lines indicating the initial position of the forming rollers and the full lines the final position of these rollers.

Figure 14 is a fragmentary perspective view illustrating the belt shifting mechanism shown in Figures 1 and 2.

Figure 15 is a diagrammatic view showing a modified form of the invention wherein the two halves of the pipe are formed successively by the same forming member or members.

Figure 16 is a diagrammatic view showing a further modified form of the invention wherein the metal sheet is bent completely around the mandrel by the same forming member or members.

Figure 17 is a diagrammatic view in side elevation partly in section, of the mechanism employed to close the edges of the metal sheet prior to welding.

Figure 18 is a diagrammatic plan view of the mechanism shown in Figure 17.

Figure 19 is a diagrammatic view in sectional elevation taken on line 19—19 of Figure 17, and

Figure 20 is a diagrammatic view in sectional end elevation of an arrangement of closing rollers through which a half section of pipe is passed before being welded to a similar half section to produce a complete pipe.

Referring to the drawings, wherein the same reference characters are used to indicate like or corresponding parts, the reference numeral 20 indicates longitudinal bearers on which the framework of the apparatus is supported. The framework comprises lower transverse bearers 21, lower longitudinal bearers 22 resting on the longitudinal bearers 20, a series of uprights 23 at each side, upper transverse members 24, and upper longitudinal members 25. The framework is braced at each side by diagonal members 26, and at each end by diagonal members 27.

A cylindrical mandrel 28 extends the whole length of the apparatus and is supported by threaded rods 29 which pass through enlarged bosses 30 formed integrally with the mandrel at each end and the rods are secured in position by nuts 31. The upper ends of the rods 29 pass through threaded blocks 32 mounted in sections of channel iron 33 welded or otherwise secured at a convenient height to uprights 34 mounted between the lower transverse bearers 21 and the upper transverse members 24. The rods 29 are provided with handwheels 35 by means of which the ends of the mandrel 28 may be raised or lowered. The uprights 34 are spaced sufficiently wide apart to allow the end of the widest mandrel used to pass between them, and when a mandrel of lesser width is used, swinging blocks 36 are pivoted to the uprights 34 as shown in Figure 12 in order to locate the mandrel between the uprights 34 and also to enable a pipe to be withdrawn longitudinally.

Immediately beneath the mandrel there is disposed an anvil 37 which extends the whole length of the apparatus. This anvil 37 is constructed of a number of separate sections which are supported on a bearer 38 which rests on the lower transverse bearers 21, and the height of the anvil at any point is varied by the insertion of packing pieces 39 between the sections of which it is composed and the bearer 38. The anvil 37 is made of the requisite strength to withstand downward pressure and it may be prevented from flexing by furnishing it with integral side fins 40.

A metal sheet 41 of length equal to that required in the finished pipe or pipe section, is inserted between the anvil 37 and the mandrel 28 by mechanism which is later described. The metal sheet 41 may be of any desired length provided that it is less than that of the mandrel 28. In Figures 4 and 6 of the drawings the metal sheet 41 is shown of width equal to the circumference of the mandrel, in order that it may be formed into a complete pipe, but it will be understood that a sheet of less width may be used where it is desired to produce a section of pipe only. After the sheet 41 has been inserted, the mandrel 28 is screwed down by means of the handwheels 35 onto the sheet 41 thereby forcing the latter firmly against the anvil 37.

It will be understood that I may employ hydraulically operated mechanism for raising and lowering the mandrel 28 in lieu of the mechanically operated mechanism described herein.

The bending of the sheet 41 around the mandrel 28 is effected by a carriage 42 and its associated mechanism, the carriage 42 being caused to reciprocate along the length of the sheet 41. The carriage 42 is formed with outstanding brackets 43 through which pass axles 44 on which are mounted flanged wheels 45. These wheels 45 run on upper and lower sets of rails 46 which are mounted on and secured to the upper transverse members 24 and the lower transverse bearers 21, respectively. Girder sections 47 are interposed between the lower rails 46 and the lower transverse bearers 21 to support the said rails at an appropriate height.

The carriage 42 is reciprocated by two cables 48, one at each side. The ends of the cables 48 are secured by means of hooks 49 to opposite sides of the carriage 42 and the cables then pass

around pulleys 50 mounted on axles 51 which revolve in bearings 53 secured to the framework of the apparatus at each end thereof. The cables 48 also pass around drums 54 at the top of the apparatus, which drums are carried on a shaft 55 which revolves in bearings 56 secured to girder sections 57. These girder sections 57 extend between, and are secured to, the ends of transverse members 58 which are disposed across the top of the framework of the apparatus.

An electric motor 59, which constitutes the source of power for the apparatus, is mounted at one end of the framework, and a belt 60 therefrom passes around a pulley 61 secured to a shaft 62 rotating in bearings 63 which are secured to a pair of girder sections 57. A wide pulley 64 is secured to the shaft 63 and from it belts 65 and 66 pass to a series of pulleys mounted on a shaft 67. This series of pulleys comprises a double width loose pulley 68, a single width fast pulley 69 in the centre and a second double width loose pulley 70. The shaft 67 is mounted in bearings 71 secured to a pair of girder sections 57. A pinion 72 is provided on the shaft 67 and meshes with a gearwheel 73 on the end of the shaft 55 in order to impart rotation to the drums 54, thereby effecting motion of the carriage 42.

The belts 65 and 66 are shifted alternately onto the driving pulley 69 by belt shifting mechanism which is illustrated in detail in Figure 14. This mechanism embodies a transverse arm 74 slidably mounted in brackets secured to the framework of the apparatus. This arm 74 carries upstanding pins 75 which engage the belts 65 and 66 and effect movement thereof. One end of the transverse arm 74 is pivotally connected to one arm of a bell crank 76 which is itself pivoted to a bracket 77 on the framework of the apparatus. The other arm of the bell crank 76 is pivotally connected to a longitudinal member 78 slidably mounted in brackets 79 secured to the framework. The longitudinal member 78 is furnished at one end with a bearing 80 to which is pivotally attached one end of a lever 81. The lever 81 is pivoted at an intermediate point to the framework and is furnished with a handle or the like by means of which it may be manually operated if required. Stops 82 are slidably disposed on the longitudinal member 78 and are adapted to be fixed in various positions along its length by means of set screws 83. The stops 82 are engaged by the carriage 42 when it reaches the limit of its travel, in each direction, thus operating the belt shifting means to shift the belts 65 and 66 and reverse the movement of the carriage 42.

The internal mechanism of the carriage 42 is operated by means of a chain rack 84 secured to the ends of the framework and arranged to engage a sprocket wheel 85 mounted on the side of the carriage. The chain rack 84 is kept in tension and in engagement with the sprocket wheel 85 by two small sprocket wheels 86 disposed adjacent the sprocket wheel 85 and on the opposite side of the chain rack 84.

Turning next to a more detailed description of the operation of the mechanism associated with the carriage 42, as illustrated in Figures 4 to 11, it will be seen that the sprocket wheel 85 is mounted on a shaft 87 which rotates in bearings 88 secured to a U-shaped bracket 89 attached to the side wall of the carriage 42. A bevel wheel 90 is carried on the inner end of the shaft 87 and engages two bevel wheels 91 and 92 rotatably mounted on a shaft 93 which is carried in bearings 94 secured to the bracket 89. The bevel wheels 91 and 92 have pawls 95 and 96 respectively secured to them, which pawls engage pinions 97 and 98 respectively which are non-rotatably mounted on the shaft 93. The shaft 93 imparts motion to a shaft 99 by means of bevel wheels 100 and 101.

It will be appreciated that the shafts 93 and 99 will be rotated in the same direction irrespective of the direction of rotation of the sprocket wheel 85, since if the sprocket wheel 85 is rotated in a clockwise direction when viewed from the right in Figure 5 of the drawings, the pawl 95 will cause rotation of the pinion 97 and the shaft 93, and if the sprocket wheel 85 is rotated in the counterclockwise direction, the pawl 96 will cause rotation of the pinion 98 and the shaft 93, the shaft 93 being rotated in the same direction in both cases.

The shaft 99 is mounted in bearings 102 secured to the front wall 103 of the carriage 42, and the said shaft carries a worm 104 which engages a worm wheel 105 on a shaft 106. The shaft 106 passes through the front wall 103 and the rear wall 107 of the carriage 42, and is rotatably carried in bearings formed in these walls. The worm wheel 105 is rotatably mounted on the shaft 106 and rotation of the shaft 106 is effected by means of clutch mechanism associated with the worm wheel 105, which clutch mechanism will be hereinafter described. The shaft 106 carries a drum 108 around which passes a cable 109 which passes over pulleys 110 mounted on brackets 111 secured to cross pieces 112 on the carriage 42. The ends of the cable 109 then pass downwards and are secured to roller carriers 113 and 114 and perform the function of turning these roller carriers about the mandrel 28 in order to effect formation of the pipe.

The roller carriers 113 and 114 are triangular in shape and their sides 115 and 116, which are uppermost in the positions shown in full lines in Figure 6, carry bearings 117 in which are mounted forming rollers 118 and 119. These rollers are arranged so as to bear against the surface of the metal sheet 41 remote from the mandrel 28, and to extend substantially from the centre of this sheet to the side edges thereof. The bearings 117 are set in slightly from the surface of the rollers 118 and 119 so that they do not come in contact with the metal sheet 41.

The roller carriers 113 and 114 are furnished with guiding rollers 120 and 121, the ends of which run in inner tracks 122 and with guiding rollers 123 and 124 the ends of which run in outer tracks 125. The guiding rollers 120 and 121 are made substantially longer than the guiding rollers 123 and 124, and the inner tracks 122 are disposed further apart than the outer tracks 125 so that the guiding rollers 123 and 124 may pass between the inner tracks 122 in the course of their path along the outer tracks 125.

The inner tracks 122 and the outer tracks 125 are bolted, riveted or otherwise secured to the front wall 103 and the rear wall 107 of the carriage 42. The front and rear walls 103 and 107 of the carriage are cut away to allow the mandrel 28, the metal sheet 41 and the anvil 37 to pass through the said carriage 42, and in Figure 4 the manner in which the inner and outer tracks 122 and 125 are secured to the front and rear walls of the carriage is clearly illustrated.

It will be appreciated that if the machine is to be used for manufacturing pipes of different diameters, it will be necessary to substitute a

different mandrel and metal sheet, and it will also be necessary to employ roller carriers and tracks of different dimensions. When it is desired to substitute a new mandrel, the mandrel in use is detached from the supporting rods 29 and the new mandrel is attached thereto.

In the case of the tracks 122 and 125, new tracks of appropriate shape and size may be readily bolted to or otherwise secured to the front and rear walls of the carriage in lieu of those previously in use. Where it is desired to substitute new inner tracks 122 to effect the formation of pipes or pipe sections of different sizes, it will be found convenient to mount the inner tracks on shaped pieces (not shown) detachably secured to the front and rear walls of the carriage, and to employ shaped pieces of different sizes with different sets of inner tracks. A set of these shaped pieces may be retained for use with each set of inner tracks.

The inner tracks 122 and the outer tracks 125 are given a pre-calculated conformation of such a character that the roller carriers 113 and 114 are caused to move upwards in a path such as that indicated by the dotted and chain-dotted lines in Figure 6. The dotted lines in Figure 6 indicate the position of the roller carriers when the sheet has been bent approximately half-way around the mandrel, and the chain-dotted lines represent the position of the roller carriers when the sheet has been bent completely around the mandrel. The roller carriers are given such a motion that the metal sheet 41 is maintained in contact with the mandrel 28 substantially along the line where the sheet leaves the mandrel 28, that is, along the line at which it is being bent, irrespective of the part of the sheet being bent. It will be seen from an examination of Figure 6 that this condtion is fulfilled in the form of the invention illustrated in the drawings.

Motion of the roller carriers 113, 114 about the mandrel 28 is caused by the cable 109, which cable passes around guides 126 at the outer ends of the roller carriers 113 and 114 and then passes down and around the axles of the rollers 123 and 124 and the ends of this cable 109 are then secured by adjustable fastenings 127 to brackets 128 secured to the roller carriers 113 and 114.

It will be noted that by this arrangement, a maximum torque is exerted on the roller carriers 113 and 114 by the cable 109 irrespective of the positions adopted by the said roller carriers.

Before proceeding to a more detailed description of the operation of the apparatus, I propose to refer to the operation of the clutch and brake mechanisms associated with the shaft 106, such mechanisms being illustrated in detail in Figures 8 to 11.

The clutch mechanism comprises two clutch members 129 and 130 secured to the worm wheel 105 and the shaft 106 respectively, the said clutch members being provided with co-acting dogs, and a clutch lever 131 pivotally and slidably mounted on a U-shaped bracket 132 secured to the front wall 103 of the carriage 42.

The clutch lever 131 is provided with a bifurcated upper end 133 which engages an annular slot 134 in the clutch member 130, which clutch member 130 is slidably, but non-rotatably, mounted on the shaft 106. The lower end of the clutch lever 131 is held in its outermost position by a recessed bracket 137 secured to the front wall 103 of the carriage, and in this position of the clutch lever 131 the clutch is closed. The clutch is closed to place the apparatus in operation by manually pulling out the lower end of the clutch lever 131 until it moves into the recess in the bracket 137.

The clutch lever 131 is held in the recess in the bracket 137 by the action of a compression spring 138 which is located on the U-shaped bracket 132 between the clutch lever 131 and a collar 139.

The clutch releasing mechanism embodies an arm 140 mounted on a rod 141 and adapted to project outwards in a direction parallel to the recessed bracket 137. The rod 141 is slidably mounted in a bearing 142 mounted on a bracket 143 secured to the carriage wall 103, and a compression spring 144 is provided on the rod 141 between the bearing 142 and a ring 145 secured to the end of the rod 141. The other end of the rod 141 is pivotally connected to an arm 146 which is mounted on the end of a shaft 147 rotatably held in a bearing 148 which is carried on a bracket 149 secured to the carriage wall 103. The shaft 147 projects through the said carriage wall 103 and carries on its inner end a tripping arm 150 which is so positioned as to be engaged by the end of the guiding roller 123 of the roller carrier 113 when the said roller carrier 113 has reached the extremity of its travel about the mandrel 28. It will thus be seen that the impact of the guiding roller 123 on the tripping arm 150 will move the rod 141 and the arm 140 in a right to left direction in the illustration shown in Figure 4, and the lower end of the clutch lever 131 will thus be disengaged from the recessed bracket 137 and will be moved into alignment with a stop 151 shown in Figures 4 and 8. This stop 151 is secured to the framework of the apparatus at one end thereof and in such a position as to engage the lower end of the clutch lever 131 when the carriage 42 reaches that end of the apparatus.

Hence, when the roller carriers 113 and 114 have reached the extremity of their travel, the tripping arm 150 will be actuated in the manner above described and the lower end of the clutch lever 131 will be moved into alignment with the stop 151. The motion of the roller carriers 113 and 114 and the motion of the carriage 42 are so timed that the former will have completed their movement about the mandrel 28 when the latter reaches the end of the apparatus carrying the stop 151, so that the declutching operation will be effected at the correct instant. The lower end of the said clutch lever 131 will then strike the stop 151 and will be forced inwards to disengage the clutch members 129 and 130. The roller carriers 113 and 114 will then be free to return to their lowermost position and will do so under the force of gravity as soon as the brake mechanism, which is described below, is released.

When the roller carriers 113 and 114 have been allowed to return to their lowermost position, the spring 144 will return the clutch releasing mechanism to its normal position.

The brake mechanism mounted on the other end of the shaft 106 comprises a brake drum 152 mounted on the shaft 106, a ratchet wheel 153 secured to or formed integrally with the brake drum 152, a pawl 154 pivotally mounted on a bracket 155 secured to the rear wall 107 of the carriage 42, a brake band 156 passing around the drum 152, and a brake lever 157 having its end secured to the ends of the brake band 156.

In addition, a lever 158 is provided to engage

with and release the pawl 154 and stops 159 on the rear wall 107 of the carriage are furnished to limit the movement of the lever 158. The levers 157 and 158 are made sufficiently long to be conveniently operable from the side of the apparatus.

A sprocket wheel 160 is secured to the shaft 106 near its rear end and a chain 161 passes around this sprocket wheel 160 and around a smaller sprocket wheel 162 mounted on a small shaft 163 carried in a bearing 164 which is secured to the rear wall 107 of the carriage. A crank 165 is secured to the shaft 163 in order to impart rotation to the sprocket wheel 162 and thence to the sprocket wheel 160, and the shaft 106. The crank 165 may be manually operated in order to impart rotation to the shaft 106 when it is desired to turn the roller carriers 113 and 114 about the mandrel 28 while the carriage 42 is stationary.

The mechanism employed to load sheets of metal into the apparatus is illustrated clearly in Figures 1, 2 and 3, and this mechanism includes a series of cables 166 provided with hooks 167 at their ends which are adapted to engage the edges of the metal sheets. The cables 166 pass around drums 168 mounted on a shaft 169 extending longitudinally of the apparatus and carried in bearings 170 secured to the framework of the apparatus. A sprocket wheel 171 is mounted on the shaft 169 and a chain 172 passes around this sprocket wheel and around a smaller sprocket 173 secured to a shaft 174 which rotates in a bearing 175 attached to one of the uprights 23 of the apparatus.

A handwheel 176 is secured to the shaft 174 and by it rotation may be imparted to the shaft 169 and drums 168 in order to wind up the cables 166.

The metal sheets are brought alongside the mandrel 28 on a truck 177 running on rails 178 suitably supported on the base of the apparatus. When it is desired to load a metal sheet 41, the ends of skids 179 are inserted beneath one side of the sheet 41 and the other ends of these skids 179 are allowed to rest on the top of the anvil 37. The hooks 167 are then slipped over the other side of the sheet 41 and the handwheel 176 is rotated to cause the sheet 41 to be slid up the skids 179 and beneath the mandrel 28. The metal sheet 41 is correctly aligned in position beneath the said mandrel by swinging arms 180 pivoted to the uprights 23 and furnished with stops 181 so positioned as to locate the sheet correctly beneath the mandrel when it abuts against said stops 181.

The hooks 167 are preferably secured to the cables 166 by a tension spring 182 so that the sheet 41 will be brought firmly against the stops 181 by rotation of the handwheel 176. When the sheet 41 has been brought into its correct position beneath the mandrel 28, the skids 179 are withdrawn and the mandrel 28 is screwed down onto the sheet 41 by the handwheels 35 thereby causing the sheet 41 to be held firmly between the said mandrel and the anvil 37. The arms 180 may then be swung away from the sheet 41 and the hooks 167 may be detached from the sheet and wound up out of the way.

When the sheet 41 has been loaded into the apparatus the carriage 42, which during the loading operation has been located at one end or the other of the apparatus, is moved so that forming rollers 118 and 119 engage the underside of the sheet 41 and the belts 65 and 66 are then moved by the belt shifting mechanism so that the carriage will be moved in the appropriate direction along the sheet 41. The apparatus will then be set in motion by the electric motor 59 and the carriage 42 will be caused to reciprocate along the length of the sheet 41, its motion being reversed at the ends of the sheet by the reversing means associated with the belt shifting mechanism. Simultaneously with the reciprocating motion of the carriage 42, the roller carriers 113 and 114 are caused to turn about the mandrel 28 by the cable 109 and the mechanism which operates this cable, this mechanism being actuated by the sprocket wheel 85 engaging the chain rack 84 which extends along the length of the apparatus.

Preferably, this mechanism is so adjusted that the roller carriers 113 and 114 are moved upwards by only a small amount during each traversal of the carriage 42. The amount of upward movement which can be imparted to the roller carriers 113 and 114 during one traversal of the carriage 42 will of course depend primarily on the thickness of the metal sheet 41 and it will be relatively simple to determine by experiment what upward movement can be given to the roller carriers without imposing undue stresses on the apparatus.

As the roller carriers move upwards, the metal sheet 41 is bent around the mandrel 28 and it will be observed that as the roller carriers approach their uppermost position, the resistance to bending exerted by the metal sheet 41 on the carriage 42 becomes more in an upward direction. When the roller carriers 113 and 114 commence the bending operation the resistance exerted by the sheet 41 is almost entirely in a downward direction and this force is of course imparted to the lower pair of rails 46, but when the roller carriers 113 and 114 reach their uppermost position, the resistance exerted by the sheet 41 is almost entirely in an upward direction and this is imparted by the carriage to the upper pair of rails 46. In some cases this force may be sufficient to balance or exceed the weight of the carriage 42 so that no pressure is exerted on the lower pair of rails.

According to a modified method of operating this apparatus, I may operate the same intermittently instead of continuously. I may effect this by turning the roller carriers 113 and 114 to a predetermined extent about the mandrel 28 when the carriage 42 is stationary and then causing the said carriage to effect one or more traversals of the sheet 41 with the roller carriers 113 and 114 maintained in this position. The means employed to raise the roller carriers 113 and 114 when the carriage 42 is stationary may comprise the crank 165 rotating sprocket wheels 160 and 162 and the shaft 109, or alternatively power operated means may be provided to achieve this purpose.

During the motion of the carriage 42 the brake mechanism may be employed to maintain the roller carriers 113 and 114 in any position to which they have been manually or otherwise raised.

When the roller carriers 113 and 114 have been turned about the mandrel 28 either by a continuous or intermittent method of operation of the apparatus, the brake lever 157 is operated to hold them in this position and the said roller carriers may then be allowed to return to their lowermost position by a gradual release of the brake lever 157. The mandrel 28 is then raised slightly from the anvil 37 by means of the handwheels 35 and the metal sheet 41, which is now in the shape

of an unseamed pipe, is slid off one end of the mandrel 28.

I have found that during the welding operation a slight camber is produced in the pipe, and I therefore arrange that the upper surface of the anvil 37 is formed with a slight camber of the requisite curvature so that when the mandrel 28 is screwed down onto the anvil, the said mandrel will have this camber imparted to it also, and the pipe formed by the apparatus will embody a camber which is in the opposite direction to that of the camber imparted by the welding operation. Hence, by proper adjustment of the camber imparted to the pipe by the apparatus, I am able to produce a finished pipe which is free from any camber.

It will be understood that when the apparatus is to be used for the manufacture of pipes of a different size, it is necessary to ensure that the anvil 37 is given a new camber of the requisite magnitude which camber may be obtained by variation of the number and thickness of the packing pieces 39 disposed beneath the sections of the anvil.

In Figure 13 of the drawings, there is illustrated a form of the invention wherein a metal sheet of width approximately one-half of the circumference of the mandrel is bent to form a half section of pipe. In this figure the metal sheet 41 is disposed between the mandrel 28 and the forming rollers 118 and 119 in the usual manner and these forming rollers are turned about the mandrel until the sheet 41 has been bent into the position shown in full lines in this figure. The sheet 41 may then be withdrawn from the mandrel in the manner previously described.

In the modified form of the invention illustrated in Figure 15 of the drawings only one forming roller 119 is provided to bear against one half of the metal sheet 41, the said forming roller being mounted on a roller carrier 114 which runs in inner tracks 122 and outer tracks 125 as previously described. The other half of the metal sheet 41 is supported on an anvil 37 and an outer support 191. The dotted and chain-dotted lines in Figure 15 of the drawings indicate intermediate and final positions of the roller carrier 114, respectively.

When one half of the sheet 41 has been bent around the mandrel 28 the sheet is withdrawn and inserted in the reverse position, and the operation of the forming roller is repeated to bend the other half of the sheet 41, thereby forming a pipe.

In the form of the invention illustrated in Figure 16 a forming roller 183 is provided, of length almost equal to the width of the metal sheet 41. The metal sheet is disposed with one side edge secured in position between the mandrel 28 and the anvil 37 by suitable means, and the forming roller 183 is turned nearly completely round the mandrel 28 thereby bending the sheet 41 therearound. To effect this motion of the forming roller 183, the roller carrier 184 is arranged to run in an inner track 185 and an outer track 186 shaped so as to guide the roller carrier in the manner described, and as illustrated in the drawings. The chain-dotted and dotted lines in Figure 17 indicate intermediate and final positions of the roller carrier 184, respectively.

The mechanism which I prefer to employ to close the pipe prior to welding is illustrated in Figures 17 to 19, and in these figures the formed sheet 41 is passed first between a lower roller 187 and two diagonally disposed upper rollers 188 by means of which the two edges of the sheet are brought to a predetermined distance apart. The sheet then passes between an upper seaming roller 189 and two lower seaming rollers 190 which are shaped so as to turn the edges of the sheet 41 slightly inwards as shown at 191.

This slight inward inclination of the edges of the sheet 41 forms a slight longitudinal recess in the pipe when the two edges are brought together, so that when the metal is deposited in the recess by the welding operation a smooth outer contour will be presented by the pipe.

The lower seaming rollers 190 are mounted inside the unseamed pipe by means of a vertically disposed plate 192 which is secured to brackets 193 attached to girders 194 which are suitably supported at each end. The plate 192 is cut away as shown at 195 to allow the upper seaming roller 189 to be introduced into position above the pipe. The upper seaming roller 189 and the lower seaming rollers 190 operate on the edges of the sheets 41 to give the said edges an approved configuration prior to the welding operation. The sheet 41 after leaving the said seaming rollers 189, 190 passes over final closing rollers by means of which the edges of the metal sheet are brought into contact, and the welding operation is performed either simultaneously with or immediately after the passage of the sheet 41 through the said final closing rollers. These closing rollers comprise a lower roller 196 and diagonally disposed upper rollers 197, the said upper rollers 197 being spaced slightly closer together than the rollers 188 in order to bring the edges of the sheet into contact with one another.

When a pipe is constructed, according to this invention, in a plurality of sections, each of these sections is preferably passed through shaping rollers before the sections are welded together. In Figure 20 of the drawings, a mechanism is diagrammatically shown through which a sheet 41 constituting a half-section of pipe may be passed. This mechanism comprises a lower roller 198 on which the pipe section rests, and outer and inner shaping rollers 199 and 200 respectively. These outer and inner shaping rollers 199 and 200 are given such a configuration that the side edges of the sheet 41 are curved slightly inwards in order that a recess for the deposition of metal may be formed when the two sections of the pipe are placed together for welding. I wish it to be understood that in constructing pipes according to my invention, I may, if necessary, employ a metal sheet 41 which is of width slightly less than the circumference of the mandrel 28, and I may pass the partly formed pipe which is fabricated from the said sheet through a series of closing rollers and through seaming rollers in order to bring the edges of the metal sheet together, thereby completely forming the pipe, and I may then weld the edges of the sheet together in an approved manner.

It will thus be seen that where it is desired to construct pipes of slightly different diameters, such pipes may be constructed on the same mandrel and different sets of closing and seaming rollers may be employed to close the partly formed pipes thereby constructed.

It will be appreciated that various other modifications may be made in the apparatus by those skilled in the art without departing from the spirit and scope of my invention. For instance,

any desired number of forming rollers may be mounted on the roller carriers and such forming rollers may extend across part or whole of the section of the metal sheet which is bent by the motion of the roller carrier on which said rollers are mounted. Moreover, I may employ two or more carriages in lieu of a single carriage, the said carriages being arranged to operate over a portion of the length of the metal sheet, and if desired, these carriages may be connected together so as to reciprocate in unison.

I claim:

1. A method of forming metal pipes or pipe sections which comprises disposing a metal sheet against a mandrel, disposing forming members against the metal sheet on each side of the centre thereof with their axes extending substantially from the centre to the side edges of the metal sheet, reciprocating the forming members along the metal sheet, and progressively turning the forming members about the mandrel in such a manner that throughout their motion the forming members maintain the sheet against the mandrel substantially along the line at which the said sheet is being bent.

2. Apparatus for forming metal pipes or pipe sections by bending a metal sheet around a mandrel, which comprises an anvil extending longitudinally of the mandrel and adapted to hold the centre of the sheet against the mandrel, a carriage arranged to reciprocate longitudinally of the mandrel, means for imparting the reciprocating motion to the carriage, roller carriers carried on the carriage, forming rollers rotatably mounted on the roller carriers and disposed transversely of the mandrel on opposite sides of the anvil, and means associated with the carriage for progressively turning the roller carriers in opposite directions about the mandrel.

3. Apparatus according to claim 2 wherein the movement of the roller carriers is constrained by tracks secured to the carriage, the said tracks being so shaped that throughout the motion of the roller carriers about the mandrel the forming rollers are maintained in contact with the metal sheet substantially along the line at which it is being bent.

4. Apparatus according to claim 2 wherein the movement of the carriage longitudinally of the mandrel is automatically reversed when the carriage reaches each end of the metal sheet.

5. Apparatus according to claim 2 wherein the carriage is moved longitudinally of the mandrel by cables to which it is attached and which pass around drums mounted on the framework of the apparatus, the said drums being rotated by a suitable source of power, and wherein means are provided to reverse the rotation of the drums when the carriage reaches each end of the metal sheet.

6. Apparatus according to claim 2 wherein the motion of the carriage is reversed when it reaches each end of the metal sheet, by means of mechanism set in action by the said carriage.

7. Apparatus according to claim 2 wherein the roller carriers are turned about the mandrel by mechanism actuated by the motion of the carriage along the mandrel.

8. Apparatus according to claim 2 wherein the roller carriers are turned about the mandrel by one or more cables which pass around a drum mounted on the carriage and have their ends secured to the carriers, motion being imparted to the drum by mechanism driven by a source of power.

9. Apparatus according to claim 2 wherein the roller carriers are turned about the mandrel by one or more cables which pass around a drum mounted on the carriage and have their ends secured to the carriers, motion being imparted to the drum by mechanism actuated by the reciprocating motion of the carriage.

10. Apparatus according to claim 2 wherein the roller carriers are turned about the mandrel by one or more cables which pass around a drum mounted on the carriage and have their ends secured to the carriers, motion being imparted to the drum by mechanism driven by a source of power, and wherein a clutch is interposed between the drum and the driving mechanism therefor, the said clutch being disengaged when the roller carriers reach the end of their travel about the mandrel.

11. Apparatus according to claim 2 wherein the roller carriers are turned about the mandrel by one or more cables which pass around a drum mounted on the carriage and have their ends secured to the carriers, motion being imparted to the drum by mechanism driven by a source of power, and wherein brake mechanism is provided in association with the mechanism actuating the roller carriers.

12. Apparatus according to claim 2 wherein means are provided to impart a slight camber to the pipe in the forming operation, the said camber being substantially equal to and in the opposite direction to the camber produced by the operation of welding the seam of the pipe.

13. Apparatus for forming metal pipes or pipe sections which comprises a mandrel, a carriage, means for reciprocating a carriage longitudinally of the mandrel, an anvil or like means extending longitudinally of the mandrel and adapted to hold a metal sheet against the mandrel, roller carriers on opposite sides of the anvil and arranged to run in tracks mounted on the carriage, forming rollers rotatably mounted on the roller carriers and extending transversely of the mandrel, means for inserting the metal sheet between the anvil and the mandrel so as to rest on the forming rollers, and means for moving the roller carriers along the tracks, characterised in that the said tracks are so shaped that the roller carriers are turned in opposite directions about the mandrel in paths such that throughout their motion about the mandrel the forming rollers maintain the metal sheet in contact with the mandrel substantially along the line at which it is being bent.

14. Apparatus according to claim 2 wherein a plurality of carriages is provided, each of said carriages being arranged to operate over a portion of the length of the metal sheet, and wherein these carriages are reciprocated independently.

15. Apparatus according to claim 2 wherein the mandrel, the forming rollers, the roller carriers, and the tracks for the roller carriers, are rendered removable so that they may be substituted by corresponding parts of different sizes to enable the formation of pipes or pipe sections of different sizes.

16. Apparatus according to claim 2 wherein a plurality of carriages is provided, each of said carriages being arranged to operate over a portion of the length of the metal sheet, and wherein these carriages are connected together to reciprocate in unison.

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