

A PRESS

This invention is concerned with an apparatus and method for pressing contoured articles from metal sheet.

5 The invention is particularly, although not exclusively, suitable for the formation of pressed metal cladding elements, such as roofing tiles, from planar metal sheet stock.

10 Although the following description is limited to the manufacture of pressed metal wall and roofing tiles or panels, it should be understood that the invention is applicable to all sheet metal pressing operations.

15 For many years, extensive efforts have been made to reduce the cost of building materials and/or to increase the cost effectiveness of such building materials in a highly competitive marketplace.

20 Pressed metal roofing tiles were introduced to overcome the cost disadvantages of conventional clay, terra cotta or masonry roofing tiles in terms of materials cost, handling and transportation costs and structural requirements to support the much greater mass of such tiles when compared to pressed metal tiles.

25 Initially, individual pressed metal tile elements were proposed to directly replace clay or masonry tiles. Such proposals are set forth in United States Patents Nos. 993281, 1648081 and 2269872 .

30 Subsequently, integrally formed "panels" having the appearance of an array of, say, four, five or six transversely overlapping roof tiles were proposed. Such a proposal is illustrated in United States Patent No. 4178731.

35 In the continuing pursuit of improvements in pressed metal roof cladding elements, it was proposed to form a pressed metal roofing panel with an integrally formed transverse beam structure to avoid the necessity of supporting battens extending transversely of a sloping

roof structure and at right angles to the inclined rafters. "Self-supporting" roofing panels of this type are described in Australian Patent No. 497135 (and corresponding British Patent No. 1499443), International Patent No. PCT/SE81/00128 (WO 81/03196), Australian Patent Application No. 78427/81 and Australian Patent No. 545158 (corresponding to European Patent No. EPO115968 and United States Patent No. 4617773).

International Patent Application No. PCT/AU86/00373 (WO87/003518) is directed to a method and apparatus for press forming sheet metal to form "self supporting" roof cladding panels of the type described immediately above.

International Patent Application NO. PCT/AU/86/00373 describes an apparatus in which a strip of metal is advanced through a forming die which has first and second stages wherein a press forming operation is performed on the metal strip in each stage of the die during each closing stroke of the die. One portion of the metal strip is formed in the second stage of the die during a first time interval of each closing stroke of the die and a further portion of the metal strip is movably clamped in the first stage of the die during the same time interval in order that it may be pulled into the second stage of the die during the first time interval. During a second time interval of each closing stroke, the metal strip is rigidly clamped in both stages of the die. The first stage of the die is employed to preform longitudinally extending fold lines to form a structural rib along one side of the panel and the second stage is employed to form alternating ribs and channels perpendicular to the structural beam.

The pressing die comprises upper and lower members which are used in a reciprocating press. Each of the upper and lower die members include portions able to slide in a vertical fashion relative to adjacent die portions and these movable portions are biased under the

constant influence of a compression spring and/or are selectively biased by pneumatic/hydraulic rams.

5 The metal pressing method and apparatus described in International Patent Application No. PCT/AU86/00373 is considered to suffer a number of serious disadvantages. In particular, the apparatus is designed to permit selective slippage of the metal sheet between "partially clamped" die elements during certain stages of the pressing operation to accommodate metal deformation without undue stretching or stress induction. 10 In other stages of the pressing operation however, portions of the metal sheet are rigidly clamped to prevent slippage of the metal between the die elements.

15 It is considered that the most serious disadvantage associated with this method and apparatus is the controlled slippage of the metal sheet during the pressing operation where lightly clamped portions of the steel sheet are allowed to slip between the clamp members of the die. With such slippage, considerable wear is likely to be experienced on the die elements over which 20 the steel sheet slips. Furthermore, the surfaces of the steel sheet which slips will be subjected to scratching and scoring of any corrosion resistant coating - usually a painted surface or a coating of zinc or zinc alloys. 25 This would lead to premature corrosion in the pressed roofing panel in service.

In other areas of the die and at stages where portions of metal sheet are rigidly clamped, stretching or even tearing of the metal sheet can occur. In any 30 event, extensive stretching leads to a reduction of metal thickness and, depending upon the extent of stretching, the integrity of the corrosion resistant coating can be breached.

35 Yet a further disadvantage of this apparatus and process is an inherent quality control difficulty arising from an apparent intolerance of normal trade variations in the thickness and ductility of the metal

sheet feedstock. Predetermined clamping pressures and clearances in both the "slipping" clamp regions and the "fixed" clamp regions are likely to give rise to excess slippage for undergauge sheet while for overgauge sheet or less ductile sheet, the risk of tearing is increased in regions of deeper draw pressings.

In summary, the method and apparatus as described in International Patent Application No. PCT/AU86/00373 is considered likely to give rise to a high degree of machine downtime due to the need for die maintenance and frequent "fine tuning" of the die to accommodate normal trade variations in metal thickness and ductility. In addition, apart from the prospect of a relatively high product reject rate, the pressed metal cladding elements are also likely to suffer regions of reduced metal thickness, regions of high induced stress and regions of reduced corrosion protection. The movement of die members in a direction strictly perpendicular to the plane of the metal sheet being pressed is considered not only to induce excessive stress in the metal sheet but also to require a considerable pressing force to stretch the metal sheet to the shape required.

It is an aim of the present invention to overcome or ameliorate the problems and shortcomings of the prior art metal pressing method and apparatus and to provide an improved method and apparatus for producing pressed metal roof cladding elements or the like.

Accordingly, in one aspect of the invention there is provided an apparatus for press forming of sheet metal, said apparatus comprising a press forming die assembly having opposed die members movable relative to each other between an open position and a closed position wherein a sheet of metal introduced between the die members in the open position is pressed, in a single pressing step, to the closed position, to form predetermined contours in the metal sheet, said opposed

die members each including die elements slidably movable relative to adjacent die elements both in a direction normal to the plane of the metal sheet to be pressed and in a direction parallel to the plane of the metal sheet be pressed whereby a reduction in area in at least one direction of the metal sheet as said sheet undergoes contouring is accompanied by a corresponding movement in the same direction of at least certain of said die elements to prevent slippage of the metal sheet between opposed die elements.

Suitably, at least certain of said movable die elements include at least one tapered side wall adapted to slidably engage with an adjacent die element having a complementary tapered side wall whereby in use, relative sliding movement between said at least certain die elements in a direction normal to the plane of the sheet of metal to be pressed causes relative movement between said at least certain die elements parallel to the plane of the sheet of metal to be pressed.

Suitably, biasing means is provided between selected adjacent die elements of said die assembly to urge said selected adjacent die elements away from each other.

If required, said biasing means may comprise fluid powered rams or alternatively a mechanical biasing means such as a compression spring or a telescopic gas filled cylinder.

Preferably said apparatus includes means for preforming said metal sheet to form a longitudinal deformation adjacent one or both edges of said metal sheet before entry into said die assembly.

Suitably said means for preforming said metal sheet comprises a roll forming device.

According to another aspect of the invention there is provided a method for contouring metal sheet, said method comprising the steps of introducing a sheet of metal between opposed die members of a press forming

die assembly including clamping elements and contouring elements;

rigidly clamping selected regions of said metal sheet between clamping elements of said die assembly;

5 urging together, of said die assembly on opposed faces of said metal sheet, selected contouring elements with complementary contoured faces to form a contour therein while simultaneously moving said clamping elements towards said contouring elements to accommodate
10 a reduction in area of said metal sheet due to contouring thereof whereby the regions of metal sheet in contact with surfaces of the die elements remain stationary relative to the respective die elements.

Preferably said metal sheet is preformed before
15 entry into the die assembly to form a longitudinal deformation adjacent one or both edges of said metal sheet.

Suitably the metal sheet is preformed by a roll forming process.

20 According to yet another aspect of the invention there is provided a contoured metal article formed by pressing a metal sheet with the apparatus according to the invention.

According to a further aspect of the invention
25 there is provided an article formed from pressed metal sheet in accordance with the method of the invention.

In order that the various aspects of the invention may be more fully understood, reference is now made to a preferred embodiment illustrated in the
30 accompanying drawings in which:-

FIG 1 illustrates a press forming die in an open or fully retracted position;

FIG 2 illustrates the die of FIG 1 in a partially closed position;

35 FIG 3 illustrates the die of FIG 1 in a more closed position;

FIG 4 illustrates the die of FIG 1 in a fully

closed position,

FIG 5 illustrates a cross sectional view of the die through A-A in FIG 4.

5 FIG 6 shows a roof cladding element produced in accordance with the invention.

FIG 7 shows a side elevation of the apparatus according to the invention.

10 FIG 8 illustrates an alternative embodiment of the die of FIG 1, showing the die in a partially closed position.

FIG 9 shows the die of FIG 8 in a fully closed position.

FIG 10 shows a cross sectional view of the die of FIG 9 through A-A.

15 FIG 1 illustrates a cross sectional view of a pressing die assembly in a direction transverse to the direction of advancement of a metal sheet through the die. For the sake of simplicity the components have been limited to a central shape forming region with clamping regions located on either side thereof. It will be
20 readily apparent to a skilled addressee that the die assembly may include a plurality of shape forming regions and clamping regions.

25 In FIG 1 the die assembly comprises an upper base member 1 and a lower base member 2. Located generally centrally of the die assembly is an upper form block 3 and a lower form block 4, each having complementary contoured surfaces 3a, 4a. On either side of form blocks 3, 4, are situated upper and lower
30 clamping blocks 5, 6 respectively.

On both sides of upper and lower base members 1 and 2 respectively are side plates 7. Between the side plates 7 associated with upper base member 1 is a support plate 8 adapted for vertical sliding movement between
35 side plates 7. Support plate 8 is urged away from upper base member 1 by compression springs or the like shown schematically at 9.

Upper clamp blocks 5 and upper form block 3 are slidably supported on upper base plate 1 by guide members 10, 11 respectively. The clamp blocks 5 are transversely slidable between side plates 7 and upper form block 3 while form block 3 is slidable in a direction normal to the plane of the sheet on which FIG 1 appears. Biassing springs 12 urge clamp blocks 5 away from upper form block 3.

The outer sides 5a, 5b of upper clamp blocks 5 are tapered in a downwardly divergent manner and are slidable on complementary tapered faces 7a, 7b respectively of upper side plates 7.

Located below upper clamp blocks 5 are pressure pads 13 biassed downwardly and away from blocks 5 by respective compression springs 14. Pressure pad 13 on the infeed side of the die assembly includes an extension plate 15 to increase the clamping area of the clamping combination comprising clamp block 5 and pressure pad 13.

Lower clamping blocks 6 are slidably mounted on guide members 16 and slide in the same direction as upper clamping blocks 5. Biassing springs 17 urge lower clamping blocks inwardly towards lower forming block 4. Forming block 4 and lower clamping blocks 6 include tapered faces 4b, 6a respectively which are selectively slidably engageable when lower forming block 6 is moved upwardly by a piston rod 18 associated with a fluid powered ram 19.

Mounted adjacent the outer sides of lower clamping blocks 6 are support plates 20, 21 at the metal sheet feed inlet and outlet sides respectively of the die assembly. Support plates 20, 21 serve to support the metal sheet as it enters and emerges from the die during the pressing operation. Support plate 20 serves also to increase the effective clamping area between upper and lower clamping blocks 5, 6 respectively by cooperation with extension plate 15.

The lower half 22 of the die assembly is

fixedly mounted in the press apparatus (not shown) while the upper half 23 of the die assembly reciprocates between an open position as shown and a closed position by an actuator 24 which may comprise any suitable mechanism such as a fluid powered ram, a powered toggle mechanism or a mechanical press apparatus.

In order to describe the operation of the die assembly shown in FIG 1, reference is now made to FIGS 1-4 of the accompanying drawings.

With the die assembly shown in FIG 1 in a fully retracted position with a clearance between upper and lower clamping blocks sufficient to permit entry of a sheet of metal, the metal sheet 25 (shown in FIG 2) is advanced into the die to a predetermined extent whereby the metal sheet rests on support plates 20, 21.

Referring now to FIG 2, the die actuator 24 is energised and initially, the upper die half 23 proceeds downwardly until pressure pads 13 engage the upper surface of metal sheet 25.

Referring now to FIG 3, as the pressing stroke of the die assembly continues, biasing springs 14 between pressure pads 13 and clamping blocks 5 retract until clamping blocks 5 contact pressure pads 13. At this point the entire assembly of upper base plate 1, side plates 7, support plate 8 and upper forming block 3 has moved towards metal sheet 25 in a unitary fashion thereby positioning the contoured face 3a of upper forming block just above the surface of metal sheet 25. Simultaneously with the movement of contoured face 3a of forming block 3 to a position adjacent the upper surface of metal sheet 3, fluid powered ram 19 is actuated to move lower forming block 4 towards metal sheet 25 until its contoured surface 6a is just below the lower surface of metal sheet 25.

As shown in FIG 3, this is the final stage of clamping the metal sheet 25 immediately prior to the metal pressing or contouring stage.

FIG 4 shows the final stage of the pressing cycle with the die assembly fully extended or closed.

Between the beginning and end of the final stage of the pressing cycle (represented by FIGS 3 and 4 respectively), upper forming block 3 remains stationary while lower forming block 4 continues to advance towards upper forming block 3. As tapered faces 4b, 6a respectively of forming block 4 and clamping blocks 6 come into sliding engagement, biasing springs 17 urge lower clamping blocks 6 inwardly towards forming block 4. Simultaneously, and in concert with lower clamping blocks 6, upper clamping blocks 5 are urged inwardly towards upper forming block 3 by coaction between the respective tapered faces 5a, 5b of clamping blocks 5 and faces 7a, 7b of side plates 7 as upper base member reaches its fully extended pressing position as shown in FIG 4.

Actuator 24 is then energised to retract upper base plate 1 and at the same time fluid powered ram 19 is actuated to retract lower forming block 4. The various components of the die progressively move to respective initial rest positions shown in FIG 1 by the reverse sequence of events represented by FIGS 4, 3, 2, 1 sequentially.

It can be seen that when the metal sheet 25 is deformed by the forming blocks of the pressing die, the deformation is achieved by a gently folding or "ironing" action without stretching of the metal in the region of the forming blocks and further, without slippage of the metal sheet between either the clamping blocks or the forming blocks.

FIG 5 shows a cross sectional view of the fully closed die assembly in the direction A-A shown in FIG 4.

The die assembly includes at its front and rear ends, upper guide blocks 26 and lower guide blocks 27, the guide blocks 26 and 27 being associated respectively with upper base plate 1 and lower base plate 2.

Support plate 8 reciprocates between guide

blocks 26 and lower forming block 4 reciprocates between guide blocks 27.

5 Upper forming block 3 comprises three portions, a front reciprocating member 3a, an intermediate member 3b fixed to support plate 8 and a rear reciprocating member 3c. In the final forming stage represented by the movement of the die elements between the positions shown in FIG 3 and FIG 4, front member 3a begins to form the lip 28 by deforming the edge of metal sheet 25 downwardly but at the same time, coaction between complementary tapered faces 29, 30 of upper block member 3a and guide block 27 respectively causes block member 3a to move inwardly against the biasing force of spring 31 to form the shoulder 32 in metal sheet 25. The combined relative die element movements in vertical and horizontal planes give rise to an angular resultant "ironing" of the shouldered deformation 32 without the shear forces normally associated with a simple vertical pressing action exemplified by the prior art.

20 Towards the rear end of the die assembly a channel shaped ridge 33 is formed by the combined upward movement of lower forming block 4, the rearward movement of block member 3a and the forward movement of block member 3c as a result of coaction between complementary tapered faces 34, 35 of guide block 27 and block member 3c respectively. A transverse channel 36 is formed in the upper surface of ridge 33 by complementary contours in block member 3c and shaping block 4.

30 Once again the contour formation is effected by a gentle "ironing" process to achieve folds in the metal sheet without stretching the metal or otherwise inducing stresses while at the same time avoiding relative sliding movement between the metal sheet and die surfaces.

35 FIG 6 shows a pressed metal roof cladding member 40 produced in accordance with the invention.

To avoid regions of undue stress and or to avoid any stretching of the metal sheet in the pressing

process, the upstanding ridges 41 extend into the transverse stiffening rib 42 and the additional metal in this area is accommodated by an appropriately shaped "hump" 43 which in use acts as a support for an overlapping portion of an adjacent roofing panel. Channel 36 serves to reinforce stiffening rib 42 but it may also be used to accommodate excess regions of metal produced adjacent intersecting fold lines to avoid wrinkles and/or stretching.

It will be clear to a skilled addressee that the apparatus and process according to the invention permits complex contoured shapes to be produced by a metal pressing technique in which the metal is simply folded or "ironed" into complex shapes without the need to stretch the metal sheet into shape. The folding or "ironing" action substantially reduces die wear associated with slippage of the metal sheet and substantially eliminates damage to any protective coating on the metal sheet.

FIG 7 shows a partial side elevation of an apparatus for continuously producing pressed metal roof cladding elements.

Broadly, the apparatus comprises a roll forming apparatus 50, a pressing station 51 and a shearing apparatus 52.

The roll forming apparatus 50 comprises a conventional roll forming mill having a material guide 53, a plurality of roll stands 54 and a drive means 55 to drive the roll stands 54.

The roll forming apparatus 50 is employed to preform the ridge section 33 (shown in FIG 5) and, if required, the shouldered step 32 (also shown in FIG 5). By preforming the ridge and shouldered step, this substantially reduces the energy requirements of the pressing station 57.

Pressing station 51 employs a die assembly 56 as exemplified in FIGS 1-5 and, in association with

shearing apparatus 52, is mounted for reciprocal sliding motion on bench 57. The die assembly 56 is operable by upper and lower hydraulic rams 58, 59 respectively and the slidable carriage 60 on which the pressing station 57 and shearing apparatus 52 are mounted is connected to hydraulic ram 61 which is extendable to move carriage 60 from an initial rest position as shown to an extended position towards the end of bench 57 at the end of the pressing cycle.

Shearing apparatus 52 comprises a fixed lower anvil 62 and a movable shearing blade 63 actuated by hydraulic ram 64. Both the lower anvil 62 and the shearing blade 63 are contoured to correspond with the cross sectional shape of contoured panel 65.

A hydraulic pump 66 is powered by electric motor 67 to operate rams 58, 59, 61, 57 and 64 and a fluid reservoir 68 is provided for the hydraulic circuit.

In use, a metal strip 69 of predetermined width is fed into roll forming apparatus 50 to preform any continuous longitudinal deformations such as ridge 33 and shouldered step 28 which may be required and otherwise which may advantageously assist the pressing operation.

The deformed strip 70 then passes into pressing station 51 to a predetermined extent at which point a mechanical, electro-mechanical or optional detection device (not shown) operates to actuate rams 58 and 59. As the clamping blocks of the die assembly initially engage the metal sheet (as shown in FIG 1), carriage 60 is advanced along bench 57. At the end of the pressing stroke (shown in FIG 4) the die 56 is opened and ram 61 operates to return the carriage 60 to its initial position.

When a roofing panel of predetermined length is obtained after a predetermined number of pressing strokes, shearing apparatus 52 is actuated to shear the completed panel from the metal strip feed stock.

FIGS 8 to 10 illustrate an alternative

embodiment of the invention which is particularly suitable for formation of pressed tile shapes having a configuration similar to that shown in FIG 6.

5 With some complex tile shapes such as that illustrated in FIG 6, the formation of the shouldered deformation 32 and lip 28 (see FIG 5) can give rise to wrinkle formation in the upright face of the shoulder 32, particularly in the region of the upstanding ridges 41. This occurs due to the inability of the coacting die
10 assemblies to initially "crack" the planar sheet material in the region of the finished fold lines as the die assemblies start to deform the planar sheet feedstock.

With a tile configuration similar to that shown in FIG 6, the initial fold or "crack" line occurs
15 outwardly from the upper edge of the shoulder in lower die element 4 thus requiring a progressive rearward refolding of the "crack" line as the die elements move towards their fully closed position. This progressive movement of the "crack" line can give rise to unsightly
20 wrinkles in the upright shoulder face. Moreover, these wrinkles, although quite small, prevent compact stacking of pressed tiles or tile panels and this in turn can add to transportation cost increases.

It is therefore desirable that in the formation
25 of pressed metal roofing tiles or roof panels according to the invention, any initial "cracking" or fold formation in the planar sheet metal stock be as close as possible to the fold lines in the finished pressing.

With this in mind, the press assembly of FIGS 1
30 to 4 may be modified according to an alternative embodiment illustrated in FIGS 8 to 10 of the accompanying drawings.

In FIG 8 the position of the die assembly corresponds to that of FIG 2 in that it is in a partially
35 closed position. FIGS 9 and 10 correspond to the closed die positions illustrated in FIGS 4 and 5 respectively.

In FIG 8 the die assembly 50 comprises an upper

base member 51 and a lower base member 52. Located generally centrally of the die assembly 50 is an upper form block 53 and a lower form block 54, each having complementary contoured surfaces 53b, 54a. On either side of form blocks 53, 54 are situated upper and lower clamping blocks 55, 56 respectively.

On both sides of upper base member 51 are side plates 57. Between sides plates 57 is a support plate 58 adapted for vertical sliding movement between side plates 57 by means of a hydraulic ram (not shown) extending through an aperture 51a in upper base plate 51.

Upper clamp blocks 55 and upper form block 53 are slidably supported on support plate 8 by guide members 60, 61 respectively. Clamp blocks 55 are transversely slidable between side plates 57 and upper form block 3 under the influence of biasing springs 62 between support plate 58 and clamping blocks 55.

The outer sides 55a of upper clamp blocks 55 are tapered in a downwardly divergent manner and are slidable on complementary tapered faces 57a of side plates 57.

Similarly, the outer sides 53a of upper form block 53 are tapered in a downwardly divergent manner and are slidable on complementary inner tapered faces 55b of clamping blocks 55.

Located on one of upper clamping blocks 55 is a pressure pad 63 on the infeed side of the die assembly to increase the effective clamping area of clamping block 55.

Upper form block 53 is slidably secured to support plate 58 by shouldered screws 64 and is biased downwardly by spring 65 between support plate 58 and upper form block 53.

Lower form block 54 is slidably mounted on guide members 66 and is slidable from a retracted position as shown to an extended position by the piston rod 67 of a hydraulic ram (not shown).

Located on each side of lower form block 54 are clamp blocks 68 slidably mounted on guide members 69. Lower form block 54 includes inwardly divergent tapered faces 70 which co-act with complementary tapered faces 71 on adjacent clamp blocks 68.

Lower pressure pads 72 are slidably retained in clamp blocks 68 by shouldered screws 73 and are biased upwardly by springs 74.

FIG 9 shows the die assembly 50 of FIG 8 in a closed position.

FIG 10 shows a schematic cross sectional view through A-A in FIG 9.

As shown in FIG 10, upper form block 53 is adapted for reciprocating movement only in a vertical plane whereas the upper form block 3a of FIG 5 is also adapted for slidable movement in a horizontal plane. Otherwise, the elements 53a, 53b and 53c correspond in function with elements 3a, 3b and 3c of FIG 5.

In the embodiment illustrated in FIGS 8 to 10, the metal sheet 100 is initially fed into the die assembly 50 and is supported on lower pressure pads 72 in the position shown in FIG 8. In its initial rest position the upper portion of die assembly 50 is fully retracted with support plate 58 lying against upper base plate 51.

As the press cycle commences, the upper half of die assembly 50 moves to the position shown in FIG 8 with sheet 100 initially clamped between upper clamp blocks 55 and lower pressure pads 72. The hydraulic ram (not shown) connected to support plate 58 continues to urge the upper portion of die assembly downwards, moving lower pressure pads 72 (and the sheet 100 clamped therebetween) to a fully retracted position resting on the upper surfaces of lower clamp blocks 68.

The hydraulic ram (not shown) continues to urge support plate 58 downwardly against the biasing influence of springs 62 and this in turn brings upper

form blocks 53 into contact with the upper surface of sheet 100 against the biasing influence of spring 65.

At this point the hydraulic ram connected to lower form block 54 is actuated and lower form block 54 moves towards the undersurface of sheet 100 as support plate 58 moves towards the upper surface of upper form block 53. As the lower form block 54 comes into contact with the sheet 100, support plate 58 comes into simultaneous contact with the upper surface of upper form block 53.

During the final stages of travel of the upper and lower form blocks 53, 54 the portion of sheet 100 between the form blocks 53, 54 is deformed upwardly and simultaneously upper clamp blocks 55 are biased inwardly by coaction between tapered faces 55a and 57a respectively of clamp blocks 55 and side plates 57. At the same time lower clamp blocks 56 are urged inwardly by coaction between complementary tapered faces of members (not shown) attached to the front and rear ends of form block 54 and end plates 80 (see FIG 10) of clamp blocks 56 respectively in concert with the inward movement of upper clamp blocks 53 until a final rest position as shown in FIG 9 and also in FIG 10.

It will be found in practice that in pressing of tiles having the general configuration shown in FIG 6 any wrinkling of the front face 81 (FIG 10) of the shouldered step is avoided.

After the pressing operation is concluded, the upper and lower portions of the die assembly 50 move apart and the relative movement of the various components is the reverse of that in the press closure cycle. With the upper and lower portions of the die assembly 50 in the fully retracted position, it will be noted that lower pressure pads 72 elevate the sheet feedstock above the lower form block 53 to permit the sheet 10 to be advance through the die assembly 50 without fouling on any of the components thereof.

The actuation of the various hydraulic and/or mechanical operations of the apparatus may be controlled by any suitable means, preferably a microprocessor to achieve a smooth continuous production of roof cladding elements or other articles produced from pressed metal sheet.

It will be immediately apparent to a skilled addressee that the pressing die and pressing process in accordance with the present invention is applicable to a wide range of metal materials, composites and laminates, regardless of variations in thickness tolerances and ductility tolerances. For example, the same apparatus and process is equally effective with high tensile steel sheet (including stainless steel), mild steel sheet or sheets of soft ductile metals such as copper or aluminum.

Furthermore, it will be readily apparent to a skilled addressee that many modifications and variations may be made to the process and apparatus of the invention without departing from the scope thereof.

For example, the compression springs employed in the pressing die may be replaced with fluid operated devices such as hydraulic and/or pneumatic rams or gas struts. Alternatively, the movable components of the die which rely upon resilient biasing means to return those components to an initial or rest position may be actuated by complementary ramped surfaces in a manner similar to that used to move those components in the first instance.

CLAIMS

1. An apparatus for press forming of sheet metal, said apparatus comprising a press forming die assembly having opposed die members movable relative to each other
5 between an open position and a closed position wherein a sheet of metal introduced between the die members in the open position is pressed, in a single pressing step, to the closed position, to form predetermined contours in the metal sheet, said opposed die members each including
10 die elements slidably movable relative to adjacent die elements both in a direction normal to the plane of the metal sheet to be pressed and in a direction parallel to the plane of the metal sheet to be pressed whereby a reduction in area in at least one direction of the metal
15 sheet as said sheet undergoes contouring is accompanied by a corresponding movement in the same direction of at least certain of said die elements to prevent slippage of the metal sheet between opposed die elements.
2. An apparatus as claimed in claim 1 wherein at
20 least certain of said movable die elements include at least one tapered side wall adapted to slidably engage with an adjacent die element having a complementary tapered side wall whereby in use, relative sliding movement between said at least certain die elements in a
25 direction normal to the plane of the sheet of metal to be pressed causes relative movement between said at least certain die elements parallel to the plane of the sheet of metal to be pressed.
3. An apparatus as claimed in claim 1 or claim 2
30 wherein biasing means is provided between selected adjacent die elements of said die assembly to urge said selected adjacent die elements away from each other.
4. An apparatus as claimed in claim 3 wherein said
biasing means comprises a compression spring.
- 35 5. An apparatus as claimed in claim 3 wherein said biasing means comprises a telescopic gas strut.
6. An apparatus as claimed in claim 3 wherein said



biassing means comprises complementary tapered surfaces on adjacent movable die elements wherein relative sliding movement in a first plane between said adjacent die elements causes movement of one of said movable die elements in a plane perpendicular to said first plane by coaction between said complementary tapered surfaces.

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7. An apparatus as claimed in any preceding claim wherein said apparatus includes means for preforming said metal sheet to form a longitudinal deformation adjacent one or both edges of said metal sheet before entry into said die assembly.

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8. An apparatus as claimed in claim 7 wherein said means for preforming said metal sheet comprises a roll forming device.

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9. A method for contouring metal sheet, said method comprising the steps of introducing a sheet of metal between opposed die members of a press forming die assembly including clamping elements and contouring elements;

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rigidly clamping selected regions of said metal sheet between said clamping elements of said die assembly;

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urging together on opposed faces of said metal sheet selected contouring elements of said die assembly with complementary contoured faces to form a contour in said metal sheet while simultaneously moving said clamping elements towards said contouring elements to accommodate a reduction in planar dimensions of said metal sheet due to contouring thereof whereby regions of metal sheet in contact with surfaces of the die elements remain stationary relative to the respective die elements.

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10. A method as claimed in claim 9 wherein said metal sheet is preformed before entry into the die assembly to form a longitudinal deformation adjacent one or both edges of said metal sheet.

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11. A method as claimed in claim 10 wherein the



metal sheet is preformed by a roll forming process.

12. A contoured metal article formed by pressing a metal sheet with the apparatus according to any one of claims 1 to 8.

5 13. An article formed from pressed metal sheet in accordance with the method of any one of claims 9 to 11.