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(54) METHOD OF MANUFACTURING A HOLLOW SELF-SUPPORTING CONCRETE STRUCTURE

VERFAHREN ZUM HERSTELLEN VON EINER SELBSTTRAGENDEN BETONKONSTRUKTION

PROCEDE DE FABRICATION D'UNE STRUCTURE AUTOPORTEUSE ET CREUSE EN BETON

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(73) Proprietor: **INTERNATIONAL DOME SYSTEMS CYPRUS LTD.**
Limassol (CY)

(72) Inventor: **VAN EEDEN, Johannes, Petrus**
NL-2992 BS Barendrecht (NL)

(74) Representative: **de Bruijn, Leendert C. et al**
Nederlandsch Octrooibureau
P.O. Box 29720
2502 LS Den Haag (NL)

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GB-A- 2 131 409
US-A- 3 139 464

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Description

The present invention relates to a method of manufacturing a three dimensional hollow self-supporting concrete structure of substantially tunnel-shaped configuration by inflating an airtight space formed by an airtight flexible sheet having its edges secured to a foundation or base and comprising a tunnel wall portion and end walls, which sheet, after having obtained its proper inflated shape is stiffened by spraying onto it a hardening material, such as mortar or concrete whilst the tunnel-shape under the pressure of the inflation is stabilized by sheet supporting ribs or trusses at spaced apart locations in planes which substantially extend in a direction transverse to the longitudinal axis of the tunnel which spraying of the hardening material primarily is performed at the location of the ribs or trusses after which the spaces in between said ribs or trusses are filled by spraying the hardening material upon the remaining sheet portions between the ribs or trusses.

Such a method is known from US-A-3 139 464. According to said known method a tunnel-shaped structure can be manufactured by premarily erecting upon the base a plurality of spaced apart prefabricated metal trusses in the shape of arches which give support to the afterwards inflated sheet which by the overpressure inside the sheet is pressed against the inner side of said trusses and bulges outwardly in the space between said trusses. According to said prior art it also is possible to provide the trusses at the inner side of the sheet in which case however additional measures are necessary to connect the sheet with the trusses and to ensure the outwardly curved shape between the trusses. After the erection of the trusses and the inflation of the sheet mortar is applied by pouring or spraying, premarily at the location of the said trusses which then are embedded within the mortar and after hardening of said mortar mortar is applied over the outwardly bulging or undulating shape of the sheet between the respective trusses. This spraying or pouring takes place from the outer side upon the outer side of the trusses and sheet.

Said trusses are necessary to obtain sufficient stability because if mortar would be applied locally upon the inflated sheet a deformation would take place under the influence of gravity forces which would prevent the obtainance of the proper tunnel shape. The outwardly bulging parts provide for a bending moment of resistance and in some cases the shape of said outwardly bulging parts is not only a result of the pressure inside the sheet but is also under control of longitudinally extending tie cables 64 to obtain resistance against the spreading loads during the application of the mortar over said outwardly bulging or arching parts between the trusses.

By means of said known method an excellent and strong tunnel structure can be manufactured but said method is very complicated and accordingly expensive.

Purpose of the invention to simplify the manufacturing of a tunnel-shaped structure and according to the invention this purpose is achieved in that the hardening material is a mortar with a micro-silica content such that the freshly sprayed concrete in its still plastic stage has form stability, and that after the inflation of the sheet the ribs or trusses are formed by spraying mortar, in the shape of ribs, against the inner side of the sheet, so that the ribs or trusses support the sheet after hardening of the mortar.

Accordingly the invention uses a sheet or sheet for the tunnel-shaped portion which prior to the attachment to the foundation is a flat sheet preferably composed of flat strips welded together at overlapping edges which sheet after attachment to the base and closing the outer ends and inflation forms a straight smooth tube which however lacks stability. Said stability is obtained by manufacturing the spaced apart ribs or trusses after the inflation with the aid of a mortar which due to its silica content obtains immediately sufficient stability to form said ribs against the inner side of the inflated sheet but without exerting load of any importance upon said sheet. After the manufacturing of said ribs and the hardening thereof the remaining areas are covered by spraying said mortar but now the ribs give support to the inflated sheet. A mortar composition containing micro-silica is known in many varieties. Usually said compositions are not suitable for spraying because the strong cohesive character of the mixture opposes the transportation towards the spray nozzle. From DE-A-39 41 152 a method and apparatus is known however by means of which spraying becomes possible due to the fact that a premarily prepared badge of mortar mixture under air pressure is fed towards an injector together with transporting air supply. The injector is close to the tank in which the mortar mixture badge is present so that the risk that the mixture sticks within the conduit due to the strong cohesive properties has been avoided. Downstream the injector air flows which air is mixed with the finally devided mortar. By using said known method and device it is possible to spray mortar which due to the immediately obtainable form stability allows the creation of objects of the ribs or trusses mentioned above.

The spraying takes place on the inner side and most preferably after the application of a synthetic foam layer because a foam layer of for instance polyurethane does adhere to the material of the sheet and provides for better adherence of the mortar than in case a direct application takes place. Spraying upon the inner side against a synthetic foam layer which has been applied first is for instance known from EP-A-0 357 151 which relates to the manufacturing of dome-shaped structures which means a structure having a vertical axis of symmetry in which case different measures are necessary to take care of the influence of gravity forces. With a horizontal axis the situation is different.

By making use of simple strips for the inflatable sheet and by using special mortar which can be sprayed and by manufacturing the ribs or trusses after inflation

an extremely simple method is obtained.

It is preferred that prior to the manufacturing of the said ribs a lower wall is formed upon the base an against the lower side wall of the inflated sheet. This improves the initial stability in particular during the subsequent manufacturing of the ribs.

The use of reinforcing bars itself is known for instance from US-A-3 139 464 and from EP-A-0 357 151. Within the scope of primarily manufacturing the ribs it is however advantageous to place reinforcing bars for the ribs at the locations where the ribs have to be manufactured and to place said bars between temporarily mounted side casing plates which allows a proper configuration of the sides of the ribs during the spraying and which are removed prior to the spraying of the final layer or layers of the ribs and of the areas between the ribs which subsequently have to be coated.

The mortar with the micro-silica content covers and adheres in an excellent manner behind and around the reinforcing rods.

Apart from the micro-silica said mortar can have any type of additional materials added to the cement such as hardening accelerators, fly ash, synthetic porcelain, quarts, sand, quartzite, tress, bauxite and acceptable synthetic materials as well as all kinds of fibre reinforcements made from resins, glass, steel, carbon or aramide.

Said fibre reinforcements are of particular use if spraying takes place without the use of reinforcing rods as well be the case with spraying on the outserside of the sheet or in the manufacturing of structures of relatively small size.

With the method according to the invention a great variety of structures by means of inflation and spraying can be made.

The areas between the ribs may be completely filled but of course it is possible to leave part of the areas between said ribs uncovered so that openings remain in which the sheet more or less allows the entrance of light or at which the sheet is removed for ventilation purposes. A preferred application is the manufacturing of a tunnel-shaped structure which spans a highway or railway track portion. This may be of importance in densely populated areas where the so called "sound-walls" are insufficient to keep traffic sound away from the living quarters of the population.

Said structures may even be covered afterwards with earth.

The present invention is, however, not limited to this form of application. The tunnel-shaped structures manufactured according to the invention can also be used as inner coating of a tunnel drilled through rock.

The invention now will be further elucidated with reference to the drawings.

Figure 1 is a side view of an inflated sheet to be used in the method according to the invention.

Figure 2 is a cross section according to the line II-II of figure 1.

Figure 3 is a cross section according to the line III-III of figure 1.

Figure 4 shows in a perspective view a section of the structure to be manufactured according to the invention.

Figures 5a to 5f incl. disclose a number of subsequent phrases in the manufacturing of the structure as shown in figure 4 or 8.

Figure 6 is a cross section through a rib at a level adjacent to the base, e.g. at the level of the arrow VI in figure 5d.

Figure 7 is a cross section through a rib, e.g. at the level of the arrow VII in figure 5e.

Figure 8 discloses schematically the supply and discharge of material during the manufacturing process.

Figure 9 is a top view of one embodiment of the structure obtained by applying the method according to the invention.

Figure 10 is another top view of the structure obtained by obtaining the method according to the invention.

Figure 11 is a cross section through a finished structure.

Figure 12 is a cross section through another embodiment of the finished structure.

Figures 1 and 4 show a base structure 1 made from concrete either prefabricated or manufactured at the site.

A plastic sheet having the general reference 2 is secured to said base in an airtight manner.

Said plastic sheet 2 is composed of a plurality of parallel webs 3, which as shown in figure 3 overlap each other and are welded with their overlapping edges upon each other by means of high frequency to form welding seam 4. The connection at said overlapping edges is a permanent connection.

At the outer ends end sheets 6 and 7 respectively are connected in a detachably manner to the outermost edges 8 and 9 respectively of the innerconnected webs 3 by clamping said outermost edges between strips 10 and 11 respectively which extend in planes parallel to the surface of the webs. Said connection, by means of bolts and nuts 12 and 13 respectively is detachable so that said end sheets 6 end 7 respectively can be removed. This removal is necessary when the required length of the tunnel-shaped structure is finished and/or an extension in one or the other direction is desirable.

The end sheets 6 and 7 are also connected to a base part 14 and 15 respectively which are removably connected with the base 1. Preferably said parts 6 and 7 have the shape of one quarter of a sphere in the inflated condition.

After inflation in a well known manner the coating of mortar can be applied.

In most cases a foam layer will be applied first.

Figure 5a shows in cross section the inflated sheet.

Figure 5b shows the situation after the application of a foam layer 15.

Figure 5c shows as well as figure 4 that primarily lower wall portions 16 and 17 respectively are made by spraying or by pouring concrete between the inner side of the sheet with or without coating with foam and a temporary casing (not shown).

After the manufacturing of said wall portions 16 and 17 ribs 18,19,20 and so one are manufactured as shown in figure 5d.

As next step reinforcing rods 19 are placed between the ribs as shown in figure 5e and finally mortar is sprayed in the areas remaining between the ribs so that the final shape shown in figure 5f is obtained in which the self supporting is substantially formed by mortar or concrete 21.

Figure 4 discloses in perspective the lower wall portions 16 and 17, the ribs 18 to 20 etc. and the reinforcing network 22 between said ribs.

The reinforcing network between the ribs is substantially the same as the reinforcing network used in accordance with the above cited prior art.

In the manufacturing of the ribs 18-20, which ribs give initial strength to the structure, allowing wide spans, it may be desirable to use reinforcements as well.

Although the mortar may contain any kind of reinforcing fibre the traditional reinforcing rods are preferred to take up the loads in particular bending loads to which the entire structure is and will be subjected.

Figure 6 discloses that reinforcing rods 23 are placed parallel to the contour of the rib to be manufactured in a space which is delimited by temporarily casing plates 22 and 25 respectively. After the mounting of said rods 25 and the casing plates 24 and 25 mortar is sprayed in the space limited in a lateral direction by said plates 24 and 25 until the reinforcing rods are covered. Thereafter the plates 24 and 25 are removed and a final layer 26 is applied either on the ribs separately or together with the spraying of the areas such as 27 between the ribs.

Figure 7 discloses the same situation but now after the application of a foam layer 15 upon the outer sheet 2.

Prior to the application of the final layer 26 additional reinforcing rods like 28 can be applied.

Figure 8 discloses one way of manufacturing the tunnel-shaped structure shown in the preceding figures by using an inflatable sheet 2 having air locks 29 and 30 respectively of a size such that a truck 31 can enter it. Said truck can enter at one end, deliver its material inside the inflated part and leave it through the other air lock 30.

Since an extension of the structure shown in figure 1 easily can be made as indicated with the interrupted lines 31 large lengths can be manufactured.

Figure 9 discloses an embodiment which may have the cross section shown in figure 11 or 12 and which in the upper part of the tunnel-shaped structure has uncoated areas 32 between the ribs 18, 19 etc. and at which the sheet 2 may have been removed.

As shown in figure 11 a highway shielded in this way from its environment can have light and ventilation openings provided by said uncoated areas 32 and it can be or not be incorporated in the landscape by the additional application of earth 33.

Instead of placing the ribs parallel to each other and perpendicular to the longitudinal axis said ribs can be placed at angles as shown in figure 10 in which each pair of ribs 34, 35 intersects at the top at a sharp angle. Also here open spaces 36 and 37 respectively can be created.

Claims

1. Method of manufacturing a three dimensional hollow self-supporting concrete structure (20) of substantially tunnel-shaped configuration by inflating an airtight space formed by an airtight flexible sheet (2) having its edges secured to a foundation or base (1) and comprising a tunnel wall portion and end walls (6, 7), which sheet (2), after having obtained its proper inflated shape is stiffened by spraying onto it a hardening material, such as mortar or concrete whilst the tunnel-shape under the pressure of the inflation is stabilized by sheet supporting ribs or trusses (18, 19, 20) at spaced apart locations in planes which substantially extend in a direction transverse to the longitudinal axis of the tunnel which spraying of the hardening material primarily is performed at the location of the ribs or trusses (18, 19, 20) after which the spaces (22) in between said ribs or trusses are filled by spraying the hardening material upon the remaining sheet portions (22) between the ribs or trusses (18, 19, 20), **characterized in that** the hardening material is a mortar with a micro-silica content such that the freshly sprayed concrete in its still plastic stage has form stability, and in that after the inflation of the sheet the ribs or trusses (18, 19, 20) are formed by spraying mortar, in the shape of ribs, against the inner side of the sheet, so that the ribs or trusses support the sheet (2) after hardening of the mortar.

2. Method as claimed in claim 1, **characterized in that** first a lower wall (16, 17) is formed upon the base (1) and against the lower side wall of the inflated sheet (2) before the said ribs (18, 19, 20) are made.

3. Method as claimed in claim 1 or 2, wherein the ribs (18, 19, 20) are made in parallel vertical planes which extend perpendicular to the axis of the tunnel.

4. Method as claimed in claim 1 or 2, wherein the ribs (34, 35) are made in vertical planes of which at least two planes intersect eachother at a sharp angle.

5. Method according to one of the preceding claims,

in which reinforcing bars are arranged prior to the spraying of the mortar, **characterized in that** prior to the spraying of the ribs (18, 19, 20) the reinforcing bars (23) for the ribs (18, 19, 20) are placed between temporarily mounted side casing plates (24, 25) to properly define the sides of the ribs, which plates (24, 25) are removed prior to the spraying of the final layer or layers (26) of the ribs (18, 19, 20) and prior to the spraying of the areas in between the ribs.

Patentansprüche

1. Verfahren zum Herstellen einer dreidimensionalen, hohlen, selbsttragenden Betonkonstruktion (20) mit einer im wesentlichen tunnelförmigen Konfiguration durch Aufblasen eines hermetisch abgeschlossenen Raums, der aus einer luftdichten flexiblen Folie (2) gebildet wird, deren Kanten an einem Fundament oder einer Grundlage (1) fest angebracht sind und die einen Tannelwandabschnitt und Endwände (6, 7) umfaßt, wobei die Folie (2), nachdem sie ihre richtige aufgeblasene Form erhalten hat, durch Aufspritzen eines hart werdenden Materials wie Mörtel oder Beton versteift wird, während die Tunnelform unter dem Aufblasdruck durch Folientragrippen oder Trägern (18, 19, 20) an voneinander beabstandeten Stellen in Ebenen stabilisiert wird, die sich in eine im wesentlichen quer zur Tunnellängsachse liegenden Richtung erstrecken, wobei das Aufspritzen des hart werdenden Materials vor allem an den Stellen der Rippen oder Trägern (18, 19, 20) ausgeführt wird, hiernach die zwischen den Rippen oder Trägern liegenden Räume (22) durch Aufspritzen des hart werdenden Materials auf die verbleibenden Folienabschnitte (22) zwischen den Rippen oder Trägern (18, 19, 20) gefüllt werden,
dadurch gekennzeichnet, daß
das hart werdende Material ein Mörtel mit einem Gehalt an Mikropartikeln aus Siliziumoxib ist, so daß der frisch aufgespritzte Beton, der sich noch in seinem plastischen Zustand befindet, eine Formstabilität aufweist, und dadurch, daß nach dem Aufblasen der Folie die Rippen oder Träger (18, 19, 20) durch Aufspritzen von Mörtel in Form von Rippen gegen die Innenseite der Folie gebildet werden, so das die Rippen oder Träger die Folie (2) nach Hartwerden des Mörtels stützen.

2. Verfahren nach Anspruch 1,
dadurch gekennzeichnet, daß
zuerst eine untere Wand (16, 17) auf der Grundlage (1) und gegen die untere Seitenwand der aufgeblasenen Folie (2) ausgebildet wird, bevor die Rippen (18, 19, 20) hergestellt werden.

3. Verfahren nach Anspruch 1 oder 2,
bei dem die Rippen (18, 19, 20) in zueinander parallelen Vertikalebenen hergestellt werden, die sich senkrecht zu der Tunnelachse erstrecken.

4. Verfahren nach Anspruch 1 oder 2,
bei dem die Rippen (34, 35) in vertikalen Ebenen hergestellt werden, von denen zumindest zwei Ebenen einander in einem spitzen Winkel schneiden.

5. Verfahren nach irgendeinem der vorhergehenden Ansprüche, bei dem Stützen vor dem Aufspritzen des Mörtels angeordnet werden,
dadurch gekennzeichnet, daß
vor dem Aufspritzen der Rippen (18, 19, 20) die Stützen (23) für die Rippen (18, 19, 20) zwischen vorübergehend befestigten Seitenverkleidungsplatten (24, 25) plaziert werden, um die Seiten der Rippen richtig zu definieren, wobei die Platten (24, 25) vor dem Aufspritzen der letzten Schicht oder Schichten (26) der Rippen (18, 19, 20) und vor dem Aufspritzen auf die zwischen den Rippen liegenden Areale entfernt werden.

Revendications

1. Procédé de fabrication d'une structure tridimensionnelle creuse autoporteuse en béton (20) de configuration sensiblement en forme de tunnel en gonflant un volume étanche à l'air formé par une feuille flexible étanche à l'air (2) ayant ses bords fixés à une fondation ou base (1) et comprenant une portion de paroi de tunnel et des parois d'extrémité (6,7), laquelle feuille (2) après avoir pris sa propre forme gonflée est rigidifiée par pulvérisation sur elle d'un matériau durcissant tel que du mortier ou du béton, tandis que la forme en tunnel sous la pression de gonflage est stabilisée par des nervures ou armatures (18, 19, 20) de support de feuille à des emplacements espacés dans des plans qui s'étendent sensiblement dans une direction transversale à l'axe longitudinal du tunnel, laquelle pulvérisation du matériau durcissant est tout d'abord effectuée à l'emplacement des nervures ou armatures (18, 19, 20) après quoi les espaces (22) entre lesdites nervures ou armatures sont remplis par pulvérisation du matériau durcissant sur les parties restantes (22) de la feuille entre les nervures ou armatures (18, 19, 20), caractérisé par le fait que le matériau durcissant est un mortier contenant de la micro-silice de telle sorte que le béton fraîchement pulvérisé, encore à l'état plastique, possède une stabilité de forme et que, après le gonflage de la feuille, les nervures ou armatures (18, 19, 20) sont formées en pulvérisant le mortier, sous la forme de nervures, contre le côté intérieur de la feuille, de telle sorte que les nervures ou armatures supportent la feuille (2) après durcissement du mortier.

2. Procédé selon la revendication 1, caractérisé par le fait que l'on forme d' abord une paroi inférieure (16, 17) sur la base (1) et contre la paroi latérale inférieure de la feuille gonflée (2) avant de réaliser lesdites nervures (18, 19, 20).

3. Procédé selon la revendication 1 ou 2, dans lequel les nervures (18, 19, 20) sont réalisées dans des plans verticaux parallèles qui s'étendent perpendiculairement à l'axe du tunnel.

4. Procédé selon la revendication 1 ou 2, dans lequel les nervures (34, 35) sont réalisées dans des plans verticaux dont aux moins deux plans se coupent mutuellement selon un angle aigu.

5. Procédé selon l'une des revendications précédentes, dans lequel des barres de renfort sont mises en place avant la pulvérisation du mortier, caractérisé par le fait qu'avant la pulvérisation des nervures (18, 19, 20) les barres de renfort (23) pour les nervures (18, 19, 20) sont placées entre des plaques de coffrage latérales montées temporairement (24, 25) pour définir correctement les côtés des nervures, lesquelles plaques (24, 25) sont retirées avant la pulvérisation de la ou des couches finales (26) des nervures (18, 19, 20) et avant la pulvérisation des zones entre les nervures.

Fig - 1

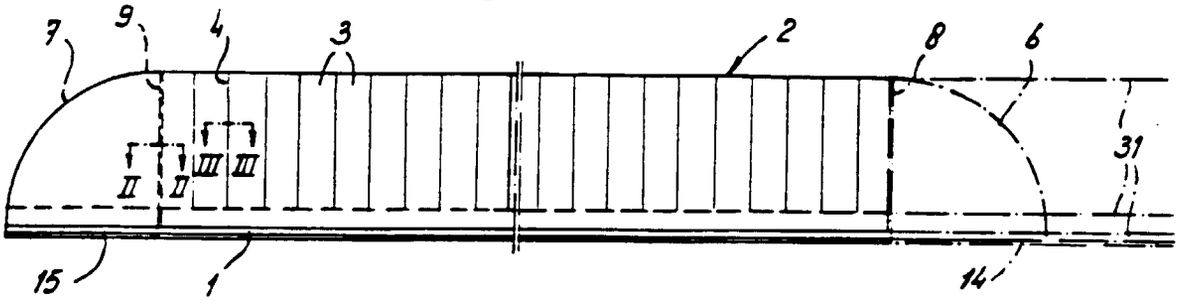


Fig - 2

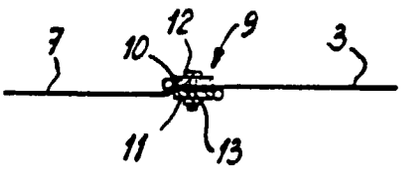


Fig - 3



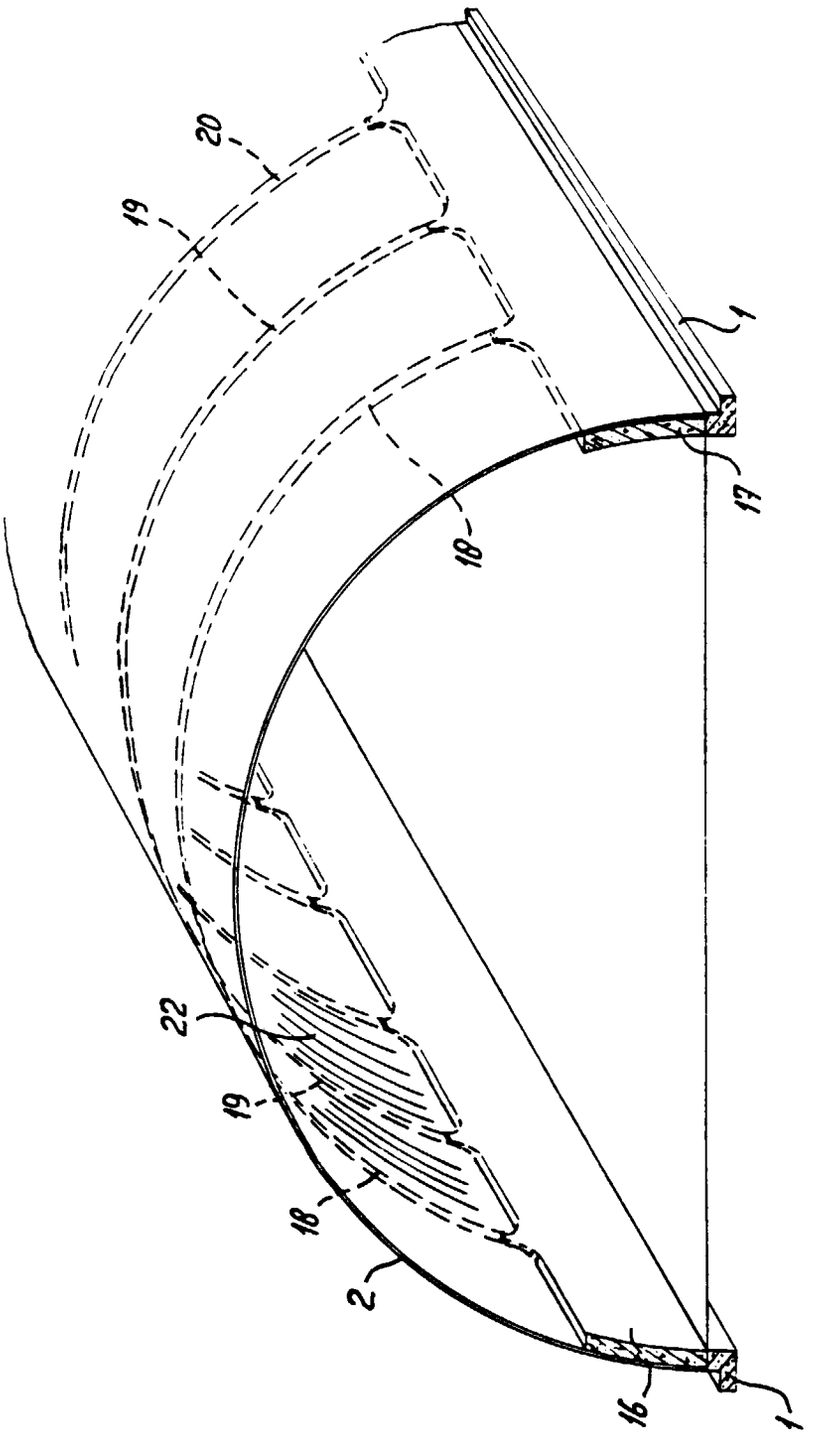


fig-4

fig - 5

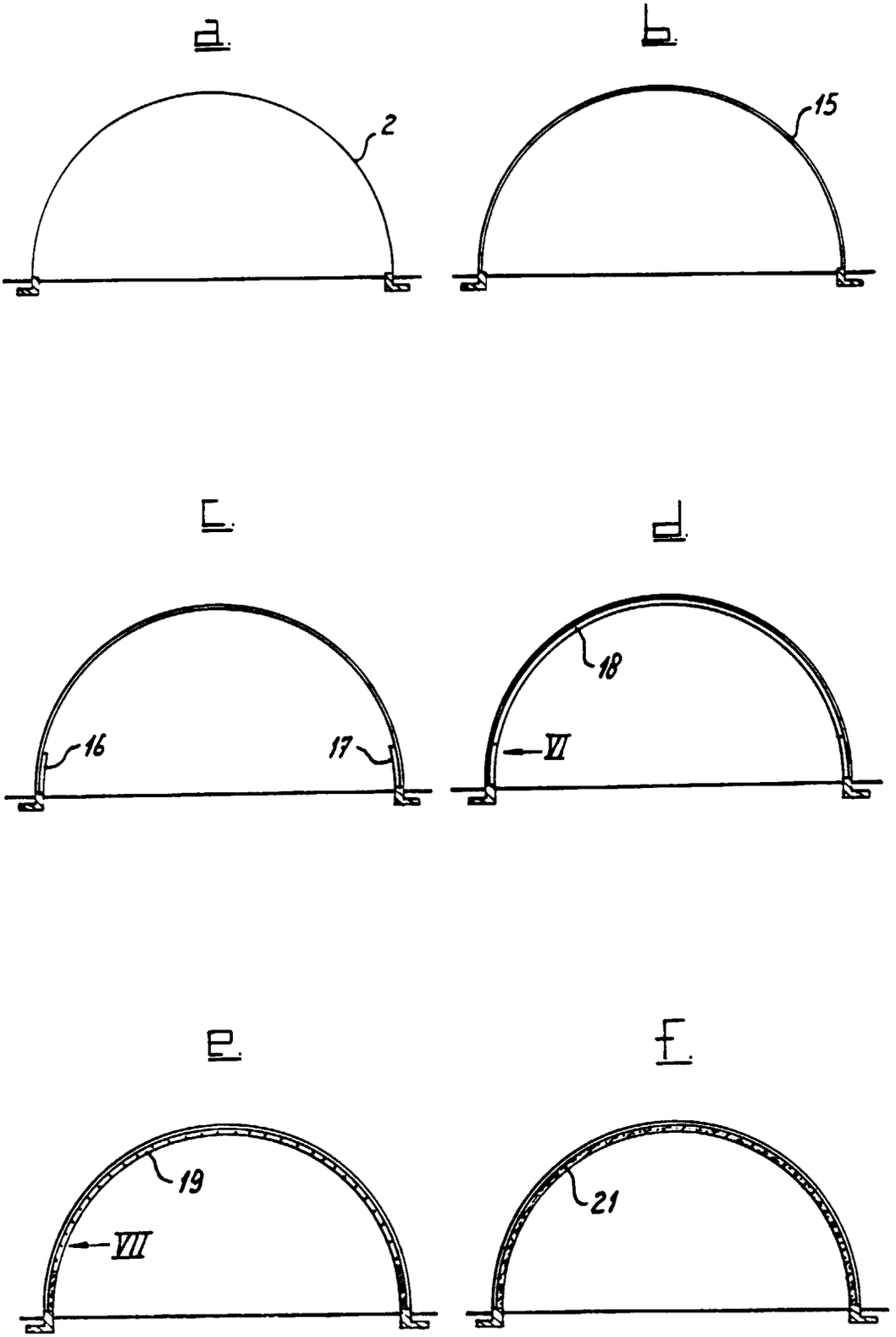


Fig - 6

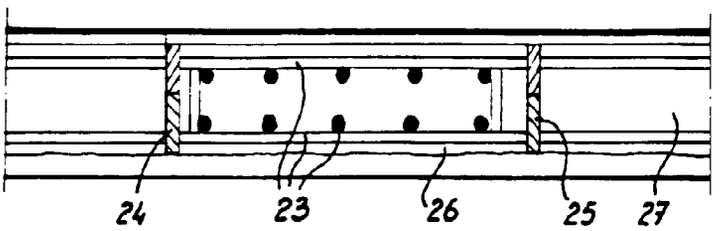


Fig - 7

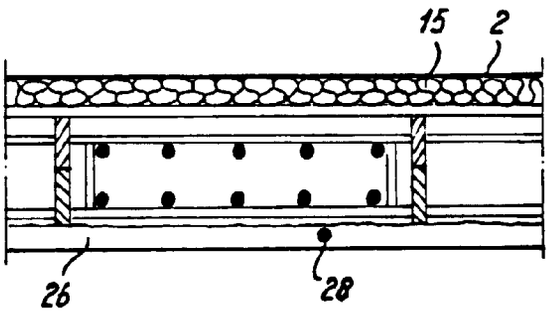


Fig - 8

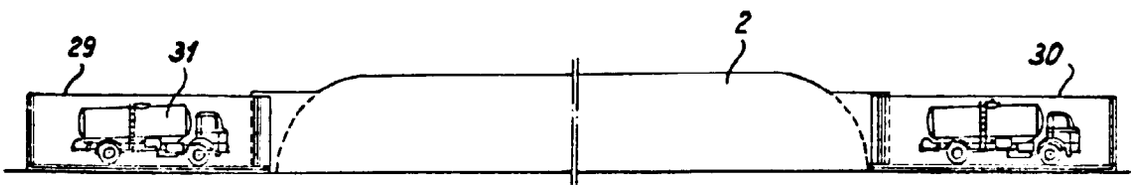


fig - 9

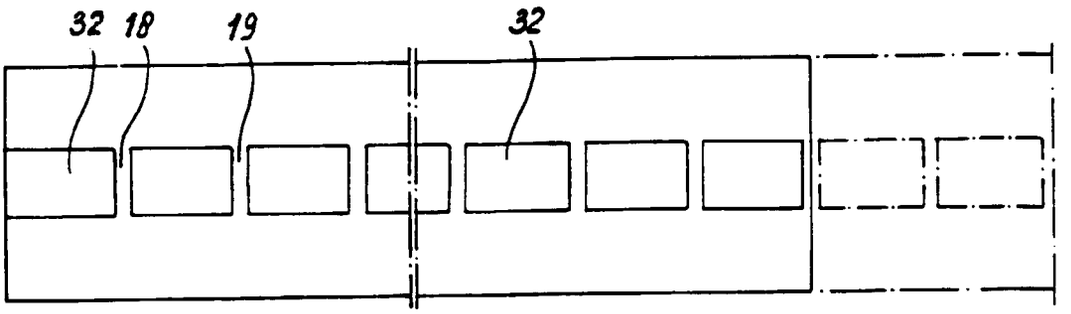


fig - 10

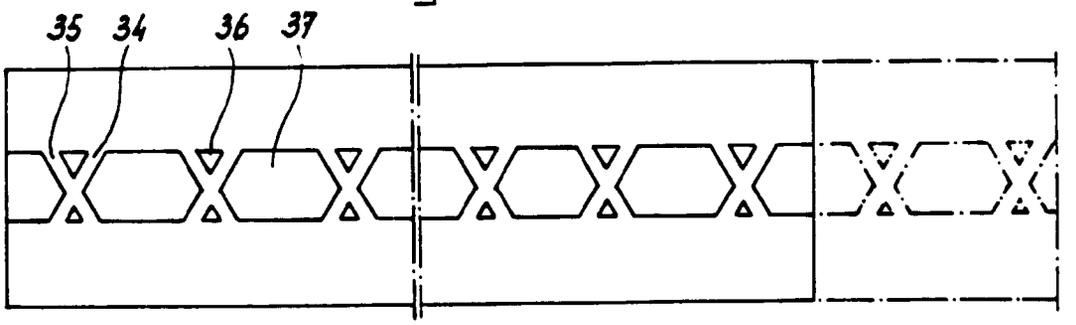


fig - 11

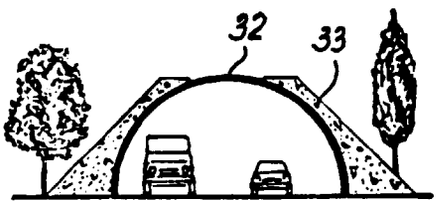


fig - 12

