June 6, 1944. W. A. WEIGHTMAN 2,350,379

MACHINE FOR BENDING METAL

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FIG. 1

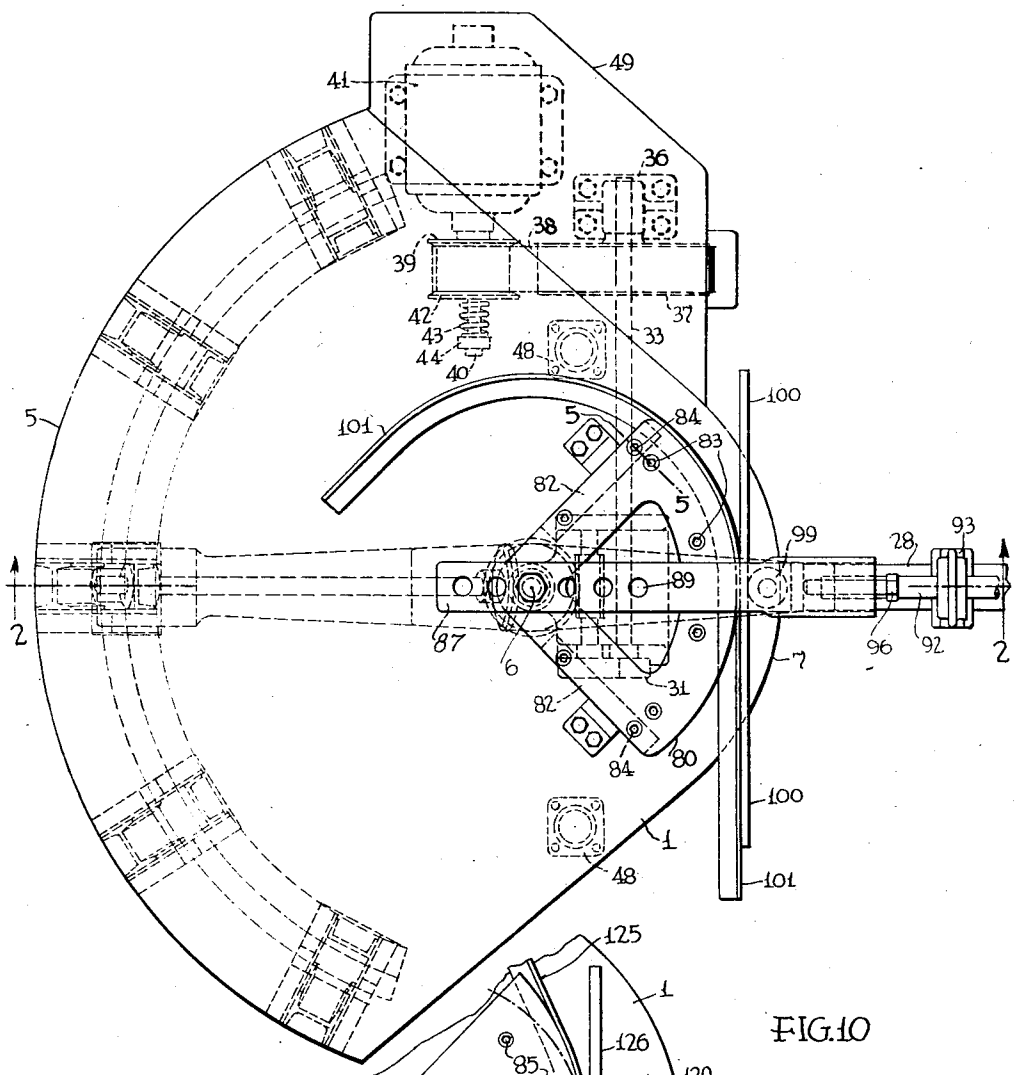
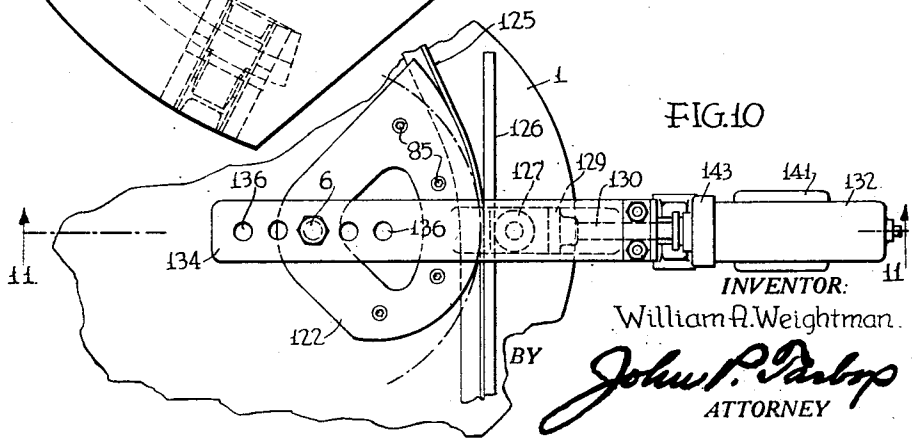


FIG. 10



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MACHINE FOR BENDING METAL

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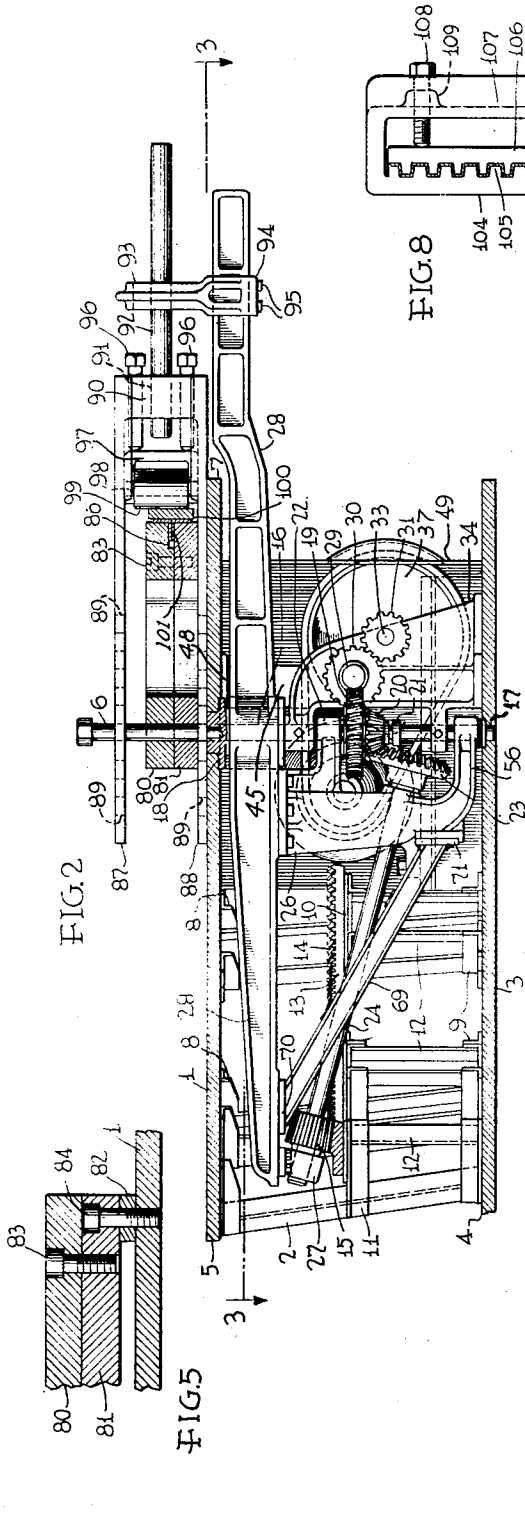


FIG. 2

FIG. 5

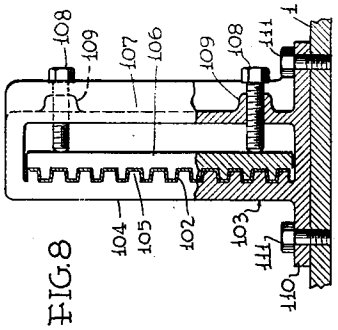


FIG. 8

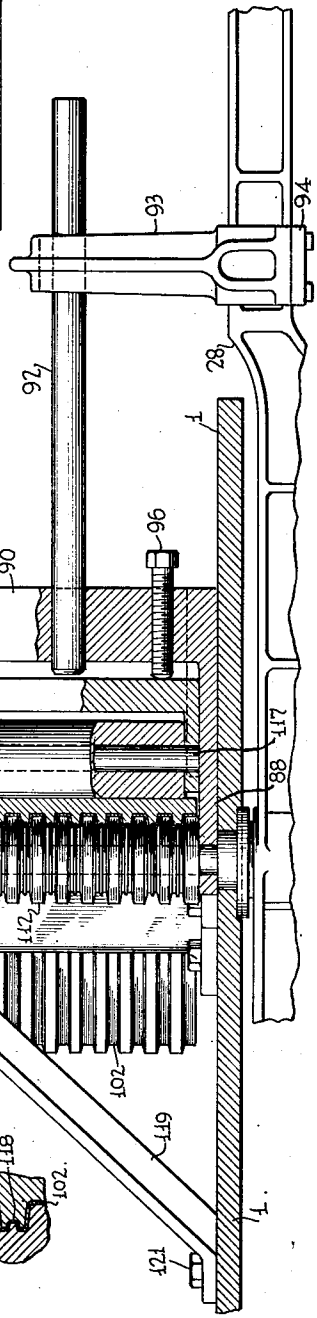


FIG. 7

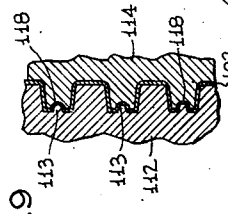


FIG. 9

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MACHINE FOR BENDING METAL

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FIG.3

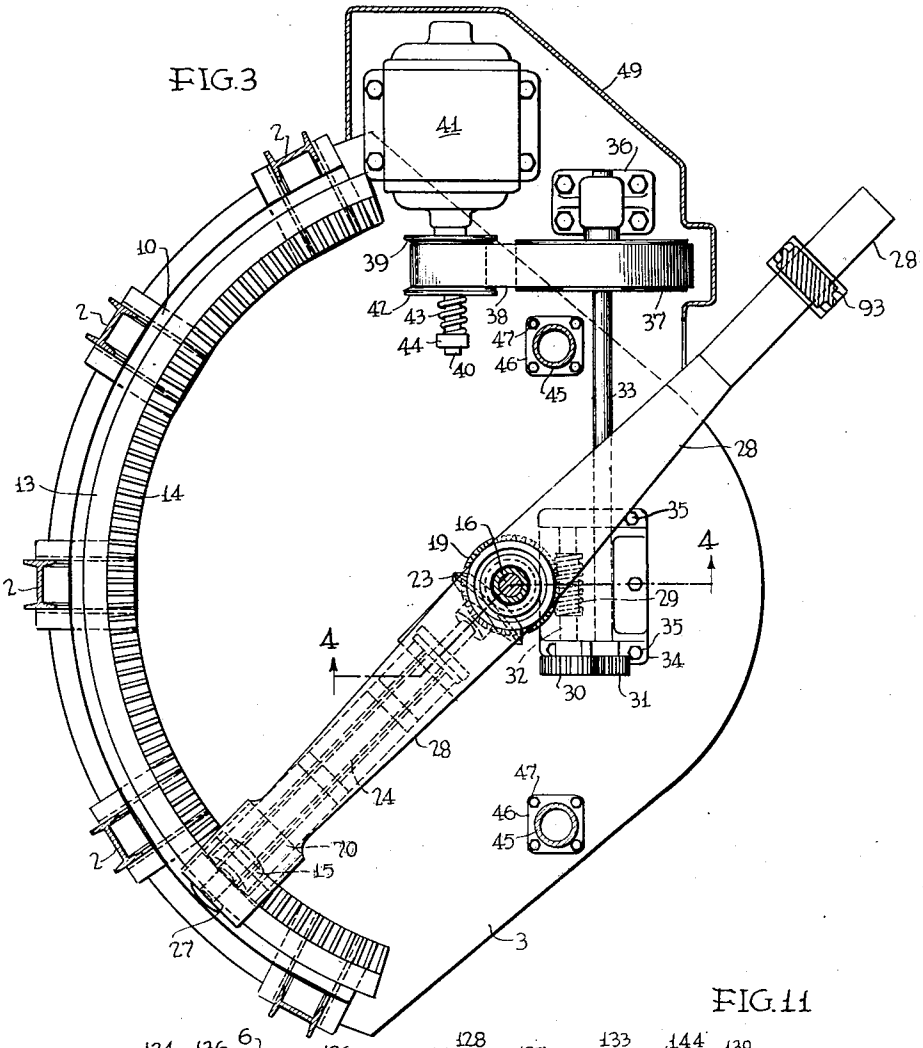
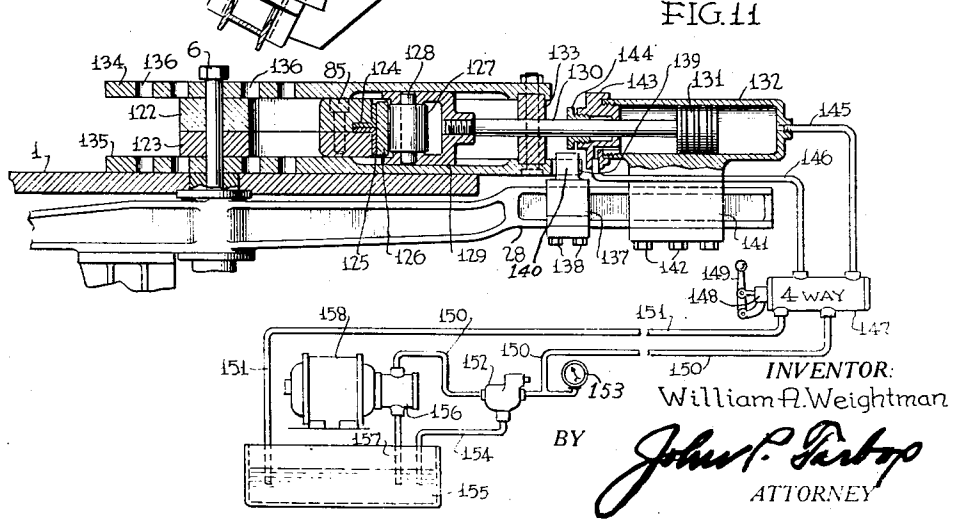


FIG.11



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MACHINE FOR BENDING METAL

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FIG. 4.

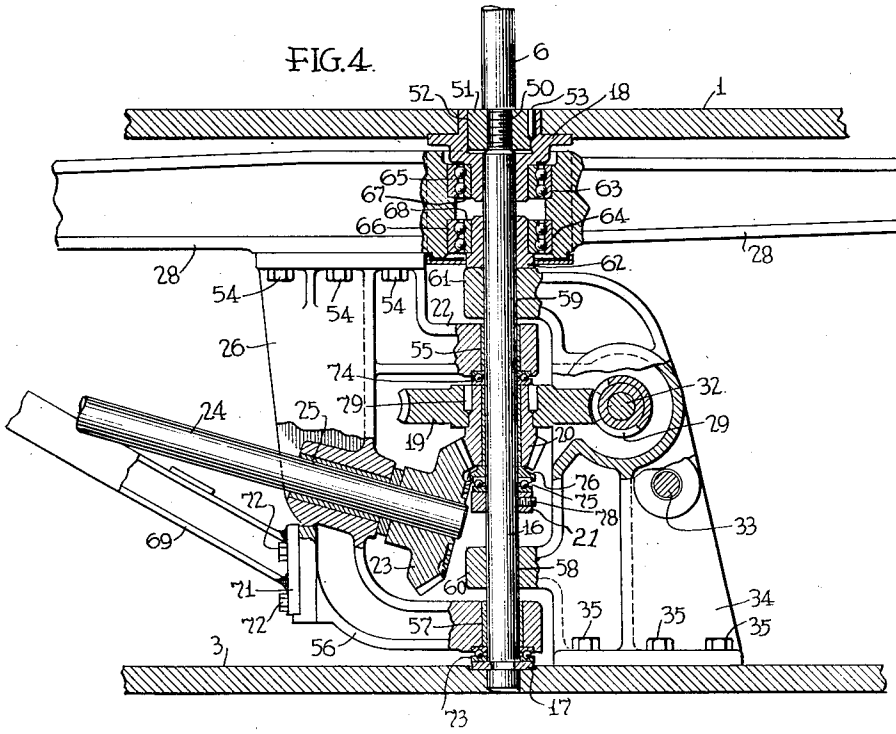
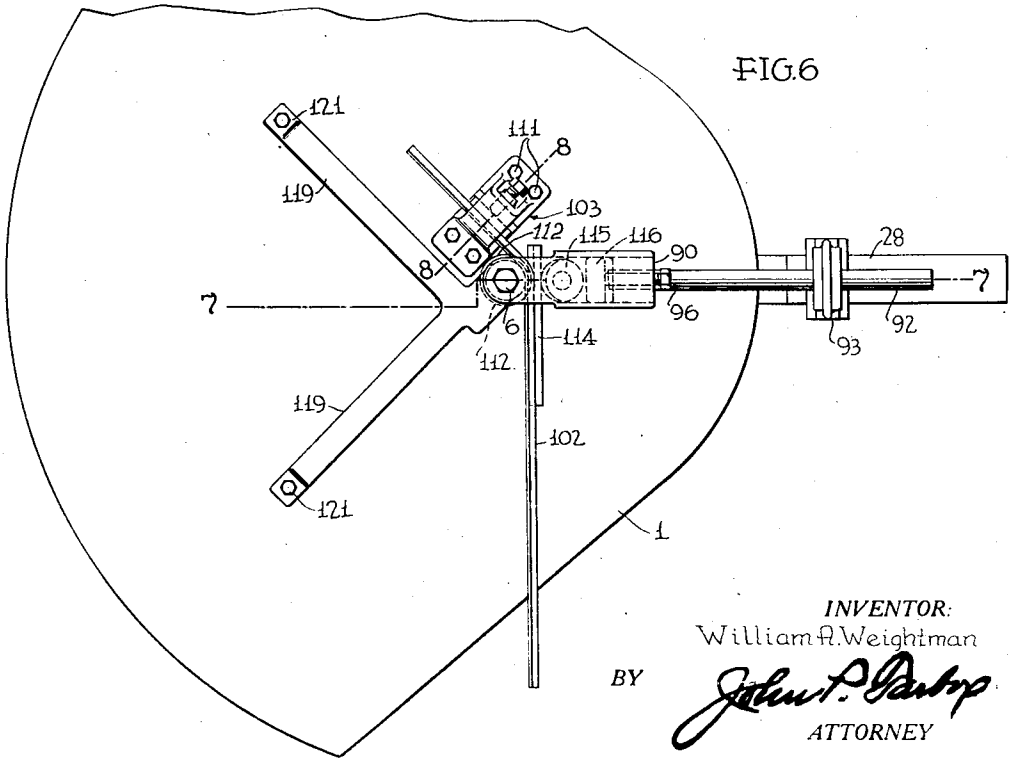


FIG. 6



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Patented June 6, 1944. 2,350,379

UNITED STATES PATENT OFFICE

2,350,379

MACHINE FOR BENDING METAL

William A. Weightman, Philadelphia, Pa., assignor to Edward G. Budd Mfg. Company, Philadelphia, Pa., a corporation of Pennsylvania

Application March 31, 1939, Serial No. 265,161

14 Claims. (Cl. 153—46)

The present invention relates to a machine primarily intended for the purpose of bending metal or the like.

More specifically, it relates to a machine, which is preferably but not necessarily driven by power, for bending metallic or other articles into definite shapes which are predetermined by the machine itself in cooperation with the tools used therewith.

The machine is capable of doing a great variety of bending work and is particularly useful in bending corrugated metal in a direction at an angle to the general longitudinal direction of the corrugations, specifically in producing an approximately cylindrical surface, whose elements are at right angles to the direction of the corrugations. The word "cylindrical" is used here in its broad mathematical sense to mean a curved surface generated by a line constantly intersecting a given curve, not necessarily circular, said line or element remaining always parallel to itself. It should, however, be noted that the machine is not restricted to cylindrical surfaces even of this very general type, but may produce conical surfaces and even warped surfaces, these surfaces being predetermined by the tools applied to the machine.

More specifically, the machine comprises a base and a table top, said base being supported in any suitable way, for example, by placing it on a floor or on the ground, and the table top being spaced a given distance thereabove by supports which are preferably inclined so as to diverge outwardly beyond the base, the table top thus being somewhat larger than the base so as to provide ample toe room for the operative or operatives, thereby enabling them to stand closely adjacent the table without discomfort or strained positions.

At the center of the table a suitable socket or the like is provided to hold a vertical stud or pin which cooperates with the internal bending die. A forked member has its tines pivoted on said pin and carries a cooperating bending die or member so that when the forked member pivots about said pin it will cause the workpiece to be bent about the internal die. An arm or lever pivoted below the table top and extending beyond the rear edge of said table, carries means for pivotally moving the forked member around the pin, and the lever itself is driven by hand or preferably by a suitable motor, where necessary through appropriate reduction gearing.

The invention will be understood clearly from the following specification descriptive of embodiments thereof, particularly upon referring to the accompanying drawings, wherein:

Fig. 1 is a plan view of the machine,

Fig. 2 is a section through the machine shown in Fig. 1 on the plane indicated by the line 2—2, looking in the direction of the arrows, the gearing being shown in elevation,

Fig. 3 is a partly sectional plan view of the mechanism beneath the table, the section being made on the plane indicated by the broken line 3—3 of Fig. 2,

Fig. 4 is a fragmentary vertical section of a portion of the machine on a larger scale, the section being made on the plane indicated by the broken line 4—4 of Fig. 3, certain portions being shown in elevation,

Fig. 5 is a fragmentary section, on about the scale of Figure 4, through a bending tool on the plane indicated by the line 5—5 of Fig. 1,

Fig. 6 is a plan view, partly broken away, showing the machine in use for bending corrugated sheet metal,

Fig. 7 is a vertical section on a larger scale than Figure 6, partly broken away and partly in elevation, the section being made on the planes indicated by the broken line 7—7 of Fig. 6,

Fig. 8 is a partly sectional vertical elevation of a means for clamping the workpiece, the section being made on the plane indicated by the line 8—8 of Fig. 6, on about the scale of Figure 7,

Fig. 9 is a fragmentary sectional view similar to part of Figure 7 but on a larger scale, showing a portion of the die and of a cooperating bar-shaped tool with a workpiece being shaped between them,

Fig. 10 is a fragmentary plan view of a machine showing a special bending die attached thereto designed particularly for bending "angle irons" and the like, without causing the flanges to warp, this machine having a hydraulic cylinder for operating the outer bending member, and

Fig. 11 is a partly diagrammatic view showing a section of the mechanism shown in Fig. 10, on the plane indicated by the line 11—11 with a hydraulic pump and control valve attached thereto.

In all the figures like parts are indicated by the same reference character.

Referring first to Figs. 1, 2, 3, and 4 the table 1, which in the illustrated embodiment is bounded by two circular arcs of very different radii and two straight lines, this being a convenient form for general use, is supported by means of the

inclined struts or columns 2 here shown as I-beams, any suitable number of which may be employed, five being specifically illustrated. The base plate 3 upon which the struts 2 rest is in general of the same shape and size as the table top 1 at the rear and sides, but is of smaller radius at the front so that the front edge 4 of the base is set back with respect to the corresponding front edge 5 of the table so that it is possible for operatives to stand very closely against the edge 5 of the table top, while placing their feet below said table top, thus giving them more comfortable positions and a greater feeling of security and firmness, thereby enabling them to concentrate their attention on the workpiece instead of on securing a good foothold as might otherwise be the case.

It will be noted that the table top has its front surface 5 formed as a circular arc of approximately 120° extent with its center at the pivot pin 6 while the rear edge 7 of the table top, approximately a quadrant, also has its center at the same point 6 but is of much shorter radius. By thus shaping the table top a large free space is available to the left of the pivot 6, where it is desirable to have plenty of room to handle large articles, certain portions of which are to be subjected to the bending action of the machine. Inasmuch as the machine may be made of large enough size to handle very heavy objects, which might require the cooperation of several workmen to support them properly in placing them on the machine and again removing them, it will be seen that this large front surface of the table provides ample facilities for such handling of heavy and bulky work and ample room for the workmen.

The struts 2 may, of course, be secured to the base 3 and top 1 in any suitable manner. In the present case flanges 8 and 9 have been illustrated for this purpose and these flanges may be secured to struts 2 in any desired way common in the art as by riveting, bolting, welding, etc. An arcuate-annular member 10 may be supported in a substantially horizontal plane upon another set of flanges 11 carried by the struts 2 and by a series of vertical supports 12 so as to provide a firm foundation for the said annular arcuate member.

Upon this member 10 may be mounted an arcuate rack member 13 having suitable teeth 14. Strictly speaking these teeth should be teeth such as would be used upon a bevel gear having its center lying in the axis of the pin 6 but in practice ordinary rack teeth set at the proper angle to the horizontal may often be found satisfactory. A pinion 15 cooperates with the rack 13 and this likewise strictly speaking should be a bevel pinion, but in practice because of the relatively large radius of the rack, may be a spur gear. A stationary shaft 16 supported in the base 3 at 17 in any suitable manner and secured against shifting by means of a suitable flanged support 18 secured to the table 1 may serve as the support for various elements which will now be described.

A worm wheel 19 having a bevel pinion 20 secured thereto or integral therewith is mounted for rotation about the shaft 16 and is held in proper vertical position between the collar 21 and the arm 22 of a support 26 so that the bevel pinion 20 will mesh properly with the bevel gear 23 carried by the shaft 24 upon which the pinion 15 is secured. The shaft 24 is journaled at one end in a suitable bearing 25 in the support 26 and at the other end the shaft 24 is journaled in a bearing 27 carried by one end of an arm 28 which is pivoted about the shaft 16.

A worm 29 secured to the gear 30, meshes with the worm wheel 19 and the gear 30 meshes with the cooperating gear 31, the worm being mounted upon the shaft 32 while the gear 31 is mounted upon the shaft 33. Both ends of the shaft 32 and one end of the shaft 33 are journaled in suitable bearings in the bracket 34 which may be secured to the base 3 in any desired manner, for example by means of the cap screws or bolts 35.

The shaft 33 has its remaining end journalled in a pedestal 36 and carries near this end a suitable pulley 37 which is connected by means of the belt 38 to the drive pulley 39 mounted on the shaft 40 of the motor 41. Other drive means may of course be substituted, if preferred. The pulley 39 is here shown as of the longitudinally expansible type wherein the flange 42 cooperates with the spring 43 and the nut 44 to maintain the proper tension of the belt 38.

While the struts 2 afford sufficient support for the front end of the table top 1 it is desirable to provide additional support for the rearward portion of the table and this may be readily accomplished by the tubular columns 45 secured to the base 3 by means of their flanges 46 and the bolts 47, these posts or columns being secured at their upper ends to the table top 1 as indicated in dotted lines at 48. A casing 49 may surround the motor and the pulley 37 so as to protect said parts from foreign material and also to prevent accidental contact of a workman with said motor and pulley.

The stud or pin 6 preferably carries threads 50 at its lower end which engage in a suitable bushing 51 fitting within a bore 52 in the flanged supporting member 18 and the bushing 51 may be held against rotation by means of the pin or key 53. In this way it is possible to provide pins or studs 6 of different lengths and diameters and to replace them as well as the bushings whenever it becomes desirable to do so, thus making it possible to provide bushings having various sizes of screw threads therein to accommodate pins of different sizes, etc.

Referring now more particularly to Fig. 4 it will be seen that the arm 28 carries the support 26 already mentioned, which may be secured thereto in any desired way, for example by means of the cap screws 54. The arm 22 extending from the support 26 may have a suitable bushing 55, serving as a bearing for the central shaft 16 and the other arm 56 may likewise have a bushing 57 therein also cooperating with the shaft 16.

It will be clear that the bracket 34 also affords support to the shaft 16, which passes through the bores 58 and 59 formed in the lateral arms 60 and 61 extending from said bracket 34 and inasmuch as the shaft 16 does not rotate no bushings or other bearings are necessary here. The arm 61 also provides support for a bushing 62 which cooperates with the flanged support 18 to provide a mounting for the lever 28. This lever may have a more massive portion near its pivot, suitably bored as shown at 63 and 64 to receive the outer rings 65 and 66 of a pair of ball bearings, whose inner rings 67 and 68 are mounted upon the flanged member 18 and the bushing 62 respectively so that the lever 28 may be firmly supported and yet be free to rotate easily about the axis of the shaft 16.

A suitable strut 69 here shown as a pair of interconnected channel section members serves to provide a rigid support for one end of the

lever 28, to which is secured the flange 70 provided at one end of the structure 69, while the other end of the said structure has a flange 71 which may be secured to the arm 56 of the bracket 26 in any suitable way, as by the cap screws 72. This strut 69 will prevent any upward yield of the end of the lever 28 adjacent the pinion 15 when considerable power is being applied to such pinion, and thus it will also serve to keep the pinion 15 in mesh with its arcuate rack 13.

Thus when the shaft 40 of the motor 41 turns, it will transmit rotation through the belt 38 to the pulley 37 then through the shaft 33 to the gear 31, then to the gear 30 and the worm 29 which will cause the worm wheel 19 to rotate about the shaft 16, thereby turning the bevel pinion 20 which in turn rotates the bevel gear 23 as well as the pinion 15 secured to its shaft 24. It is clear that when the pinion 15 turns it must move along the arcuate rack 13 because the said rack is stationary and therefore the only motion possible is that of the bearing which supports the shaft 24. Since this is attached to the lever 28 it is clear that operation of the motor 41 will cause the lever 28 to rotate about the axis of the shaft 16. Because of the tremendous speed reduction ratio produced by the gearing described, it will be clear that a very great turning moment will be exerted by the lever 28 in its rotation so that it will have ample power to perform the bending operations dependent thereon.

In order to minimize friction as far as conveniently possible ball thrust bearings are preferably provided around the stationary shaft 16, one of them being located between the plate 17 and the arm 56, and designated as a whole by reference character 73, another being located between the arm 22 and the top of the worm wheel 19, this ball bearing being designated by reference character 74, and finally a third ball bearing 75 located below the bevel pinion 20.

This ball bearing 75 is positioned between two collars, the upper one 76 being interposed directly between the bottom of the bevel pinion and the top of the ball bearing while the lower one 21 is secured to the shaft 16 in any suitable way, for example by means of the diagrammatically shown set screw 78. Suitable keys 79 may be provided to secure the worm wheel 19 to the hub of the bevel pinion 20, as shown.

A form or bending die is secured to the table 1 in any suitable way. Reference to Figs. 1, 2 and 5 discloses a bending die of quadrant shape designated by reference characters 80 and 81. In the form shown this is supported somewhat above the table level by suitable raising strips 82. It will be noted that the bending die is made of two parts 80 and 81, which are substantially alike except that the upper portion 80 has an arcuate groove 86 therein for a purpose which will be described hereinafter. The two parts 80 and 81 are separable from one another and are held together in any suitable way for example by means of the screws 83. The lower member 81 may be secured to the table 1 by screws 84 passing through the spacing strips 82 and threaded into the table top 1.

A bifurcated bending yoke having the upper arm 87 and the lower arm 88 is pivotally held on the stub shaft or pin 6 which passes through a selected one of the series of holes 89 in said yoke arms so as to bring the outer end 90 of the yoke into proper position to cooperate with the bending die 80 and 81, in other words, the yoke arms permit the end 90 of the yoke to be adjusted radially with respect to the shaft or stud 6 about which the yoke is pivoted. The yoke end 90 has a suitable bore therein at 91 to receive an operating rod 92 which preferably fits easily therein, said rod 92 also passing through a yoke 93 which is securable to the movable arm 28 in any suitable way, for example by means of the plate 94 and cap screws 95.

The yoke end 90 carries adjusting screws or set screws 96 the inner ends of which bear against the U-shaped carriage 97 which has mounted therein a shaft 98 carrying the rotatable roll 99 which bears against the bending bar 100. This bar 100 which is here shown straight, bears against the outer portion of the workpiece 101 and conveys the bending stress thereto so that when the yoke is rotated about its pivot 6 the roller 99 bearing against the bar 100 will cause the workpiece 101 to be bent against the bending dies 80 and 81.

In the example shown in Figs. 1 and 2 the workpiece consists of two angle shapes, hereinafter called "angle-irons" (without necessarily implying that they are made of iron or steel however), which are lightly welded together on their mutually contacting flanges to facilitate their bending and subsequent separation. It is well known that it is difficult to bend an angle section because the radially extending flange must thereby be subjected to severe compression in its radially innermost part, which tends to produce twisting and warping because of the non-symmetrical shape. This tendency to warping is readily eliminated by forming a symmetrical T-shaped section from the two angle-irons, by temporarily securing them together by spot welding or the like, whereupon the members are again separated after they have been bent, by breaking the welds.

The size of the arcuate groove or channel 86 is of course chosen so as to cooperate properly with the double thickness of the arms of the angle-irons so as to force the doubled flange to assume precisely the desired position while being bent. Since this bending usually will result in wedging the angle-irons tightly into the groove 86 it is advantageous to provide for separating the bending dies 80 and 81, to facilitate removing the bent workpiece. For this purpose it is necessary merely to loosen the screws 83.

The above description applies to bends which follow approximately circular paths. It is clear that where the bend is other than circular the roller 99 would have to move in and out radially during the bending and for this purpose another form of bending mechanism has been devised and will be described later. The bar 100 which rests against the workpiece does not slide on the workpiece and, therefore, said workpiece does not become disfigured in any way during the bending operation. The roll 99 also minimizes the friction on the said bar 100 and decreases the power required to operate the machine.

Figures 6 to 9 show the machine set up to make bends of relatively short radius in relatively wide material and is particularly useful for bending corrugated metal as indicated at 102, although it may also be used for rods and tubes.

The chief difference between bending rods and tubes and bending corrugated metal is of course in the necessary height of the inner guide or bending guide.

A clamping device indicated as a whole by reference character 103 is secured to the table 1 and

this may be made as shown in Fig. 8. A suitable bracket or yoke 104 having formed therein projections 105, corresponding to the corrugations of the workpiece, has a clamping member 106 also having projections thereon spaced alternately with the projections 105 so that the workpiece 102 will fit between members 104 and 106. The opposite side of the yoke 107 is preferably ribbed, as shown, for stiffness and has screws 108 threaded through suitable bosses 109, so that upon tightening the screws 108 the clamping member 106 will secure the workpiece 102 against the upright 104. The bracket 103 has a flange 110 at its lower end which may be suitably clamped to the table 1, as by the screws 111. This whole device, therefore, constitutes a vise or holding means which will securely clamp the corrugated metal 102 without bending it out of shape or mutilating it in any way.

The inner bending die 112 shown in Fig. 7 consists of a circumferentially grooved cylindrical member, the grooves of which fit the corrugations of the workpiece 102. It is clear that when a piece of corrugated metal is bent, particularly about an inner bending die having a relatively small radius, there is a surplus of material at the portions of smallest radius and this material must be disposed of in order to prevent warping, tearing, or incorrect shaping of the bend.

This function is accomplished in a novel and extremely successful way by providing additional raised projections 113 at the centers of the grooves in the die 112 and, of course, corresponding grooves in the bending bar 114 which rests against the outer side of the corrugated metal, so that additional small corrugations are produced in the corrugated metal throughout the extent of the bend. The bar 114 is of course shaped properly to receive the corrugated metal workpiece between it and the die 112 and it will be understood that the supplemental relatively narrow corrugations produced by the ribs 113 serve to take up the surplus material at the innermost parts of the bend to prevent tearing, warping, etc.

A roll 115 rotatably held in the U-shaped member 116 by means of the shaft or pin 117 bears against the outside of the bending bar 114 in the same way that the roll 99 cooperates with the bar 100 in the Fig. 1 form of device. The bifurcated bending yoke again consists of the arms 87 and 88 pivoted about the pin or shaft 6 and moved about said pivot by means of the operating rod 92, passing through the yoke 93 secured to the arm 28 and the said roller 115 is adjusted in a radial direction by the screws 96 to conform to the material being bent.

Reference to Fig. 9 will show more clearly the relative shapes of the bending die 112 and the bar 114 with the workpiece 102 between them, the supplemental corrugating ribs being shown at 113 and the corresponding grooves in the bar being indicated at 118. It will be clear that considerable strains must be supported by the upper or remote end of the pivot shaft 6 and in order to brace the said upper end thereof suitable angularly arranged struts 119 may be provided. These in the form illustrated consist merely of a single piece having two arms 119 arranged at an angle to one another and having a bore 120 at one end to receive the pin 6, while the lower end of each bar 119 is secured to the table 1 by a screw or bolt 121. It will be noted that the arms 119 extend toward the front of the table and thus are kept out of the way of the workpiece and of the tool for bending the same.

When the workpiece is to be bent into a curve which is not a circle or a circular arc, that is, where the radius of curvature varies, it is clear that provision must be made for moving the outer bending die or follower radially in or out in conformity with the shape of the inner bending die.

Reference to Figs. 10 and 11 shows one way in which this may be accomplished, namely, by means of a hydraulic cylinder or the like. Here it will be noted that the inner bending die is composed of two parts having similar configurations, namely, the upper part 122 and the lower one 123 which are held together detachably by any suitable means such as the screws 85. The member 122 has an arcuate groove as shown at 124 to receive the doubled flange of the two angle-shapes which are welded together detachably like the workpiece 101 already described, and which are designated jointly by the reference character 125.

A bar 126 bears against the remaining oppositely extending flanges of the workpiece 125 and a roll 127 pivotally mounted on the shaft 128 held in the forked or U-shaped yoke member 129 bears against the outer face of the bar 126 so as to force it against the workpiece 125 during the bending operation. The yoke 129 is attached in any suitable way to the piston rod 130 which is connected at its other end to a piston 131 moving in a hydraulic cylinder 132 whereby hydraulic pressure may be applied to the piston and thus to the bar 126 so as to keep the said bar always forced tightly against the workpiece 125.

The piston rod 130 moves freely through the yoke 133 which has the upper arm 134 and the lower arm 135 attached thereto, said arms having suitable holes 136 through which the pin 6 may extend to serve as a pivot. The lower arm 135 is secured to the power arm 28 by means of the member 137 which is adjustable along the arm 28 and securable thereto by means of the cap screws 138. A projection 139 on the outer end of the arm 135 may engage with a suitably loose fit in a bore provided in the upwardly projecting yoke 140 of the member 137 so that upon rotation of the lever arm 28 the arms 135 and 134 will also rotate and binding will be prevented by reason of the looseness of said fit.

The hydraulic cylinder 132 is likewise secured adjustably to the arm 28 by means of the slidable support or carriage 141 which is securable by the screws 142. The hydraulic cylinder may have a suitable inner head 143 with the customary packing nut 144, and the pressure fluid is admitted to or discharged from the respective ends of the cylinder through the conduits 145 and 146 respectively. A suitable four-way valve 147 having a control plunger 148 with operating means 149 is provided to connect either the conduit 145 or the conduit 146 to the pressure conduit 150, while at the same time automatically connecting the other said conduit to the exhaust pipe 151.

A pressure regulating valve 152 may be inserted in the conduit 150 and a pressure gage 153 will conveniently indicate the pressure existing in the conduit 150. A return or waste pipe from the pressure regulating valve is shown at 154 and discharges into the liquid supply container 155. The pressure is produced by the pump 156 having an intake conduit 157 leading into the container 155, and the said pump is

preferably driven by any suitable device, such as a motor 158.

While several specific forms of the device have been disclosed it will of course be understood that these are given purely by way of illustration and not in any limiting sense.

It is believed that the operation of the device will be understood from the description of the structure, however, it may be briefly summarized as follows:

Referring first to the form illustrated in Figs. 1 to 5, the workpiece 101 will be placed on the table 1 and the doubled flanges will be started in the groove between the inner bending dies 80 and 81, which may be accomplished in certain cases after the members 80 and 81 are in place, or in other cases may require the loosening of the screws 83 and their subsequent re-tightening. In either event, after the end of the workpiece or the end of the portion thereof which is to be bent is secured firmly, the motor 41 is put into operation whereupon the power arm 28 will turn about its pivot, in line with the pin 6, carrying with it the yoke which holds the roller 99, which has previously been adjusted into sufficiently close contact with the outer face of the bar 100 so that during the progressive rotation of the arm 28 the workpiece 101 will be forced into contact with the inner bending die 80 and 81, the motion continuing until the necessary bend has been imparted to said member, or if the angle of the bend exceeds the capacity of the bending die (approximately one quadrant as shown) the machine may be stopped, and the arm 28 returned to the starting position, the workpiece 101 unclamped and resecured in a new position whereupon the bending may continue through the second quadrant if desired, and so on until substantially an entire circle has been formed if necessary.

In certain cases it may be possible to continue the bending even beyond a complete circle, if the material 101 is sufficiently thin and pliable to permit it to be bent slightly upward from the table top 1 so that its initial end will not interfere with the bending of the second circle, and so on, resulting in a helix being formed. Such helix may, of course, be subsequently cut into arcuate pieces of the desired length. After the two angle-sections have been bent jointly they may be detached from one another by breaking or cutting the temporary spot welds between their radial flanges.

When corrugated metal is to be bent the machine is arranged as shown in Figs. 6 to 9. The corrugated metal workpiece 102 is suitably clamped in the end clamp or vise 103 so as to maintain its end portion rigidly held to the table and thereupon the yoke carrying the roller 115 is adjusted to the proper position to force the bending bar 114 against the outer surface of the workpiece 102, the inner surface being engaged against the grooved inner bending die 112. When the bending arm 28 is set into rotation by the motor 41 and intermediate mechanism the roller 115 will maintain the bar 114 in close contact with the outer surface of the workpiece while the lever 28 is turning, the result being that a bend of the desired extent and nature is imparted to the workpiece and furthermore additional small corrugations are formed at the location of the bend by means of the ridges 113 on the inner bending die 112 for the purpose of taking up the surplus metal as already mentioned. This, moreover, gives an ornamental and workmanlike appearance to the bend and very satisfactorily solves the problem of accommodating the excess metal at the interior of the bend which would otherwise cause difficulty because of lack of accommodation for the same and might produce wrinkled, folded, or torn bends.

By securing the vise 103 at a new location on the table top it is, of course, possible to continue the bending beyond its original extent so that even hairpin bends may be made if desired, that is, the far end of the corrugated metal may be bent back substantially into parallelism with its intial portion.

Referring now to the set-up shown in Figs. 10 and 11, it is clear that bends other than circular arcs may also be made in any desired material by suitably shaping the inner bending dies 122 and 123, the hydraulic pressure cylinder 132 taking care of the problem of providing adequate but yieldable pressure against the bending bar 126 which forces the workpiece 125 against the shaping surface of the inner bending dies.

It will be understood that the machine is capable of many modifications in order to accommodate the various types of workpieces and that workpieces which are formed as structural shapes or which consist of corrugated metal or plane metal and which are of varying heights and cross-sections, may be successfully bent into a large variety of shapes, since the machine provides ample capacity and power for the most varied range of bending work.

While structural shapes such as angles and T's have been illustrated as well as corrugated shapes, it will be clear that pipes, tubes, rods, half rounds, quarter rounds, etc., may be bent with equal success by providing merely the proper shapes of inner bending dies and outer bending bars to cooperate therewith and that in every instance there is no sliding or rolling of the outer bending member, that is, the roller, against the material itself so that no scratching or scoring of the workpiece will take place, since the roller does not come in contact with the workpiece during the bending operation.

It will be understood that the motor 41 is provided with the usual electrical controls for varying its speeds and direction of rotation and for starting and stopping the same, as well as with the customary electrical safety appliances, but such features are well known in the electrical arts and are not specifically illustrated because they form no part of the present invention.

Certain features as disclosed in the drawings and described in the foregoing specification from the subject matter of applicant's co-pending applications Serial Nos. 489,507 Method and means for bending and 498,508 Method and means for bending corrugated material, both filed on August 13, 1943 as divisions of the present application.

The novel features of the machine and process are defined in the following:

What I claim is:

1. A machine for bending workpieces comprising a source of power, an arm, a table supported adjacent its periphery by standards, the said arm being pivoted for movement about an axis intersecting the said table, an arcuate stationary rack mounted beneath the table on said standards, a pinion engaging the said rack and operatively connected to the arm and to the source of power, a bending die secured to the table, on top thereof, and bending-force applying means

carried by the said arm to cooperate with the bending die in bending the workpiece.

2. A machine for bending workpieces comprising a motor, an arm, a table supported adjacent its periphery by standards, the said arm being pivoted for movement about an axis intersecting the said table, an arcuate rack, stationary with respect to the table and mounted therebeneath inwardly of said standards, a pinion engaging the said rack and operatively connected to the arm, reduction gearing connecting the said pinion to the motor, to be rotated thereby, a bending die secured to the top of the table, and bending-force applying means carried by the said arm to cooperate with the bending die in bending the workpiece.

3. A machine for bending workpieces comprising a motor, an arm, a table supported adjacent its periphery by standards, the said arm being pivoted below the table for movement about an axis intersecting the said table, the arm being entirely below the level of the table top so as not to obstruct the same, an arcuate rack, below the table, within the peripheral margin thereof adjacent said standards and stationary with respect to the table, a pinion engaging the said rack and operatively connected to the arm, reduction gearing connecting the said pinion to the motor, to be rotated thereby, a bending die arranged on top of and secured to the table, and bending-force applying means carried by the said arm to cooperate with the bending die in bending the workpiece.

4. A machine for bending workpieces comprising a source of power, an arm driven thereby, a table, the said arm being pivoted for movement about an axis intersecting the said table, a yoke, an inner bending die secured to the table, a driving member carried by the said arm and having driving engagement with said yoke, pivot means axially in line with the pivot of the arm for rotatably supporting the said yoke above the table, the said yoke having a number of bearings at varying distances from its outer end to receive the said pivot means, whereby to adjust the operative length of the yoke, and a cooperating bending member mounted in the yoke to apply force to bend the workpiece.

5. A machine for bending corrugated metal workpieces comprising a source of power, an arm driven thereby, a table, the said arm being pivotally mounted for movement about an axis intersecting the said table, an inner bending die located above the table and secured to the said table, the said inner die fitting in the corrugations, bending-force applying means carried by the said arm and a workpiece-engaging member, having its inner surface shaped to fit in the corrugations and having substantially no longitudinal movement with respect thereto, anti-frictionally associated with the said means, the workpiece being engaged between the said member and the inner bending die.

6. A machine for bending a corrugated metal workpiece comprising a source of power, an arm driven thereby, a table, the said arm being pivotally mounted for movement about an axis intersecting the said table, means cooperating with the table for securely holding the workpiece against movement while being bent, an inner bending die secured to the said table, the said inner die fitting in the corrugations, bending-force applying means carried by the said arm and a workpiece-engaging member associated with the said means and anti-frictionally engaged thereby, having its inner surface shaped to fit in the corrugations and having substantially no longitudinal movement with respect thereto, the workpiece being engaged for bending between the said member and the inner bending die.

7. A machine for bending workpieces comprising a source of power, an arm driven thereby, a table, the said arm being pivoted for movement about an axis intersecting the said table and being disposed for the most part beneath said table but having one end thereof projecting therebeyond, an inner bending die secured to the table, bending-force applying means, comprising a hydraulic cylinder and piston, carried by and longitudinally adjustable on the projecting end of said arm, and a workpiece-engaging member associated therewith, the workpiece being engaged between the said member and the inner bending die.

8. A machine for bending workpieces, comprising a table, a source of power associated therewith, and an arm for applying the bending force, the said arm being pivoted about an axis intersecting the said table, and driven by the said source of power through means including an arcuate rack fixedly secured beneath the table, the table top having a portion of relatively short radius extending on one side of the said axis beyond which one end of the arm extends and a portion of relatively longer radius extending on the other side thereof and adjacent the margin of which the rack is disposed, thus affording a large free table space on the said one side of the axis to support large workpieces while at the same time providing a sufficiently large table area on the said other side of the said axis for receiving the portion of the workpiece which is to be subjected to the bending action of the machine.

9. In a machine of the kind defined in claim 8, supports for the forward portion of the table, said supports slanting away from the table top as they descend, whereby the table top overhangs the bases of the said supports and affords room for an operative to stand so that he may assume a position close to the front of the table without bending over.

10. A bending machine comprising a flat-topped table, a fixed spindle projecting above the flat top of the table, a bending die comprising two superimposable portions having substantially the same peripheral contour and having at their working margins a deep channel between them to receive a flange of the work, the lower of said die portions being rigidly secured through spacing means to the flat table top, the upper of said die portions being readily removably secured thereto, a yoke pivoted to said spindle and having one arm extending between the lower die portion and the table top, and the other arm extending above the upper die portion, and a cooperating bending member mounted in the yoke to press the work against the working face of the die.

11. A bending machine having a base and a table rigidly secured in spaced relation by standards interconnecting the peripheral portion of the table to the base, a fixed vertical shaft secured at its ends in said base and table, a bracket fixed to said base supporting said shaft intermediate its ends, an arm pivotally mounted to rotate on said shaft through spaced bearings, a gear rotatably mounted on said shaft, a shaft carried by said arm and having at one end a gear meshing with said gear rotatable on the shaft, and at its opposite end a pinion meshing with a

fixed arcuate rack carried by said standards, and power means for driving said gear rotatable on the shaft whereby to swing the arm about its axis, a bending die secured to the top of the table, and opposed bending means cooperative with said bending die, pivoted about the axis of said shaft and connected to be moved by the end of said arm opposite the rack.

12. A bending machine comprising a base and a table to receive the work spaced apart to bring the table to a convenient height, and rigidly interconnected by standards secured to the marginal portion of the table and to the base, a vertical shaft mounted in the base and table, an arm pivoted to rotate about the axis of said shaft and having most of its length disposed beneath the table with one end projecting therebeyond, and means for driving said arm disposed for the most part in the space between said base and table, a fixed bending die secured to the top of the table and a movable bending die rotatably secured to an axis concentric with said shaft and connected to be rotated by the projecting end of said arm.

13. A bending machine comprising a base and a table supported therefrom by spaced standards, a vertical shaft mounted in said table and base, a socket for mounting the shaft in the table, a shaft extension removably secured in said socket, and projecting above the table, a fixed bending die secured to the top of said table in spaced relation thereto, for most of the extent of its working face, a yoke carrying a movable bending die and having arms pivoted to said shaft extension above and below the fixed die.

14. A bending machine comprising a base and a table supported therefrom by spaced standards, a vertical shaft mounted in said table and base and having a part in extension thereof projecting above the table, a fixed bending die secured to the top of the table and spaced therefrom in its major portion, a yoke carrying a movable bending die and having arms pivoted, above and below said fixed die, to said extension projecting above the table, an extension from the yoke parallel to said arms and midway between them, an arm pivoted beneath the table to rotate about the axis of said shaft, one end of said arm having rigidly secured thereto a vertical extension engaging said yoke extension, and means for rotating said arm and through it the yoke.

WILLIAM A. WEIGHTMAN.