Jan. 23, 1962 J. L. WALMSLEY 3,017,915

BEAM BENDING MACHINE

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Fig. 1

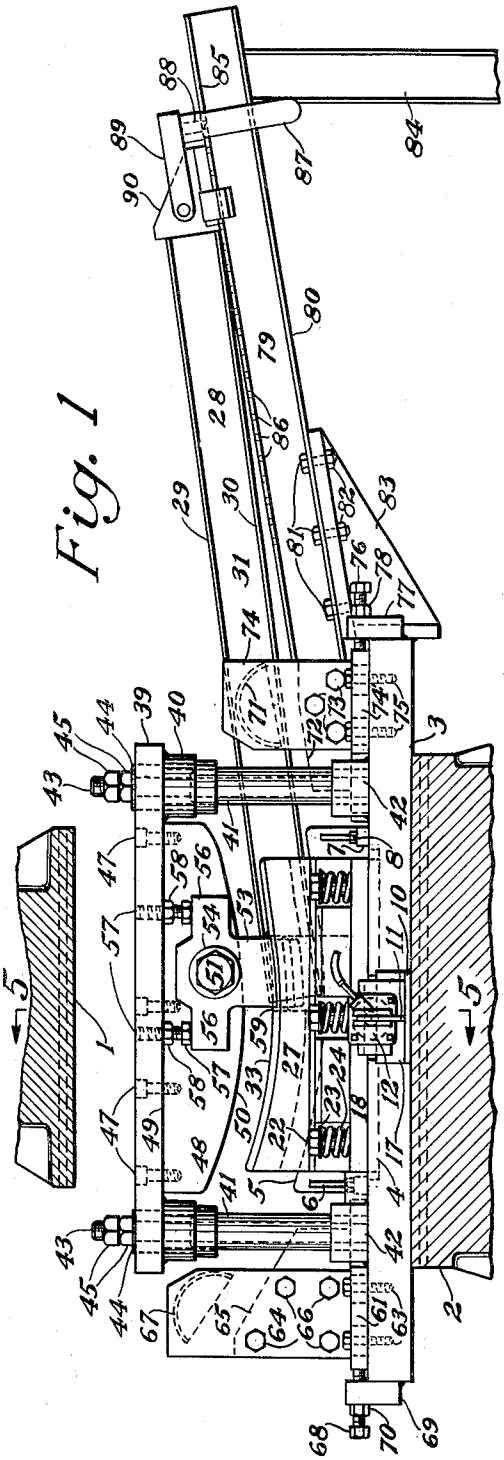
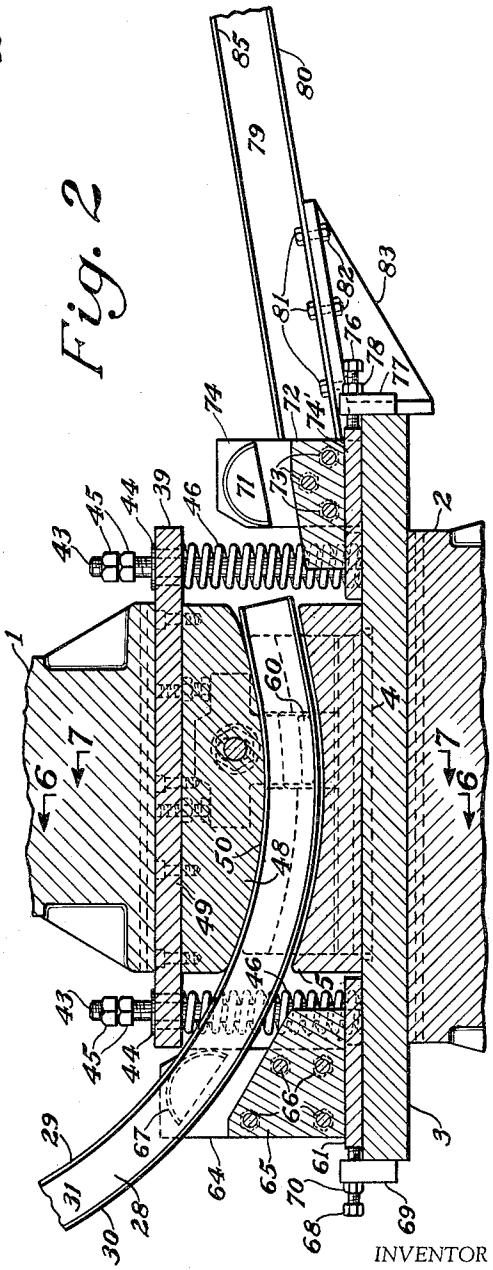


Fig. 2



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Fig. 3

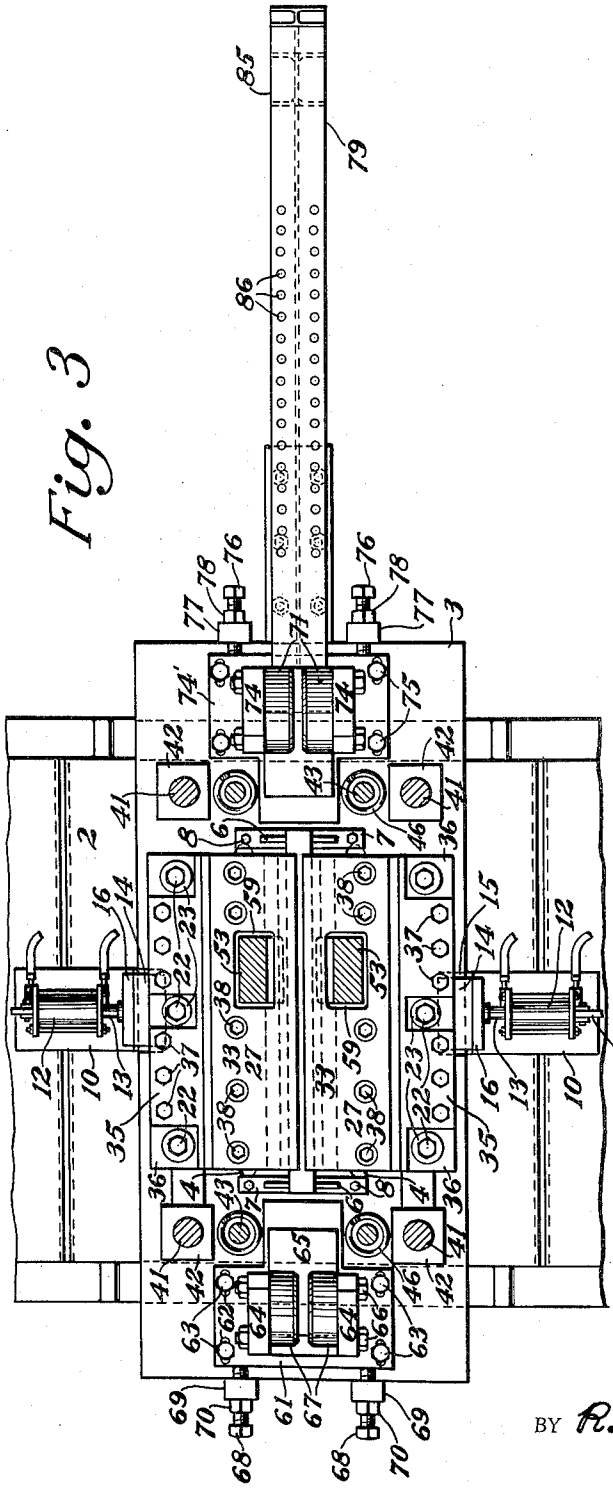
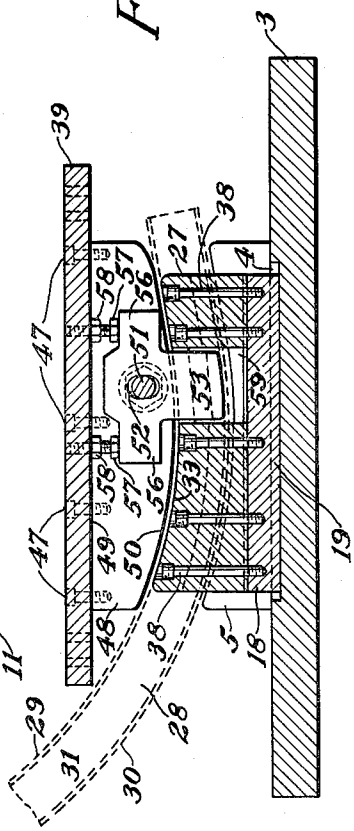


Fig. 4



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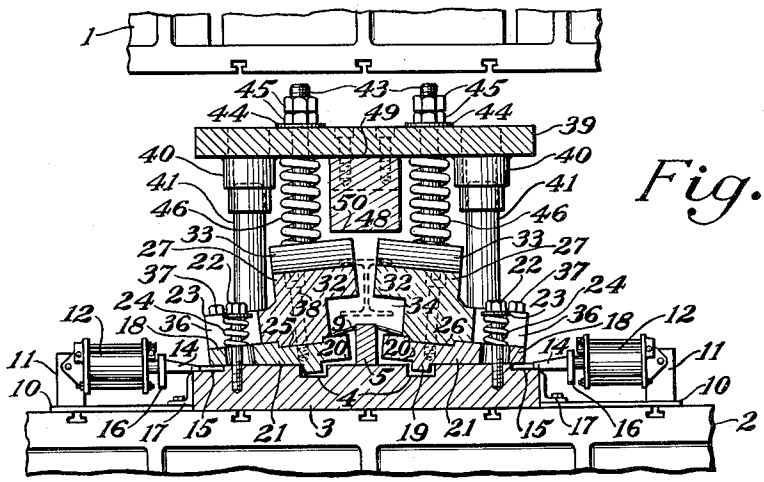


Fig. 5

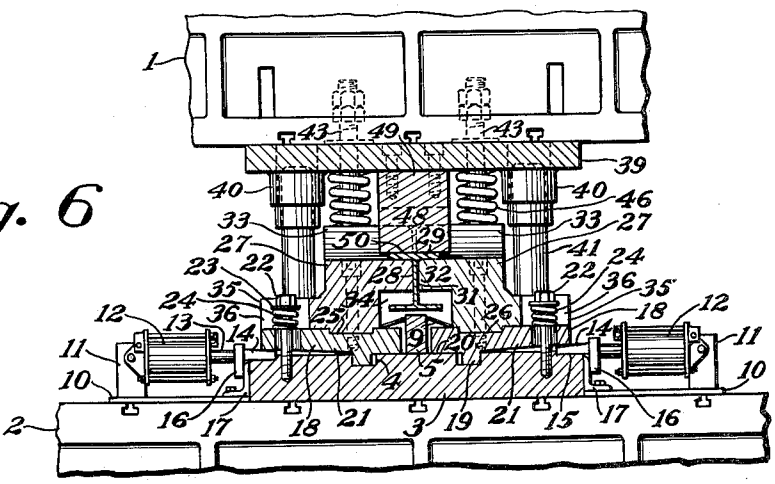


Fig. 6

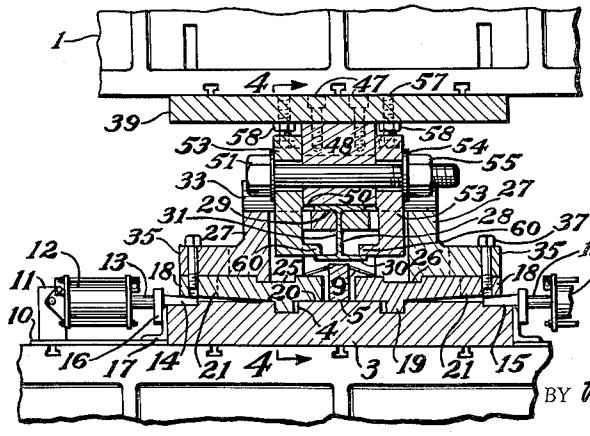


Fig. 7

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3,017,915

BEAM BENDING MACHINE

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9 Claims. (Cl. 153—33)

This invention relates in general to a method and apparatus for forming metal, and more particularly to a method and apparatus for bending rolled structural beams while cold.

The production of structural beam sections curved in the plane of the web for use as arch rings or transversely spanning tunnel rings or the like has been limited heretofore to those cases in which the required radius of curvature was large in comparison with the depth of the section, the exact ratio depending upon the proportions of the particular section, so that compression of the inner flange and stretching of the outer flange were not excessive. In such cases, the desired curvature can usually be imparted by free cold bending without much difficulty, and without special devices to prevent or remove distortion.

Mining companies and tunnel contractors, however, sometimes have need for ribs curved to such small radii that they cannot be produced by free cold bending methods because of the resultant buckling and wrinkling of the inner flange and other unacceptable distortions of the beam. Wide flange beams are particularly difficult to bend satisfactorily under such conditions. Reheating before bending is obviously undesirable because of expense and other considerations.

One object of this invention, therefore, is to provide a method and apparatus for producing on a standard press those sections and curvatures which cannot be successfully formed on a particular structural beam in a free bending operation.

Another object is to provide an apparatus with vertically adjustable means for restraining the outer or tension flange of the beam from curling while it is being bent.

An additional object is to provide means for ironing out buckles in the inner and compression flange or the web of a beam during the final stages of a bending operation.

A further object is to provide a self-contained die-set which can readily be moved and used in any vertical press of adequate capacity and sufficient clearances.

Still other objects, purposes and advantages of the invention will appear hereinafter in the specification and claims, and in the three (3) sheets of drawings herewith.

In the drawings:

FIG. 1 is a side elevation, partly in section, showing the apparatus with the press ram raised, the side wedges free, and the rocking dies in open position prior to their effecting the first stroke on the entering beam;

FIG. 2 is a longitudinal vertical section of the apparatus, showing the formed beam ready to emerge from the exit end of the dies;

FIG. 3 is a horizontal section of the apparatus, looking downward upon the lower dies;

FIG. 4 is a longitudinal vertical section taken on the line 4—4 of FIG. 7;

FIG. 5 is a transverse vertical section on the line 5—5 of FIG. 1;

FIG. 6 is a transverse vertical section on the line 6—6 of FIG. 2; and

FIG. 7 is a transverse vertical section on the line 7—7 of FIG. 2.

Referring more particularly to the drawings, the reference numeral 1 designates the ram of a vertical press which is actuated by suitable hydraulic or mechanical power means (not shown). Horizontally mounted on a

suitable bed 2 thereunder is a flat die shoe or base plate 3 having on its upper surface a pair of longitudinally extending parallel grooves 4 between which but spaced therefrom is interposed a central longitudinal concave filler block 5 having welded wing plates 6 and hold-down plates 7 secured by bolts 8 at each end. A pair of loose flat strips 9 of light gage metal resting on the die holders 18 in leaning contact with each side of the filler block 5 will serve to intercept any scale or dirt which may fall from the object being formed.

On each side of the base plate 3 at approximately the longitudinal center is a short rectangular plate 10 on which is mounted an upright member 11 horizontally supporting a two-way fluid pressure cylinder 12 connected to any suitable fluid pressure source (not shown). The piston rod 13 of each cylinder terminates in a flat-bottomed horizontal wedge 14 laterally movable into a short shallow lateral recess 15 in the top surface of bed plate 3. A depending short bar 16 on the piston rod will engage an angle bar 17 at the side of the bed plate and thus will provide a stop for the wedge 14 when the latter is fully extended into the recess 15. It may be preferred to omit the fluid pressure actuated wedges 14 in some installations.

A pair of die holders 18, each having a longitudinal bottom tongue 19 somewhat narrower than the groove 4 in which it is engaged, are supported on the base plate 3 on opposite sides of the filler block 5. To accommodate various thicknesses of web 31, thin metal shims (not shown) may be inserted in each groove 4 if needed. The bottom surfaces of said die holders 18 are flat on their inner portions as at 20 and upwardly beveled on their outer portions as at 21 to permit said die holders 18 to be rocked or tilted toward each other by the inward movement of the wedges 14 in recesses 15 thereunder. Hold-down bolts 22 having washers 23 and compression springs 24 yieldingly engaging the outer edges of the die holders 18 are threaded into the top face of the base plate 3.

The upper surface of each die holder 18 is provided with a longitudinal recess 25 into which is interfitted a bottom shoulder 26 on each one of a pair of female forming dies 27 which will coact in shaping an I-beam 28 having conventional top flange 29 and bottom flange 30 connected by web 31. Each of said dies 27 has an inwardly projecting upper portion 32 having a concave upper face 33 of the required curvature for supporting the top flange 29 and engaging the upper portion of the web 31 upon the inward tilting of the die holders 18. In cases where the work-piece 28 is what is conventionally known as a sloping flange beam, the inner surfaces of the flanges 29 and 30 of said work-piece 28 are not parallel to the outer surfaces of said flanges but have a small slope thereto when viewed in transverse section. In such cases, the upper surfaces 33 of the dies 27 should be provided with a transverse inward slope to match that of the work-piece. The lower inner portion of each die 27 is recessed as at 34, so that the lower portion of the web 31 and the bottom flange 30 are not engaged by these dies. On the outer lower portion of each die 27 is a side flange 35, cut away as at 36 to allow clearance to the springs 24. Bolts 37 through said flange and countersunk center bolts 38 will securely fasten said dies 27 to their respective die-holders 18.

The upper die set 39 comprises a rectangular flat plate of substantial thickness, having at each corner a depending shoulder bushing 40 which is vertically slidable on one of four guide posts 41 mounted upright in guide blocks 42. Stud bolts 43 having washers 44 and lock nuts 45 on their upper threaded ends are mounted upright on the base plate 3 in inwardly spaced parallel relation to the

guide posts 41 and are encircled by heavy coil springs 46 which yieldingly support the upper die set 39.

Suspended by bolts 47 from the under surface of said die set 39 is the male die or forming punch 48, having a flat upper face 49 and a convex lower face 50 slightly wider than the top flange 29 of the beam and of the required curvature.

A large bolt 51 extends transversely through said forming punch 48 at a point between the longitudinal center and the beam entering end thereof, and through vertically extending oval bolt holes 52 in depending arms 53, thereby permitting a limited range of vertical movement to said arms 53.

The aforementioned arms 53 are suspended on opposite sides of said forming punch 48 by said bolt 51, which is secured by washers 54 and nut 55. Said arms 53 are provided with horizontally extending cross-arms 56 on each side which limit the range of vertical adjustment as determined by the depending set-bolts 57 and lock-nuts 58. The lower ends of said arms 53 project downwardly through rectangular openings 59 in the lower forming dies 27 and bridge the inner or compression (top) flange 29, and terminate in inwardly extending curved fingers 60 which engage the outer or tension (bottom) flange 30 of the beam. The bottom surfaces of said fingers 60 should be long enough to prevent curling along a considerable length of the bottom flange, say 6½ inches or more, or slightly more than each advancement of the beam during bending.

Adjacent the beam exit end of the dies, a flat rectangular slide plate 61 having longitudinally extending oval slots 62 is adjustably secured by through bolts 63 to the base plate 3. Mounted on said slide plate 61 and preferably welded thereto is an inclined spacer block 65 to which a pair of upright plates 64 are fastened on opposite sides by means of bolts 66. A pair of half-round beam support saddles 67 are welded or otherwise secured on the upper inner surfaces of said upright plates 64. To assist in moving the slide plate 61 longitudinally of the device for the slight distance necessary, adjusting screws 68 bearing against said slide plate 61 are threaded into upwardly projecting spaced end bars 69 welded to the base plate 3 and provided with lock nuts 70.

Adjacent the beam entrance end of the dies, a pair of half-round beam support saddles 71 and upright plates 74 on either side of a spacer block 72 and secured thereto by bolts 73 are similarly positioned on a slide plate 74' which is adjustably secured by bolts 75 to the base plate 3. Adjusting screws 76 bearing against the slide plate 74' and threaded into spaced end bars 77 and secured by lock nuts 78, are likewise provided.

Also at the beam entrance end of the above-described apparatus is a downwardly inclined I-beam support 79 having its lower flange 80 attached at one end by bolts 81 and nuts 82 to a connecting bracket 83 on the base plate 3 between the end bars 77 and supported at the outer end by upright beam 84.

The incoming workpiece is slidingly supported on the top flange 85 of said beam 79, upon which it may be advanced into the dies in measured increments determined by a series of uniformly spaced pairs of pinholes 86 in said top flange. A depending handle 87 will bring into holding engagement with said holes 86 a pair of downwardly extending gage pins 88 on an arm 89 pivotally mounted on a slidable bracket member 90.

In operating the press, a good adhesive lubricant of the type designed for use on high pressure bearing surfaces is first applied on the die surfaces which must work in contact with the beam 28 during bending. A stable leaded lubricant such as that sold commercially under the name "Leadolene Type I.P." has proven very satisfactory. The beam 28 is pushed through the dies manually on the filler block 5, being advanced about 6 inches after each stroke of the press, with the support saddles 67 and 71 supporting said beam 28 at one or both ends.

The dies open both horizontally and vertically by spring action when the ram is up, as in FIG. 5. The fluid pressure operated wedges 14 initially cause the lower forming dies 27 to rock into a position in contact with the web 31 of the beam 28 and beneath the upper flange 29 thereof. During the downward movement of the forming punch 48, the said lower forming dies 27 clamp and prevent distortion of the upper portion of the web 31 of the beam 28, the lower portion of the web being left free to stretch, and the curved fingers 60 are brought into engagement with the lower flange 30 of the beam 28. The filler block 5 provides support for the bottom of the beam 28, and effectually opposes the tendency of the upper flange 29 to tear away from the web 31. The inner or compression flange 29 is permitted to buckle under the action of the forming punch 48, and then as the desired radius or bend is reached the buckles are ironed out. This is effected by having the lower surfaces of the compression flange 29 bear against the rocking dies 27 while the forming punch 48 continues its downward movement to perform the ironing. The rocking action of the lower forming dies 27, bringing them to bear against the web as the beam is driven home against them, serves to hold the beam in proper position and also to iron out any small buckles in the web of the beam.

The exact vertical position of the lower flange engaging fingers 60 is preferably adjusted by trial at the beginning of each run. They are not primarily designed to bend the beam, but function principally to restrain the outer or tension flange 30 from curling as bending of the beam takes place.

Although this invention has been shown and described hereinabove in considerable detail, it is not intended to have it narrowly limited thereby, but there may also be used all such modifications, substitutions or equivalents thereof as are embraced within the scope and spirit of the invention or as are pointed out in the appended claims.

I claim:

1. A beam bending apparatus comprising a stationary press bed, a press ram adapted to travel in vertical relation to said bed, a base plate horizontally supported on said press bed, a central longitudinally extending filler block on said base plate, longitudinally extending grooves in the top surface of the base plate in spaced parallel relation to the filler block, a pair of die-holders on the base plate on opposite sides of the filler block, the bottom surface of each die holder being outwardly beveled and having a shoulder engaging in one of the parallel grooves, scale-catching means between the filler block and the die-holders, a lateral upper recess on each side of the base plate, a fluid pressure cylinder adjacent each recess, a wedge movable by the fluid pressure cylinder into the recess beneath the beveled portion of the die holder for tilting the die holder inwardly, resilient means yieldingly holding down the outer edges of the die holders, female die sections mounted on the die holders and having inwardly projecting upper portions for engaging therebetween the upper portion of the web and supporting the top flange of the beam, and an upper die set engageable by the press ram and including a forming punch and a pair of depending fingers, the forming punch engaging the upper surface of the top flange and the depending fingers engaging the upper surface of the bottom flange of the beam during the bending operation while the filler block supports the bottom of the beam.

2. A beam bending apparatus comprising a base plate, a pair of female die sections rockingly mounted on the base plate, said dies having an inwardly projecting upper portion supporting the compression flange of the beam and applying lateral pressure to the adjacent portion of the web of the beam during the bending operation, an upper die set comprising a rectangular flat plate spaced above said female die sections, a depending tubular member at each corner thereof, upright guide posts on the base plate and slidable within said tubular members, upright

threaded members adjacent to the guide posts on the base plate and having lock nuts on their upper ends engaging the die set, resilient means about the threaded members and yieldingly supporting the die set, a male forming punch suspended from the die set, an upright longitudinally extending filler plate mounted on the base plate, said filler plate being of complementary form to the punch and disposed centrally thereunder, a pair of depending arms each having a vertically extending slot, a headed member extending through the punch and each slot, downwardly and inwardly extending curved fingers terminating each depending arm, cross-arms on said depending arms, set bolts in the die set engaging said cross-arms, beam support members at opposite ends of the base plate, and beam gaging and advancing means at the beam entrance end of the base plate.

3. An apparatus for bending a beam having substantially parallel flanges and a connecting web, comprising a base plate, a pair of dies having web-engaging faces and concave upper faces for intially supporting a beam at a pair of spaced points, means for pressing said dies into engagement with the web of a beam, a die having a convex lower surface complementary to the upper faces of said pair of dies, and a pair of depending fingers secured thereto, said surface and said fingers being adapted for simultaneously engaging the outer face of the compression flange and the inner face of the tension flange of a beam, and means for actuating said last-mentioned die.

4. A beam bending apparatus comprising a base plate, a press ram adapted to travel in vertical relation to said base plate, means on said base plate for initially supporting a beam, a pair of female dies rockably mounted on the base plate, means for tilting said dies toward each other, said dies having inwardly projecting portions for engaging the upper portion of the web and finally supporting the top flange of the beam, a forming punch movable by the press ram into engagement with the upper surface of the top flange of the beam, and a pair of fingers depending from the forming punch and bending the bottom flange of the beam while the beam is being pressed against said pair of female dies.

5. A beam bending apparatus comprising a base, a pair of dies thereabove having elongated concave upper surfaces and opposed elongated inner surfaces of lesser depth than the depth of a beam inserted therebetween, means for moving said dies laterally toward each other to engage and support the web of a beam inserted therebetween, a third die having an elongated convex lower surface complementary to the concave surfaces of the pair of dies for engaging the outer side of the compression flange of the beam and having a pair of depending inwardly projecting fingers for engaging the inner face of the tension flange of the beam, means for moving said third die toward said pair of dies to bend the beam by pressure thereon exerted by said third die and said fingers on the flanges of the beam while the web is supported by the inner surfaces of said pair of dies and thereafter to press the compression flange of the beam between the concave upper surfaces of said pair of dies and the convex lower surface of said third die.

6. A beam bending apparatus comprising a base plate, a press ram adapted to travel in vertical relation to said base plate, means on said base plate for supporting a

beam, a pair of die holders mounted on the base plate on opposite sides of the beam-supporting means, the bottom face of each of the die-holders being outwardly beveled, pushing means adjacent each die holder, wedge means insertable by the pushing means beneath the beveled portions of the die-holders for tilting said die-holders inwardly, resilient hold-down means on the outer edges of the die-holders, female die sections supported on the die-holders and having inwardly projecting portions for engaging the upper portion of the web of the beam, a forming punch movable by the press ram into engagement with the upper surface of the top flange of the beam, and a pair of fingers depending from the forming punch and engaging the bottom flange of the beam to bend said flange while the top flange is being bent by said forming punch.

7. A beam bending apparatus comprising a base plate, a pair of female die sections rockingly mounted on the base plate, each die section having an inwardly projecting upper portion applying lateral pressure to the web of the beam during the bending operation, a male forming punch adapted to travel in vertical relation to said base plate, means for applying pressure to said forming punch, means for initially supporting the beam beneath said forming punch, a pair of arms depending from said forming punch, inwardly extending fingers terminating each depending arm, and beam advancing means at the beam entrance end of the base plate.

8. A beam bending apparatus comprising a base plate, a pair of female die sections rockingly mounted on the base plate, each die section having an inwardly projecting upper portion applying lateral pressure to the web of the beam during the bending operation, an upper die set including a male forming punch adapted to travel in vertical relation to said base plate, means for advancing the beam beneath said forming punch, means for guiding the travel of the upper die set and forming punch into engagement against the compression flange of the beam, a pair of arms depending from said forming punch, and inwardly extending fingers depending from said forming punch and engaging the inner surface of the tension flange of the beam during the bending of the supported beam.

9. An apparatus for bending a beam having substantially parallel flanges and a connecting web, comprising a base plate, a pair of dies mounted on said base plate having elongated concave upper faces for initially engaging the inner face of the compression flange of a beam at a pair of spaced points and having web-engaging faces of less depth than the web of the beam, means for pressing said dies into engagement with the web of a beam, a die having an elongated convex lower surface complementary to the upper faces of said pair of dies, and including a pair of depending fingers having elongated convex lower surfaces, said surface and said fingers being adapted for simultaneously engaging the outer face of the compression flange and the inner face of the tension flange of a beam, and means for actuating said last-mentioned die.

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