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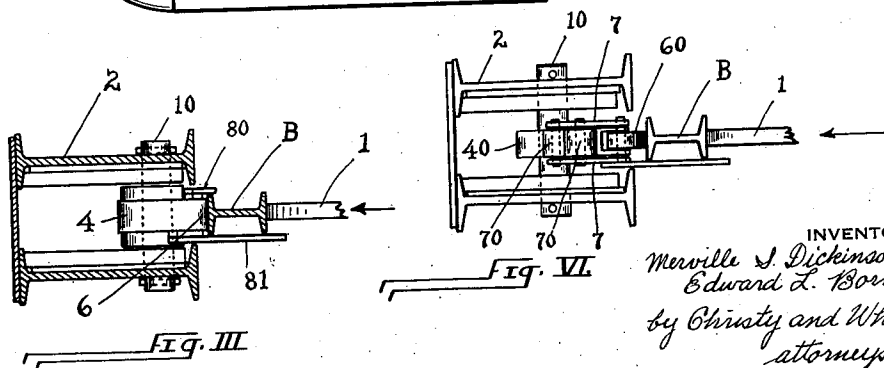
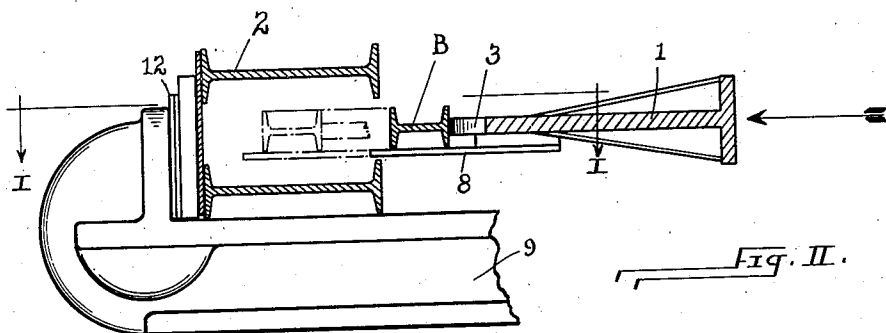
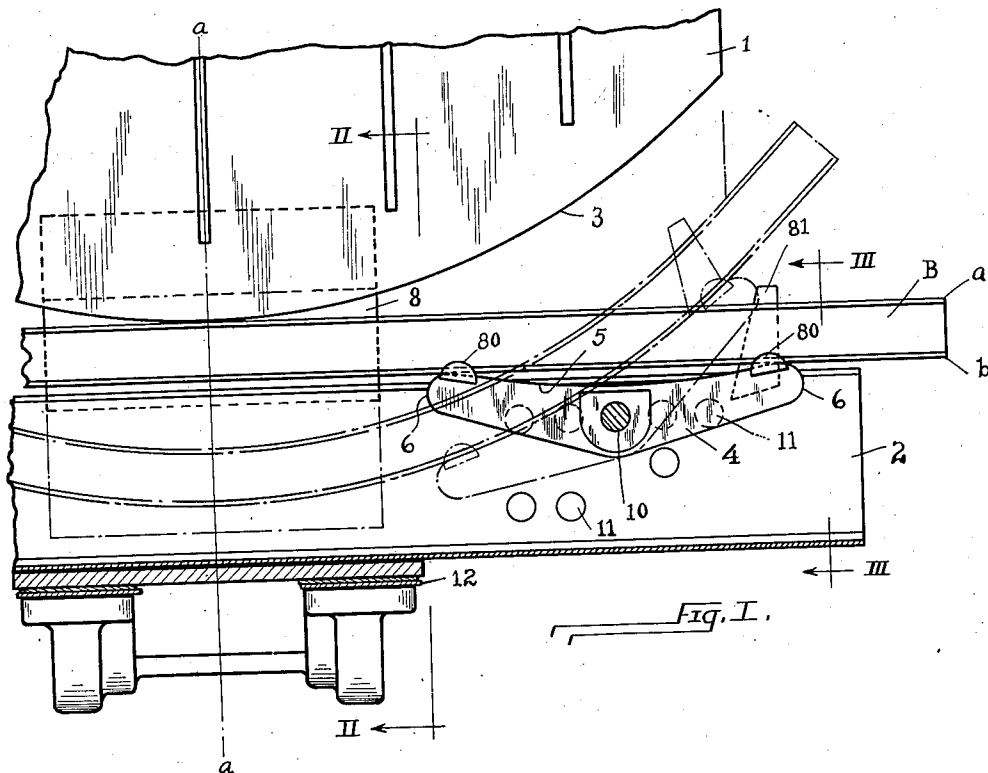
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BENDING MACHINE

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2 Sheets-Sheet 1



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Technical drawing of a mechanical assembly, likely a vehicle chassis or suspension component. The drawing shows a cross-section of a curved structure (1) with internal components (3, 8, 60, 40, 7, 70) and a dashed line indicating a hidden part. A section line VI-VI is shown on the right side.

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UNITED STATES PATENT OFFICE

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BENDING MACHINE

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3 Claims. (Cl. 153—33)

This invention relates to metal bending apparatus. Though applicable in the bending of elongate bodies of metal generally, it has been developed in the bending of steel bars; and, specifically, of I-beams; and in such association it will be illustrated and described. The objects in view are precision, economy, and speed of production.

In the accompanying drawings Fig. I is a view in horizontal section of a bending machine in which and in the operation of which the invention is realized. Fig. II is a view of the same machine in vertical section. The plane of section of Fig. I is in Fig. II indicated by the broken line I—I, and the plane of section of Fig. II is indicated in Fig. I at II—II. Fig. III is a fragmentary view in vertical section on the plane indicated at III—III, Fig. I. Figs. IV and V are views corresponding to Fig. I of a machine of more elaborate structure and illustrative of further features of invention, both in structure and in method. Fig. VI is a fragmentary view in elevation in the field of view indicated in Fig. IV by the line VI—VI and the associated arrows.

The bending machine of the invention consists essentially of a pair of relatively reciprocable dies, between which metal bars are bent. As shown, the dies are reciprocable on horizontal lines, but that feature will be understood to be merely a matter of convenience.

Referring particularly to Figs. I, II, and III, the two dies are indicated at 1 and 2, and the work upon which they operate is shown in the form of an I-beam B. Fig. I is diagrammatic, particularly in that it shows but half of the machine; the line *a—*a** is the centre-line, and it will be understood that the structure to the right of this line is in fact duplicated symmetrically to the left.

The male die 1 has a convex face 3 to which in machine operation the work B is shaped. The female die is compound. It consists of a support, to which the numeral 2 is immediately applied, and which is shown to be a rugged box or casing, mounted in a suitable bed 9, and of two blocks 4, freely pivoted in the casing. The face 3 of the male die is of length and breadth suited to the work, and in this case is a band-like circumferential portion of a cylindrical surface whose axis is vertical in its extent. The band extends horizontally. The blocks 4 are pivoted upon vertical axes and they present to the opposed face 3 of the male die concave faces 5, terminating in rounded convex ends 6. The concavity 5 is advantageously of a curvature not

substantially greater in radius than, and preferably approximately equal in radius to the curvature of the face 3 of the male die. The surfaces of the ends 6 of the blocks conform to cylinders of vertically arranged axes, and are of a breadth (vertically) suited to the work. Both dies are, by the features of shape that have been described, adapted initially to engage the surfaces of the work tangentially, on vertical lines of tangency. When the dies are closed, the faces 5 of the blocks 4 make surface to surface contact with the work.

Means for effecting relative reciprocation of the dies in the direction of the centre-line *a—*a**, not shown, will be understood to be provided.

Referring particularly to Fig. I and to the full-line showing of that figure, it will be remarked that the blocks 4 are swung to positions in which their ends lie in a common vertical plane, perpendicular to the centre-line of the machine; and, the blocks being in such position, a small range in the relative reciprocation of the dies suffices, to permit the endwise introduction of the work B, to the position illustrated. A plate 8 borne by the male die affords support for the work, and brackets 80, 81 borne by the blocks 4 cooperate to hold the work against displacement as the dies close upon it.

The dies close upon the work B when brought to the position shown in full lines in Fig. I. It will be remarked that, at the beginning of the bending operation, the male die is tangent to the work on one side and at a middle point, and that the two blocks 4 are at their ends 6 tangent to the work on the opposite side, each at two points spaced at successive intervals on the two sides of the point of tangency of the male die.

The dies close. In this case the male die advances from the full-line position shown to the dotted-line position. As it advances the blocks 4 swing pivotally to the dotted-line position, and the work is shaped upon the convex face 3 of die 1 to the dotted-line position. In this advance it will be remarked (1) that, by virtue of the pivotal mounting of the blocks, the bending pressure brought to bear upon the work at the points of engagement of the blocks is equalized between the points of bearing; (2) that the convex face 3 of the male die on the one side, and the convex faces of the ends 6 of the blocks 4 on the other, define a work-occupied space: a space that, initially rectilinear in extent, becomes curved as the dies close, and that the curvature, as die-closing progresses, decreases in radius, until it corresponds to the curvature of the face

3 of the male die; (3) that throughout the closing stroke the ends 6 of the blocks 4 engage the work at spaced apart points (leaving the intervening length of work to respond freely to the bending stress), until at length the dies are fully closed, when for the first time the concave surfaces 5 of the blocks come to surface bearing upon the now fully bent piece of work, and exert upon the bent piece a distributed compressive stress; (4) that the bending is effected under very much smaller stress than would be requisite were the work-engaging face of the female die a fixed and continuous surface; and (5) that the work is evenly and gradually bent between the extreme points of engagement from initial rectilinear shape to a curve of diminishing radius until the desired curvature is attained.

The blocks 4 are shown to be pivotally mounted upon pivot pins 10, removably set in orifices in the support 2. In Fig. I a plurality of orifices 11 is indicated, formed at successive points, both transversely of and longitudinally of the direction of die reciprocation, and it will be understood that the blocks 4 may be pivotally mounted in any of the correlated pairs of orifices 11. It will be apparent that, as the spacing of the blocks is varied transversely of the line of direction of die reciprocation, the work itself being of uniform transverse section, the extent of the curvature may be varied longitudinally of the piece of work; and that, as the position of the blocks 4 is varied longitudinally of the direction of die reciprocation, the effective depth of the stroke of the reciprocating dies may be varied, even though no change be made in the actual length of stroke of the moving die (in this case the male die 1) relatively to the fixed die 2. We have found that for an I-beam whose central web is of a given breadth ($a-b$, Fig. I) there is an ideal position for the pivoting of the blocks 4—a position such that in the bending operation the relative movement of the ends 6 of the blocks upon the surface of the work (in any case slight) may be practically eliminated. The effective stroke of the die 1 may be minutely varied by means of shims 12, adjusting the position of the die 2 in the bed 9.

It will be remarked that, when the die is completely closed, the outer end of the block 4 is in substantial alignment with the outer end of the convex face of die 1. This is an advantageous though not an essential feature in the proportioning of parts.

Fig. III serves to show work B restrained above and below by the brackets 80 and 81 as the dies close upon it. A rolled steel I-beam, here chosen for purposes of illustration, is an article that is flexible and susceptible to bending, but it possesses a certain elasticity too, and, when released by the opening of the dies, springs slightly from the curvature to which it is brought when the dies are fully closed, and assumes a curvature of slightly longer radius. When curvature for the finished article is specified, it will be understood that a male die 1 will be employed, whose work-engaging face 3 is curved to a sufficiently smaller radius; and it need only be added that, when dealing with I-beams of given cross-section, the proper curvature for the face of the male die may be empirically determined, to afford a finished article of curvature of desired radius well within the margin of tolerance permissible in such work.

Turning to Figs. IV-VI of the drawings, certain elaborations of structure and of method are to be explained. The ends of the blocks 40 are

shown to be equipped with rollers 60, whose effect in the bending operation is to reduce frictional wear, through the range of relative movement (ordinarily slight) at the lines of contact. To the outer end of each block 40 a second block 7 is freely pivoted on a vertical axis. This second block may be swung at will between the inactive position shown in Fig. IV and the active position shown in Fig. V. The block 7 is essentially such in shape as the block 40: when in operative position it presents to the work a concave face, not greater in radius of curvature than the opposed face of the male die 1; it is equipped at its two ends with rollers 70 that in operation engage the work at spaced-apart points at successively greater distances from the centre-line of the machine; and, while the inner end of block 7 is nearer the centre-line of the machine than the outer end of block 40, the two ends of block 7 together have their shaping effect in a portion of the work more remote from the centre-line of the machine than the portion upon which block 40 has effect; and, accordingly, we characterize the engagement of the block 7 with the work as an engagement at two points more remote from the point of initial tangency of the male die with the work than the two-point engagement of the block 40 with the work.

Figs. IV and V show the faces of blocks 40 to be more deeply concave than those of blocks 4 of Fig. I; and while in this case, as is particularly manifest from the dotted-line showing of Fig. IV, the block does not, even on the completion of the closing movement of the dies, abut upon the work over all the extent of the concave face, the deeper concavity here is advantageous in affording space for the free play of the second block 7 in performing its part in the operation (cf. Fig. V).

The operation of the machine in the more elaborate structure of Figs. IV-VI is advantageously a two-step operation; and the method performed is a two-step and progressive method, with the advantages, first, that in the progress of the bending operation the work is more certainly stabilized in position, and the danger of tipping is more certainly guarded against; second, that greater uniformity in curvature throughout the length of the article is gained; third, that less power is required and wear and tear are less.

In operation, then, initially, the blocks 7 of the second pair are swung aside, to the position indicated in Fig. IV. With the parts so arranged, the first step in the operation is identically that already described with reference to Figs. I and II. In this initial step the work is bent substantially to ultimate form from the centre-line of the machine outward throughout part only of the extent of the piece or throughout part only of so much as is ultimately to be shaped. The dies then are separated, the work is moved away sufficiently from the female die, and the blocks 7 on the two sides of the machine are swung from the inactive position of Fig. IV to the active position of Fig. V; whereupon (the work remaining properly centered) the dies are closed again and then, as particularly shown in Fig. V, the work in regions more remote from the centre-line of the machine is by the cooperation of the blocks 7 with the male die shaped to the face of the male die. The second bending supplements the first, and completes the bending of the piece of work. In this two-step operation the two reciprocations of die 1 will be through identically the same range, but on the second reciprocation the bend-

ing effect of the blocks 7 will be supplementary to that of the blocks 40 in the first reciprocation.

As has been said and as shown in Fig. I, the outer end of the block 4 (the right-hand end) is when the dies are closed in substantial alignment (in the direction of die-movement) with the outer end of the face 3 of the male die against which the work is shaped. In Fig. V it appears that in the ultimate closing of the dies the outer end of the second block 7 extends to the right, beyond the limit of the face of the male die. It will be realized that, particularly with work of substantial breadth (in the direction of die reciprocation) some excess here of the extent of the engagement of the female die upon the convex face of the shaped piece of work may be found desirable.

The circumferential extent of the curve to which the beam is shaped is, in the exemplary showing of the drawings, about 90°. It is manifest that precisely as, in the machine of Figs. IV—VI, the bending by means of the blocks 7 supplements that by means of blocks 40, so by shifting of the work in its position between the dies the bending effected in one operation may be supplemented by bending in a succeeding operation, and so the circumferential extent of the bending may (within the limits imposed by the length of the article) be extended indefinitely.

We have chosen for purposes of illustration an I-beam as the specific material that in the operation of the machine is bent. It is manifest that the invention is applicable to the bending of elongate metal articles generally.

We claim as our invention:

1. In apparatus for bending a length of metal that includes a die having a convex face, a support and a die-block with concave face pivotally mounted upon said support, the two said die members being relatively reciprocable, and adapted simultaneously to engage a length of metal when brought to position between them and by reciprocation to effect a bending thereof in an intermediate portion of its extent, the invention herein described which consists in the provision for a range of further reciprocation between the convex-faced die and the said support, and a second die-block with concave face pivotally mounted intermediate its ends upon the first-named concave-faced die-block and adapted to be swung to and from a position of cooperation with the convex-faced die, and adapted in such position of cooperation to engage by its two ends simultaneously the length of metal

under treatment and in the further reciprocation between the convex-faced die and the support to effect a bending of the length of metal in a terminal portion of its extent.

2. In metal-bending apparatus including a male die having an extended band-like face shaped in one plane to a convex curved surface and a female die, the two said dies being mounted for relative reciprocation, the invention herein described in which the female die includes a support, a beam pivotally mounted upon said support on an axis perpendicular to the plane in which the face of the male die is curved, and having on either side of its pivotal mounting abutments adapted simultaneously to engage at spaced-apart points a piece of work introduced between the dies, together with a second beam pivoted upon the first at a point to one side of the pivot of the first-named beam upon the support, the second-named beam having at either side of its pivotal mounting abutments adapted simultaneously to engage at spaced-apart points such piece of work introduced between the dies, the second-named beam being movable upon its pivot from a remote position to a position of co-operation with the male die.

3. In metal-bending apparatus including a male die having an extended band-like face shaped in one plane to a convex curved surface and a female die, the two said dies being mounted for relative reciprocation, the invention herein described in which the female die includes a support, a pair of beams pivotally mounted upon said support on axes perpendicular to the plane in which the face of the male die is curved, each having on either side of its pivotal mounting abutments adapted simultaneously to engage at spaced-apart points a piece of work introduced between the dies, together with a second pair of beams pivoted severally upon the beams of the first pair at points to one side of the pivots of the first-named beams upon their support and at points that in the assembly are outward from the pivots of the first-named beams upon their support, the beams of the second pair in turn having each at either side of its pivotal mounting abutments adapted simultaneously to engage at spaced-apart points such piece of work introduced between the dies, the beams of the second-named pair being movable upon their pivots from remote positions to positions of co-operation with the male die.

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