An elongated purlin for use in roof structures including an elongated solid continuous strip of metal, the strip of metal having multiple bends parallel with the longitudinal axis to form and define an elongated mounting wall, an elongated upright wall extending from the mounting wall, a first cross piece extending horizontally outwardly in opposite directions from the plane of the upright wall, a second cross piece integrally attached to the first cross piece and extending horizontally outwardly in opposite directions from the plane of the upright wall, and each of the first and second cross pieces having bent double layer construction. The first and second cross pieces are spaced apart to define channels designed to receive an edge of a solar panel or roof section engaged therein.
FIG. 4
FIG. 11
PURLIN CONSTRUCTION FOR ROOF STRUCTURES

CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

[0002] This invention generally relates to purlin type supports for roof structures and more specifically purlins formed from a single strip of metal. The invention further relates to a solar panel roof mounting system.

BACKGROUND OF THE INVENTION

[0003] At the present time, metal roof structures and/or solar panel mounts include purlins in a generally C-shape or, in some instances, a box-shape for extra strength. The solar panels are then mounted on the purlins by means of bolts, screws, or other fastening devices. The purlins have an upper flat surface to which the solar panels are attached. The problem that arises is that the process of attaching the solar panels to the upper flat surface of the purlins is exceptionally difficult and time consuming.

[0004] For example, the solar panels or other roof sections must be placed on the upper flat surface of the purlins which can be a difficult task for larger roof areas, and then attached to the purlins by some attachment devices. The attachment devices can, primarily, be inserted through the purlins and into the solar panels or roof sections from the bottom or beneath the roof. This can be a daunting task since the roof sections are loose and held in place only by their weight. Thus, during the step of fixing the roof sections to the purlins the roof sections can become misaligned or incompletely attached. That is some bolts, screws, or other attachment devices can be inadvertently inserted through the solar panel proper or roof section proper rather than through supporting structures surrounding the solar panels or roof sections. Also, even if the assembly is error free, the task is very work intensive with the time and effort increasing as the errors are eliminated or attempted to be eliminated.

[0005] An additional requirement in the formation of purlins and especially purlins that hold roof sections of solar panels in place to form a flat roof is that they must be strong enough to hold the sections firmly in place during various weather conditions (e.g. wind, snow, rain, etc.). Generally, the solar panels or roof sections are held in place only along a small portion of opposite edges that are fixed to the purlins so as to provide maximum area exposed to the sun. Weather conditions, such as snow, rain, or even wind can produce a tremendous downward pressure on solar panels or roof sections with a relatively large area (e.g. a rectangle multiple feet wide by multiple feet long) so that any physical structure gripping and holding the edges must be able to withstand relatively large vertical forces. Further, the physical structure holding the edges must be designed to cover as small an amount of surface area as possible to provide more upper surface for solar cells and the like.

SUMMARY OF THE INVENTION

[0006] It would be highly advantageous, therefore, to remedy the foregoing and other deficiencies inherent in the prior art.

[0007] Accordingly, it is an object of the present invention to provide a new and improved purlin for roof structures.

[0008] It is another object of the present invention to provide a new and improved purlin for roof structures to which solar panels or roof sections can be easily and quickly attached.

[0009] It is another object of the present invention to provide a new and improved purlin for roof structures that are relatively simple and inexpensive to manufacture and install.

[0010] It is another object of the present invention to provide a new and improved purlin for roof structures that can be conveniently formed from a single strip of metal.

[0011] It is another object of the present invention to provide a new and improved system for roof structures including purlins and end caps that form a complete roof structure.

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bent double layer construction, and a second cross piece integrally attached to the first cross piece and extending horizontally outwardly from the plane of the upright wall in a direction parallel with the direction of the mounting wall, the second cross piece having bent double layer construction. The first cross piece and the second cross piece are spaced apart to define a horizontal channel therebetween opening outwardly from the plane of the upright wall, and the second channel being designed to receive an edge of a solar panel or roof section engaged therein.

The desired objects of the instant invention are further realized in accordance with a preferred embodiment of an elongated purlin for use in roof structures combined with the end cap purlin to form a system for mounting solar panels in a roof structure.

The desired objects of the instant invention are further realized in accordance with a specific method of fabricating an elongated purlin for use in roof structures including the steps of providing an elongated solid continuous strip of metal with a longitudinal axis and bending the strip of metal parallel with the longitudinal axis with multiple bends not necessarily in the order below. The multiple bends include bending the strip of metal parallel with the longitudinal axis to form an elongated mounting wall designed to be mounted to and supported on roof beams, bending the strip of metal parallel with the longitudinal axis to form an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane, bending the strip of metal parallel with the longitudinal axis to form a first cross piece integrally attached to the upright wall with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the upright wall, and bending the strip of metal parallel with the longitudinal axis to form a second cross piece integrally attached to the first cross piece with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the plane of the upright wall. Each of the first portion and the second portion of each of the first and second cross pieces have a bent double layer construction. The steps of bending the strip of metal parallel with the longitudinal axis to form the first cross piece and the second cross piece in a spaced apart relationship define first and second horizontal channels opening outwardly in opposite directions from the plane of the upright wall. The first horizontal channel is defined between the first portion of the first cross piece and the first portion of the second cross piece and the second horizontal channel is defined between the second portion of the first cross piece and the second portion of the second cross piece. Each of the first and second channels is designed to receive an edge of a solar panel or roof section engaged therein.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects and advantages of the instant invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment thereof taken in conjunction with the drawings, in which:

Fig. 1 is an isometric top view of a flat, cantilevered multi-column roof structure of a type anticipated for the present invention;

Fig. 2 is an end view of an improved purlin used in the structure of Fig. 1;

Fig. 3 is a partial longitudinal perspective view of the improved purlin illustrated in Fig. 2;

Fig. 4 is an end view of another embodiment of an improved purlin used in the structure of Fig. 1;

Fig. 5 is an end perspective view illustrating another purlin and one method of assembling the purlin;

Fig. 6 is an end perspective view illustrating another purlin and one method of assembling the purlin;

Fig. 7 is an end perspective view illustrating another purlin and one method of assembling the purlin;

Figs. 8 and 9 are an end perspective view and an end view, respectively, illustrating another purlin;

Fig. 10 is an end view of another embodiment of an improved purlin used in the structure of Fig. 1 in accordance with the present invention; and

Fig. 11 is an end view of an end cap used in conjunction with the purlin of Fig. 10 in a complete roof system, in accordance with the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Turning now to Fig. 1, a flat, cantilevered multi-column structure 10 is illustrated. Structure 10 includes a plurality of vertical columns or posts 12 each with a cantilever beam 14 attached to an upper end 16. A plurality of purlins 18 are affixed to upper surfaces of beams 14 and positioned to extend longitudinally in parallel spaced apart relationship to substantially define the roof area. Additional purlin braces 19 can be incorporated between cantilever beams 14 for additional support if desired or deemed necessary. Some roofing material, such as solar panels or flat roof sections 20 are attached to the upper surface of purlins 18 to form a complete roof. One example of roofing material or flat sections that can be used for sections 20 is provided in copending United States patent application entitled “Solar Support Structure”, bearing Ser. No. 13/036,858, filed on 28 Feb. 2011, and incorporated herein by reference.

For purposes of this disclosure it should be understood that structure 10 is chiefly assembled at the site and it is highly desirable that each step of the assembly procedure be as simple as possible. Basically, each of the components mentioned above (i.e. column 12, beams 14, purlins 18, and roof sections 20) are provided as individual items from a factory/shop and assembled on site into structure 10. By providing the items separately each item can be relatively easily handled by workmen conveying the items to the site and by workmen doing the assembling at the site. Briefly, the assembly procedure includes fixing a lower end 22 of each column 12 in the ground or in a base that serves as the ground. One end of a cantilever beam 14 is affixed to the upper end 16 of each column 12 by structure that is described in more detail in a copending United States patent application entitled “Flat Roof Support Structure”, bearing Ser. No. 61/481,747 filed on 3 May 2011, and incorporated herein by reference.

With cantilever beams 14 fixedly attached, purlins 18 are attached to the upper surface of cantilever beams 14 in a direction perpendicular to cantilever beam 14. Again the attachment of purlins 18 to cantilever beams 14 is illustrated in detail in the above described copending patent application. At this point additional purlin braces 19 can be affixed to purlins 18 between cantilever beams 14 if desired or deemed necessary. Roof sections 20 are then attached to the upper surfaces of purlins 18 in any well known manner (see for example the structure disclosed in the above identified
copending patent application) and using any well known attachment devices such as screws, bolts, etc. It will be understood that structure 10 is used simply as an example of a flat roof structure and many alterations and changes may be incorporated for specific applications.

[0030] Purlins 18 illustrated in the above described copending patent application and FIG. 1 are illustrated as the prior art purlins with a standard C-shaped cross section. As explained above, attaching solar panels or flat roof sections to the upper surface of purlins 18 can be extremely difficult and time consuming. To overcome this problem the new and novel purlin illustrated in FIGS. 2 and 3 and designated 118 is designed to replace purlins 18 in FIG. 1. [0031] Referring specifically to FIGS. 2 and 3, purlin 118 includes a major side or upright wall 120 with a lower or mounting wall 122 extending horizontally at a right angle to upright wall 120. An upright flange 124 is optionally formed at the outer edge of mounting wall 122 to add stiffness or additional lateral support to purlin 118. Upright wall 120, mounting wall 122, and flange 124 extend longitudinally the entire length of purlin 118. The lower surface of mounting wall 122 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 118 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0032] A first cross piece 130 is formed integrally with and at the upper end of upright wall 120. Cross piece 130 extends horizontally outwardly in opposite directions from upright wall 120 to form a T-shape with upright wall 120. The portion of cross piece 130 extending outwardly to the right in FIG. 2 is designated 130a and the portion of cross piece 130 extending outwardly to the left in FIG. 2 is designated 130b. In a similar fashion a second cross piece 132 is formed integrally with upright wall 120 and spaced downwardly from cross piece 130. Cross piece 132 extends horizontally outwardly in opposite directions from upright wall 120 to form a T-shape with upright wall 120. The portion of cross piece 132 extending outwardly to the right in FIG. 2 is designated 132a and the portion of cross piece 132 extending outwardly to the left in FIG. 2 is designated 132b.

[0033] As can be seen best in FIG. 2, portions 130a and 132a cooperate to form a longitudinally extending channel 136 therebetween. Similarly, portions 130b and 132b cooperate to form a second longitudinally extending channel 138 therebetween positioned in an opposed direction with channel 136. It will be understood that channel 136, along with a facing channel in the next adjacent purlin form a complete track for receiving and holding opposed edges of a solar panel or flat roof section. Similarly, channel 138, along with a facing channel in the next adjacent purlin, form a complete track for receiving and holding opposed edges of an adjacent solar panel or flat roof section. Thus, solar panels or flat roof sections are quickly and easily attached by simply sliding them longitudinally into cooperating channels in adjacent purlins. The solar panels or flat roof sections can be fixed in place by optionally inserting attachment devices such as screws, bolts, etc. upwardly through the proper portion 132a or 132b supporting the solar panel or flat roof section.

[0034] It will be understood that portions 130a and 130b and portions 132a and 132b can be the same horizontal length or one or the other can be extended slightly horizontally to add additional support where desired. Also, in the form of a specialty item, purlins with portions 130b and 132b can be eliminated to form edge purlins for the edge of the roof.

[0035] Some measurements for purlin 118 manufactured in accordance with the present invention, as illustrated in FIG. 2, include the following. The total vertical height of upright wall 120 is 7.0"; the horizontal width of mounting wall 122 is 2.50"; the vertical height of flange 124 is 0.50"; portions 130a and 130b extend horizontally a total distance of 2.250" from edge to edge; and each portion 132a and 132b extends horizontally outwardly 0.750". Also, the vertical spacing between the lower surface of cross piece 130 and the upper surface of cross piece 132 is 1.750". Preferably, the thickness of the material forming purlin 118 is 0.070". It will be understood that these measurements are simply included for example and any measurements may change for specific applications. Further, since the purlin 118 is preferably formed as a single integral unit for the entire length, at least one method of manufacture includes extruding in a well known operation.

[0036] Turning now to FIG. 4, an end view is illustrated of another embodiment of an improved purlin 218 that can be used in the structure of FIG. 1 in accordance with the present invention. Purlin 218 basically includes a C-shaped channel structure, generally designated 220, with a T-shaped structure, generally designated 222, integrally attached to an upper surface thereof. It will be appreciated that purlin 218 incorporates a much sturdier structure without being unduly heavier or more difficult to manufacture.

[0037] C-shaped channel 220 includes a horizontal lower or mounting wall 224 with an upright wall 226 extending vertically upwardly from one edge. An upright vertical flange 228 is optionally formed at the outer edge of mounting wall 224 to add stiffness or additional lateral support to purlin 218. A second horizontal wall 230 extends from the upper edge of upright wall 226 in a parallel spaced apart overlying relationship to mounting wall 224. A downwardly directed vertical flange 232 is optionally formed at the outer edge of second horizontal wall 230 to add stiffness or additional lateral support to purlin 218. Integrally formed mounting wall 224, upright wall 226, second horizontal wall 230, and flanges 228 and 232 extend longitudinally the entire length of purlin 218 and cooperate to define C-shaped channel 220.

[0038] T-shaped structure 222 includes an upright wall 240 extending vertically upwardly from the upper surface of second horizontal wall 230 and longitudinally the entire length of purlin 218. Upright wall 240 is affixed to the upper surface of second horizontal wall 230 approximately midway between the edges so that second horizontal wall 230 is divided into approximately equal portions 230a (extending to the right) and 230b (extending to the left). A cross piece 242 is integrally formed in a horizontally extending orientation along the upper edge of upright wall 240. A portion of cross piece 242 extending to the right from upright wall 240 is designated 242a and a portion of cross piece 242 extending to the left from upright wall 240 is designated 242b.

[0039] Thus portion 230a of second horizontal wall 230 and portion 243a of cross piece 242 form a longitudinally extending, outwardly opening channel 250 and portion 230b of second horizontal wall 230 and portion 243b of cross piece 242 form a longitudinally extending channel 252 opening outwardly in an opposed direction to channel 250. It will be understood that channel 250, along with a facing channel in the next adjacent purlin form a complete track for receiving and holding opposed edges of a solar panel or flat roof section. Similarly, channel 252, along with a facing channel in
the next adjacent purlin, form a complete track for receiving and holding opposed edges of an adjacent solar panel or flat roof section.

[0040] It should be noted that in this preferred embodiment C-shaped channel 220 and T-shaped structure 222 are formed as an integral unit with all components formed as a single integral structure. However, it will be understood that in some special applications portions of purlin 219 might be formed separately and attached by welding or the like. For example T-shaped structure 222 and C-shaped channel 220 might be formed separately and attached in the orientation illustrated by welding or the like. In the instance where purlin 218 is formed as a single integral unit for the entire length, at least one method of manufacture includes extruding in a well known operation.

[0041] Some measurements for purlin 218, manufactured in accordance with the present invention as illustrated in FIG. 4 include the following measurements. The total vertical height from the lower surface of mounting wall 224 to the upper surface of cross piece 242 is 6.00"; the horizontal width of mounting wall 224 and second horizontal wall 230 is 2.50"; the vertical height of flanges 228 and 232 is 0.50"; the vertical height from the upper surface of second horizontal wall 230 to the upper surface of cross piece 242 is 1.750"; and the total horizontal width of cross piece 242 is 2.00" with each portion 242a and 242b extending 1.00" from the center of upright wall 240. In this specific embodiment, flange 232 and second horizontal wall 230 are formed with a thickness of 0.120" and the remainder of C-shaped channel 220 is formed with a thickness of 0.060". Also, cross piece 242 is formed with a thickness of 0.120" and upright wall 240 may be formed with a thickness of 0.600". It will be understood that these measurements are simply included for example and any measurements may change for specific applications.

[0042] Turning now to FIG. 5, an end perspective view is illustrated of another purlin, designated 318, which may be used in the structure illustrated in FIG. 1 instead of the purlin illustrated in FIG. 2. Purlin 318 includes a major side or upright wall 320 with a lower or mounting wall 322 extending horizontally at a right angle to upright wall 320. An upright flange 324 is optionally formed at the outer edge of mounting wall 322 to add stiffness or additional lateral support to purlin 318. Upright wall 320, mounting wall 322, and flange 324 extend longitudinally the entire length of purlin 318. The lower surface of mounting wall 322 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 318 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0043] In this specific method and structure, upright wall 320, mounting wall 322, and flange 324 are provided as a unit or a stand-alone component of purlin 318. A first U-shaped channel member 330 and a second U-shaped channel member 332 are also provided as components of purlin 318. The components are then assembled into purlin 318 by abutting channel member 330 against upright wall 320 adjacent the right upper end so that it defines an outwardly extending channel 336 and abutting channel member 332 against upright wall 320 adjacent the left upper end so that it defines an outwardly opening channel 338. Upright wall 320, U-shaped channel member 330, and U-shaped channel member 332 are then fixedly attached together by some convenient means such as spot welding (preferably), riveting, etc.

[0044] In the preferred embodiment purlin 318 is manufactured from any convenient metal such as aluminum, sheet steel, etc. Generally, upright wall 320, U-shaped channel member 330, and U-shaped channel member 332 can be fabricated from convenient metal material, such as a relatively heavy gauge sheet metal (e.g. 14 gauge to 25 gauge) with the specific metal selected for any specific roof application. For example in roof applications requiring substantial support the sheet metal selected might be sheet steel while in applications requiring less support but where weight might be a consideration sheet aluminum might be used. Thus, spot welding can be used to conveniently and quickly assemble the three components into a complete purlin at the factory.

[0045] Turning now to FIG. 6, an end perspective view is illustrated of another purlin, designated 418. Purlin 418 includes a major side or upright wall 420 with a lower or mounting wall 422 extending horizontally at a right angle to upright wall 420. An upright flange 424 is optionally formed at the outer edge of mounting wall 422 to add stiffness or additional lateral support to purlin 418. Upright wall 420, mounting wall 422, and flange 424 extend longitudinally the entire length of purlin 418. The lower surface of mounting wall 422 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 418 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0046] In this specific method and structure, upright wall 420, mounting wall 422, and flange 424 are provided as a unit or a stand-alone component of purlin 418. A first L-shaped member 430 and a second L-shaped member 432 are also provided as components of purlin 418. The components are then assembled into purlin 418 by abutting L-shaped member 430 against upright wall 420 adjacent the right upper end so that it defines an outwardly extending shelf or arm 436 and abutting L-shaped member 432 against upright wall 420 adjacent the left upper end so that it defines an outwardly extending shelf or arm 438. For purposes of this disclosure, L-shaped members 430 and 432 will be deemed to define horizontally outwardly opening channels. For purposes of ease of understanding the pair of elongated L-shaped members 430 and 432 may be hereinafter referred to as “angle-irons” (although not necessarily formed of iron or steel) affixed to an upper end of the upright wall in an upright leg-to-upright leg orientation. Upright wall 420, L-shaped member 430, and L-shaped member 332 are then fixedly attached together by some convenient means such as spot welding (preferably), riveting, etc.

[0047] In the use of Purlin 418 of FIG. 6, the purlins are positioned and affixed on a roof as described above but rather than sliding roof sections 20 into channels (as described in conjunction with purlin 118), roof sections 20 are simply placed on the upper surfaces of each shelf or arm 436 and 438. Roof sections 20 can then be fixedly engaged to each shelf or arm 436 and 438 by inserting screws, bolts, etc. from the bottom.

[0048] Turning now to FIG. 7, an end perspective view is illustrated of another purlin, designated 518. Purlin 518 includes a major side or upright wall 520 with a lower or mounting wall 522 extending horizontally at a right angle to upright wall 520. An upright flange 524 is optionally formed at the outer edge of mounting wall 522 to add stiffness or additional lateral support to purlin 518. Upright wall 520, mounting wall 522, and flange 524 extend longitudinally the
entire length of purlin 518. The lower surface of mounting wall 522 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 518 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0049] In this specific method and structure, upright wall 520, mounting wall 522, and flange 524 are provided as a unit or a stand-alone component of purlin 518. A flat strip of sheet metal 530 is formed with a U-shaped, downwardly opening channel 540 in the mid portion thereof. Channel 540 extends longitudinally the length of strip 530 and is further formed with transversely outwardly extending arms 536 and 538. The components are assembled into purlin 518 by positioning the upper end of upright wall 520 in the downwardly opening channel 540 and fixing the components together by some convenient means, such as spot welding (preferably), riveting, etc. Outwardly extending arms 536 and 538 define outwardly extending horizontal shelves on opposite sides of upright wall 520 adjacent the upper end. For purposes of this discussion strip 530 and outwardly extending arms 536 and 538 will be deemed to define horizontally outwardly opening channels.

[0050] In the use of Purlin 518 of FIG. 7, the purlins are positioned and affixed on a roof as described above but rather than sliding roof sections 20 into channels (as described in conjunction with purlin 118), roof sections 20 are simply placed on the upper surfaces of each arm 536 and 538 on opposite sides of U-shaped, downwardly opening channel 540. Roof sections 20 can then be fixedly engaged to each arm 536 and 538 by inserting screws, bolts, etc. from the bottom.

[0051] Turning now to FIGS. 8 and 9, another purlin, designated 618 is illustrated. Purlin 618 includes a major side or upright wall 620 with a lower or mounting wall 622 extending horizontally at a right angle to upright wall 620. An upright flange 624 is optionally formed at the outer edge of mounting wall 622 to add stiffness or additional lateral support to purlin 618. Upright wall 620, mounting wall 622, and flange 624 extend longitudinally the entire length of purlin 618. The lower surface of mounting wall 622 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 618 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0052] In this specific method and structure, the material forming upright wall 620 continues and is bent into a first U-shaped channel member 630 and a second U-shaped channel member 632. U-shaped channel 630 is defined by a lower horizontal wall 634, extending at approximately a ninety degree angle to the upper end of upright wall 620, a vertical wall 635 extending upwardly from horizontal wall 634, and a horizontal wall 636 extending parallel to and spaced upwardly from horizontal wall 634. U-shaped channel member 632 is defined by horizontal wall 636, which forms a lower wall, a vertical wall 637 extending upwardly from horizontal wall 636, and a horizontal wall 638 extending parallel to and spaced upwardly from horizontal wall 636. Here it should be specifically noted that all of the walls and components of purlin 618 are most conveniently formed from a single piece of sheet metal and can be bent into the shape illustrated or extruded directly in a well known operation. Thus, the manufacture of purlin 618 is a simple one step operation. While the sheet metal can vary in thickness and type, in a preferred embodiment 14 gauge sheet steel is employed.

[0053] In the use of Purlin 618 of FIGS. 8 and 9, the purlins are positioned and affixed on a roof as described above and roof sections 20 are slide lengthwise into channels 630 and 632 (as described in conjunction with purlin 118). Holes 631 are illustrated in the vertical walls of channels 630 and 632 which may be used to secure roof panels 20 therein if desired. It will be noted that channels 630 and 632 open in opposite directions so that during assembly of a structure such as structure 10 of FIG. 1 it will be necessary to alternate purlins 618 so that channels 630 in adjacent purlins open toward each other and channels 632 in adjacent purlins open toward each other. It will also be noted that roof sections 20 in channels 632 are offset upwardly from roof sections 20 in channels 630. However, roof sections 20 in channels 632 overlap the edges of roof sections 20 in channels 630 so that there is no loss of integrity.

[0054] Turning now to FIG. 10, an end view of an improved purlin, designated 700 is designed to be used in the structure of FIG. 1 in accordance with the present invention. First and foremost it must be noted that purlin 700 is conveniently formed from a single elongated strip of metal that extends longitudinally or along a longitudinal axis at least the desired length of the purlin and that has a width sufficient to allow the formation of the various flats and bends parallel to the longitudinal axis as described in further detail below. As an example, purlin 700 can be formed with an overall vertical height of 8" or 10" and the width of the strip of metal used will be 19.00" and 21.00", respectively. Also, preferably, the strip of metal will be galvanized steel with a thickness of 0.050" to 0.068" to provide the desired workability and the required strength.

[0055] Referring more specifically to FIG. 10, the various flat portions and bends are described in more detail but not necessarily in the steps in which they are formed. Also, because all of the bends and flats are parallel with the longitudinal axis of the strip of metal each bend and flat is integrally attached to adjacent bends and/or flats. Purlin 700 includes a major side or upright wall 720 with a lower or mounting wall 722 extending horizontally at a right angle to upright wall 720. An upright flange 724 is optionally formed at the outer edge of mounting wall 722 to add stiffness or additional lateral support to purlin 700. Upright wall 720, mounting wall 722, and flange 724 extend longitudinally the entire length of purlin 700. The lower surface of mounting wall 722 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1. The attaching of purlins 700 to the roof beams is described in detail in one or both of the above cited copending patent applications and will not be elaborated upon further herein.

[0056] A cross piece 730 is formed integrally in the strip of metal composing purlin 700 and at the upper end of purlin 700. Cross piece 730 extends horizontally outwardly in opposite directions from a plane containing upright wall 720 to form a T-shape with the plane of upright wall 720. A portion of cross piece 730 extends upwardly in FIG. 10 and is designated 730a. A portion of cross piece 730 extends downwardly in FIG. 10 and is designated 730b. To form portions 730a and 730b the strip of metal composing purlin 700 is bent first approximately 90° away from the plane of upright wall 720 for approximately 0.75" and then reversed or bent approximately 180° back toward the plane of upright wall 720. The
strip of metal continues across the top, past the plane of upright wall 720, and approximately 0.75" away from the plane of upright wall 720 in the opposite direction to define portion 730b. The upper edge of the strip of metal is bent downwardly and back approximately 180° toward the plane of upright wall 720, as a lower part of portion 730b. Thus, both portions 730a and 730b include bent double layers of the metal strip to provide the necessary strength to hold solar panels fixedly in place.

In a similar fashion, a cross piece 732 is formed integrally with upright wall 720 and spaced downwardly from cross piece 730 a distance of approximately 2.00". Because cross piece 732 is formed in the strip of metal composing purlin 700 between mounting wall 722 and cross piece 730, the upright wall could be considered to be constructed in two portions. However, for convenience of understanding the portion integrally formed between mounting wall 722 and cross piece 732 is herein referred to and designated as upright wall 720, with the portion extending between first cross piece 730 and second cross piece 732 simply being referred to as integrally connecting first cross piece 730 and second cross piece 732.

Cross piece 732 extends horizontally outwardly in opposite directions from upright wall 720 to form a T-shape with upright wall 720. A portion of cross piece 732 extending upwardly in FIG. 10 is designated 732a and a portion of cross piece 732 extending downwardly in FIG. 10 is designated 732b. In the example illustrated, to form portion 732a, the strip of metal composing purlin 700 is bent first approximately 90° away from the plane of upright wall 720 for approximately 1.25" and then reversed or bent approximately 180° back toward the plane of upright wall 720. The strip of metal continues across the top of portion 732a, past the plane of upright wall 720, and approximately 1.25" away from the plane of upright wall 720 in the opposite direction to define portion 732a. In this example, to make portions 732a and 732b lie approximately in a common plane (i.e. produce a flat roof) the strip of metal jogs slightly at approximately the plane of upright wall 720 as it proceeds from portion 732a to portion 732b. At approximately 1.25" away from the plane of upright wall 720 the strip of metal is bent approximately 180° back toward the plane where it is bent approximately 90° to continue upwardly toward cross piece 730 so that both portions 732a and 732b include bent double layers of the metal strip to provide the necessary strength to hold solar panels fixedly in place. It will be understood that the bent double layers of portions 730a, 730b, 732a, and 732b provide a very rigid support for solar panels or roof portions that will hold the solar panels rigidly in place throughout the occurrence of virtually any external force (e.g. wind, snow, rain, etc.).

Here it must be specifically noted that upright wall 720 holds the entire roof structure spaced from the roof beams and, therefore, must be a continuous or complete wall with no cutouts, panels or other openings formed therein that would weaken the vertical strength of the purlin as it extends in a horizontal direction. It will be understood that because purlin 700 extends horizontally in a flat roof structure, all of the pressure and forces encountered by a normal roof (including gravity) produce a vertical pressure or force perpendicular to the length or longitudinal direction of purlin 700, i.e. in the plane of upright wall 720 and perpendicular to its length.

It will be understood that the above bends and measurements describe a preferred embodiment and different measurements can be incorporated for different or special applications. Further, the specific measurements described provide the optimum strength and solar panel holding or fixing capabilities without using an undue amount of material or interfering with the operation of the solar panels. Also, it is believed that the double layer construction of the portions 730a, 730b, 732a, and 732b are required to provide the strength necessary to hold solar panels in a flat roof structure and withstand vertical pressures under any conditions.

As can be seen, portions 730a and 732a cooperate to form a longitudinally extending channel 736 therebetween. Similarly, portions 730b and 732b cooperate to form a second longitudinally extending channel 738 therebetween positioned in an opposed direction with channel 736. It will be understood that channel 736, along with a facing channel in the next adjacent purlin form a complete track for receiving and holding opposed edges of a solar panel or flat roof section. Similarly, channel 738, along with a facing channel in the next adjacent purlin, form a complete track for receiving and holding opposed edges of an adjacent solar panel or flat roof section. Thus, solar panels or flat roof sections are quickly and easily attached by simply sliding them longitudinally into cooperating channels in adjacent purlins. The solar panels or flat roof sections can be fixed in place by optionally inserting attachment devices such as screws, bolts, etc. upwardly through the proper portion 732a or 732b supporting the solar panel or flat roof section.

Turning now to FIG. 11, an end view is illustrated of an end cap purlin 750 used in conjunction with purlin 700 of FIG. 10 in a complete roof system, in accordance with the present invention. As described above in conjunction with FIG. 1, a plurality of purlins 18 are affixed to upper surfaces of beams 14 and positioned to extend longitudinally in parallel spaced apart relationship to substantially define the roof area. When purlins 18 are replaced with purlins 700 of FIG. 10, the outside purlins (i.e. upper and lower edges of flat, cantilevered multi-column structure 10) are preferably an end cap purlin 750 as illustrated in FIG. 11 to form a complete roof system.

End cap purlin 750 is constructed similar to purlin 700 with a major side or upright wall 751 with a lower or mounting wall 752 extending horizontally at a right angle to upright wall 751. An upright flange 754 is optionally formed at the outer edge of mounting wall 752 to add stiffness or additional lateral support to purlin 750. Upright wall 751, mounting wall 752, and flange 754 extend longitudinally the entire length of purlin 750. The lower surface of mounting wall 752 is designed to be mounted to and supported on roof beams, such as cantilever beams 14 in FIG. 1.

The difference between end cap purlins 750 and purlin 700 is that a pair of channel defining portions 753 and 754 are formed adjacent the upper end of upright wall 751 extending away from the plane of upright wall 751 only in a direction parallel to and overlying mounting wall 752. Thus, in a finished roof system using end cap purlins 750 and purlins 700 no unsightly channels are left empty and extending outwardly from the edges of the roof. In this preferred embodiment, portions 753 and 754 defining a channel 756 are formed with the bent double layer construction in a fashion similar to that described in conjunction with the formation of channel 736 in FIG. 10.

Thus, it will be understood that the new and improved purlins for use in roof structures easily position and mount solar panels or other flat roof sections with substantially reduced effort and error. The new and improved purlins
for use in flat roof structures are manufactured from any convenient metal such as aluminum, sheet steel, etc. The new and improved purlins include the bent double layer construction for portions required to hold solar panels in place under any conditions and the purlins further include continuous (i.e. no breaks or openings) upright walls that are sufficiently strong to support a roof under substantially any conditions. Also, a complete roof system is described in which end cap purlins are included to provide a finished edge of the roof. Further, the new and improved purlins for use in flat roof structures can be easily bolted to roof beams at the site and do not require any on-site welding or any special tools.

Various changes and modifications to the embodiment herein chosen for purposes of illustration will readily occur to those skilled in the art. To the extent that such modifications and variations do not depart from the spirit of the invention, they are intended to be included within the scope thereof which is assessed only by a fair interpretation of the following claims.

Having fully described the invention in such clear and concise terms as to enable those skilled in the art to understand and practice the same, the invention claimed is:

1. An elongated purlin for use in roof structures comprising:
   - an elongated solid continuous strip of metal with a longitudinal axis, the strip of metal having multiple bends parallel with the longitudinal axis to form and define:
     - an elongated mounting wall designed to be mounted to and supported on roof beams;
     - an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane;
     - a first cross piece integrally attached to the upright wall with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the upright wall, each of the first portion and the second portion of the first cross piece formed with bent double layer construction;
     - a second cross piece integrally attached to the first cross piece with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the plane of the upright wall, each of the first portion and the second portion of the second cross piece formed with bent double layer construction;
     - the first cross piece and the second cross piece being spaced apart to define first and second horizontal channels opening outwardly in opposite directions from the plane of the upright wall, the first horizontal channel being defined between the first portion of the first cross piece and the first portion of the second cross piece and the second horizontal channel being defined between the second portion of the first cross piece and the second portion of the second cross piece, and each of the first and second channels being designed to receive an edge of a solar panel or roof section engaged therein.

2. An elongated purlin as claimed in claim 1 wherein the elongated upright wall between the elongated mounting wall and the first cross piece is continuous with no breaks or openings therein.

3. An elongated purlin as claimed in claim 1 wherein the elongated solid continuous strip of metal has a length at least equal to a desired length of the elongated purlin and a width approximately 19.00 inches to 21.00 inches.

4. An elongated purlin as claimed in claim 1 wherein the first portion and the second portion of the first cross piece extend horizontally outwardly a greater distance than the first portion and the second portion of the second cross piece.

5. An elongated purlin as claimed in claim 4 wherein the first cross piece extends horizontally outwardly in opposite directions from the plane of the upright wall a distance greater than 1 inch.

6. An elongated purlin as claimed in claim 4 wherein the second cross piece extends horizontally outwardly in opposite directions from the plane of the upright wall a distance less than 1 inch.

7. An elongated end cap purlin for use in roof structures comprising:
   - an elongated solid continuous strip of metal with a longitudinal axis, the strip of metal having multiple bends parallel with the longitudinal axis to form and define:
     - an elongated mounting wall designed to be mounted to and supported on roof beams;
     - an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane, the mounting wall extending from the upright wall in a direction;
     - a first cross piece integrally attached to the upright wall and extending horizontally outwardly from the upright wall in a direction parallel with the direction of the mounting wall, the first cross piece formed with bent double layer construction;
     - a second cross piece integrally attached to the first cross piece and extending horizontally outwardly from the plane of the upright wall in a direction parallel with the direction of the mounting wall, the second cross piece formed with bent double layer construction;
     - the first cross piece and the second cross piece being spaced apart to define a horizontal channel therebetween opening outwardly from the plane of the upright wall, and the second channel being designed to receive an edge of a solar panel or roof section engaged therein.

8. A solar panel mounting system for use in roof structures comprising:
   - a plurality of elongated purlins with each purlin comprising an elongated solid continuous strip of metal with a longitudinal axis, the strip of metal having multiple bends parallel with the longitudinal axis to form and define:
     - an elongated mounting wall designed to be mounted to and supported on roof beams;
     - an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane;
     - a first cross piece integrally attached to the upright wall with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the upright wall, each of the first portion and the second portion of the first cross piece formed with bent double layer construction;
     - a second cross piece integrally attached to the first cross piece with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the plane of the upright wall, each of the first portion and the second portion of the second cross piece formed with bent double layer construction; and
the first cross piece and the second cross piece being spaced apart to define first and second horizontal channels opening outwardly in opposite directions from the plane of the upright wall, the first horizontal channel being defined between the first portion of the first cross piece and the first portion of the second cross piece and the second horizontal channel being defined between the second portion of the first cross piece and the second portion of the second cross piece, and each of the first and second channels being designed to receive an edge of a solar panel or roof section engaged therein;
a plurality of elongated end cap purlins, each end cap purlin comprising:
an elongated solid continuous strip of metal with a longitudinal axis, the strip of metal having multiple bends parallel with the longitudinal axis to form and define:
an elongated mounting wall designed to be mounted to and supported on roof beams;
an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane, the mounting wall extending from the upright wall in a direction;
a first cross piece integrally attached to the upright wall and extending horizontally outwardly from the upright wall in a direction parallel with the direction of the mounting wall, the first cross piece formed with bent double layer construction;
a second cross piece integrally attached to the first cross piece and extending horizontally outwardly from the plane of the upright wall in a direction parallel with the direction of the mounting wall, the second cross piece formed with bent double layer construction; and
the first cross piece and the second cross piece being spaced apart to define a horizontal channel therebetween opening outwardly from the plane of the upright wall, and the second channel being designed to receive an edge of a solar panel or roof section engaged therein; and
a plurality of solar panels;
the plurality of elongated purlins and the plurality of elongated end cap purlins attached to roof beams to define a flat roof and the plurality of solar panels engaged in each of the first and second horizontal channels of the plurality of elongated purlins and the horizontal channel of each of the plurality of elongated end cap purlins to form a continuous flat roof.

9. A method of fabricating an elongated purlin for use in roof structures comprising the steps of:
providing an elongated solid continuous strip of metal with a longitudinal axis, bending the strip of metal parallel with the longitudinal axis with multiple bends not necessarily in the order listed below;
bending the strip of metal parallel with the longitudinal axis to form an elongated mounting wall designed to be mounted to and supported on roof beams;
bending the strip of metal parallel with the longitudinal axis to form an elongated upright wall integrally affixed to and extending from the mounting wall and extending in a plane;
bending the strip of metal parallel with the longitudinal axis to form a first cross piece integrally attached to the upright wall with a first portion and a second portion extending horizontally outwardly in opposite directions from the plane of the upright wall to form a T-shape with the upright wall, each of the first portion and the second portion of the first cross piece formed with bent double layer construction; and
bending the strip of metal parallel with the longitudinal axis to form the first cross piece and the second cross piece in a spaced apart relationship to define first and second horizontal channels opening outwardly in opposite directions from the plane of the upright wall, the first horizontal channel being defined between the first portion of the first cross piece and the first portion of the second cross piece and the second horizontal channel being defined between the second portion of the first cross piece and the second portion of the second cross piece, and each of the first and second channels being designed to receive an edge of a solar panel or roof section engaged therein.

10. A method as claimed in claim 9 wherein the steps of bending the strip of metal parallel with the longitudinal axis to form the first cross piece and bending the strip of metal parallel with the longitudinal axis to form the second cross piece includes forming the first cross piece to extend horizontally outwardly a greater distance than the second cross piece.

11. A method as claimed in claim 9 wherein the step of bending the strip of metal parallel with the longitudinal axis to form the first cross piece includes extending the first cross piece horizontally outwardly in opposite directions from the plane of the upright wall a distance greater than 1 inch.

12. A method as claimed in claim 9 wherein the step of bending the strip of metal parallel with the longitudinal axis to form the second cross piece includes extending the second cross piece horizontally outwardly in opposite directions from the plane of the upright wall a distance less than 1 inch.