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(54) APPARATUS FOR FORMING CONTOURED SECTIONS FROM FLAT METAL STRIPS

(71) We, JOHN LYSAGHT (AUSTRALIA) LIMITED, a Company incorporated under the laws of the State of New South Wales, Australia, of 50 Young Street, Sydney, in the State of New South Wales, Australia, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for forming contoured metal sections such as channels, studs, corrugated cladding sheets, ribbed decking sheets, highway guard rails, other structural or like elongated elements; from flat strip, sheet or plate metal (hereinafter referred to simply as "strip").

Metal sections of the kind indicated have longitudinally extending formations such as flutes, corrugations, flanges, ribs and the like. These give the section a "non-flat" or contoured lateral or transverse cross-sectional shape which is constant throughout the length of the section. For descriptive convenience, the term "profile" is used herein to indicate a contoured lateral or transverse cross-sectional shape whether it be that of a finished section or one imposed transitionally on a piece of strip as it is being formed from a condition of flatness into a finished section of longitudinally constant transverse cross-sectional shape.

Contoured metal sections are formed by apparatus in accordance with the present invention, purely by bending the strip; that is, in such a way that the gauge thickness of a finished section is substantially constant throughout its profile and substantially equal to that of the strip out of which it is formed.

Hitherto, the production of metal sections in accordance with the foregoing, has necessitated the use of press brakes or roll-forming machines.

A relatively light-weight press brake can be employed where the strip is of correspondingly light gauge, but with such a press, where the whole section is formed directly from the strip in a single blow of the press, production is limited to sections

of a length too short for most structural and like purposes.

Where a section is to be made from heavy gauge strip (material which by common usage in the art would be called "plate" rather than "sheet") in the formation, for example, of such things as highway guard rails, a press brake can still be employed, but its size and cost would be such as to be economically prohibitive unless the size of the order for the articles is impracticably large. Because of this, articles or sections of the kind under discussion have been predominantly made by roll-forming.

Roll-forming, while better than pressing in most cases, is not without serious shortcomings. In the first place, roll-forming machines are expensive in themselves, and expensive in occupying extensive factory floor-space. Moreover, roll-forming is necessarily performed by rolls which progressively shape and transport the strip through the successive stages of formation. This imposes, upon both the designer and the maker of the rolls, the need for accuracy and the need to ensure close matching of co-operating roll profiles for effective performance of the forming function and the transfer function. This latter necessity gives rise to differential roll surface speeds due to roll portions of different diameters rotating in contact with linearly moving strip; and this, in turn, is expensively destructive of the rolls, impairs the strip surface, or coating thereon, by scuffing and, due to enormous frictional loads, is expensively wasteful of power.

The object of this invention is to overcome or eliminate the shortcomings indicated above. The apparatus of the invention enables metal sections of the kind indicated to be produced very simply on relatively cheap equipment. Thus the apparatus can be used for the continuous, long length production of stock from which sections of the required length may be cut.

Thus the apparatus of the invention provides the ability to produce continuous section lengths without the high cost of roll forming machine toolage. This allows its use in short work runs which otherwise

cannot justify the cost of production by other methods. The apparatus of the invention therefore fills an important gap which exists between conventional press brakes and roll-forming machines in being capable of producing metal sections of any required length more economically than by known apparatus.

According to the present invention there is provided apparatus for forming, from a flat metal strip, a contoured section having a constant profile which prevails throughout the length of the section; said apparatus comprising:—

(a) two press tools, viz. a stationary tool and a movable tool, each having longitudinally-extending relatively fixed work surfaces able cooperatively to bend strip being longitudinally and intermittently advanced between said work surfaces from an upstream end of said tools to a downstream end thereof;

(b) means to reciprocate said movable press tool rectilinearly and normally relative to the stationary tool so that the movable tool repetitively assumes a final work position in which the respective work surfaces of the two tools remain spaced apart by a pre-selected distance; and,

(c) strip bending formation which constitute said work surfaces and whereof the profiles progressively change throughout the length of said tools from a profile at said upstream end substantially without bending capacity relative to said strip, to a profile at said downstream end which imposes said constant profile on said strip, all of said work surfaces being characterised in that they are rectilinear in at least one dimension.

Apparatus in accordance with the invention, will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a perspective view of two co-operative press tools, in mutually retracted position, for pressing a section having a longitudinally extending formation which gives it a semi-annular constant profile.

Fig. 2 is a side elevation of the press tools shown in Fig. 1 when in final work position; that is, at the point of nearest mutual approach.

Figs. 3 to 5 are sectional end elevations respectively taken on lines 3-3, 4-4 and 5-5 in Fig. 2.

Figs. 6 to 10, respectively, are the same kind of views as Figs. 1 to 5. They show a pair of press tools for producing a corrugated strip.

Fig. 11 is a side elevation of a press brake comprising press tools of the kind illustrated in Figs. 1 to 5, Figs. 6 to 10.

Fig. 12 is a sectional end elevation of a top hat section.

Fig. 13 is a perspective view of two co-operative press tools, in mutually retracted

position, for pressing the top hat section shown in Fig. 12.

Fig. 14 to 16 are sectional end elevations of the press tools shown in Fig. 13 but with the tools in final work position. These views are respectively taken on the planes indicated at 14, 15 and 16 in Fig. 13.

Fig. 17 is a sectional end elevation of a "C" section.

Fig. 18 is an end elevation of two press tools, in mutually retracted position, for making the C-section shown in Fig. 17.

Fig. 19 is an incomplete end elevation of a press brake carrying two press tools for making a section to be used as a roofing tile batten. The profile of this batten section is shown in Fig. 27 (I).

Fig. 20 is a side elevation of the two press tools shown in Fig. 19.

Figs. 21 to 26 are sectional end elevations of the press tools shown in Figs. 19 and 20 (but in final work position) respectively taken on lines 21-21 to 26-26 in Fig. 20.

Fig. 27 shows a series of stages in the formation, from the flat strip shown at (a), of the batten section shown at (I), by use of the apparatus shown in Figs. 19 to 26.

Referring to Figs. 1 to 5, a top press tool in the form of a die block 33 is tapered from its upstream end face 34 to its downstream end face 35; the bottom press tool which co-operates with the top tool is a die block 36 of constant profile throughout its length. Thus, the mound portion 37 of the bottom block also has a constant profile which is a total envelope for the inner curved surface of the section to be formed. This curved surface is shown in the constant profile of the section indicated at 38 in Fig. 5.

The tapered top die provides a downstream finishing portion 39 which is a full envelope for the outer curved surface of section 38 while the longitudinal taper of the top die causes its upstream end (34) to be virtually zero in the enveloping sense. The forming surfaces of the two press tools or dies are spaced apart, when they are in their fully approached or final work positions (as shown in Figs. 2 to 5) by an amount equal to the gauge thickness of both the flat strip (to be entered between the dies at the upstream ends thereof) and the resulting section shown dotted at 41 in Fig. 2.

When a section such as 41 is to be made, a press brake of known kind, as shown in Fig. 11 may be employed.

Referring to Fig. 11, the press brake has a vertically reciprocable head or ram 42 to which a top die such as 33 (as also shown in Figs. 1 to 5) is attached, and a bed or base 43 to which a bottom die (such as 36) is secured.

The flat strip to be pressed may be fed to and through the forming dies either as sheets

pre-cut to length or as continuous coil. Inter-mittent feed of the strip through the dies may be effected manually or automatically as well understood. For continuous coil operation automatic feeding, with advancement steps of equal length, would be more appropriate, but by no means essential as very satisfactory results have been obtained experimentally with hand feeding; and this, in the production of heavy gauge corrugated sections for use as highway guard rails on a relatively light-weight press brake. In this connection it will be appreciated that strip feed is performed while the forming dies are retracted, and that there is nothing particularly critical about the length of each feeding step or whether the steps are of uniform length. The only limiting factor in this regard is to ensure that no feed step is so great as to present the dies with a single blow task which is beyond the capacity of the press employed. In many instances it has been found that a very satisfactory result is obtained using a light-weight press brake having a short-stroke rapidly reciprocating head accompanied by very short feed steps; but, as already indicated, the nature of the strip feeding may vary enormously. In preceeding through the dies the strip (from flat to final section) may undergo as few as two forming blows or hundreds of such blows; it all depends on the power of the press employed, the gauge thickness of the strip, the width of the strip, the extent of profile change and like parameters.

When the strip is in the form of continuous coil, the cutting off to required section length may be performed, while the strip is halted, either prior to entry into the dies or at the exit end after the final profile has been formed. If cut off prior to entry, the process would be essentially similar to that for pre-cut sheets or strips.

Edge guide fences of known kind are preferably provided on the upstream side of the dies and additional guides may be incorporated to control tracking of the sheet through the dies.

Reverting to Fig. 11, pre-cut strips are laid on the feed table 44 and located against pre-aligned stops 45 to ensure central feeding into feeding pinch rolls 46 and, hence, into the forming dies 33 and 36. Feed table height is set conveniently below the bite line of the entry pinch rolls 46.

The bite line of rolls 46, should be adjustable vertically. For example, from about 9" below a line projected from the top face of the bottom die. There should be about 6" of available vertical adjustment from this height. This adjustment is necessary to ensure good entry and a straight product. Once optimum level is attained no further adjustment should be necessary.

The pinch rolls 46 may be driven by a

ratchet device and suitable levers or other linkage connected to the press brake ram 42 so that when that ram is on its upwards stroke, the pinch rolls will feed forward. When the press is on the downward stroke, or nearing the end of that stroke, the rolls will be stationary and the driving ratchet re-set for the next stroke.

Downstream or exit pinch rolls 47 are preferably provided, particularly where the formation of the sections is on a pre-cut strip length basis. These rolls are operated synchronously with the upstream rolls 46 so to deposit the formed sections on a receiver table, as indicated at 48, or on a belt conveyor or the like.

It will be seen from the foregoing that if the top die block 33 is alteratingly reciprocated towards and from the bottom die block 36, and flat strip material of width equal to the perimeter of mound 37 of the bottom die block is advanced (in correct longitudinal alignment) step-by-step from left to right (that is, in the downstream direction) into the variable shaped gap of the two dies, it will be wrapped around the bottom die as shown dotted in Figs. 3 to 5.

An alternative form of the press tools is illustrated in Figs. 6 to 10. These tools (top die 33A and bottom die 36A) are used for the progressive press-bending of corrugated sections of the kind shown at 49 in Fig. 10. The use and operation of the apparatus of Figs. 6 to 10 are so like those described above in terms of Figs. 1 to 5 that further description, in terms of Figs. 6 to 10, is considered unnecessary.

Fig. 12 shows a top hat section 50, and Figs. 13 to 16 show a pair of press tools for forming it from a flat strip. These tools perform progressive press-bending in substantially the same manner as already described with reference to Figs. 1 to 5 or Figs. 6 to 10. Hence (it is felt) further explanation in terms of these figures is unnecessary, except to point out that the stepless lateral convergence of top die portions 51 and 52, in the downstream direction and the stepless and progressive increase in height of bottom die portion 53 also in the downstream direction, are such that the web width dimension indicated at 54 in Figs. 14 to 16 remains substantially constant throughout the forming process. Thus, the throughgoing strip is progressively re-profiled substantially purely by bending as distinct from metal drawing, so as to keep power consumption and surface scuffing to a minimum.

Fig. 17 shows a C-section, and Fig. 18 a pair of press tools for forming it partly by what has been referred to above as a press-bending action resembling that of blunt shears. This action can be explained in terms of an ordinary sheet metal guillotine having a movable blade in shear relationship with a

stationary blade. If the movable blade is very blunt it will tend to bend a piece of sheet metal, presented for cutting, rather than cleanly shear it. And if in addition to being extremely blunt, the movable blade is also spaced from the stationary blade by an amount equal to the gauge thickness of the sheet metal, a working stroke of the movable blade, instead of cutting off the sheet metal margin which overhangs the stationary blade, will bend that margin downwardly so that it bears flatly against the front of the stationary blade. This press-bending action is employed, in the disc assembly of Fig. 18, to form a channel section consisting of web 55 and flanges 56 from the flat strip consisting of web 55 and the two marginal portions 57.

Still referring to Fig. 18, the press tool assembly there shown in end elevation, consists of a top vertically reciprocable die block 58 and a stationary bottom die block 59 or base portion which carries, on a number of compression springs 60, a floating die block 61. The items 58, 59 and 61 extend for the full length (not shown) of the die assembly.

The upstream end portion of block 58 (that end portion nearer to a viewer of Fig. 18) has a pair of "blunt-shear" bars 62 fixed to its sides to extend longitudinally of the block; that is, in the direction of strip advancement through the die assembly. The downstream end portion of block 59 has a pair of "side-bend" bars 63 fixed on its upper face; these being located downstream of bars 62 so that they cannot obstruct descent of bars 62 into their final work position.

Bars 62 are tapered so that they increase in depth in the downstream direction. The degree of this taper may be (for example) about the same as that shown for bottom die portion 53 in Fig. 13. Bars 62 each have a press-bending edge represented by longitudinally extending rounded corner 64 and a bend-finishing face 65 which (when the top die is fully descended) is laterally spaced from the adjacent side face 66 of floating block 61 by an amount equal to the thickness of the strip being formed.

Bars 63 are mutually convergent in the downstream direction in much the same way as the top die portions 52 in Fig. 13, and these bars (63) have bend-finishing top surfaces as indicated at 67.

When a C-section is to be formed, a flat strip 57-55-57 is presented to the upstream end of the die assembly with the top die vertically reciprocating. When the leading end edge of the strip is first entered into the working ambit of the dies it rests on block 61 and descends with it until that block is halted by contact with the top 68 of a centre portion 69 of bottom block 59. At this initial

entrance of the strip into the die ambit it will scarcely bend at all because it will be contacted merely by the upstream end of block 58 and bars 62. However, as the strip inches its way downstream its margins 57 become more-and-more bent downwardly until finally bent into flanges 56 by the bend-finishing faces 64. Once the channel 56-55-56 has been formed and the inching movement of the strip maintained, the distal longitudinal edges of flanges 56 ride into contact with bars 63 so that sub-flanges 70 are progressively formed and given final profile by being pressed between the underface of block 61 and the bend-finishing surface 67.

It will be appreciated that if the required section were merely a channel such as 56-55-56, block 61 could be stationary and bars 63 could be omitted.

Referring to Figs. 19 to 27, a conventional press brake is indicated at 71 (Fig. 19). It includes a stationary base 72 for a bottom press tool 73 and a reciprocable head 74 which carries a top press tool 75. These tools are for the progressive press-bending of a baton section as shown in Fig. 27 (i) from a flat strip as shown in Fig. 27 (a). Figs. 19 and 20 show the press tools mutually retracted. Figs. 21 to 26 show six stages in the formation of the batten section all with the press tools in their final work positions. Fig. 27 shows ten transitional profiles (b) to (k) which occur at 100 mm. intervals of the travel distance of the strip from the upstream to the downstream ends of the press tools. This 100 mm. interval could be equal to the length of each of the strip advancement steps through the press tool assembly, but not necessarily so; the advancement steps may be shorter or longer depending mainly upon the power of the press as previously explained.

The top press tool 75 consists of a longitudinal spine 76 with flanging plates 77 and curling plates 78 fixed on either side. The upstream end portion of spine 76 is tapered as indicated at 79 (Fig. 20) so progressively to impose on the flat strip the profile changes indicated in Figs. 21 to 23 or as also indicated by the transitory profiles (b) to (f) in Fig. 27.

The flanging plates 77 are also tapered as indicated at 80 (Fig. 20) so as to provide for progressive formation of the section flanges (81 in Fig. 27 (i)) as indicated in Figs. 24 and 25 or as also indicated by the transitory profiles (g) to (i) in Fig. 27.

The curling plates 78 have longitudinal recesses 82 in their under faces is shown in Figs. 19 and 26. These recesses have rounded edges 83 which are mutually convergent in the downstream direction so progressively to enwrap the free edges of the flanges 81 about the bottom die rounded beads indicated at 84 in Figs. 19, 20 and 26, thus to

form the curls shown at 85 in Fig. 27 (I). The recesses 82 are tapered to zero in the upstream direction, in much the same way as the die groove in top die 35 (see Fig. 1) tapers to zero in the same direction, so as to avoid any abrupt profile change in proceeding to curled flanges from uncurled flanges. The flange curling action is illustrated in terms of Fig. 26 and by the transitory profiles (j) and (k) and the final profile at (l) in Fig. 27.

The bottom press tool 73 consists of a base-plate 86 with forming bars 87 and retention bars 88 fixedly held on its upper face. The retention bars carry floating bottom die blocks 89 and 90 which are vertically movable within the limits imposed by step formations 91 and 92 (see Figs. 24 to 26), these die blocks being lowered by top die pressure thereon and, at all times, influenced to rise by the loading effect of compression springs 93. The reason for the vertical movability of blocks 89 and 90 is, of course, due to the section curls 83 underlapping the beads 84 thus making it imperative for the bottom die blocks to be no longer movable (vertically) relative to the section under formation. When the strip is moved forwards, the cross section of the strip shown in Figure 21 moves along the inwardly tapering gap between blocks 87 and in doing so, it climbs upward. If the block 90 Figure 26 was prevented from vertical movement, the strip would not be able to rise since it is locked onto beads 84. By providing vertical movement in the block 90, as the top tool 76 is withdrawn, the strip is lifted out of the forming bars 87 to allow forward movement of the strip to the next forming stage as from Figure 21 to Figure 22, Figure 22 to Figure 23. The same consideration applies to the spring mounting of the floating die block 61 (Fig. 18) due to underlapping of the sub-flanges 70.

WHAT WE CLAIM IS:—

1. Apparatus for forming, from a flat metal strip, a contoured section having a constant profile which prevails throughout the length of the section; said apparatus comprising:—

(a) two press tools, viz. a stationary tool and a movable tool, each having longitudinally-extending relatively fixed work surfaces able co-operatively to bend strip being longi-

tudinally and intermittently advanced between said work surfaces from an upstream end of said tools to a downstream end thereof;

(b) means to reciprocate said movable press tool rectilinearly and normally relative to the stationary tool so that the movable tool repetitively assumes a final work position in which the respective work surfaces of the two tools remain spaced apart by a pre-selected distance; and,

(c) strip bending formations which constitute said work surfaces and whereof the profiles progressively change throughout the length of said tools from a profile at said upstream end substantially without bending capacity relative to said strip, to a profile at said downstream end which imposes said constant profile on said strip, all of said work surfaces being characterised in that they are rectilinear in at least one dimension.

2. Apparatus according to Claim 1 which includes means to advance said strip between said work surfaces by advancement steps of equal length.

3. Apparatus according to either preceding Claim, wherein one of said press tools includes a base portion, a floating die block and a plurality of springs by which said floating die block is mounted on said base portion.

4. Apparatus according to any preceding Claim, wherein one of said press tools consists of a longitudinal spine having flanging plates and curling plates fixedly mounted on said spine, and the other of said press tools consist of a base plate, forming bars and retention bars fixedly mounted on said base plate, and a floating die block spring-mounted on said base plate, the movement range of said floating die block being restricted by complementary step formations on said retention bars and said floating die block.

5. Apparatus for forming a contoured section from a flat strip, substantially as herein described with reference to Figs. 1 to 5, Figs. 6 to 10, Figs. 12 to 16, Figs. 17 and 18, or Figs. 19 to 27 of the accompanying drawings.

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form the curls shown at 85 in Fig. 27 (l). The recesses 82 are tapered to zero in the upstream direction, in much the same way as the die groove in top die 35 (see Fig. 1) tapers to zero in the same direction, so as to avoid any abrupt profile change in proceeding to curled flanges from uncurled flanges. The flange curling action is illustrated in terms of Fig. 26 and by the transitory profiles (j) and (k) and the final profile at (l) in Fig. 27.

The bottom press tool 73 consists of a base-plate 86 with forming bars 87 and retention bars 88 fixedly held on its upper face. The retention bars carry floating bottom die blocks 89 and 90 which are vertically movable within the limits imposed by step formations 91 and 92 (see Figs. 24 to 26), these die blocks being lowered by top die pressure thereon and, at all times, influenced to rise by the loading effect of compression springs 93. The reason for the vertical movability of blocks 89 and 90 is, of course, due to the section curls 83 underlapping the beads 84 thus making it imperative for the bottom die blocks to be no longer movable (vertically) relative to the section under formation. When the strip is moved forwards, the cross section of the strip shown in Figure 21 moves along the inwardly tapering gap between blocks 87 and in doing so, it climbs upward. If the block 90 Figure 26 was prevented from vertical movement, the strip would not be able to rise since it is locked onto beads 84. By providing vertical movement in the block 90, as the top tool 76 is withdrawn, the strip is lifted out of the forming bars 87 to allow forward movement of the strip to the next forming stage as from Figure 21 to Figure 22, Figure 22 to Figure 23. The same consideration applies to the spring mounting of the floating die block 61 (Fig. 18) due to underlapping of the sub-flanges 70.

WHAT WE CLAIM IS:—

1. Apparatus for forming, from a flat metal strip, a contoured section having a constant profile which prevails throughout the length of the section; said apparatus comprising:—

(a) two press tools, viz. a stationary tool and a movable tool, each having longitudinally-extending relatively fixed work surfaces able co-operatively to bend strip being longi-

tudinally and intermittently advanced between said work surfaces from an upstream end of said tools to a downstream end thereof;

(b) means to reciprocate said movable press tool rectilinearly and normally relative to the stationary tool so that the movable tool repetitively assumes a final work position in which the respective work surfaces of the two tools remain spaced apart by a pre-selected distance; and,

(c) strip bending formations which constitute said work surfaces and whereof the profiles progressively change throughout the length of said tools from a profile at said upstream end substantially without bending capacity relative to said strip, to a profile at said downstream end which imposes said constant profile on said strip, all of said work surfaces being characterised in that they are rectilinear in at least one dimension.

2. Apparatus according to Claim 1 which includes means to advance said strip between said work surfaces by advancement steps of equal length.

3. Apparatus according to either preceding Claim, wherein one of said press tools includes a base portion, a floating die block and a plurality of springs by which said floating die block is mounted on said base portion.

4. Apparatus according to any preceding Claim, wherein one of said press tools consists of a longitudinal spine having flanging plates and curling plates fixedly mounted on said spine, and the other of said press tools consist of a base plate, forming bars and retention bars fixedly mounted on said base plate, and a floating die block spring-mounted on said base plate, the movement range of said floating die block being restricted by complementary step formations on said retention bars and said floating die block.

5. Apparatus for forming a contoured section from a flat strip, substantially as herein described with reference to Figs. 1 to 5, Figs. 6 to 10, Figs. 12 to 16, Figs. 17 and 18, or Figs. 19 to 27 of the accompanying drawings.

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