Oct. 7, 1941. S. SZEGÖ 2,257,769

ROOF STRUCTURE

Filed Sept. 16, 1940

Fig. 1

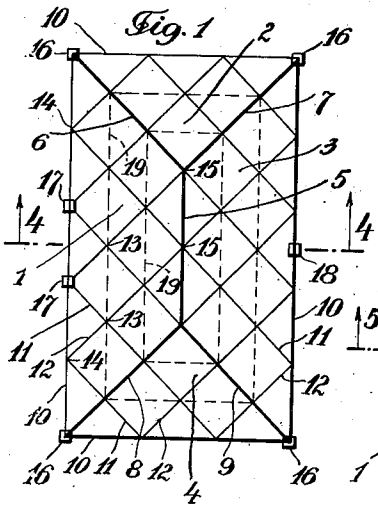


Fig. 2

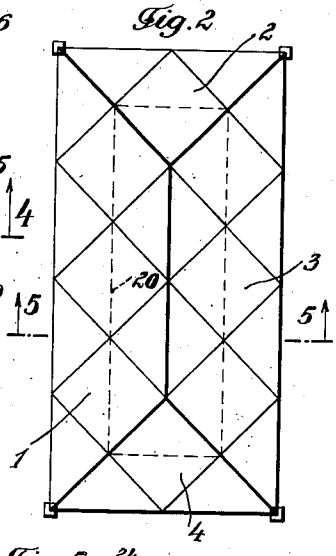


Fig. 3

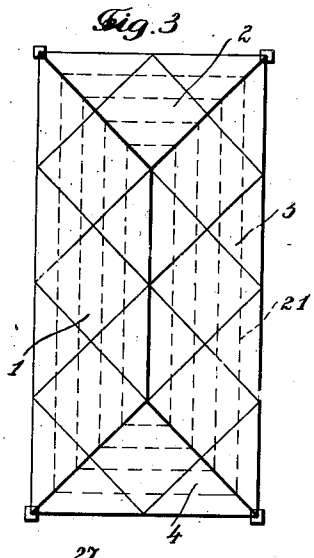


Fig. 4

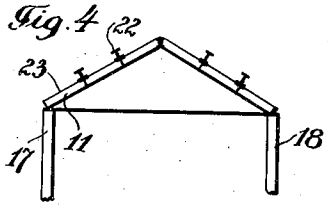


Fig. 5

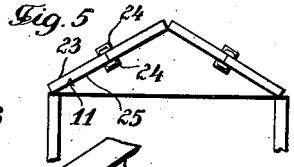


Fig. 7

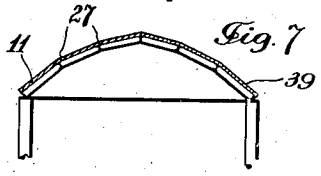


Fig. 6

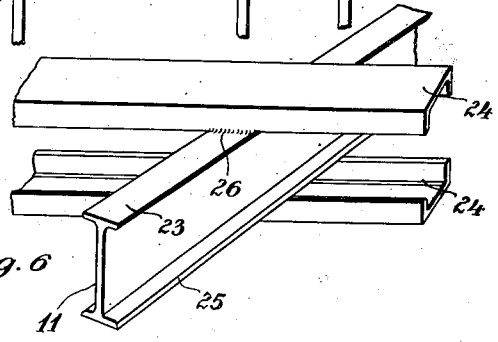


Fig. 8

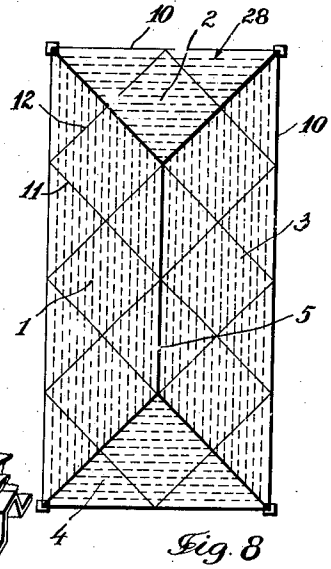
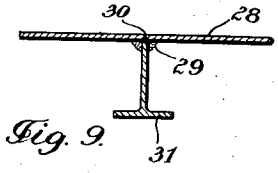


Fig. 9



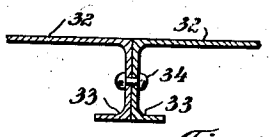
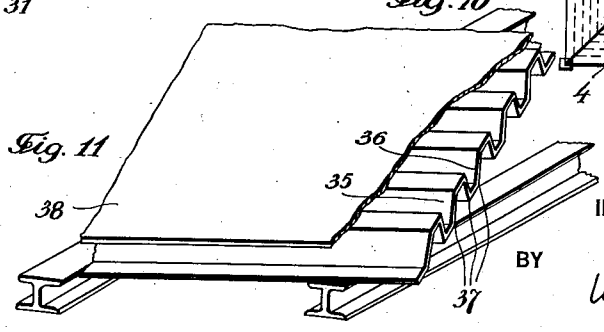


Fig. 10

Fig. 11



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ROOF STRUCTURE

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Application September 16, 1940, Serial No. 356,947
In Switzerland June 14, 1940

20 Claims. (Cl. 108—1)

My invention relates to improvements in roof structures and more particularly to roof structures comprising spatial beam grids.

The main object of my invention is to provide a roof structure being adapted to cover large floor areas, while being supported at a few points only.

It is a further object of my invention to provide a rectangular roof structure comprising a spatial beam grid, being adapted to cover a large floor area, although being supported only at the four corners of the roof structure.

Another object of my invention consists in providing a spatial beam grid construction being adapted for such roof structures.

Still another object of my invention consists in providing stiffening means for the beam grid supporting the roof, thus reducing the bending moments in these grid beams.

In order to attain the above objects, I propose, in accordance with my present invention, to use for covering large floor areas a rectangular roof structure comprising a spatial beam grid formed by two groups of parallel beams being arranged within rectangular roof edges; each of the beams of the grid should be diagonal to one of these roof edges, should be continuous between these roof edges, and should be cranked at its intersection point with one of the hips or the ridge of the roof; furthermore, the beams of one of these beam groups should be arranged intersecting the beams of the other beam group, and means should be provided for securing these intersecting beams at their intersecting points to each other.

In accordance with a preferred embodiment of my present invention, this roof structure comprises also rectangularly disposed edge beams, supporting and supplementing the above beam grid structure; in this case the beams of one beam group are arranged parallelly to one of the roof hips and the beams of the other beam group to another of these, causing thereby the beams of one beam group to intersect the beams of the other beam group; also in this case means are provided for securing said intersecting grid beams at their intersecting points to each other. Roof structures of this type can be supported by means of columns arranged at the grid corners only.

I have found that the beams of beam grids of this type are subject to bending moments in addition to axial forces and my experience has shown that the resulting distribution of stresses within such roof structures is rather heterogenous, inasmuch as some parts are highly stressed, while others remain comparatively unstressed.

In order to avoid these disadvantages, I propose the use of stiffening means adapted to avoid these bending forces by equalizing them over the whole structure. Stiffening means for this purpose should be preferably arranged horizontally, interconnecting points of the grid beams lying at the same horizontal level.

I found it of advantage to arrange the beams of one beam group as intersecting the beams of the other beam group in such a manner that a part of the intersecting points come to lie at the same horizontal level, and to arrange the aforesaid horizontal stiffening means interconnecting these intersecting points at the same horizontal level.

In accordance with a preferred embodiment of these combined grid and stiffening means, I arrange the grid in such a way that groups of intersecting points come to lie at the same horizontal level; I furthermore provide means connecting these intersecting beams at these intersecting points to each other, forming thereby groups of grid nodes lying at the same horizontal level; then I arrange a series of rectangular horizontal stiffening means adapted to carry axial forces at the level of each of these node groups in such a way that they surround the entire beam grid and interconnect the grid nodes of the same horizontal level.

Further characteristic features of my new roof structure and the stiffening means for this structure, and advantages of the improvements proposed by me, will appear from the following description and the accompanying drawing, illustrating several embodiments of my invention.

In the drawing:

Figs. 1 to 3 show different roof structures in accordance with my invention;

Fig. 4 shows a cross section of the roof structure along line 4—4 of Fig. 1;

Fig. 5 shows a cross section of the roof structure along line 5—5 of Fig. 2;

Fig. 6 shows a detail of the roof structure shown in Figs. 2 and 5;

Fig. 7 shows a roof structure with "broken" grid beams, in cross section;

Fig. 8 shows a roof structure with a stiffening roof shell;

Figs. 9 and 10 show different embodiments of grids used in connection with the roof structure shown in Fig. 8, in cross section, and

Fig. 11 shows a perspective view of another embodiment of the roof structure shown in Fig. 8.

In accordance with my present invention the roof consists of two pairs of oppositely disposed roof planes 1, 3, and 2, 4, respectively, intersecting each other and forming thereby a roof ridge 5, and two pairs of roof hips 6 and 7, and 8 and 9 respectively. This roof structure comprises rectangularly disposed edge beams 10, and a beam grid formed by two groups of beams, 11 and 12 respectively; as shown in the drawing, each of the grid beams 11 and 12 is continuous between the edge beams 10, and is cranked at its intersection point with one of the roof hips 6, 7,

8 and 9, or the roof ridge 5. The beams 11 of one beam group are arranged parallel to hips 6 and 9, and the beams 12 of the other beam group are arranged parallel to the hips 7 and 8, causing thereby the beams 11 of one beam group to intersect the beams 12 of the other beam group at their interesecting points 13. At these points means are provided for securing these intersecting beams 11 and 12 to each other, forming thereby rigid grid nodes.

Of course, beams 11 and 12 are rigidly secured to the edge beams 10 also, forming thereby rigid edge nodes 14; they are also secured to the ridge beam 5 at the points at which they intersect this beam, forming thereby ridge nodes 15.

It is evident that also the hips and the ridge of the roof structure are formed by grid beams, being thus a part of the grid itself.

Four columns 16 in the corners of the roof structure would be sufficient to support the whole roof structure, but further columns 17 may be provided for under any of the edge nodes 14, or even columns 18 may be arranged between the edge nodes, supporting thus the edge beams 10 themselves.

In order to avoid bending moments and bending forces in the grids 11 and 12 of the roof grid, I provide horizontal stiffening means 19, adapted to carry axial forces; as shown in the drawing these stiffening means are rectangular, surround the entire beam grid, and interconnect the inner grid nodes 13, lying at the same horizontal level.

In Figs. 1 to 3 different embodiments of my new roof structure are shown: Fig. 1 shows a roof structure with narrowly spaced beam grids, necessitating thereby the arrangement of two stiffening bands 19, interconnecting groups of inner nodes lying at the same horizontal level; Fig. 2 shows a roof structure with widely spaced grid beams and one stiffening band 20. Fig. 3 shows the arrangement of a series of stiffening bands 21 spaced more closely, and interconnecting points of these beams lying at the same horizontal level. Each of these constructions is adapted to reduce bending moments in the grid beams by carrying large parts of the load through axial forces over the whole structure of the roof.

As stiffening means different structures may be used: thus I may provide rings of purlins or rafters at various horizontal levels and utilize their bottom flanges to carrying axial forces; as shown in Fig. 4 the bottom flanges of these rafters 22 may be secured to the top flanges 23 of the grid beams by welding, riveting or the like. I may also provide as stiffening means cords 24, substituting purlins or rafters, secured to the top flanges 23 and bottom flanges 25 of the beams 11 and 12, respectively. As shown in Fig. 6, these cords 24 are secured by welding 26 to the top flanges 23 and bottom flanges 25 of the grid beam 11. The cords 24 are horizontal, and the beams 11 are diagonal to the direction of these cords.

Fig. 7 shows a monolithic reinforced concrete construction in which the stiffening slabs 27 are placed flush with the top of the grid beams 11 and 12, respectively; the grid is covered by the concrete roof cover 39; this figure furthermore shows that it is possible also to use "broken" grid beams; I want to stress that it is possible to give the roof practically any desired shape within its rectangular boundaries: thus, for instance, it can be folded, or "broken" once or more, it can be arc-shaped or the like. From the point of view of my present invention it is only essential that the roof be shaped in such a way that all edge nodes are lying in the same horizontal plane, that the connecting line between these edge nodes forms a rectangle, and that the roof has such a shape that it is possible to connect rectangular stiffening means to the beams forming the roof grid.

In Fig. 8 a roof structure is shown in which the horizontal stiffening rafters or cords are replaced by a roof shell 28, covering the grids; this roof shell must be adapted to carry stresses being parallel to the roof edges, i. e. to the edge beams 10 forming the roof edges; furthermore, this roof shell must be secured to substantially each of the beam grids 11 and 12, in order to avoid unwanted bending moments in these beams.

As shown in Fig. 9 the roof shell 28 can be secured to the longitudinal edges 30 of the T-shaped grid beams 31 by welding 29, forming thereby simultaneously the upper flange of these beams.

It is also possible to provide a roof shell consisting of parallelogram-shaped roof shell portions, corresponding to the roof portions lying between the grid beams; in this case I prefer to connect these shell portions as shown in Fig. 10, i. e., to bend the edges of the shell portions 32 in the shape of half beams 33 and to connect these bent, beam-shaped, edges of the shell portions, e. g. by rivets 34, to each other. As these beam-shaped shell edges serve as grid beams, this construction eliminates the necessity of special grid beams for the roof structure.

As shown in Fig. 11, I may provide as stiffening means also a roof shell made of corrugated metal sheet material 35; this roof shell has to be arranged in such a manner that its corrugations 36 are parallel to the roof edges, being thereby adapted to carry stresses in this direction. It is preferable to secure a great part or all of the corrugations 37, contacting the grid beams 11, to these beams. This roof shell 35 should be preferably covered by a roof cover 38.

It will be understood that each of the elements of my new roof structure, my new spatial beam grid, and the new stiffening means thereto, or two or more of these elements together, may also find a useful application in other type of building structures deferring from the types described above.

It will furthermore be understood that I do not intend to be limited to the exact shape of the roof structures proposed by me, since various modifications and changes in shape, size and relative dimensions may be made without departing in any way from the spirit of my invention.

Without further analysis the foregoing will so fully reveal the gist of my invention that others can by applying current knowledge readily adapt it for various applications without omitting features, that, from the standpoint of the prior art fairly constitute essential characteristics of the generic or specific aspects of my invention, and therefore such adaptations should and are intended to be comprehended within the meaning and range of equivalency of the following claims.

What I claim as new and desire to secure by Letters Patent is:

1. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure comprising a spatial beam grid formed by two groups of parallel beams and being arranged

within rectangular roof edges, each of said beams being diagonal to one of said roof edges, being continuous between said roof edges, and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged intersecting the beams of the other beam group, and means securing said intersecting beams at said intersecting points to each other.

2. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby a roof ridge and two pairs of roof hips meeting at the ends of said roof ridge, said roof structure comprising rectangularly disposed edge beams, a beam grid formed by two groups of beams and being supported by said edge beams, each of said grid beams being continuous between the edge beams supporting it and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged parallel to one of said meeting roof hips and the beams of the other beam group being arranged parallel to the other of said meeting roof hips, causing thereby the beams of one beam group to intersect the beams of the other beam group, and means securing said intersecting grid beams at said intersecting points to each other.

3. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby a roof ridge and two pairs of roof hips meeting at the ends of said roof ridge, said roof structure comprising rectangularly disposed edge beams, a beam grid formed by two groups of beams and being supported by said edge beams, each of said grid beams being continuous between the edge beams supporting it and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged parallel to one of said meeting roof hips and the beams of the other beam group being arranged parallel to the other of said meeting roof hips, causing thereby the beams of one beam group to intersect the beams of the other beam group, means securing said intersecting grid beams at said intersecting points to each other, and supporting means supporting said rectangularly arranged edge beams at the grid corners only.

4. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure comprising within rectangular roof edges a spatial beam grid formed by two groups of beams being diagonally arranged to one of said roof edges, the beams of one beam group being arranged intersecting the beams of the other beam group in such a manner that a part of the intersecting points come to lie at the same horizontal level, and horizontal stiffening means interconnecting said intersecting points at the same horizontal level.

5. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure comprising within rectangular roof edges a spatial beam grid formed by two groups of beams being diagonally arranged to one of said roof edges, the beams of one beam group being arranged intersecting the beams of the other beam group in such a manner that groups of intersecting points come to lie at the same horizontal level, and a series of horizontal stiffening means arranged at the levels of said groups of intersecting points, each of said stiffening means surrounding the entire beam grid and interconnecting intersecting points of the same horizontal level.

6. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure comprising within rectangular roof edges a spatial beam grid formed by two groups of beams being diagonally arranged to one of said roof edges, the beams of one beam group being arranged intersecting the beams of the other beam group in such a manner that groups of intersecting points come to lie at the same horizontal level, means connecting at these intersecting points said intersecting beams to each other, forming thereby groups of grid nodes lying at the same horizontal level, and a series of rectangular horizontal stiffening means adapted to carry axial forces and being arranged at the level of said groups of grid nodes, each of said stiffening means surrounding the entire beam grid and interconnecting grid nodes of the same horizontal level.

7. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby a roof ridge and two pairs of roof hips meeting at the ends of said roof ridge, said roof structure comprising rectangularly disposed edge beams, a beam grid formed by two groups of beams and being supported by said edge beams, each of said grid beams being continuous between the edge beams supporting it and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged parallel to one of said meeting roof hips and the beams of the other beam group being arranged parallel to the other of said meeting roof hips, thus causing the beams of one beam group to intersect the beams of the other beam group in at least one group of intersecting points lying at the same horizontal level, means securing said intersecting grid beams at said intersecting points to each other, and at least one horizontal stiffening means arranged at the level of each group of intersecting points, said stiffening means surrounding the entire beam grid and interconnecting intersecting points of the same horizontal level.

8. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby a roof ridge and two pairs of roof hips meeting at the ends of said roof ridge, said roof structure comprising rectangularly disposed edge beams, a beam grid formed by two groups of beams and being supported by said edge beams, each of said grid beams being continuous between the edge beams supporting it and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged parallel to one of said meeting roof hips and the beams of the other beam group being arranged parallel to the other of said meeting roof hips, causing thereby the beams of one beam group to intersect the beams of the other beam group, means securing said intersecting grid beams at said intersecting points to each other, forming thereby at least one group of grid nodes lying at the same horizontal level, at least one rectangular horizontal stiffening means

adapted to carry axial forces, said stiffening means surrounding the entire beam grid and interconnecting grid nodes lying at the same horizontal level, and supporting means adapted to support said rectangularly arranged edge beams at the grid corners only.

9. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure comprising within rectangular roof edges a spatial beam grid formed by two groups of beams being diagonally arranged to one of said roof edges, the beams of one beam group being arranged intersecting the beams of the other beam group in such a manner that groups of intersecting points come to lie at the same horizontal level, means connecting at these intersecting points said intersacting beams to each other, forming thereby groups of grid nodes lying at the same horizontal level, at least one horizontal rectangular stiffening means, said stiffening means consisting of a band of rafters, adapted to carry axial forces, said rafter band surrounding the entire beam grid and interconnecting the grid nodes lying at the same horizontal level, and means securing each of said rafters to said grid nodes.

10. In a roof structure according to claim 9, stiffening means, said stiffening means consisting of a horizontal rectangular band of rafters adapted to carry axial forces, said rafter band surrounding the entire beam grid and interconnecting grid nodes lying at the same horizontal level, and means securing at said grid nodes each of said rafters to the top flanges of the grid beams.

11. In a roof structure, according to claim 4, a horizontal rectangular stiffening means consisting of cords adapted to carry axial forces only, said cords surrounding the entire beam grid and interconnecting grid nodes lying at the same horizontal level, and means securing said cords to said grid nodes.

12. In a roof structure, according to claim 4, a horizontal rectangular stiffening means, consisting of cords adapted to carry axial forces only, said cords surrounding the entire beam grid and interconnecting grid nodes lying at the same horizontal level, and means securing said cords at said grid nodes to the top and bottom flanges of said grid beams.

13. In a roof structure according to claim 4, a horizontal rectangular stiffening means consisting of stiffening members, adapted to carry horizontal forces and being placed flush with the grid beams to be connected, said stiffening members surrounding the entire beam grid and interconnecting grid nodes lying at the same horizontal level, and means securing each of said stiffening members to said grid beams.

14. Rectangular roof structure consisting of two pairs of oppositely disposed roof planes intersecting each other and forming thereby sloping roof hips and a roof ridge, said roof structure consisting of a spatial beam grid formed by two groups of beams and being arranged within rectangularly disposed roof edges, each of said beams being diagonal to one of said roof edges, being continuous between said roof edges, and being cranked at its intersection point with one of said roof hips or said roof ridge, the beams of one beam group being arranged intersecting the beams of the other beam group, and at least one horizontal rectangular stiffening means surrounding said beam grid, and being adapted to carry axial forces, said horizontal stiffening means interconnecting points of said beams lying at the same horizontal level, and securing means fixing said stiffening means to substantially each grid beam, thus avoiding by arrangement of said stiffening means unwanted bending moments in said grid beams.

15. In a roof structure according to claim 2, a series of horizontal rectangular stiffening means, each of said stiffening means surrounding said beam grid and being adapted to carry axial forces, said horizontal stiffening means being arranged at and between the intersecting points of said grid beams in such a manner as to interconnect points of said grid beams lying at the same horizontal level, and securing means fixing each of said stiffening means to substantially each of said grid beams, avoiding thus by arrangement of said stiffening means unwanted bending moments in said grid beams.

16. In combination with a roof structure according to claim 1, a roof shell covering said beam grid, and being adapted to carry stresses being parallel to said roof edges, said roof shell being secured to substantially each of said grid beams, in order to avoid unwanted bending moments in these beams.

17. In combination with a roof structure according to claim 1, a roof shell consisting of corrugated metal sheet material, said roof shell covering said beam grid in such a manner that its corrugations are parallel to the roof edges, and means securing at least a great part of the corrugations, contacting the grid beams, to these beams, avoiding thereby unwanted bending moments in these beams.

18. In a roof structure a beam grid according to claim 1, said beam grid consisting of T-shaped beams, a roof shell covering said beam grid, said roof shell being adapted to carry stresses being parallel to said roof edges, said T-shaped beams being arranged in such a manner as to contact the shell along one longitudinal edge, and means securing said T-shaped beams along said contacting edges to said roof shell.

19. In a roof structure according to claim 1, a roof shell having the shape of said roof planes, said roof shell being adapted to carry stresses being parallel to said roof edges, said roof shell consisting of parallelogram-shaped roof shell portions corresponding to the roof portions lying between the grid beams, the edges of said roof shell portions being bent in shape of beams and connected to each other, serving thus as beams for the grid of the roof.

20. In a roof structure according to claim 1, a roof shell having the shape of said roof planes, said roof shell consisting of corrugated metal sheet material and being arranged in such a manner that its corrugations are parallel to the roof edges, said roof shell consisting of parallelogram-shaped roof shell portions corresponding to the roof portions lying between the grid beams, the edges of said roof shell portions being bent in shape of beams and connected to each other, serving thus as beams for the grid of the roof.

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