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SELF-SUPPORTING PANELED STRUCTURE AND METHOD OF CONSTRUCTING SAME

Filed May 18, 1965

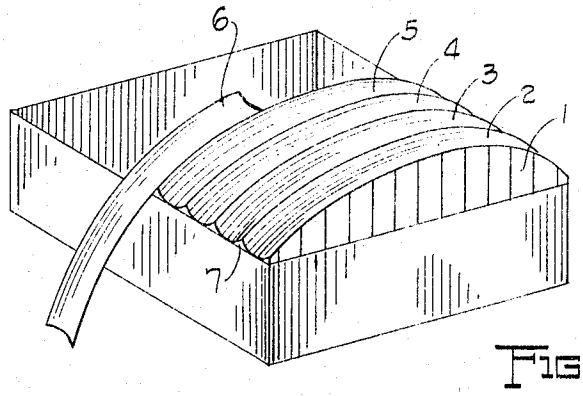

FIG. 1

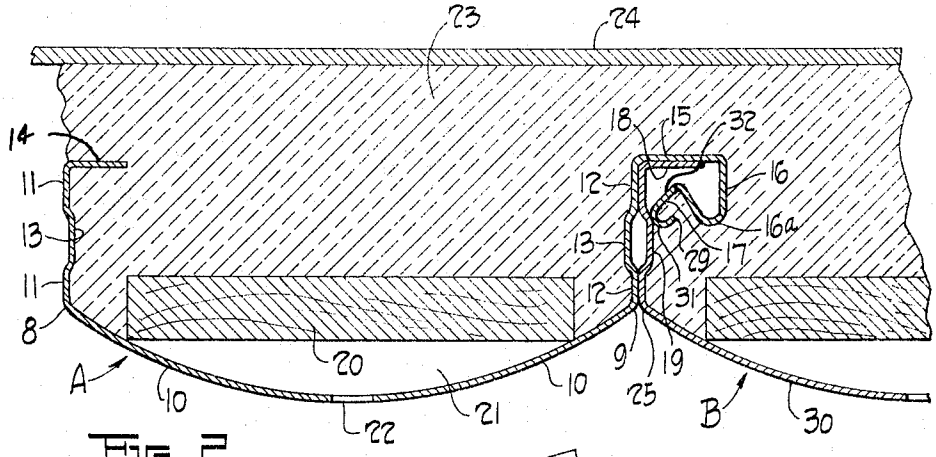

FIG. 2

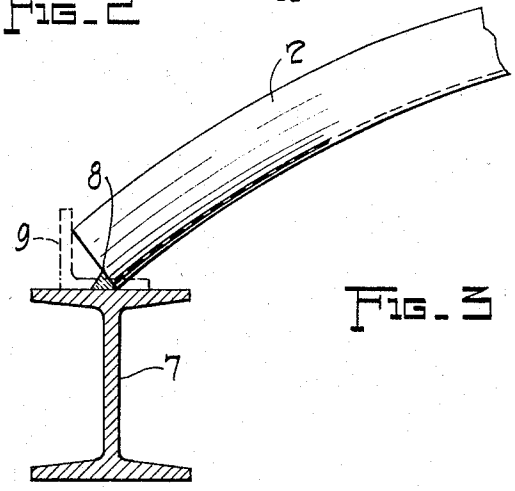

FIG. 3

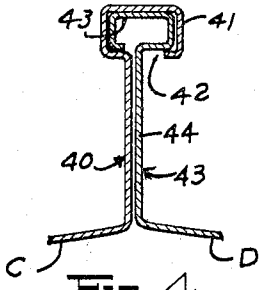

FIG. 4

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SELF-SUPPORTING PANELED STRUCTURE AND METHOD OF CONSTRUCTING SAME

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This application is a continuation-in-part of my copending application Serial No. 306,070 filed September 3, 1963, now abandoned.

This invention relates, as indicated, to roofs and the method of constructing such roofs, and more particularly to roof decks formed from metallic beams, and still more particularly to arcuate roof structures and beams therefor.

Recent trends in building construction, particularly industrial building construction, have emphasized single story contiguous units employing arched roof construction wherein the full roof load is supported at the extremities of the arch without employing intermediate pillars or supporting columns. Free span structures of the arched roof type having a cord length of from 40 to 100 feet or more, and a height of the arch above the ground ranging from about 15 feet to as high as 2 or more stories above the basic framework have been made. These structures depend upon supporting beams of large and cumbersome structure, usually of laminated wood, or made up of a plurality of metallic arcuate roof members in short sections which sections are individually installed and secured together, such as by bolting, welding or some other such fastening means. The installation of such structures has always involved the erection of costly scaffolding. For proper installation, the entire span must be scaffolded.

It has now been found that installation of metallic roof decks may be greatly simplified and accomplished without the necessity for the erection of costly scaffolding means in order to enable the construction of arched type roofs.

To the accomplishment of the foregoing and related ends, the said invention, then, consists of the means hereinafter more fully described and particularly pointed out in the appended claims, the following description and annexed drawings setting forth in detail certain illustrative embodiments of the invention, such disclosed means constituting, however, but a few of the various forms in which the principle of this invention may be employed.

The invention may be better understood by having reference to the annexed drawings wherein:

FIG. 1 is a perspective illustration of a building structure having partially completed an arched type roof deck fabricated from the improved roof deck members of the present invention, and showing the manner in which such a roof is installed.

FIG. 2 is a fragmentary cross-sectional view on an enlarged scale of a built-up roof deck formed from improved roof deck members in accordance with the present invention and having the exposed surface thereof built up with a porous fibrous board insert and an inorganic composition containing a settable ingredient, such as gypsum.

FIG. 3 is a fragmentary cross-sectional view showing a detail of the eave of a roof structure in accordance with the present invention.

FIG. 4 is a fragmentary cross-sectional view of another form of male and female interlocking flange structure showing parts of a pair of adjacent beams in interlocked relation.

Briefly stated, the present invention is in the provision of an improved continuous, flexible arcuate roof deck member comprising an elongated, full length or span arcuate beam having a concave web portion defining longitudinal parallel marginal edges, a male interlocking flange extending from one of said marginal edges having an abutment portion, and a female interlocking flange portion disposed along the opposite marginal edge of said web, and including an abutment receiving portion adapted for slidably receiving a male interlocking flange portion of an adjacent member. More particularly, the present invention contemplates a roof deck formed from a plurality of such roof deck members in juxtaposed laterally extending interlocked relation.

These roof decks are formed in accordance herewith by a process including the following steps. There are first erected at least a pair of elevated, parallel roof supporting members or plates formed from I-beams, wooden beams, masonry walls or framed walls provided with a suitable top plate, the like, for supporting the ends of the full length arcuate beams or strips. Where a single bay is to be erected, two such parallel members are erected. For each additional contiguous bay, an additional parallel member may be supplied and each intermediate single member used as a common end supporting member for the flexible beams or strips forming the roof deck. The distance between each pair of supporting members is less than the length of the arcuate strips or beams, and there is no limit to the length of such supporting members. The first roof deck strip is usually hand positioned with each of the extremities supported on the respective support members. Alternatively, a guide mandrel may be provided at the starting end of the bay to be roofed and removed after at least the first roof deck beam has been set into place, i.e. with the extremities resting on the respective support members. The procedure with respect to all succeeding beams (and the first, if means such as a guide mandrel or form are used) is to partially span the distance between the support members with a first flexible continuous strip of metal. Thus, one end of the strip, is resting on or, more preferably, approaching a seated position on the remote support member, but not yet seated thereon, and the other end of the strip is overhanging the nearest support member and approaching a seated position thereon. An interlocking flange portion of a second strip, is introduced into mating relation with the adjacent overhanging flange portion of the first strip.

Since the interlocking flanges are longitudinally slidable, one relative to the other, the second strip may be fed along and guided by the marginal edge of the first strip, until the respective distal extremities and proximal extremities are adjacently disposed. As the second strip is moved along the marginal edge of the first strip, frictional forces will result in the latter being moved and guided along the marginal edge of the first strip, or guide mandrel, the remaining distance across the span between the support members. Thus, the overhanging proximal extremity serves as a leader for the next strip as well as an integral hoist to raise the strip into position. The respective distal and proximal ends are sequentially disposed on the supporting members and desirably anchored to prevent movement in a direction normal to the support member. These steps are repeated until the roof is completed.

Metallic roof decks formed in the foregoing manner may be still further improved by filling the concavity between the marginal interlocking flange members with an inorganic composition containing a settable ingredient, e.g. gypsum, cement, etc. Still more preferably, the built-up roof comprises a metallic roof deck of the foregoing structure, a rigid porous fibrous board disposed in the concavity and having superimposed thereon an inorganic composition containing a settable ingredient, and a finish layer such as an asphaltic composition, e.g. asphalt impregnated paper.

Referring now more particularly to FIG. 1, there is here shown in diagrammatic illustrative form a perspective of a partially completed building unit including an end wall **1** and a roof deck partially formed from a plurality of improved roof deck members in accordance with this invention, **2**, **3**, **4**, **5**, etc. and showing flexible roof deck member or strip **6** being slidably positioned in the assembly adjacent next preceding roof deck member **5** by inserting one interlocking flange member of roof deck member **5** into the complementary interlocking flange member of next adjacent roof deck member **6** and sliding the beam from the proximal end of beam **5** to the opposite or distal extremity thereof. As is suggested by the illustration of FIG. 1, the assembly of successive roof deck members, e.g. roof deck member **6** may be accomplished by one individual from the ground with the aid of another to start beam **6** in interlocking relation with beam **5**.

Power driven rolls drive the members **6** into place to provide integral means for hoisting the strips into place. No scaffolding is necessary for this operation, and the amount of labor required to install the complete roof is greatly reduced. The roof deck members **6** are conveniently delivered to the site as flat, flanged strips. These are individually fed through a field bender, e.g. a pair of power driven crimping rolls, which embosses transverse ribs in the web portion of the members **6** to put a curve or arc of desired preselected radius in the members **6**.

FIG 2 shows a portion of a built-up roof in cross section and formed from the improved arcuate roofing beams of the present invention. While a plain roof deck, i.e. one which is not built up as shown in FIG. 2 may be used, it has been found that greatly increased strength of the roof may be secured by filling the channels of the individual beams forming the roof deck with a settable composition containing an inorganic settable ingredient. The metallic arcuate beam as shown in cross section in FIG. 2 is composed of a concave web portion **10** defining parallel marginal edges **8** and **9**, respectively. In relation to the figure as shown in FIG. 2, there is provided upwardly extending from longitudinal marginal edge **8** a male interlocking flange portion **11** having a laterally extending abutment portion **14**. In the preferred embodiment, the flange **11** extends the entire length of the arcuate beam.

Along the opposite marginal portion **9** there is provided a female interlocking flange **12** having abutment receiving means which in the preferred embodiment shown in FIG. 2 includes a laterally extending abutment lip **15** lying in the plane adapted for mating coaction with abutment **18** extending from flange **19** secured to the marginal edge **25** of web **30** of an adjacent correspondingly formed arcuate beam member generally indicated by the letter B. Abutment **18** extending from flange **19** has the same geometric configuration as abutment **14** extending from male interlocking flange **11**.

Means are also provided for retaining an adjacent beam in interlocking relation with another beam so as to restrict movement in both vertical and horizontal planes. In the preferred embodiment shown in FIG. 2, the interlocking flange portions **11** and **12**, are provided with reinforcing rib portions **13**, e.g. each struck inwardly out of the plane of the flange **11** and **12**, respectively. Resilient retaining means **17** in the form of in inverted V-shaped channel is secured to laterally extending abutment plate **15** by means of depending flange **16**. The lower marginal portion **16***a* of flange **16** is conveniently bent on a radius to impart resiliency to the retaining channel **17**. The free marginal edge **29** of inverted V-channel **17** is conveniently reversely bent upon itself to a small radius **31** to provide an engaging abutment **32** adapted for retaining coacting abutment against laterally extending flange portion **18** of beam B. The V-shaped portion is adapted to be rolled after insertion into interlocking relation to bring the abutment **32** into contiguous relation with laterally extending abutment portion **18** of beam B.

It will be observed that in the embodiment illustrated in FIG. 2, there is a coaction between the resilient retaining means comprising the inverted V-shaped channel **17** and the male interlocking flange portion **19** of adjacent beam member B, which limits both lateral movement of the beam B with respect to beam A, and vertical movement of the beam B with respect to the beam A.

As indicated above, a roof deck of satisfactory construction may be formed as shown in FIG. 1 by slidably interlocking a plurality of full length of full span arcuate beam members such as beam members A and B of FIG. 2 to cover a given area between a pair of building end walls such as end wall **1** shown in FIG. 1. Protection from the elements may be provided by merely painting the exposed surface of the roof deck with a suitable weather resistant coating composition. In certain instances, however, it may be desirable to further build up the roof in the manner shown in FIG. 2. In such a case, it is desirable to provide the web portion with breather vents such as vent **22**. Sheets **20** of a relatively light weight porous fibrous material e.g. fiberglass mat or board **20** and preferably having a sufficient rigidity to support a poured settable composition, for example gypsum, is placed in the upper portion of the beams A, B and so on, and the balance of the concavity filled with a material such as indicated above to a level which extends preferably above the extremities of the laterally extending abutment portions **14** and **15**. One of the functions of the fibrous material is to aid in water removal e.g. by wicking action. The fibrous material also acts as a sound deadening body and as an insulator. There may be applied over the settable composition layer **23**, a roofing material **24**, such as building paper, which when applied thereover protects the gypsum substrate from the deleterious effects of the weather. A built-up roofing structure of the type here described provides a smooth surface canopy surface of great strength and durability.

As a specific example, the full length arcuate beams having a transverse arcuate cross section defining a concavity **21** when viewed from the upper surface has a span of 40 feet. Spans up to 100 feet may be made. In general, the width of the beam is 6 inches, and is formed from steel by rolling, the steel having a thickness of 0.035 inch. The clearance between the male and female interlocking flanges is conveniently about 1/16" to allow easy fabrication of the roof deck without difficult binding problems. For a built-up roof of the type shown in cross section in FIG. 2, breather holes **22** may be provided at suitable intervals, such holes having a diameter of about .25 inch and located on two foot centers across the beam, or disposed in transversely extending rows of 4 such quarter inch holes at 10 foot intervals across the beam. As indicated above, the presence of the breather holes aids in curing or setting of the settable composition. The fiberglass board **20** is a conventional 6 pound density fiberglass material disposed inside each rib and allowing one inch from the top of the abutment portions, e.g. portions **14** and **15**. The fiberglass board curves and extends the full length of the steel ribs or beams. The gypsum deck is conveniently two inches thick poured on top of the fiberglass board and providing a level of gypsum about one inch above the top surface of the steel beam.

Although the use of gypsum on steel as a general practice has fallen into disuse because of the poor tensile strength characteristics of gypsum, the combination in the present invention is particularly valuable. Gypsum, or concrete formed from a light weight aggregate, is excellent in compression, and in the present structure where the former is a permanent part of the structure, the settable material resists the natural tendency of the arcuate member to flex within its elastic limit. The combination of the arcuate steel beam as a former and the superimposed inorganic settable material is stronger than the sum-

mation of the strengths of either the beam or the gypsum filler alone. It is believed that the two elements coact especially well because the bulk of the tensile forces is taken by the steel beam, or permanent former, and the bulk of the compressive forces by the settable material.

Where the structure is formed with a single bay or vault, it may be found desirable to provide cross tie members or tension rods at spaced intervals, e.g. every 6 feet, spanning the distance from eave to eave, to provide a reaction member for the lateral forces caused by the arched roof deck. Where a plurality of bays or vaults in side-by-side relation are employed, each acts as a reaction member for the next, and accordingly only the outer walls may require reinforcement. The valleys between vaults may be easily filled with light weight aggregate concrete for example to provide proper drainage.

In installation, the settable composition is applied uniformly from both eaves toward the top of the arch to avoid uneven flexure of the beam. The rapidity with which some of such compositions set makes this desirable practice.

Tests have shown that a built-up structure formed from beams made according to the cross section shown in FIG. 2 and having the foregoing specifications is able to withstand loadings in the neighborhood of about 60 pounds per square foot without failure. Steel beam roof decks which are not built-up but formed of beams having substantially the same dimensions with the exception that breather holes are not drilled therethrough and will not support loads as large as a built-up roof as above described. Thus, where similar load factors are specified, thinner sections of metal may be used for forming built-up roof structures that are required to yield the same load factor with a roof deck which is not built-up.

FIG. 3 shows one means of securing the extremities of the individual beams. I-beam **7** forms a top plate, and is supported in spaced parallel relation to the ground as diagrammatically shown in FIG. 1. The ends of the roof deck beam, such as beam **2**, may be maintained in aligned relation by means of an angle iron **9** secured to plate beam **7**, and if desired, the extremity of the beam may be anchored by spot welding to the angle beam **9**.

FIG. 4 is a fragmentary cross-sectional view of the interlocking relation of another form of beam in accordance herewith. Thus, beam C is provided with a female flange portion **40** having a box-like abutment receiving portion **41** along its marginal extremity, one surface of which is incomplete and forms a slot **42** for the admission of male flange portion **43** of beam D. Abutment portion **44** of male flange **43** is also of corresponding box-like structure and adapted to fit within the abutment receiving portion **41** of flange **40**, the upstanding wall portion **44** being received at its outer extremity in slot **42**. The clearance between abutment portion **44** and abutment receiving portion **41** is conveniently about $\frac{1}{16}$". It will be seen that this structure also provides limitations on both lateral and vertical movement of beam C with respect to beam D. Instead of box-like marginal portions as shown in FIG. 4, telescopically coacting tubular members may be used. In forming the continuously arched members of the present invention, the flange portions of the devices shown in FIGS. 2 and 4, for example, undergo stretching and valley portions **10** (FIG. 2) undergo compression. To take up excess metal in the valley portions, indentations transversely of the arch may be provided at spaced intervals along the valley. The shorter the radius of the arch, the more numerous and/or deeper will be the indentations for the purpose of taking up excess metal. This is preferably done at the job site by passing the flat beams through crimping rolls to provide a predetermined arc to the metallic strips.

A particular advantageous feature of the roof deck of this invention is that instead of covering and reinforcing the roof with a pumpable slurry of gypsum or other settable material, rock lath, fiberboard, plywood, or gypsum board sheets may be used as a base in finishing the roof. These are secured to the exterior of the deck by nailing through the board into the interlocked upwardly extending flange with concrete nails. The several layers of relatively thin sheet steel traversed by such nails provide an excellent anchor. Such a feature enhances the economics of these roof decks through ease of installation.

There has thus been provided an improved roof deck member or beam with which it is possible to form arch-type roofs of considerably longer span than heretofore possible with a single full length beam member. No bolts or other fastening means are required to secure the beams in adjacent contiguous relation, this being accomplished instead by providing complementary mating interlocking flange portions along the respective marginal portions of an intermediate concave web portion, the complementary interlocking flange portions of adjacent contiguous roof deck beam members being adapted for longitudinal slidable interlocking engagement along the length of the span. Once a member intended for adjacent or contiguous disposition with respect to a beam already in place has been started into or threaded into the interlocking engagement at the respective extremities of the beams, the member intended for contiguous disposition to an already positioned next preceding member may be pushed from the ground level until the contiguous relation has been established throughout the entire length of the respective beam members. Supporting scaffolding is unnecessary, and only ladder means are required to enable the workman to assemble this roof. Ordinarily two men can install a roof deck of this structure placing under roof a much larger area per unit of time than heretofore possible. The inherent elasticity of the metal beams enables the eave extremities of the beams to be sprung by hand sufficiently to enable proper insertion of the male flange portion into the female flange portion preliminary to completing the positioning of the next adjacent beam member.

Other modes of applying the principle of this invention may be employed instead of those specifically set forth above, changes being made as regards the details herein disclosed, provided the elements set forth in any of the following claims, or the equivalent of such be employed.

It is, therefore, particularly pointed out and distinctly claimed as the invention:

1. A self supporting paneled structure comprising in combination:

(a) a pair of spaced parallel beams;

(b) a substantially continuous paneled assembly disposed in self-supporting relation between said spaced beams, said paneled assembly comprising a plurality of contiguous interlocked arcuate full length panel members each supported at its ends on said spaced beams, and each of said members comprising:

(1) a web portion spanning the distance between said supports;

(2) a male interlocking flange along one of the marginal edges of said web and having an abutment portion extending therefrom;

(3) a female interlocking flange along the other marginal edge of said web and including a coacting abutment receiving portion telescopically receiving the male interlocking flange portion of an adjacent contiguously disposed panel member; and

(4) retaining means integral with said abutment receiving portion coacting with the abutment portion extending from the male flange, and the flange of said adjacent member to place the adjacent flanges of the assembled panel members in substantially abutting juxtaposition, whereby movement of said adjacent panel members upwardly and downwardly in a vertical plane and laterally in a horizontal plane is

restricted while permitting relative telescopic movement of the respective male and female flanges during assembly of said self-supporting paneled structure.

2. A structure in accordance with claim 1 including:

(c) means for securing said full length arcuate panel members at the longitudinal extremities thereof.

3. A structure in accordance with claim 2 in which the securing means includes a laterally extending right angle beam on each of said parallel beams for retaining in lateral alignment the extremities of each of said panel members.

4. A structure in accordance with claim 1 in which each panel member includes means coacting with said members to permit passage of air through the members.

5. A structure in accordance with claim 1 wherein said structure includes a superimposed layer formed from a settable composition of an inorganic settable material.

6. A structure in accordance with claim 5 in which the inorganic settable material is gypsum.

7. The method of constructing an arched roof comprising a plurality of interlocked contiguously disposed continuous flexible metal strips for spanning the distance between a pair of elevated parallel roof supporting members, each of said strips having distal and proximal extremities, and each having a web portion having parallel longitudinal marginal edges, a male interlocking flange along one of said marginal edges and a female interlocking flange along the other of said marginal edges, said flanges, respectively, adapted for mating interlocking coaction with the opposite mating flange of a next adjacent continuous strip, comprising the steps of:

(a) erecting at least a pair of elevated parallel roof supporting members;

(b) at least partially spanning the distance between said room supporting members with a first flexible continuous strip of metal having a length greater than the distance between said roof supporting members;

(c) introducing into mating relation an interlocking flange portion at the distal extremity of a second continuous strip into the corresponding mating interlocking flange portion at the proximal extremity of the first continuous strip while said first strip is at least partially spanning said roof supporting members;

(d) telescopically feeding said second continuous strip along the marginal edge of said first continuous strip in sliding mating relation and guiding said second continuous strip along the interlocking mating flange of said first continuous strip into proper position with the proximal and distal extremities of said continuous strips adjacently disposed; and

(e) sequentially disposing and supporting said distal and proximal extremities of each of said continuous strips on said roof supporting members.

8. The method of claim 7 which is additionally characterized by the step of:

(f) overlaying the exterior of said arched roof with a nailable sheet material to cover and reinforce said arched roof; and

(g) securing said sheets to said arched roof with nails extending through the sheet material into the interlocked flange portions of said metal strips.

9. The method of claim 8 in which the sheet material is a plywood board.

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