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(54) **RETRACTABLE DOME STRUCTURE.**

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US-A- 4 727 688 US-A- 4 738 057

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Description

The present invention relates to dome structures and, more particularly, to a retractable dome stadium.

The desirability of providing an arena or stadium which can be fully open to the sun and fresh air in times of good weather and yet can be closed, or partially closed, in times of inclement weather or excessive wind, is widely recognised. To accomplish this goal is very difficult because of the massive size of such structures.

It is therefore an object of this invention to provide a relatively simple design for such a stadium which is capable of being fully open as well as fully closed, which utilises conventional spaceframe technology, which does not require an excessive amount of land, and in which the panels that move are relatively small and lightweight, thereby simplifying the support and actuation thereof, as well as the speed of movement thereof.

US-A-4 682 449, which provides the basis for the prior art portion of claim 1, discloses a structure for a stadium roof which is retractable to expose a large rectangular area. The roof sections are relatively massively built in order to provide the necessary span and to be formed as two only separately retracting leaves. The present invention appreciates that a lighter structure can be achieved, as defined in claim 1, using symmetrically truncated, generally lune-shape panels which can readily be retracted and which have the benefits of a spherical dome type structure, rather than a rectangular roof structure. Preferably, the panels are of identical size and shape which can be stacked in their stowed retracted position and which are readily movable. Preferably, arches are provided intermediate the length of the panels for supporting the panels during movement and in their closed position with additional tracks receiving the truncated ends of the panels.

While there have been other proposals for roofs with a stacking arrangement of roof panels in their closed position, none have used the symmetrically truncated lune-shaped panels as required by the present invention, see for example the massive stacking structure shown in US-A-4 716 691.

Other advantages and features will become apparent from the following specification taken in connection with the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a pictorial view of a retractable dome stadium embodying the principles of the present invention, showing the dome in a closed position;

Figure 2 is a view similar to Figure 1 but showing the dome in an opening position;

Figure 3 is a transverse vertical sectional view taken generally along line 3-3 in Figure 1;

Figure 4 is a view similar to Figure 3 but taken at right angles thereto, the left portion of the Figure showing the dome in its closed position and the right-hand portion of the Figure showing the dome in its open position;

Figures 5, 6 and 7 are diagrammatic sectional views taken generally in the same plane as Figure 4 and illustrating the sequence of movement of the dome panels from a closed to an open position;

Figure 8 is an enlarged fragmentary diagrammatic sectional view taken generally in the same plane as Figure 3 and illustrating the manner in which the ends of the dome panels are supported and actuated, the panels being shown in their open stacked position;

Figure 9 is a fragmentary vertical sectional view taken generally along line 9-9 in Figure 8; and

Figure 10 is a fragmentary view taken generally from line 10-10 in Figure 3, with parts broken away.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is applicable to virtually any type of structure, including stadiums or the like, but for exemplary purposes is illustrated embodied in the athletic stadium of Figures 1-4. The stadium generally comprises an activity surface in the form of a playing area 10, a plurality of tiers of seating 12, seating boxes 14, parking levels 16, pedestrian ramps 18 and like features common to most stadiums.

The present stadium is unique in that it can be fully opened and closed utilizing an improved retractable dome arrangement, generally comprising a plurality of generally equal width lune-shaped dome panels 20 movable between a closed position such as shown in Figures 1 and 4 (left side) in which the panels are disposed in side-by-side relationship to define a generally spherical segment shaped dome, and an open position such as shown in Figures 2 and 4 (right side) in which the panels are stacked one above the other. A lune is the surface of a sphere included between two great circles disposed at a given included angle of inclination. The dome of the present invention approximates a circular segment of a sphere and it is the shape of a truncated lune which is used for each of the movable dome panels. The top of the stadium complex is provided with a deck 22 defining a generally circular opening 24 disposed in close and slightly overlapping relationship with the

outer ends of panels 20 in all positions thereof.

Panels 20 are supported intermediate their ends by a pair of arcuate support rails 26 each having an upper surface having a plurality of arcuate steps 28, one for each panel 20 (Figure 5-7), and which lie generally on a great circle of the imaginary sphere defined by the dome. The center of curvature of each step 28 is coincident with the center of the imaginary sphere with the radius of each step surface differing from the adjacent step surface by an amount approximately equal to the thickness of a panel 20. Each panel 20 has at least two supporting wheels 30 in alignment with each rail 26, and when the dome is closed each panel 20 is directly supported by rail 26 (Figure 5) with the adjacent edges of panels 20 slightly overlapping one another to provide a weatherproof joint. The two centermost panels 20 abut one another at an interface 32 (Figure 1) which can be provided with a suitable weatherproof seal. When panels 20 are moved downwardly and outwardly to the open position they roll from rail 26 onto the top surface (properly reinforced) of the next lower panel, and so on (Figure 6-7) until they reach the nested or stacked condition shown at the right side of Figure 4. Rails 26 are held in position by a suitable pair of arcuate supports 34, which can also be located on great circles of the imaginary sphere.

Panels 20 are also supported on arcuate arches 40 disposed at each end thereof. Arches 40, illustrated generally in Figures 3 and 4, are substantially parallel to one another, being disposed in parallel vertical planes equally spaced from the center of the dome. The overall arc of each arch is the arc defined by the intersection of the vertical plane in which the arch lies and the imaginary sphere of the dome itself. Each arch 40 has a flat inclined arcuate surface 42 facing the ends of each panel 20 and being perpendicular to the longitudinal axis thereof. Surfaces 42 each lie on the plane of a great circle of the imaginary sphere of the dome, and each has on the face thereof a plurality of parallel arcuate slots 44 through which extend end supports 46 for each of the panels 20. Each support 46 extends for the full width of each panel 20 and is in turn supported on its lower surface by means of a plurality of rollers 48. Support 46 has upstanding outer flange 47 supported on opposite sides by a plurality of rollers 50 and 52 and at the upper edge of flange 47 is a rack 54 engaged by a pinion 56 driven by a plurality of motors 58. Slots 44, in plan, are arcs of a circle having the same center as the imaginary sphere of the dome, and are of a length to accommodate the maximum length of travel of the panel or panels (i.e., at opposite sides of the stadium) disposed therein. The motors 58 for each track are spaced apart a distance less than the length of rack 54 so that

each panel will always be under the control of at least one motor. The same is true for the sets of rollers 48, 50 and 52.

As best seen in Figures 8 and 9, each support 46 has rigidly affixed thereto a plurality of rods 60 each slidably received within a cylindrical bore 62 at the free end of each panel 20. Each rod 60 extends generally in the direction of the longitudinal axis of the panel and the inner free end thereof is connected to a suitable shock absorbing and/or fluid-type compensating device 64 which is in turn affixed to panel 20. Device 64 can be of any desired construction and serves the purpose of dampening flopping movement of the panels under high wind conditions. They also can serve to compensate for thermal expansion and contraction of the entire structure.

Panels 20 may be of any desired lightweight construction, such as a standard spaceframe construction, with the outer panel skin being either fabric or metal, or a combination of both. The structural design of the panels, rails, arches, tracks, etc. can be in accordance with standard engineering and architectural practices based on the anticipated structural and weather loading.

In operation, if the dome is closed it is opened by first actuating the motors in the top tracks which control the centermost panel to cause it to start retracting. As it retracts, it rolls over the top of the next centermost panel until they are fully stacked (Figure 6). Thereafter, the motors for both these panels are actuated to cause them both to retract together (Figure 7); and so on until the dome is fully opened, or at least opened to the desired extent. Both halves of the dome can be opened simultaneously if desired. The dome may be closed by simply reversing the opening sequence. Operating can be accomplished using conventional controls, sensors and the like.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to provide the advantages above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departure from the proper scope or fair meaning of the subjoined claims.

Claims

1. A retractable dome comprising: a plurality of panels (20) mounted for movement between an open position and a closed position in which they are disposed in a generally side-by-side relationship; and means (58) for moving said panels (20) between said open and closed positions, characterised in that the panels (20) are each of a symmetrically truncated generally lune-shape and in their closed positions

define a part-spherical surface.

2. A retractable dome as claimed in claim 1, further comprising at least one generally arcuate rail (26) disposed generally transversely to said panels (20) for movably supporting same intermediate the ends thereof. 5
3. A retractable dome as claimed in claim 1 or 2, wherein said panels (20) are stacked one above the other in superimposed relationship when in said open position. 10
4. A retractable dome as claimed in claim 1, 2 or 3, wherein said panels (20) move with a generally pivotal-like motion between said positions, the axis of said motion extending generally through the centre of an imaginary spherical segment defined by said panels (20) when they are disposed in said closed position. 15 20
5. A retractable dome as claimed in any preceding claim, further comprising a base structure including a pair of generally parallel arches (40), said panels (20) being movably supported on and being disposed between said arches (40). 25
6. A retractable dome as claimed in claim 5, further comprising at least one track (44) on each said arch (40) for movably supporting the ends of said panels (20). 30
7. A retractable dome as claimed in claim 6, wherein said tracks (44) are disposed parallel to one another. 35
8. A retractable dome as claimed in any preceding claim, wherein each said dome panel (20) extends to points on the opposite sides of the same transverse substantially vertical plane passing through the centre of an imaginary sphere partially defined by the dome. 40 45
9. A retractable dome as claimed in any preceding claim, wherein a first plurality of said panels (20) is disposed on one side of said structure and a second plurality of said panels (20) is disposed on the opposite side of said structure and wherein the centremost panels (20) of said first and second pluralities of panels abut one another when all said panels are in said closed position. 50
10. A retractable dome as claimed in any preceding claim, wherein each of said panels (20) is of substantially the same size and shape. 55

Patentansprüche

1. Zurückziehbare Kuppel mit:
einer Mehrzahl von Platten (20), die für eine Bewegung zwischen einer offenen Position und einer geschlossenen Position angebracht sind, in der sie allgemein nebeneinander vorgesehen sind; und Mittel (58) zum Bewegen der Platten (20) zwischen der offenen und der geschlossenen Position;
dadurch gekennzeichnet, daß die Platten (20) von einer symmetrisch abgeschnittenen, allgemeinen Kugelzweieckform sind und in ihrer geschlossenen Position eine Teilkugeloberfläche definieren.
2. Zurückziehbare Kuppel nach Anspruch 1, weiter mit mindestens einer im allgemeinen gebogenen Schiene (26), die im allgemeinen quer zu den Platten (20) zum bewegbaren Tragen dergleichen zwischen den Enden davon vorgesehen ist.
3. Zurückziehbare Kuppel nach Anspruch 1 oder 2, bei der die Platten (20) eine über der anderen auf übereinander gelagerte Weise gestapelt sind, wenn sie sich in der offenen Position befinden.
4. Zurückziehbare Kuppel nach Anspruch 1, 2 oder 3, bei der sich die Platten (20) mit einer im allgemeinen schwenkartigen Bewegung zwischen den Positionen bewegen, wobei die Bewegungsachse sich im allgemeinen durch das Zentrum eines imaginären Kugelabschnittes erstreckt, der durch die Platten (20) definiert wird, wenn sie in der geschlossenen Position vorgesehen sind.
5. Zurückziehbare Kuppel nach einem der vorhergehenden Ansprüche, weiter mit einer Basisstruktur mit einem Paar von im allgemeinen parallelen Bögen (40), wobei die Platten (20) bewegbar auf den Bögen (40) gelagert und dazwischen vorgesehen sind.
6. Zurückziehbare Kuppel nach Anspruch 5, weiter mit mindestens einer Spur (44) auf jedem der Bögen (40) zum bewegbaren Tragen der Enden der Platten (20).
7. Zurückziehbare Kuppel nach Anspruch 6, bei der die Spuren (44) parallel zueinander vorgesehen sind.
8. Zurückziehbare Kuppel nach einem der vorhergehenden Ansprüche, bei der sich jede Kuppelplatte (20) zu Punkten auf den gegenüber-

liegenden Seiten der gleichen, im wesentlichen vertikalen Querebenen erstreckt, die durch das Zentrum einer imaginären Sphäre geht, die teilweise durch die Kuppel definiert ist.

9. Zurückziehbare Kuppel nach einem der vorhergehenden Ansprüche, bei der eine erste Mehrzahl der Platten (20) auf einer Seite der Struktur vorgesehen ist und eine zweite Mehrzahl der Platten (20) auf der gegenüberliegenden Seite der Struktur vorgesehen ist und bei der die mittlersten Platten (20) der ersten und zweiten Mehrzahl von Platten aneinander anstoßen, wenn sich alle Platten in der geschlossenen Position befinden.
10. Zurückziehbare Kuppel nach einem der vorhergehenden Ansprüche, bei der jede der Platten (20) von im wesentlichen der gleichen Größe und Form ist.

Revendications

1. Dôme rétractable comprenant : une multiplicité de panneaux (20) montés pour se déplacer entre une position ouverte et une position fermée, dans laquelle ils sont disposés généralement côte à côte; et des moyens (58) pour déplacer ces panneaux (20) entre la position ouverte et la position fermée, caractérisé en ce que chaque panneau (20) a la forme générale d'un fuseau symétriquement tronqué et que les panneaux définissent dans leur position fermée une surface d'une partie de sphère.
2. Dôme rétractable selon la revendication 1, comprenant en outre au moins un rail généralement incurvé (26) disposé sensiblement transversalement à ces panneaux (20) pour les supporter de façon mobile entre leurs extrémités.
3. Dôme rétractable selon la revendication 1 et la revendication 2, dans lequel les panneaux (20) sont empilés l'un sur l'autre en étant superposés lorsqu'ils sont dans leur position ouverte.
4. Dôme rétractable selon l'une des revendications 1, 2 ou 3, dans lequel les panneaux (20) se déplacent avec un mouvement analogue à un pivotement entre ces positions, l'axe du déplacement s'étendant sensiblement à travers le centre d'un segment sphérique imaginaire défini par ces panneaux (20) lorsqu'ils sont disposés dans leur position fermée.
5. Dôme rétractable selon l'une des revendications précédentes, comprenant en outre une

structure de base comprenant deux arceaux généralement parallèles (40), les panneaux (20) étant supportés de façon mobile sur ces arceaux (40) et étant disposés entre eux.

6. Dôme rétractable selon la revendication 5, comprenant en outre au moins une piste (44) sur chaque arceau (40) pour supporter de façon mobile les extrémités des panneaux (20).
7. Dôme rétractable selon la revendication 6, dans lequel les pistes (44) sont disposées parallèles l'une à l'autre.
8. Dôme rétractable selon l'une des revendications précédentes, dans lequel chaque panneau de dôme (20) s'étend jusqu'à des points sur les côtés opposés du même plan transversal sensiblement vertical passant par le centre d'une sphère imaginaire partiellement défini par le dôme.
9. Dôme rétractable selon l'une des revendications précédentes, dans lequel une première multiplicité de panneaux (20) est disposée sur un côté de la structure et une deuxième multiplicité de panneaux (20) est disposée sur le côté opposé de la structure et dans lequel les panneaux les plus au centre (20) des première et deuxième multiplicités de panneaux viennent en butée l'un contre l'autre lorsque tous les panneaux sont en position fermée.
10. Dôme rétractable selon l'une des revendications précédentes, dans lequel chaque panneau (20) a pratiquement la même forme et la même dimension.







