May 30, 1944. D. KELLEHER 2,350,046

METHOD AND APPARATUS FOR BENDING STRUCTURAL SHAPES

Filed Dec. 4, 1941 3 Sheets-Sheet 1

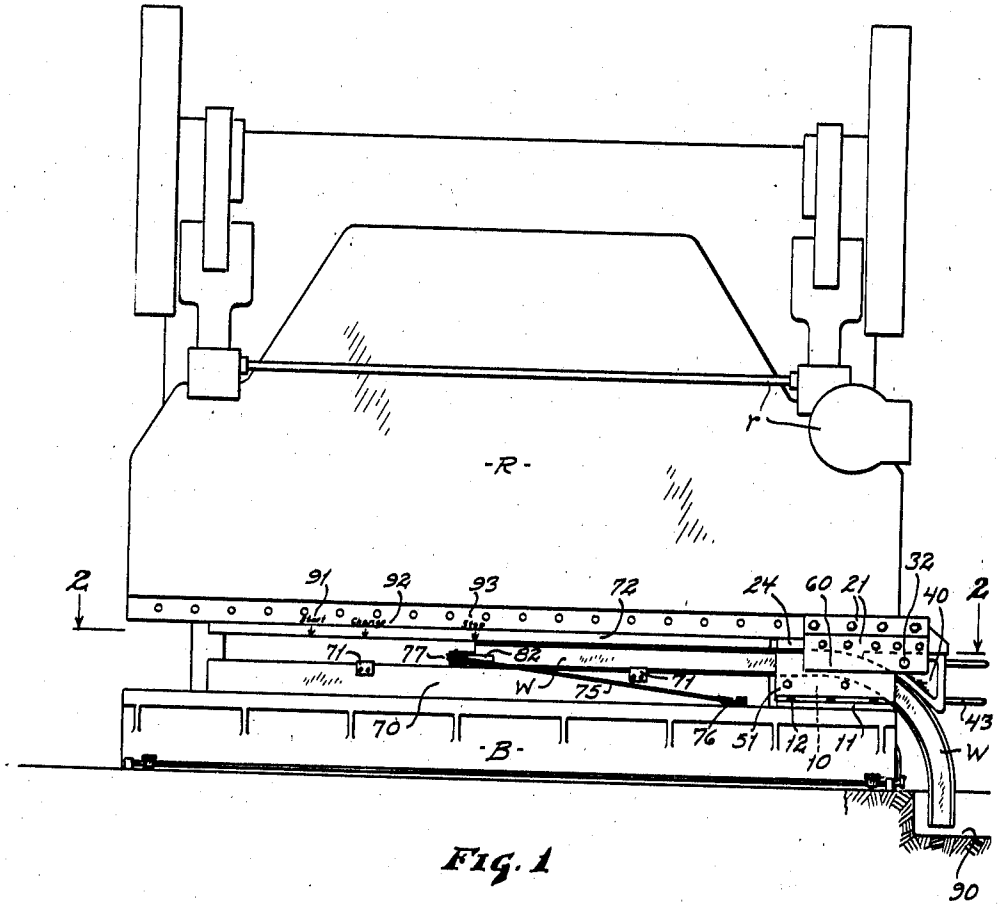


FIG. 1

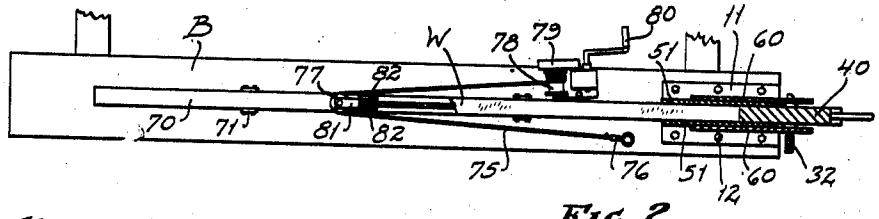


FIG. 2

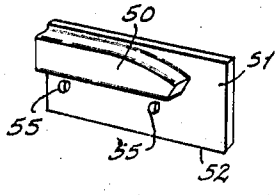


FIG. 3

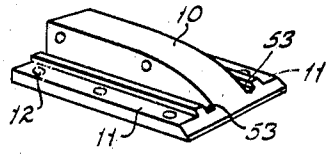


FIG. 4

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METHOD AND APPARATUS FOR BENDING STRUCTURAL SHAPES

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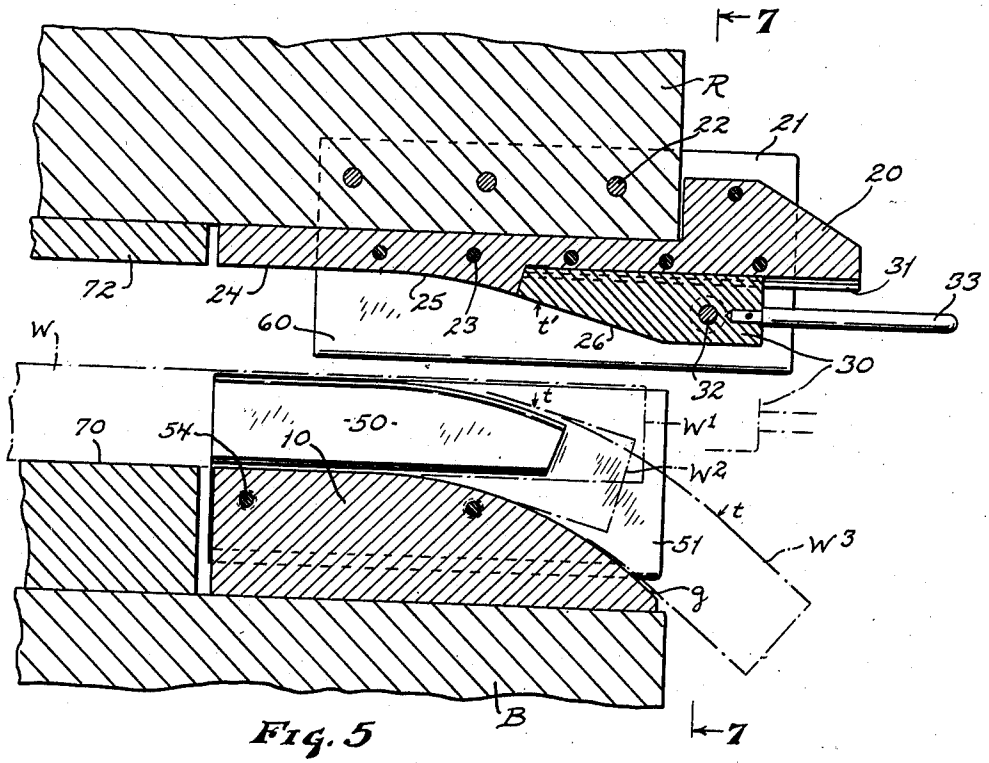


Fig. 5

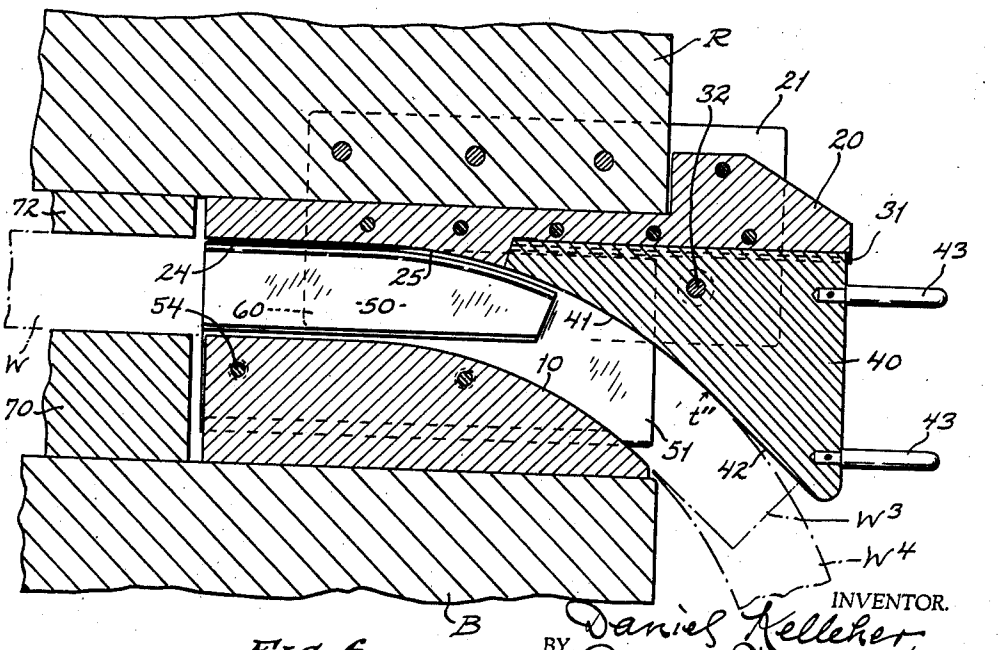


Fig. 6

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METHOD AND APPARATUS FOR BENDING STRUCTURAL SHAPES

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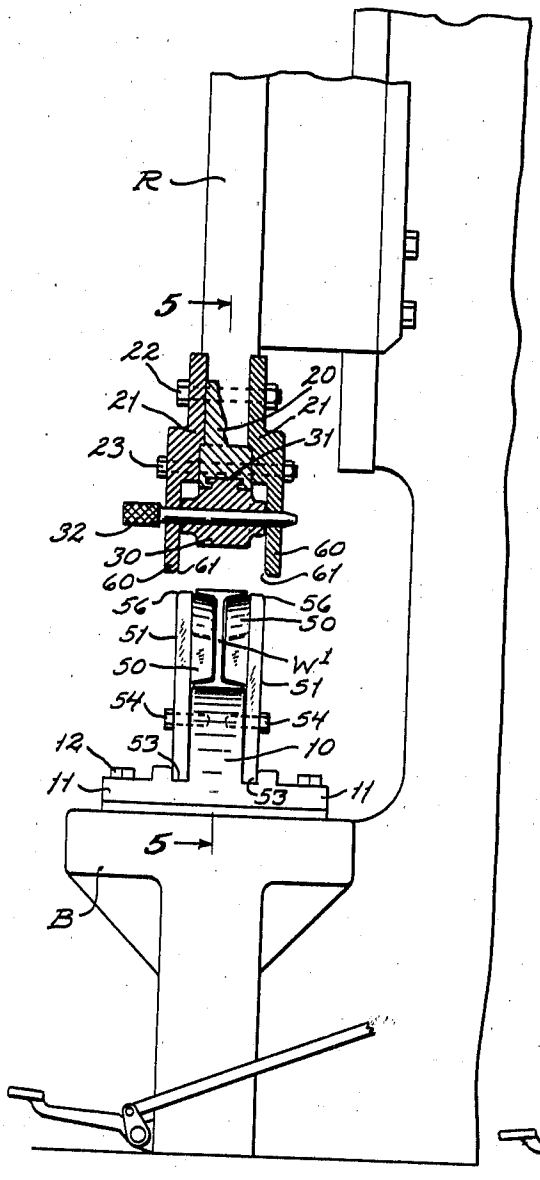


FIG. 7

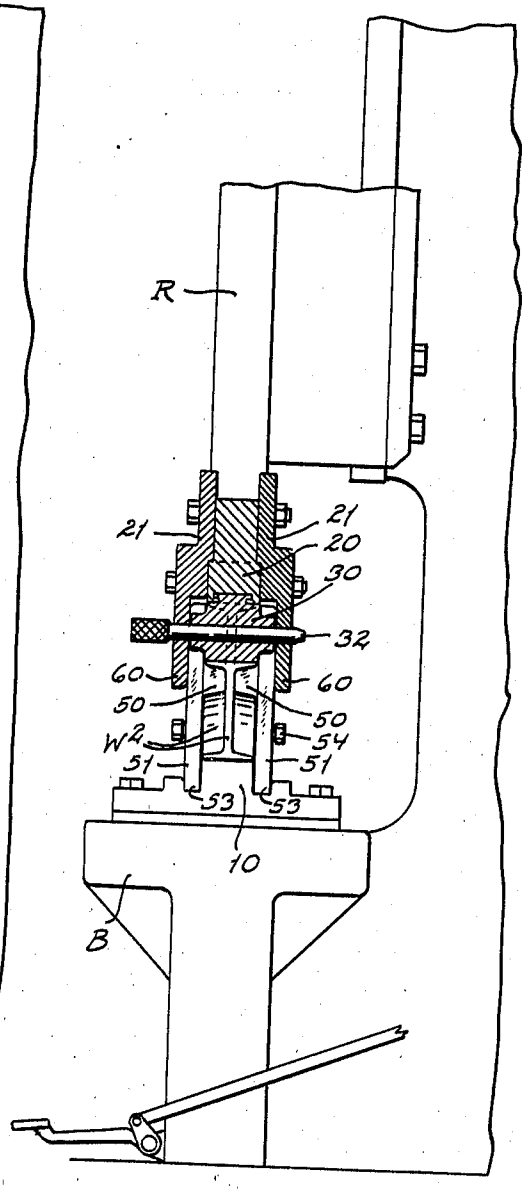


FIG. 8

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UNITED STATES PATENT OFFICE

2,350,046

METHOD AND APPARATUS FOR BENDING STRUCTURAL SHAPES

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Application December 4, 1941, Serial No. 421,655

12 Claims. (Cl. 153—48)

This invention relates to a method and apparatus for bending structural members such as I-beams, channels, and so forth. In bending such members, difficulty arises when a component element of the cross section of the member, such as the vertical web of an I-beam, lying in the plane of the bend possesses insufficient lateral strength to keep from buckling or wrinkling under the stress of bending. Various means have heretofore been tried to overcome this, but have not been completely satisfactory, being either too slow and difficult in operation or too complicated and expensive to manufacture, or have allowed some unwanted distortion of cross sectional elements, especially where bends of short radius are involved.

It is an object of this invention, therefore, to provide a method whereby structural members of the class described may be bent quickly and efficiently without distortion of their cross sectional shape. It is a further object to provide an apparatus which will be simple and inexpensive to manufacture and which may be effectively employed in carrying out the method of this invention.

It is a further object of this invention to provide such an apparatus wherein dies may be readily incorporated in the various types of power presses now in use.

Where the band which is to be made does not start immediately at the end of the member, that is, where a straight portion remains at both sides of the bend, a further difficulty arises in forming the dies and in the method of their use.

A further object of this invention, therefore, is the provision of a method and apparatus employing dies for making this type of bend in a structural member quickly and easily without unduly complicating the apparatus. Additional features and objects of this invention will be apparent from the specification and accompanying drawings therein referred to and from the appended claims.

In the drawings, Fig. 1 is a front elevational view of the bending dies of my invention as applied to a conventional press brake, illustrating an I-beam at the completion of the bending operation; Fig. 2 is a horizontal section taken on a plane indicated by the line 2—2 in Fig. 1; Fig. 3 is a perspective view of a clamping plate employed in the apparatus; Fig. 4 is a perspective view of the lower die; Fig. 5 is a longitudinal vertical section as indicated by the line 5—5 in Fig. 7 on a much larger scale, the dies being shown in open position; Fig. 6 is a view similar to Fig. 5 but showing the dies closed and a different upper die; Fig. 7 is a vertical transverse section taken on the line 7—7 of Fig. 5, showing the dies in open position; Fig. 8 is a view similar to Fig. 7, showing the dies in closed position.

The embodiment of my invention which I have illustrated comprises a lower die, an upper die, and a pair of clamping plates between which the work-piece is adapted to be held. While any suitable source of power may be utilized to operate the dies, I have found that a press brake of the type illustrated in Fig. 1 is well adapted to the work, the lower die being secured to the bed of the press and the upper die to the movable ram. The dies are carried at their sides by the bed and the ram, leaving the ends of the die-pass open so that the work-piece, while being bent, may travel downwardly beyond the end of the press.

It will be noted from Fig. 1 that the particular work-piece which the present embodiment is designed to accommodate is an I-beam which is to be bent through a circular arc of 90° near one end thereof, a short straight portion being left at that end. The lower die 10, best seen in Figs. 4 and 5 and about which the I-beam or work-piece W is to be bent, comprises a solid block having base flanges 11 bolted to the bed B of the press as at 12. The central portion of the block is of the same width as the I-beam flange, the upper surface being horizontal for approximately half its length and being formed as a circular arc for the remainder of its length with a radius equal to that of the proposed bend in the I-beam.

The upper die is carried by the movable ram R of the press and is, therefore, reciprocated by it. As will be seen in Figs. 5 and 7, the upper die comprises two portions, an elongated block 20 and a replaceable, supplementary block 30 carried thereby. The block 20 is secured to the ram R by means of two side plates 21, bolted to the ram as at 22 and to the block 20 at 23. The supplemental block 30 is rigidly supported on the block 20 by means of a dovetail guideway 31 and is held in place by a removable pin 32. A handle 33 is provided for convenient removal and replacement of the block 30.

The lower surfaces of the blocks 20 and 30 are formed complementary to the upper surface of the lower die 10 for the major portion of their length; that is, there is a horizontal reach 24 merging into a circular arc 25. It will be noted,

however, that since the I-beam is to have a short straight portion at the end, extending from the tangent point *t* in Fig. 5 to the end of the beam, the circular arc terminates at a point *t'* on the die, and the surface continues as a tangent at 26.

The I-beam is advanced step-by step into the die by means later to be described and the die acts on a portion of it at a time, the operation being repeated until the complete bend has been formed.

It has been found that the short extent of the curved portion 25, necessitated by the provision of the flat portion 26, may not be sufficient to completely form the I-beam to its finished shape, the I-beam tending to leave the lower die as indicated by the gap *g* in Fig. 5 and thus introducing an error in the finished shape. Therefore provision has been made to replace the block 30 with another block 40, illustrated in Fig. 6 and so shaped as to be complementary to the lower die throughout the entire length of the latter. The circular arc 41, which is a continuation of the arc 25 on the block 20, terminates at the tangent point *t''* and the surface continues as a straight portion 42 to accommodate the straight end of the I-beam. The block 40 is provided with handles 43 for ease of manipulation and is supported in the dovetail guideway 31 of the block 20 and secured in place by the removable pin 32.

A feature of the present invention is the means which I employ to prevent buckling or wrinkling of the web of the I-beam during the bending process. To prevent such deformation of the web, I cause it to be confined and clamped in a vise consisting of two clamping shoes which, while allowing the web to slide downwardly between them during the bending process, effectively prevents any lateral movement thereof.

As best seen in Figs. 3 and 7, the shoes 50 above mentioned are integrally formed on flat plates 51, the lower edges 52 of which are adapted to hinge or pivot in grooves 53 in the base flanges of the lower die 10. The plates stand at either side of the die portion 10, as illustrated in Figs. 7 and 8, and are prevented from falling outwardly by the heads of bolts 54 threaded into the die and projecting loosely through holes 55 in the plates. While thus loosely held, the clamping shoes offer no hindrance to longitudinal movement of the I-beam therebetween. As the upper die descends, however, the lower cam portion 60 of the side plates 21, aforementioned as securing the upper die to the ram, engage the clamping plates 51, causing the shoes to bind upon the web of the I-beam. In the form illustrated, the inner surfaces of the cam portions 60 are parallel, the lower edges 61 being rounded to engage the upper rounded corners 56 of the clamping plates 51.

It will be noted from the drawings that the lower edges of the clamping shoes 50 are horizontal throughout their length, while the upper surfaces are curved to correspond to the I-beam after it has been bent. The surfaces are so formed as to nest securely against the web while allowing a slight clearance with the inner surfaces of the I-beam flanges, so as to provide as much support for the web as possible.

At the beginning of the operation, the I-beam is placed in the press upon a supporting block 70 which is at the same level as the upper surface of the lower die or anvil 10, and the beam is then introduced into the left hand end of the die and between the two shoes 50. The supporting block 70 is mounted upon the bed of the press by means not shown and may be provided with guide plates 71 to position the I-beam. The stroke of the ram is adjusted (as by the usual adjusting mechanism indicated at *r* in Fig. 1) so that in its lowermost position the lower face of the elongated block 72 secured to the ram, and the lower face of the straight portion 24 of the upper die, are a distance above the bed block 70 equal to the cross-sectional height of the beam being bent.

The I-beam may be advanced step-by-step into the die by any suitable means, such, for instance, as the winch and cable arrangement illustrated in Figs. 1 and 2. As there shown, a cable 75 is anchored at one end 76 to the bed of the press and passes around a sheave 77 carried by the end of the I-beam. The other end of the cable is wound upon a drum 78 of a winch mechanism 79 which may be operated by a hand crank 80. The sheave 77 may conveniently be carried by a clip 81, the two prongs 82 of which may removably embrace the web of the I-beam.

A complete bending operation will now be described to illustrate the method used and to set out more clearly the functions of the various parts. The I-beam, after being heated in a furnace to the proper degree for ready bending but not sufficiently to render it flexible by gravity is placed upon the support 70, being positioned thereon by the guide plates 71. The clip 81 is then placed upon the beam end and the cable 75 runs over the sheave. By means of the winch 79, the I-beam is slid into the die between the shoes 50 to its initial position indicated by the broken lines W–1 of Fig. 5.

The ram is now operated to cause the upper die 20—30 to descend upon the I-beam and bend it into the position W–2, where it will be noted that the flat portion 26 has allowed the straight portion to remain at the end of the beam. Before the upper die contacts the I-beam, the cam plates 60 engage the clamping plates 51, causing the shoes 50 to securely bind upon the web to prevent its distortion during the subsequent bending.

As the die portion 26 extends below the under surface of the block 72 at the bottom of the ram, the die will engage the I-beam before the block engages it, and as the die bends the I-beam downwardly it will tip the rear end upwardly until it strikes the block 72, the clearance between the shoes 50 and the I-beam flanges allowing this movement. Then, as the ram continues to descend, the block 72 shoves downwardly on the rear end of the beam and the die portion 26 continues to bend the projecting end of the beam until at the lower end of the stroke the beam is firmly held in horizontal position, being clamped between the bed 70 and the ram block 72, and the die has performed its maximum bending operation.

As the ram subsequently rises, the cam plates 60 leave the clamping plates and the shoes again free the I-beam. The winch is then again operated to slide the beam forward a distance of approximately one fifth of its depth and as the ram descends in its next cycle the shoes 50 are again caused to grip the web, and the dies bend the I-beam still further.

The described operation is repeated until the beam has progressed to the position indicated at W–3 in Fig. 5, at which time the straight end portion has been projected far enough to clear the arcuate portion 41 of the larger supplemental block 40, which will now be substituted for the

block 30 in the upper die and secured in place by the pin 32. The press is now again put in operation and the I-beam advanced step-by-step through the die to complete the bend, its subsequent and final positions being indicated by the broken lines W–4 of Fig. 6 and the final form of the I-beam being illustrated in Fig. 1.

When the press is opened after the final forming operation, the pin 32 is removed and block 40 withdrawn. The I-beam may then be slid through the die and removed from the right hand end of the press. If, as indicated in Fig. 1, the end of the I-beam is now projecting below the level of the floor, a trench 90 is provided therein to accommodate the beam and to allow its withdrawal.

As is illustrated in Fig. 1, suitable indicia may be placed upon the upper block 72 of the ram to aid in the proper positioning of the beam at the start of the bending operation, at the point at which the dies are changed, and at the finish of the bend, such indicia being illustrated at 91, 92, and 93, respectively.

While I have illustrated an embodiment of my invention designed to be fitted to a press brake and adapted for the bending of an I-beam, it will be understood that numerous other applications can be made within the scope and spirit of the invention. For example, it can be well adapted to the bending of other structural shapes such as channels, in which case a single shoe would project into the channel and clamp the web against a flat plate on the opposite side, and a similar arrangement could be used in the case of angle beams.

I claim:

1. An apparatus for bending flanged beams comprising a bed having a straight portion to support the beam and a curved anvil about which it may be bent, a movable ram having a straight portion to oppose the straight portion of the bed and having a deflected portion to engage and bend the bar, a pair of clamping plates having shoes to engage opposite sides of the bar loosely enough to allow the bar to be fed, means on the ram to force the plates inwardly to clamp the web as the ram moves into active engagement to bend the beam, such clamping action being relieved when the ram recedes, whereby at that time the beam may be fed lengthwise.

2. An apparatus for bending I-beams and similar members comprising a flat bed on which the beam may rest and a curved anvil at the end of the bed about which the beam may be bent, a pair of plates loosely held on opposite sides of the anvil and projecting over the sides of the beam thereon, shoes on the inner faces of said plates adapted to enter the spaces on opposite sides of the I-beam, while the said beam is overhanging the curved portion of the anvil, a ram having a die diverted toward the I-beam which rests on the anvil, and means on the ram for forcing said shoes toward each other to clamp the I-beam in place on the anvil while allowing the overhanging portion of the I-beam to move toward the anvil and relative to the shoes, and means for progressing the I-beam when the clamping is released.

3. An apparatus for bending bars comprising a bed, an anvil carried by the bed about which the bar may be bent, a ram opposing the anvil adapted to engage the bar to bend it about the anvil, shoes carried by the bed for engaging opposite faces of the bar to clamp it in position, means actuated coincident with the active movement of the ram to cause said shoes to approach each other to effect the clamping of the bar and for releasing such clamping when the ram recedes, and means whereby the bar may be periodically fed lengthwise of itself when the clamp is released.

4. An apparatus for bending bars having webs and edge flanges comprising a holding device having inwardly projecting shoes for engaging opposite side faces of the web of the bar while leaving the flanges free to move, to prevent the web being bent out of its own plane while it may slide between said devices, a pair of straight members for engaging the top and bottom flanges of the bar, a convex anvil merging with the plane of one of said straight members and a pressing die forming a continuation of the face of the other member and coacting with said anvil, one of said members being movable toward the other, and means operated by the movable member to force the shoes toward each other.

5. An apparatus for bending I-beams in a plane in which the web lies, comprising a flat support which has a curved anvil at the end thereof over which the I-beam may extend while the under flange of the I-beam engages said flat support, holding blocks adapted to engage the opposite sides of the web of the I-beam, means engaging the upper flanges of the I-beam to press the I-beam toward the anvil, said beams engaging the upper flanges having a straight portion parallel with the flat support and another portion deflected from the straight portion in the general direction toward the anvil, and means for feeding the I-beam lengthwise of itself between successive pressing operations.

6. An apparatus for bending a flanged bar in the plane of a web thereof, comprising a straight bed, a convex anvil diverging from the plane of the bed, a movable ram coacting with the bed, a die carried by the ram and adapted to engage a portion of the bar overhanging the anvil to bend the bar about the anvil, a clamping shoe adapted to engage the face of the web of the bar and be overhung by a flange thereof, said shoe extending across the convex anvil and being cut off gradually on the edge adjacent said flange to clear the flange and allow it to be bent toward the anvil while the adjacent portion of the web slides across the face of the shoe.

7. An apparatus for bending an I-beam in the plane of the web of the beam comprising a straight bed, a convex anvil at the end of the bed diverging from the plane of the bed, a movable ram coacting with the bed and adapted to act on a beam between the bed and ram with the under flanges of the beam engaging the bed and the upper flanges engaged by the ram, a die carried by the ram and adapted to engage a portion of the beam overhanging the convex anvil to bend the beam about the anvil, a pair of clamping shoes on the opposite sides of the beam adapted to engage the web thereof, said shoes lying partly above the flat portion of the support and partly above the curved portion thereof provided by the bed and anvil, the part above the flat portion substantially filling the space between the I-beam flanges and the part above the curved portion being cut away gradually on the upper side to clear the upper flanges of the I-beam and allow it to be bent down as the lower flanges are bent around the convex portion of the anvil.

8. An apparatus for bending flanged beams comprising a straight bed with an anvil at the end thereof which bends away from the straight

line of the bed, a ram coacting with the bed and anvil to hold the body portion of a beam to be bent in place while bending the portion overhanging the curved face of the anvil, said ram having a guideway at its underside, and a removable die slidably mounted on said guideway, whereby a different die may be substituted for it.

9. An apparatus for bending bars comprising a bed, an anvil at one end of the bed about which the bar may be bent, a movable ram opposing both the bed and anvil adapted to engage the opposite side of the bar to force it against the bed and simultaneously bend it about the anvil, restraining members carried by the bed and adapted to engage opposite faces of the bar which are not to be bent out of their own planes, and means operated by the movement of the ram to move the restraining members toward each other.

10. The method of bending bars comprising placing one edge of the bar in position against a support with one end thereof overhanging the support, exerting pressure on the overhanging portion of the bar against its opposite edge thereby swinging the bar about the support as a fulcrum, and simultaneously exerting pressure on the end portion of the bar opposite the overhanging portion, and continuing the pressure on both end portions of the bar until the bar is engaged on longitudinally coextensive top and bottom surfaces thereof, relieving the pressure, successively repeating such operation, and between successive operations feeding the bar lengthwise of itself.

11. The method of bending bars comprising placing one edge of the bar in position against a support with one end thereof overhanging the support, exerting pressure on the overhanging portion of the bar against its opposite edge thereby swinging the bar about the support as a fulcrum and simultaneously exerting pressure on the end portion of the bar opposite the overhanging portion, and continuing the pressure on both end portions of the bar until the bar is engaged on longitudinally coextensive top and bottom surfaces thereof, clamping the bar by pressure exerted against surfaces which are not to be bent out of their own planes, feeding the bar a short distance lengthwise of itself between successive pressing operations and relieving the clamping action during the feeding operation.

12. The method of bending bars comprising placing a bar in a position where one edge of the body thereof rests on a support and the end portion thereof overhangs a convex abutment, exerting pressure on the overhanging portion of the bar against its opposite edge, thereby swinging the bar about the support as a fulcrum, and simultaneously exerting pressure on the end portion of the bar opposite the overhanging portion, and continuing the pressure on both end portions of the bar until the bar is engaged on longitudinally coextensive top and bottom surfaces thereof, clamping the bar in a direction normal to the direction of the bending force, feeding the bar a short step lengthwise of itself and thereafter pressing the body of the bar against the support and the overhanging portion further about the convex abutment until its adjacent surface is substantially parallel therewith, and relieving the clamping action during the feeding operation.

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