March 16, 1965 M. W. GOODWILL ETAL 3,173,225

MODULAR FRAMELESS ROOF CONSTRUCTION

Original Filed June 6, 1956 2 Sheets-Sheet 1

FIG. 1

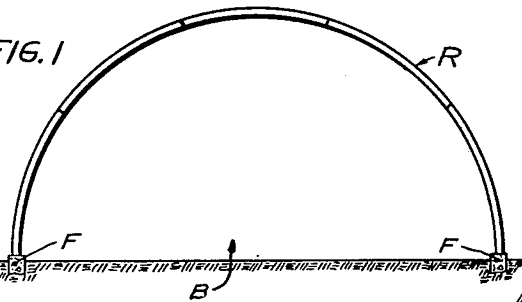


FIG. 2

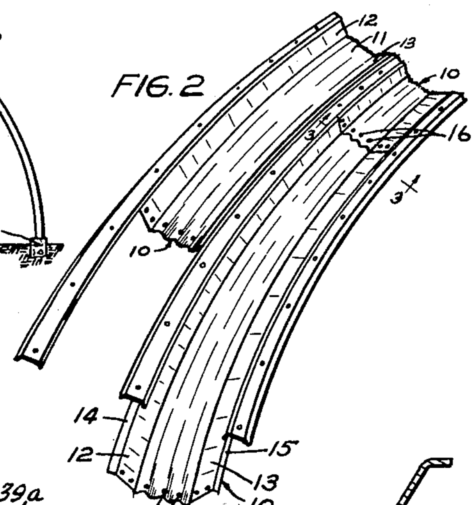


FIG. 7

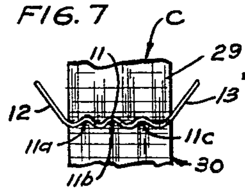


FIG. 9

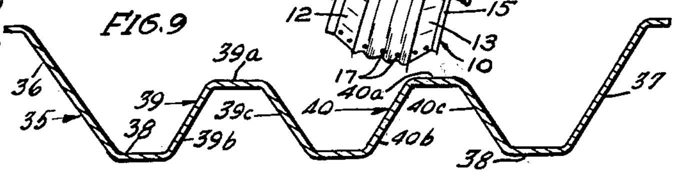


FIG. 8

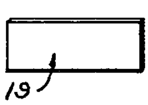


FIG. 3

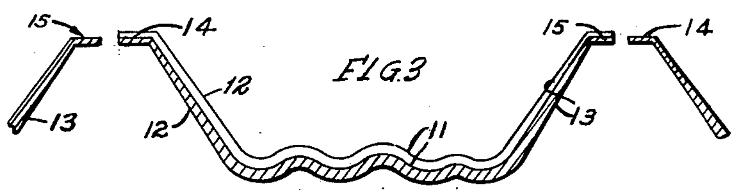


FIG. 4

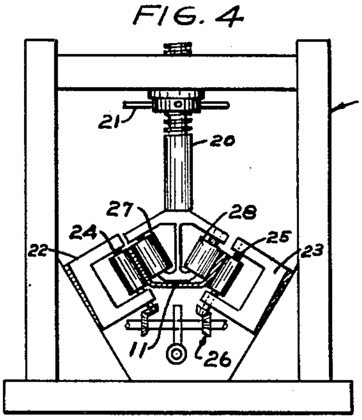


FIG. 5

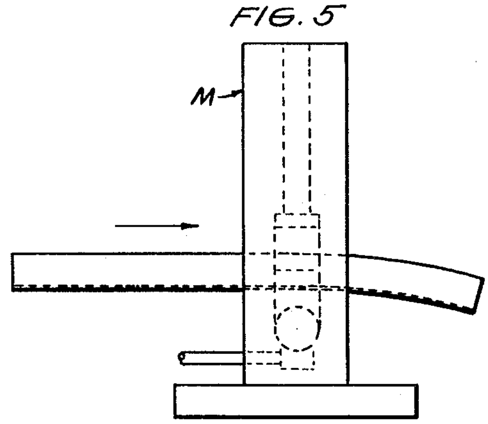
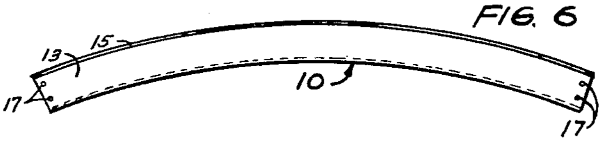


FIG. 6



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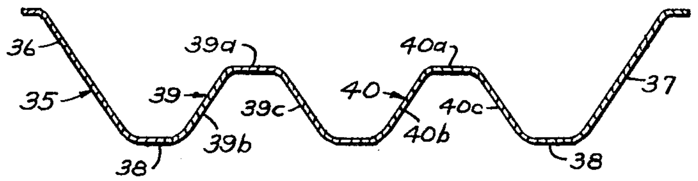
MODULAR FRAMELESS ROOF CONSTRUCTION

Original Filed June 6, 1956 2 Sheets-Sheet 2

FIG. 9



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3,173,225

MODULAR FRAMELESS ROOF CONSTRUCTION

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Original application June 6, 1956, Ser. No. 589,717, now Patent No. 3,073,021, dated Jan. 15, 1963. Divided and this application Feb. 17, 1959, Ser. No. 793,812
3 Claims. (Cl. 50—61)

This invention relates to modular frameless roof constructions. More particularly it relates to the construction of arched roof steel buildings without utilizing trusses or other cross extending supporting structure to support the roof.

This application is a divisional application of our co-pending application, Ser. No. 589,717, now Patent No. 3,073,021, filed by us on June 6, 1956, and now entitled "Method of Forming Modulator Frameless Roof Construction."

Experience in the building of arched roof steel buildings has shown that there are weaknesses in all buildings presently available on the commercial market. The weaknesses referred to are that all frame type buildings have a relatively high cost due to the additional steel required to provide a structure of sufficient strength.

Of the frameless buildings which are available none are able to take full advantage of the economy effected by using the same steel as both structural support and as a covering. This is true of the frameless buildings because the methods of curving the panels under fabrication in such construction entails the imparting of a cross corrugation to the metal. Under the severe load conditions usually encountered by such a structure, this corrugated area is under compression stress. However, this design does not allow the full utilization of the normal compression stress of steel because the steel is actually under a bending stress rather than a compression stress since the corrugations run transversely of the axis of the compression force. Thus, although the particular material which is corrugated may be increased in its load-bearing capacity in one direction of the plane of the panel, it is found that these corrugations have actually weakened the panel in the transverse direction of the same planes. Our invention is directed toward eliminating these disadvantages and toward taking full advantage of the allowable compression stress of the metal within the panel, taken longitudinally of the panel.

The advantages of a frameless roof construction are well recognized in the art. However, such a roof construction may be called upon to support unusually heavy loads in the form of snow collecting thereupon, large bulk grain storage, or to withstand considerable thrust from high winds and storms. As a result, it is imperative that the frameless roof construction utilized be amply strong to withstand such loads as are imposed upon it. At the same time, of course, it is imperative that the cost of manufacture of such a frameless roof construction be maintained at a minimum. The better the design of the individual panel of such a frameless roof construction, the less metal will be required to be incorporated therein and thereby the cost of manufacturing the same will be reduced. Our invention is directed toward providing such a frameless roof panel at a very minimum of cost.

It is a general object of our invention to provide a novel and improved modular frameless roof panel of simple and inexpensive design and construction.

A more specific object is to provide a novel and improved modular frameless roof panel having increased strength while utilizing less steel than heretofore required.

Another object is to provide a novel and improved

modular frameless roof panel which is less expensive to produce and yet has a load-bearing capacity considerably in excess of corresponding structure heretofore known.

Another object is to provide a novel and improved modular frameless arched roof construction which requires no trusses or cross extending suporting structure and yet is amply strong to bear the loads normally imposed thereupon while utilizing a minimum of steel in the manufacture of the same.

Another object is to provide a novel and improved method of forming a modular section of a frameless roof construction which will substantially increase the load-bearing capacity of the section without the addition of additional metal thereto or providing additional supporting structure.

Another object is to provide a novel and improved modular frameless arched roof construction which will take full advantage of an economy effected by using the same steel as both structural support and covering material.

Another object is to provide a novel and improved modular frameless roof construction which affords economy by virtue of simple and speedy erection.

Another object is to provide a novel and improved method of forming a modular frameless roof panel which utilizes a reduction in thickness of material by cold working of portions of the panel and thus increases the overall strength of the panel.

These and other objects and advantages of our invention will more fully appear from the following description made in connection with the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views, and in which:

FIG. 1 is an end elevational view of an arched roof steel building formed from a plurality of panel members embodying our invention.

FIG. 2 is a perspective view of a plurality of panel members embodying our invention and connected in side-by-side relationship and in an end-to-end overlapping relationship.

FIG. 3 is a sectional view on an enlarged scale taken along line 3—3 of FIG. 2.

FIG. 4 is a diagrammatic view of a machine which may be utilized to form one of the panel members embodying our invention.

FIG. 5 is a diagrammatic view illustrating the formation of one of the panel members embodying our invention and passing through the machine shown in FIG. 4.

FIG. 6 is a side elevational view of one of the embodiments of our invention after it has been formed.

FIG. 7 is an end elevational view diagrammatic in nature and illustrating the manner in which the corrugations may be imparted to the central portion of one of the panel members embodying our invention.

FIG. 8 is a perspective view on a reduced scale of one of the blanks from which the panel members embodying our invention may be formed; and

FIG. 9 is a vertical sectional view similar to FIG. 3 and taken through a second embodiment of our invention.

Our invention as shown in the figures described above, includes a modular roof construction comprising an elongated longitudinally channelled panel member **10** formed of metal such as steel and having a generally horizontal base portion **11** and channel-defining wall portions or flanges **12** and **13** extending upwardly and outwardly from opposite sides of the base portion **11**. As will be described hereinafter, these channel-defining wall portions **12** and **13** have been stretched longitudinally to impart convex curvature to the panel member **10** and its base portion **11** about a horizontal axis extending transversely of the length of the panel member. This is best shown in FIG. 6.

The base portion **11** has a plurality of longitudinally extending corrugations **11***a*, **11***b* and **11***c* formed therein. These corrugations, as shown, extend the full length of the panel member **10** and are the only corrugations formed therein.

The outermore areas of the channel-defining portions **12** and **13** of the panel member **10** are each formed into a laterally and outwardly extending flange or lips **14** and **15** respectively. These flanges **14** and **15** provide connecting portions whereby the panel members **10** may be connected in side-by-side relationship.

FIG. 1 shows an arched steel roof building indicated generally as B, the roof R having been constructed upon a cement foundation F from a plurality of panel members **10**. These panel members **10** are connected in end-over-end over-lapping relationship through the use of rivets or bolts such as **16** and are arranged to extend from one side of the foundation to the other. The bolts or rivets **16** extend through openings **17** which are provided at each end of each of the panels **10** to receive the bolts or rivets therein. The panel members **10** are arranged in side-by-side relation and secured to each other in that relation by clamps indicated generally as **18**, the clamps engaging the adjacent laterally extending flanges **14** and **15** of the panel members as best shown in FIG. 3. The clamp includes an upper plate member **18***a*, a lower plate member **18***b*, and a connecting bolt or rivet **18***c*.

The individual panel members **10** are formed from a rectangularly shaped sheet of steel such as **19**, as shown in FIG. 8. This sheet of steel **19** may be first formed into a channel member, if preferred, or it may be so formed simultaneously with the stretching of the channel-defining portions **12** and **13** as illustrated in FIG. 4. In FIG. 4 the sheet **19** is passed through a metal working machine indicated generally as M.

The machine M preferably includes a pressure-adjustment assembly **20** which is controlled by a pressure-adjustment wheel **21**. This pressure-adjustment assembly is mounted so as to overhang a pair of driven roller mountings **22** and **23** which rotatably support a pair of driven rollers **24** and **25**. These driven rollers **24** and **25** are driven by a driving gear mechanism indicated generally as **26**. The lower end of the pressure-adjustment assembly carries a pair of idling pressure rollers **27** and **28** as is best shown in FIG. 4, the idling rollers being positioned by the pressure-adjustment assembly relative to the driven rollers so as to permit a panel member such as **19** to be passed therebetween and to apply substantial pressure to the channel-defining portions **12** and **13** so as to cause these portions to elongate longitudinally. In other words, this machine, when properly adjusted, causes the channel-defining portions **12** and **13** to stretch longitudinally and the amount of pressure applied to these portions increases outwardly from the base portion **11** so that the areas adjacent the base portion **11** are stretched less than the more remote areas. Therefore, the material of the portions **12** and **13** is thinned or stretched out more at the outermore areas than at the areas adjacent to the base portion **11** and hence convex curvature is induced within the base portion **11**.

As the sheet **19** is passed through this machine M, it is formed into a longitudinally channelled panel member and at the same time the channel-defining portions **12** and **13** are stretched as a result of passing between the pairs of rollers **24–27** and **25–28**. This stretching simultaneously imparts convex curvature to the base portion **11** and increases the tensile strength of the wall portions **12** and **13**. If desired, longitudinal corrugations such as **11***a*, **11***b* and **11***c* may be formed in the base portion **11** thereafter by passing the panel through a corrugating machine indicated generally as C in FIG. 7.

FIG. 7 illustrates a machine having a pair of interfitting rolls or rollers **29** and **30** which will impart corrugation to any piece of metal passed therebetween. Even without the corrugations, however, we find that our panel members **10** are much stronger than similarly channelled members having transverse corrugations in the base portions since the cross corrugations would tend to cause premature failure in bending. Our panel members **10** are also much stronger than similarly channelled members having merely flat base portions without stretched channel-defining portions by virtue of the increase in tensile strength of channel-defining portions **12** and **13** by cold working.

We have found that by forming the panel members as hereinbefore described, the load-bearing capacity of such a panel member is substantially increased. By stretching the chanel-defining portions **12** and **13**, this material from which it is formed increases in tensile strength as a result of the cold working of the metal involved in stretching, and as a direct result, the load-bearing capacity of the panel member is substantially increased from this fact alone. In addition, the omission of the transversely extending corrugations eliminates any weakening which would otherwise take place between the adjacent corrugations insofar as supporting a load is concerned.

FIG. 9 shows a second embodiment of our invention. We have found that panels are preferably about two feet in width and, in such instances, it is desirable to corrugate the base portion of the panel longitudinally. We have found, however, that the panel is even stronger if we form the longitudinally extending corrugations similarly to the manner in which the basic panel members are formed. In other words, we induce channel shaped longitudinally extending corrugations in the base portion of the panel member and stretch the channel-corrugation defining portions as well as the side wall portions of the panel which correspond to the portions **12** and **13** of the panel shown in FIGS. 1–8. The extent of the stretching of the channel-corrugation defining portions is proportional to the distance of these portions from the base portion of the panel member and is correlated with the pressure applied to the side wall portions of the panel member.

In FIG. 9, we show in vertical cross-section such a panel member **35** having side wall portions **36** and **37** and a base portion **38**. The base portion **38** has a pair of longitudinally extending inverted channels **39** and **40** formed therein. The channel **39** has a generally horizontal portion **39***a* and vertically outwardly extending portions **39***b* and **39***c*. The channel **40** has a similar generally horizontal portion **40***a* and vertically outwardly extending portions **40***b* and **40***c*. In forming these channels **39** and **40** pressure-controlled rollers are used and the pressure and spacing between these rollers is adjusted so that the areas of the portions **39***b*, **39***c*, **40***b*, and **40***c* more closely adjacent to the base portion **38** are subjected to less pressure and are thinned out or stretched longitudinally less than the more remote portions. The portions **39***a* and **40***a* are also stretched longitudinally, the amount of stretching being dependent upon the vertical distance thereof from the base portion **38**, as will be readily appreciated, and being correlated with the amount of stretching of the portions **36** and **37**.

The structure shown in FIG. 9 is even stronger than the same type of panel member with longitudinal corrugations in the base portion of the usual curved type wherein no stretching is involved.

It should be noted that, in a roof structure utilizing modular panels such as shown herein, the base portion of the channelled member such as element **11** constitutes the compression flange while the side wall portions **12** and **13** constitute the tension flanges of the beam, if the panel member is viewed as a beam under a critical load. In structures such as grain storage bins the load of the grain against the base portion **11** is usually the most strenuous condition met and this is not experienced at the top of the roof but rather at a point between the base and the top of the roof. By making our panels as herein described we have substantially reduced the possibility of compression failure at the base portion.

The outstanding advantage of our construction of course, is its increased load capacity. In addition, however, it should be noted that we have provided a modular frameless roof panel which is extremely simple and inexpensive in design and construction, while at the same time utilizing less steel than has heretofore been required in the construction of the modular frameless roof. It will be noted that there are no trusses or cross-extending supporting structures required to support the weight of the roof R and any loads which will normally be imposed thereupon. The amount of metal required to make one of our panel members is substantially less than when transversely extending corrugations are used because the latter obviously require more material in a given length panel due to the imposition of the transverse corrugations which tend to shorten the length of a blank of predetermined length.

It will also be noted that the method by which we form our channel members is extremely simple and inexpensive and yet produces a panel member of substantially increased load-bearing capacity.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the parts without departing from the scope of our invention.

What is claimed is:

1. An arcuate roof construction curved about a longitudinal axis and comprising a plurality of circumferentially extending and side by side channel members each having substantially the same degree of curvature, each channel member integrally formed from a sheet of metal and comprising a base portion and a pair of spaced side walls curved circumferentially about said axis, the side walls of each channel member diverging in a direction away from said base member, each side wall gradually decreasing in thickness in a direction away from said axis and having a high tensile strength as a result of being cold worked, each side wall having a free edge adjacent to the free edge of a side wall of an adjacent channel member, and means connecting adjacent channel members together.

2. An arcuate roof construction as defined in claim 1 including an arcuate lip integrally secured to each of said free edges and extending axially therefrom towards the lip of an adjacent channel member, said connecting means comprising an arcuate channel extending over each adjacent pair of lips and free edges of adjacent pairs of said side walls, and threaded means securing said arcuate channel to said lips.

3. An arcuate roof construction as defined in claim 2, wherein each of said base members has circumferentially corrugated grooves formed therein, each groove being defined by a pair of opposing side wall members extending generally radially outwardly from said base portion, each of said side wall members gradually decreasing in thickness in a direction away from said base portion as a result of having been cold worked.

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