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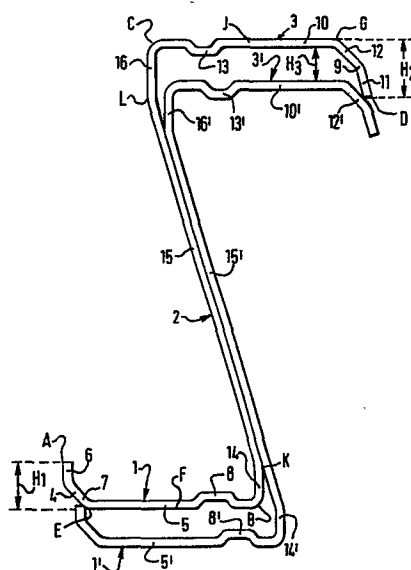
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54 Improvements in purlins.

57 Cold-rolled steel purlins have parallel oppositely directed flanges, one major (3) and one minor (1) with a flat outer fixing surface, terminal intumed lip (4, 9) and longitudinal strengthening groove (8, 13) nearer the inner edge where a central connecting web (2) joints at 90° (14, 16) but is so angled in central regions that a notional plane at right-angles to each flange flat surface longitudinal midline passes through the web and the other flange flat surface. The minor flange outer contour matches the major flange inner contour. The flange lips (4, 9) are angled at least in part at less than 90°. The purlin has good mechanical properties, and can be nested in pairs (with minor flanges inside major flanges) or stacked in the same sense either as individuals or as nested pairs (Figure 1).



Title: "Improvements in Purlins"

This invention relates to purlins cold-rolled from steel strip, and to roof structures incorporating such purlins.

5 It is well known to fabricate purlins i.e. lateral roofing members, by severing from a roll a desired length of steel strip and passing it through a succession of roller pairs. Each roller pair deforms the strip along its length and after the successive deformations caused by the successive roller pairs the desired purlins is
10 obtained having uniform transverse cross-section and corresponding in length to the original severed strip.

A simple and widely used cross-section provides a flat central web with two flanges, possibly of equal width,
15 but usually of different widths each at right angles to the web at opposite sides thereof. Such flanges are provided with outermost lips, bent inwards at right angles to the flange so as to lie parallel to the web.

Another known cross-section similarly provides a
20 central web with two integral flanges at right angles thereto and, if desired inturned lips. In this case, however, the flanges extend from the same side of the web, to provide a channel section, and the web itself is deformed along its central region so as to give a substantial strengthening

ridge of generally trapezoidal cross-section extending within and along the channel.

5 We have established that the design of purlins while being based partly on aesthetic appearance also involves a compromise between various considerations for example (a) convenience of manufacture, (b) convenience of storage and transport, (c) convenience of assembly, and (d) performance under static or dynamic load.

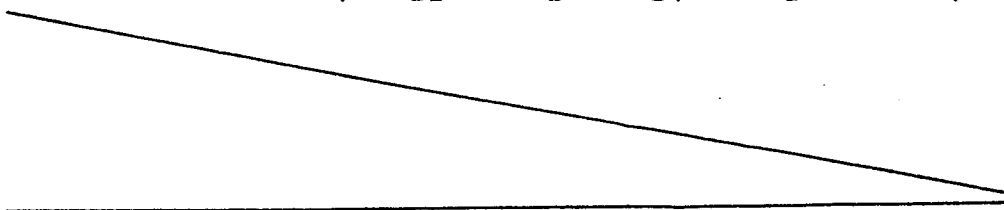
10 By way of example, a simple prior art purlin discussed above is easy to roll since only right-angled bends, obtainable with relatively few roller pairs, are involved. The other prior art example, however with flanges turned the same way, and lips rolled to oppose
15 one another, needs the trapezoidal web profile to be incorporated. This needs more distortion and more rollers of more complicated shape.

Another difference, in storage and transport convenience, can be seen between the two prior art purlins
20 discussed above. A notional purlin with flat oppositely-directed flanges would stack with faces contacting, to minimise storage space or transport space and to facilitate bulk handling. Such a purlin as commercially used with additional lips and differently sized flanges will stack
25 in a convenient manner. The channel-shaped purlin however,

does not stack for storage or transport and for these purposes needs a larger envelope of space.

During assembly, however, the generally channel-shaped prior art purlin possesses certain advantages over the prior art purlin with oppositely directed flanges. This is because the latter tends to "rotate" around its longitudinal axis since its weight is distributed to either side of that axis. With a channel-shaped purlin, there is no maldistribution of weight, with consequently easier assembly techniques e.g. temporary or partial fixing until other members are placed and fitted.

This problem of "rotation" persists in the assembled roof structure. In general, however, the detailed characteristics of performance under static load (from the roof itself) temporary excess static load (e.g. from snow loading) dynamic loading (e.g. by wind pressure) or non-uniform loading e.g. during repair or extension are not predictable. They depend on performance of the purlin under torsion, its bending and buckling performance, and its performance under longitudinal stress. While computer simulation studies can give partial answers it is in this technology usually more practical to assemble the purlin at a desired load, support spacing, and position, and



monitor its performance empirically.

5 The present invention provides purlins with a different type of cross-section, having a novel and advantageous combination of properties, and with good mechanical characteristics in use.

10 Purlins according to the present invention possess mutually parallel flanges extending from the central web in opposite directions (as in the first mentioned example of prior art discussed above) but with the central web so shaped that the flanges, viewed from above the purlin, overlap least in part (as in the second example of prior art discussed above). They further possess features of relative dimension and shaping as defined below.

15 The invention consists in a cold-rolled steel purlin of the type possessing a central web with two oppositely-directed generally parallel flanges each with a flat outer fixing surface and intumed lips, in which: (a) a plane vertical to the midline of either
20 flange flat surface passes through the other flange flat surface (b) the web meets each flange at an angle of substantially 90° (c) each flange is deformed to provide a strengthening groove along the flange between the midline of the flange and the web (d) one flange is a minor
25 flange and the other a major flange, the outer contour of the minor flange and adjacent web portion substantially

matching the inner contour of the major flange and adjacent web portion and (e) each intumed flange lip is angled with respect to its flange to allow two identical purlins to be placed together with the minor flange of one inside the major flange of the other, with the substantially matching flange contours face-to-face to provide a stably nested pair of purlins for transport, storage, or assembly.

We have found that this combination of characteristics gives an optimum product suitable for a range of roof pitches, for reasons, set forth in more detail below, connected with the so-called "neutral plane" of the section.

Because the plane from the midline of each flange flat surface passes through the other such surface the purlin does not "rotate" during fixing. It is however preferred for strength if each such plane passes through the other flange at points nearer the web, e.g. between the web and the groove.

It will be apparent that with this constraint on the relative flange positions the web must be in some way angled in relation to the flanges. We have found, however, that a simple plane web departing from each flange at an angle is not desirable, and that each edge of the web should be at substantially 90° to the flange, moreover, the strength thus imparted, given the behaviour under compression

imposed by the "overlapping" flanges should be supplemented by the strengthening groove as defined.

5 This can be achieved in different ways. In one, the web leaves the flanges at right angles, and joins these portions by a simple angled plane central portions. In other, the web leaves the flanges at right angles, proceeds inwardly at an angle and joins these angled portions by a central plane portion itself at right angles to the flange flat faces.

10 The edge portions of the web, at right angles to the flange, can extend for example to a depth equal to the vertical depth of the inturned lip on that flange.

15 The groove cross-section can be rounded or angled e.g. trapezoidal. If desired additional grooves, e.g. on the outer side of the flange surface mid-line, can be incorporated, although of course a generally flat fixing surface must be preserved at the outer face of the flange.

20 Since the major flange inner contour and the minor flange outer contour substantially match, it will be apparent that (a) the right-angled marginal region of the web in the two cases has a different depth; that at the minor flange being less than that at the major flange

and (b) that correspondingly the grooves should have different cross-sections, that in the minor flange being wider and deeper than that in the major flange. The vertical height of the lips in each case, however, can be the same or different, depending on whether it is desired for the lips at one end of a nested pair to end in a common plane parallel to the flange face, or not. In any case, small differences in the original strip width tend to show up as eventual differences in lip height, so that it is valuable if the design is such as to accommodate these differences.

These flange lips themselves are not simply at 90° to the flange flat faces since the approximate Z-shape of the purlin, would then render it impossible to bring two purlins edge to edge together for nesting.

Optionally, the shape of the purlins can be such that other modes of stacking are also possible.

One useful optional characteristic is to design the flanges and lips so that purlins can be stacked in the same sense (i.e. with major flanges adjacent). Clearly, these flanges will not fit closely one inside the other. Therefore the lips must contact the outer flange faces (or possibly the outer lip faces) of the same size flange. This can be readily achieved if the lips have the same vertical height and rest in each

case upon the outer flange faces. If the major flange lip has a greater vertical height than the minor flange lip, it will need to rest upon the outer angled lip surface, i.e. the major flanges will need to stack slightly inside each other, to compensate for this difference.

With such stacking, the angled region of the web imposes a lateral shift of adjacent purlins. Where the web is of the type where there is a simple angled plane joining the marginal web regions, this still permits a high proportion of face-to-face web contact; where the web is of more complex shape, the detailed dimensions and proportions of the purlin should preferably allow at least two spaced web-to-web contact regions in the stack. Examples of this are described more fully below.

A major desirable characteristic is to dimension the flanges and lips so that it is possible to stack the nested pair as described above. A nested pair, as distinct from a single purlin, is symmetrical. In such cases, it is sometimes desirable that the major flange lip vertical height is greater than the minor flange lip vertical height, to an extent such that they terminate in a common plane parallel to the flange flat face; this facilitates subsequent stacking of such pairs. As noted above, however, the individual differences in lip height arising from differences in strip width from batch to batch can be accommodated without

detracting from this stackability.

Although the invention is primarily directed towards purlins as described above, optionally stackable in the additional modes defined, it also extends to a roof structure incorporating such purlins.

The invention will be further described with reference to the accompanying drawings, in which:-

Figure 1 shows an end view of a purlin according to the invention in stacking relationship with another identical purlin,

Figure 2 shows a partial end view of a purlin as in Figure 1 paired with an identical purlin, and also such pairs of purlins in a further stacking relationship,

Figure 3 shows an end view of another purlin according to the invention, in a stacking relationship as in Figure 1,

Figure 4 shows the paired and stacked purlins of Figure 3.

Figures 5a to 5d show diagrammatically the neutral plane of a prior art purlin, and the positioning of such

a purlin on a roof, in comparison with the neutral plane of purlins according to the invention.

The purlin of Figure 1 has a minor flange 1 extending from A to B, a web 2 extending from B to C and
5 a major flange 3 extending from C to D generally parallel to flange 1. It is of a general Z-cross-section, so that each flange has an outer surface and an inner surface in relation to the Z-shape.

Flange 1 is further divided into lip 4 from A to
10 E and flat face 5 from E to B. Lip 4 has an outermost portion 6, at 90° to flat face 5 and an inner lip portion 7 at 135° thereto as shown. The vertical distance from flat face 5 outer surface and the end of lip 4 at A is H_1 . Point F is halfway between E and B. Between F and B is a
15 swaged groove 8.

Flange 2 is similarly divided into lip 9 from D to G and flat face 10 from G to C. Lip 9 has outermost portion 11, at 115° to flat face 10, and inner lip portion 12 at 135° thereto. The vertical distance from flat face 10 outer
20 surface to the end of lip 9 at D is H_2 . Point J is halfway between C and G. Between J and B is a swaged groove 13.

Web 3 extends from B to C as (i) a connecting
portion 14 from B to K, at 90° to flat face 5, point B also
being at distance H_1 from the flat face 5 (ii) a central

portion 15 from K to L and (iii) a connecting portion 16 from L to C at 90° to flat face 10, point L also being at distance H_2 from flat face 10.

5 A notional line from F at right angles to flat face 5 passes between C and G, and similarly a notional line at right angles to flat face 10, from point J, passes between B and E.

10 H_2 is greater than H_1 by an amount approximately equal to the thickness of the material. Distance CG is greater than distance EB by at least a thickness of material. The inner contour from J' to L is the same as the outer contour from K to F. Two such purlins can be stacked, as shown in Figure 1. Flat surfaces 10 and 10' come to rest at a distance H_3 (slightly less than 15 H_2) apart, because the angled outermost lip portion 11 permits the next purlin flange 3' to fit to a minor and stabilising extent within flange 3. Similarly, flange 1' will fit over flange 1, again with the flat surfaces 5 and 5' a distance H_3 apart since outermost 20 portion 6' is at 90° to 5' and rides on portion 4 slightly differently from portion 11 riding on 12'.

25 At this stage, there is good face-to-face contact of web central portions 15, 15'. The portions 16, 16' or 14, 14' or grooves 13, 13' and 8, 8' do not abut or destroy stable stacking behaviour.

Figure 2 shows other modes of stacking. Since as described above, the inner contour L C J G D is over most of its length (not the extreme end) the same as outer contour K B F E A; and since moreover groove 8
5 outer flange contour is the same as groove 13 inner flange face contour, with complementary spacing from the points B and C respectively, good nesting in pairs as shown in Figure 2 is achieved.

Such pairs of purlins are symmetrical and
10 accordingly only one end of the section is shown, for clarity of illustration. Such symmetrical pairs, especially when H_1 is less than H_2 to give a termination of paired flanges at the same level, can be easily stacked in a stable fashion, also as shown in Figure 2.

15 Figures 3 and 4 show how a more complex shape of purlin, still possessing swaged grooves in the flat faces, and still having 90° angled connecting portions at the ends of the web (in relation to those flat faces) can also be designed to stack in several modes.

20 In this case, flange lips 17 and 18 generally resemble flange lips 4 and 9 in Figure 1, except that they project to the same vertical height H_4 from their respective flat face. Moreover, the central web has a major portion 19 at right-angles to these flange flat
25 faces.

Stacking as at Figure 3 involves the end of each flange lip 17 or 18 nesting on the flat face of the neighbouring flange, because of the rather larger displacement to one side necessitated by the shape of the web. However, since they both have the same vertical height H_4 the purlins are stacked parallel. As shown, the angled portions 20, 21 of the web are in minor but adequate contact at 22 and 23, contact area 22 being slightly larger due to the small size differences between the major and minor flanges as in Figure 1. Thus, even for this more elaborate shape stable stacking can be achieved.

Figure 4 shows that purlins of Figure 3 can be nested in pairs (as achieved in Figure 2 for the purlins of Figure 1). There is a minor flange 24 nesting within a major flange 25, by virtue of the matching of the respective outer and inner contours. The size of gap 26 at the end is optional, but should be adequate to permit the minor flange to slide in past the angle at 27. However, the good matching of groove contours is adequate to ensure good nesting.

Figure 4 also shows how the symmetrical pairs can be stacked. In this case the webs have two symmetrical patches of face-to-face contact (one not shown) e.g. at 28 on the central web region. Again this provides stable stacking behaviour.

Figure 5a shows the cross-section of a well-known type of purlin. When installed under load, there is a neutral plane or axis, indicating the effective resultant of forces and depending upon the geometry of the section.

This neutral plane passes at an angle through the web of the purlin. The size of this angle depends predominantly on the relative dimensions a and b , as shown in Figure 5b, these being the flange width and the web height respectively. In theory, a given a/b ratio is optimum for a roof of a given pitch θ , since the neutral plane is then vertical.

Such profiles as shown in Figures 5a and 5b cannot however usefully be made over a wide range of a to b . Other physical characteristics such as torsion, buckling and bowing resistance are also potentially affected by this ratio. Also, if a is too small on an absolute basis, it becomes difficult in site conditions to ensure fixing of cladding panels to these flanges. Typically the edges of such panels meet along a flange, and a narrow flange cannot accommodate casual differences of panel dimension or alignment over a long run of purlins. The height dimension b can be altered to some extent, so as to be used on a lower pitched roof, but then the total weight of purlin, and its overall size and cost is increased.

Currently, roofs are made to lower pitches than hitherto. We have found that a more useful shape for a low pitched roof is as shown, according to the invention, in Figures 5c and 5d. The neutral plane is at a very small angle to the vertical, or even parallel to the vertical web portion of Figure 5d. Moreover, the flange is wider for a given angle of roof, so as to provide for easier fixing over a long run. Purlins as shown according to the invention, in Figures 5c and 5d are usable with little variation over a wider range of roof types than those of Figures 5a and 5b.

CLAIMS:

1. A cold-rolled steel purlin of the type possessing a central web with two oppositely-directed generally parallel flanges each with a flat outer fixing surface and inturned lips, characterised in that: (a) a plane vertical to the midline of either flange (1 or 3; 24 or 25) flat surface passes through the other flange (3 or 1; 25 or 24) flat surface (b) the web (2, 19) meets each flange at an angle of substantially 90° (14, 16) (c) each flange is deformed to provide a strengthening groove (8,13) along the flange between the midline of the flange and the web (d) one flange is a minor flange (1,24) and the other a major flange (3,25), the outer contour of the minor flange and adjacent web portion substantially matching the inner contour of the major flange and adjacent web portion and (e) each inturned flange lip (4, 9 or 17, 18) is angled with respect to its flange to allow two identical purlins to be placed together with the minor flange of one inside the major flange of the other, with the substantially matching flange contours face to face to provide a stably nested pair of purlins for transport, storage or assembly.

2. A cold-rolled steel purlin as claimed in claim 1 characterised in that the web portions

(14, 16) defined where the web meets each flange at right angles are themselves joined by a single angled planar central portion (15).

3. A cold-rolled steel purlin as claimed in claim 1 characterised in that the web portions defined where the web meets each flange at right-angles are themselves joined first by angled portions (20,21) and then by a central plane portion (19) itself at right angles to the flange flat faces (24,25).

4. A cold-rolled steel purlin as claimed in claim 1, 2 or 3 characterised in that the web portions (14,16 etc) defined where the web meets each flange at right angles extend in each case for a depth equal to the vertical depth of the intumed lips (4,9 or 17,18) on the said flange.

5. A cold-rolled steel purlin as claimed in claim 1, 2 or 3 characterised in that the flange lips (17,18) have the same vertical height whereby two such purlins can be stacked (Figure 3) in the same sense with a lip of each purlin in each case contacting the outer flange surface of the other purlin.

6. A cold-rolled steel purlin as claimed in claim 1, 2 or 3 characterised in that the flange

lips (4, 9) have different vertical heights, whereby two such purlins can be stacked in the same sense with a lip (4) of at least one purlin contacting an outer surface (12') of an angled lip of the other purlin (Figure 1).

7. A cold-rolled steel purlin as claimed in claim 1, 2 or 3 characterised in that the flange and lip shape and dimensions are such that a nested pair of purlins, assembled with the minor flange of each within the major flange of the other, can be stacked with another such pair, in the same sense with a lip or the lips of each contacting flange pair itself contacting the outer flange surface of an adjacent flange pair (Figure 2 or Figure 4).

8. A cold-rolled steel purlin as claimed in any one preceding claim characterised in that the groove cross-section is rounded.

9. A cold-rolled steel purlin as claimed in any of claims 1 to 7 characterised in that the groove cross-section (8 or 13) is trapezoidal.

10. A cold-rolled steel purlin as claimed in any one preceding claim characterised in that it

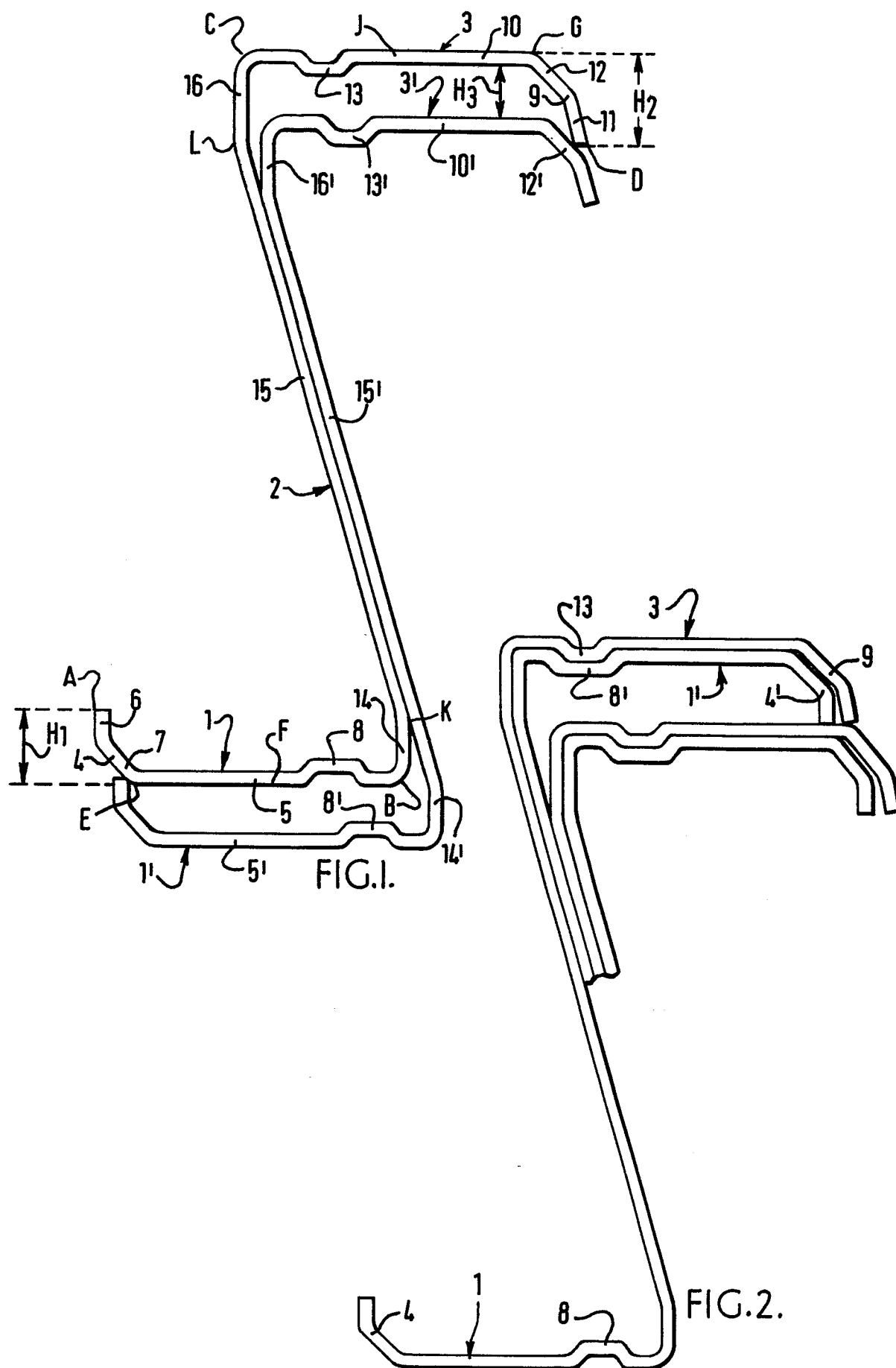
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19.

possesses an additional groove on the outer side of each flange surface midline.

11. A roof-structure characterized in that it incorporates purlins as claimed in any one preceding claim.

1:2



2:2

