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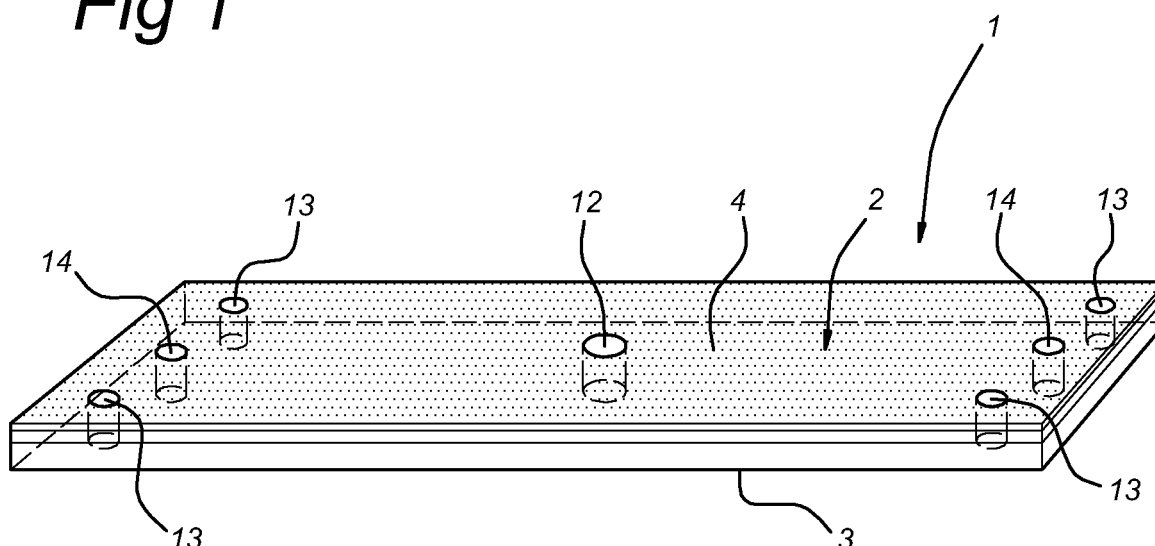
(54) **Method for improving a steel bridge, as well as a steel bridge improved in this manner**

(57) A method for improving a bridge provided with a bridge deck construction which comprises a steel cover plate as well as stiffeners attached to the underside of the steel cover plate, comprises the step of: covering the upper side of the steel cover plate with a

prefabricated concrete deck.

Furthermore, the method comprises adjusting the concrete deck in the vertical direction with respect to the steel bridge deck, as well as filling an open space between the upper side of the steel bridge deck and the underside of the concrete deck with a filling agent.

Fig 1



Description

[0001] The invention relates to a method for improving a steel bridge. Such a steel bridge comprises a steel supporting structure, for example two steel arches which are connected to one another by means of transverse connections, as well as a steel bridge deck construction provided with edge beams which are suspended from arches by means of tension rods. Between the edge beams, there is an orthotropic plate structure with a steel cover plate which is stiffened at the underside with stiffeners. These stiffeners, usually designed in the shape of inverted T-profiles, are welded to the underside of the cover plate. At regular intervals in the longitudinal direction of the bridge, cross members are welded to the underside of the cover plate, which have to transfer the loads to the edge beams. The stiffeners in each case extend between two cross members.

[0002] The upper side of the steel cover plate is covered with an asphalt layer which forms the actual driving surface for the traffic. Such an asphalt layer is indispensable since the steel material of the cover plate cannot provide the desired properties in connection with the driving surface, such as an acceptable skid resistance and evenness. By contrast, the asphalt layer, which in a known manner consists of a mixture of bitumen and filler materials, such as in particular road metal, does have these desired properties.

[0003] In use, the bridge deck construction is exposed to the loads of the driving traffic. The main concern in this case is the behaviour of the steel cover plate. This steel cover plate, for which a thickness of approximately 10 mm was chosen in the past, not only has to be sufficiently strong to carry the traffic, but also has to be sufficiently stiff. As is known, steel has great strength, which is coupled with a relatively great flexibility. However, in connection with the increase in traffic load, it appears that a steel cover plate of such thickness leaves something to be desired both regarding strength and stiffness. The relatively great flexibility of the steel cover plate leads to those parts of the steel cover plate which are located between two stiffeners being pushed slightly downwards on account of the wheel load. As a result thereof, the parts of the steel cover plate which extend over the stiffeners are bent in the opposite direction, with the upper side of the cover plate exhibiting signs of elongation. The same effect occurs at the cross members.

[0004] In this connection, it has to be remembered that the respective signs of elongation are constantly occurring on account of the constant road traffic. As a result thereof, fatigue cracks are found to occur in the steel structure. A further problem which results from these signs of elongation is that cracks also appear in the asphalt layer which covers the steel cover plate. These cracks are very detrimental, as sections may break away from the asphalt layer, enabling water and grit to reach the steel cover plate and damage the latter.

[0005] US patent 4,691,399 proposes to improve a

steel bridge by providing the main supporting structure thereof with additional supporting arches, in such a manner that the total strength and stiffness of the bridge are increased. However, such an approach does not improve the situation of the steel cover plate and the asphalt layer which is situated on top of it. Such an addition of additional supporting arches therefore does not offer a solution to the problems outlined above.

[0006] As discussed above, the strength and stiffness of the steel cover plate are not sufficient to be able to withstand the traffic load. Therefore, it has been proposed to fit a strong, stiff layer onto the steel cover plate. This additional layer would have to be made of high-strength concrete which, at a limited thickness of, for example, 6 cm, can spread the concentrated wheel loads over a larger surface area.

[0007] In this connection, it has already been proposed to pour high-strength concrete on top of the steel cover plate in situ. Pouring such a layer of high-strength concrete has to be carried out under specific conditions, which means that a cover, such as a tent, has to be arranged over the road surface to be treated. In practice, however, it has proved to be not that simple to apply a high-strength concrete of this type in the correct manner. Not only does reinforcement, in some cases comprising several reinforcement mats on top of one another, have to be incorporated in such a layer of concrete, but it also appears to be not very easy to level off the layer flatly. A further problem may occur if the pouring of the concrete is carried out on one half of a bridge while the other half of the bridge is still in use. Such a procedure is often required as it is not possible to close the bridge completely due to the traffic load. However, the traffic on the bridge half which is still in use causes vibrations in the freshly poured concrete on the other bridge half, as a result of which the concrete cannot set properly, resulting in small cracks in the latter. Finally, it also appears to be difficult to ensure the required skid resistance of a surface which is obtained in this way. The required roughness has to be brought about by mechanically treating the surface of the concrete, for example with high-pressure water jets, which would lead to an increase in a possible crack pattern.

[0008] It is therefore an object of the invention to provide a method for improving a steel bridge, in which concrete is used, but in which the abovementioned problems can be avoided. This object is achieved by means of a method for improving a bridge provided with a bridge deck construction which comprises a steel cover plate as well as stiffeners attached to the underside of the steel cover plate, comprising the step of covering the upper side of the steel cover plate with a prefabricated concrete deck.

[0009] The prefabricated concrete deck brings several advantages. A first advantage is the fact that the concrete deck can be produced and can set under the appropriate, controlled conditions, in such a manner that the desired high quality thereof is ensured. A further advantage is

the fact that such a concrete deck acts as a load distributor. The concrete deck does not have to be rigidly connected to the steel bridge deck itself to such a degree, but only has to ensure that concentrated loads, in particular wheel loads of lorries, are distributed over a larger surface area of the steel cover plate. The distribution has to take place in any case across several areas of the cover plate which are defined between the stiffeners and the cross members, in such a manner that no sagging or microdeformation can occur locally in the steel cover plate.

[0010] In this case, it should be considered that the concrete deck does indeed have to be able to resist such microdeformation of the steel cover plate, but should not affect the macrodeformation of the bridge as a whole. The steel supporting structure of the bridge itself also has a certain degree of flexibility, but this does not have any detrimental effect on the fatigue of the bridge and it should therefore be possible to retain this. In this connection, preference is therefore given to a concrete deck which consists of a number of concrete elements arranged one behind the other. These concrete elements have to be of a sufficiently great width in order to distribute the load from two lorry wheels which are next to one another over the steel cover plate. In this connection, the dimension of the concrete elements in the longitudinal direction of the bridge may be smaller than their dimension in the transverse direction of the bridge.

[0011] In a preferred embodiment, the method according to the invention therefore comprises the steps of:

- providing a number of concrete elements,
- placing a series of concrete elements one behind the other on the steel cover plate.

[0012] By sealing the concrete elements with respect to one another and by fastening them to the bridge deck construction, it can be ensured that the steel cover plate is well protected against the effects of water, de-icing salt and the like.

[0013] The concrete elements can be installed on the steel cover plate in various different ways. According to a first possibility, they can be installed one by one, and sealed with respect to one another. However, a more efficient way of installing the concrete elements is preferred. The method according to the invention may in this connection in particular comprise the steps of:

- connecting a number of concrete elements to one another to form a subseries,
- placing a number of subseries one behind the other on the steel cover plate.

[0014] If desired, the method may comprise the following step:

- sealing neighbouring concrete elements with respect to one another.

[0015] The subseries can be installed at the desired location on the steel cover plate by means of mobile lifting devices. In order to facilitate handling such a subseries, the concrete elements thereof may be connected to one another by means of a strip extending on the upper side of the concrete elements. Each concrete element is attached to one and preferably two such strips which extend next to one another.

[0016] Once the subseries have been put in position, they can be connected to one another and the filling layer can be applied. The subseries can be connected to one another by coupling pieces or another ancillary structure. In this connection, it is desirable to put the concrete elements in the correct position with respect to the steel cover plate first. In this case, the desired course of the driving surface, as well as possible local deviations in the position of the steel cover plate should be allowed for. For this reason, the method according to the invention comprises the step of adjusting the concrete deck in the vertical direction with respect to the steel bridge deck. In this case, the strips play an important part as temporary ancillary structure by means of which the concrete elements are connected to one another. These strips have to have a certain stiffness in such a manner that they can be deformed in accordance with an even, flowing line. Therefore, they should not be excessively stiff, since the series would then not be able to readily follow the normal curvature of the carriageway on the bridge deck construction in the longitudinal direction. On the other hand, these strips should not be excessively flexible, since local depressions and elevations could then be created which would have a detrimental effect on the quality (evenness) of the carriageway.

[0017] The advantages of the strips are best used to full advantage if the upper sides of the concrete elements are pulled against the strips. In this case, the adjacent edges of the concrete elements can be at the same level, which makes it possible to form a very even road surface. In addition, any differences in thickness of the concrete elements can thus be compensated for. A further advantage of the use of such strips is the fact that an accurately determined interval can be maintained between the concrete elements. As a result thereof, the interval can be relatively small, since a certain interval can always be maintained, even in the case of expansion by heat, sagging and the like. This also makes it possible to prevent the seals between the concrete elements, such as rubber strips, from being loaded too heavily or from having too much space, resulting in a loss of sealing action.

[0018] Thereafter, the open space between the upper side of the steel bridge deck and the underside of the concrete deck is preferably filled with a liquid filling and bonding agent which can cure or set, such as for example polyurethane. The modulus of elasticity of this filler in cured or set state is relatively low compared to the modulus of elasticity of concrete or steel, in such a manner that this filling layer allows a certain degree of settling (sagging) of the steel bridge deck construction (in its en-

tirety), while the mutual bond is sufficiently strong to withstand the loads from the traffic. Once the filler has cured/set, the strips can be removed. Preferably, the concrete elements themselves are made from self-compacting, high-strength concrete. Furthermore, the concrete elements may be reinforced with fibres. Such concrete elements can be of limited thickness, yet nevertheless offer the required strength and stiffness.

[0019] The invention also relates to a bridge provided with a bridge deck construction which comprises a steel cover plate as well as stiffeners which are attached to the underside of the steel cover plate. Such a bridge has the above-described problems; in order to overcome these, a prefabricated concrete deck is arranged on the upper side of the steel cover plate. In a preferred embodiment of the invention, the concrete deck comprises a series of concrete elements connected to the bridge deck. If desired, they can be sealed with respect to one another.

[0020] Viewed in the longitudinal direction of the bridge, the dimension of these concrete elements is smaller than their dimension in the transverse direction of the bridge. In connection with the correct positioning, each concrete element is preferably provided with an adjusting means for adjusting the height of the concrete element with respect to the steel cover plate. In particular, these adjusting means may be provided on both ends of each concrete element. The space between each concrete element and the steel cover plate is filled with a filling (bonding) agent, such as a polyurethane. The surface of the concrete deck and of the concrete elements which forms the carriageway is roughened in order to provide the desired properties for driving.

[0021] The invention furthermore relates to a method for moulding a body having a surface with a surface structure.

[0022] Usually, a mould provided with a surface structure is used to produce such a body with a surface structure into which mould a mass is poured which cures or sets. An example of such a mass is a concrete mass. Often, gravel or other filler material is mixed in with this concrete mass. After the concrete body has been released from the mould, the surface is often treated in order to give the structure an appearance, or the surface is treated in order to release the enclosed particles of granular material. For other masses or compositions, it is not even possible to release the particles, or very difficult.

[0023] A problem of the known method is producing a body having a surface structure with the desired properties. In particular, it is a problem to produce a body made of concrete mixed with granular material, in which the granular material has to protrude from the concrete surface in order to produce a surface with a desired, modifiable and reproducible surface property.

[0024] It is an object of this aspect of the invention to provide a method which at least partially solves the abovementioned problems and/or to provide an alterna-

tive method.

[0025] It is a further object of this aspect of the invention to provide a method, with which the surface structure can be made reproducible and modifiable.

5 **[0026]** It is a further object of the invention to provide a method for producing a concrete body, with which a concrete body, in particular a concrete tile, can be produced having a surface with a durable skid resistance, such as for road construction.

10 **[0027]** To this end, this aspect of the invention provides a method for moulding a body having a surface with a surface structure, comprising the steps of:

- providing a mould with a mould wall, at least partly provided with a layer of coating material;
- 15 - introducing granular material into the mould, with particles of granular material partly penetrating into the coating material as far as the mould wall;
- subsequently introducing a composition into the mould which composition can be solidified, with the composition penetrating between the particles of the granular material up to the coating material and at least partially surrounding that part of the particles which has not penetrated into the coating material;
- 20 - once the composition has solidified, removing the body which has thus been formed from the mould, with the side of the body facing the coating material having the surface structure.

30 **[0028]** By means of the method for moulding a body, it is possible to orient particles of granular material in a desired manner, as a result of which a desired, modifiable surface structure having a desired durable skid resistance and polishing resistance can be created. In addition, the method has little, if any, negative impact on the composition.

35 **[0029]** In this context, the term composition is in principle intended to refer to a mass which can be introduced into a mould and can be brought to a solid state during which process the mass is shaped. Such a mass may be a plastic or a plastic compound which sets, such as is the case with a melted thermoplastic, for example but not limited to polyethylene, polypropylene or the like.

40 **[0030]** Such a mass may also be a curing mass, such as a thermosetting plastic. Examples thereof are, inter alia, polyurethane, radiation-curable plastics and the like.

45 **[0031]** However, the method can particularly suitably be used for moulding a concrete body, in which the mass or composition therefore is a concrete mass which (at least partly) sets in the mould. The method appears to be highly suitable specifically for moulding a body of high-strength concrete and/or fibre-reinforced concrete, since the quality of the finished product is hardly negatively affected by the method. Preferably, high-strength concrete has a compressive strength of at least 60 N/mm², preferably even more than 100 N/mm². In many cases, concrete of this type is self-compacting.

[0032] It has been found that such a body, in particular

such a concrete body, can be made particularly suitably for use as driving surface, in particular on bridges.

[0033] The polished value, also known as Polished Stone Value or PSV, which this application refers to, is a value which indicates the effect of wear by vehicle tyres on a road surface. The so-called PSV test is defined in test BS 812, which has been established by the "Permanent International Association of Road Congresses PI-ARC, the RILEM and the ASTM. In particular, the test is defined in BS 812 Part 1 14:1989. Natural materials in particular have a high polished value.

[0034] In one embodiment, the temperature of the granular material relative to the melting point of the coating material is chosen such that the particles penetrate at least partially into the coating material.

[0035] In a further embodiment of the method for moulding a body, the coating layer remains connected to the concrete body when the latter is removed from the mould. In this embodiment, the coating layer is removed from the concrete body after the concrete body has been released.

[0036] In an alternative embodiment, the coating layer remains behind in the mould when the concrete body is released from the mould.

[0037] In an embodiment of the method for moulding a body, the coating layer is a plastic film, in one embodiment having a thickness of 1-5 mm. Preferably, the thickness is chosen in such a manner that the particles of the granular material penetrate the layer of coating material up to the surface of the mould, but the particles still protrude to a large degree, preferably to at least 50 %, from the layer of coating material. The layer has to be chosen such that the particles are retained therein so that the position is fixed and remains fixed while the composition is introduced into the mould, but that the particles remain behind in the solidified composition when the coating layer is removed. It is also preferable if the coating material is chosen in such a manner that when it is penetrated by the particles a closed contact surface is created, as a result of which the liquid composition is unable to permeate the latter. Preferably, the particles are essentially oriented in such a manner that the parts thereof which protrude furthest out of the composition are substantially in one plane (in the case of a body provided with a plane).

[0038] Thermoplastic has been found to be particularly suitable as coating layer since the granular material can easily penetrate this in the desired manner. In addition, it is more cost-efficient and can be readily introduced into a mould and removed from the concrete body.

[0039] In one embodiment thereof, the coating layer comprises a thermoplastic, preferably LDPE. During use, this plastic has been found to be particularly suitable, inter alia because it has been found that it can easily be removed from concrete.

[0040] An alternative is a curable plastic layer which is liquid when the granular material is introduced into the mould, and is subsequently cured, following which the composition is introduced. Such a plastic may be, for

example a polyurethane, or another curable plastic. It is preferable to choose a coating material which does not adhere, or hardly adheres at all, to the solidified composition and the granular material.

[0041] Alternatively, the thermoplastic may be introduced into the mould in liquid form, after which the granular material is introduced into the mould, and the thermoplastic is allowed to solidify.

[0042] In one embodiment of the method for forming a body, the granular material comprises stone granules, preferably road metal such as broken quarry material such as grey quartzite or Gres d'Ardenne. Preferably, the average diameter of granular material is at least approximately 5 mm.

[0043] The specific material is particularly suitable for applications which require a high resistance to wear, such as with roads. In addition, it can easily be heated and introduced into a mould. In addition, it has a durable skid resistance.

[0044] In one embodiment of the method for moulding a body for producing a concrete body having a surface with a high polishing resistance, a granular material with a high polished value (PSV) is chosen, in one embodiment having a PSV of more than 60. Because of these unique properties, such a concrete body can readily be used in road construction. In addition to the high resistance to wear, the concrete body has a durable roughness or skid resistance as a result of the use of the specific granular material which is, in addition, introduced into the concrete body in a unique manner, for example enabling vehicles to brake very effectively. In addition, the orientation of the upper surfaces of the granulate results in a reduction in the tyre noise of vehicles.

[0045] In one embodiment of the method for moulding a body in which the mould has a mould bottom which is provided with the layer of coating material. When the granular material is introduced, the mould can be made to vibrate so that the granular material is oriented. Preferably, the particles of the granular material partially penetrate through the coating layer up to the wall of the mould.

[0046] The invention furthermore relates to a method for moulding a concrete body having a concrete surface with a surface structure, comprising the steps of:

- providing a mould provided with a layer of coating material;
- introducing granular material into the mould, with the temperature of the granular material being set such that particles of the granular material partly penetrate into the coating material, preferably up to the surface of the mould;
- subsequently introducing a concrete mixture into the mould, with the concrete mixture penetrating between the particles of the granular material up to the coating material and at least partially surrounding that part of the particles which has not partially penetrated into the coating material;

- once the concrete mixture has solidified, removing the concrete body which has thus been formed, with the side of the body facing the coating material having the surface structure.

[0047] The invention furthermore relates to a method for moulding a body provided with a surface structure, in which a coating layer is applied to the mould bottom of a mould, a granular material having a mean particle size of at least approximately 5 mm is subsequently introduced into the mould and penetrates into the coating layer and substantially rests on the mould bottom, following which the coating layer essentially determines the position of the granular material in the mould, after which a composition is introduced into the mould, with the composition penetrating between the particles of the granular material up to the coating material and at least partially surrounding that part of the particles which has not partially penetrated into the coating material, following which the composition is allowed to solidify, after which the body which has thus been formed, with the side of the body facing the coating material having the surface structure.

[0048] The invention furthermore relates to a concrete body produced by means of the method described above.

[0049] The invention furthermore relates to a concrete slab produced by means of the method as described above.

[0050] The invention furthermore relates to a bridge provided with a road surface made up of concrete slabs produced by means of the method as described above.

[0051] The invention furthermore relates to a concrete body made of high-strength concrete, comprising a top surface provided with broken quarry material, particles of which partially protrude from the concrete in order to produce a surface having a polished value PSV of at least 58.

[0052] The invention furthermore relates to a concrete slab made of high-strength concrete, comprising a top surface provided with broken quarry material, particles of which partially protrude from the concrete in order to produce a surface having a polished value PSV of approximately 60.

[0053] In one embodiment of such a concrete slab, the latter has dimensions of approximately 2-4 metres by approximately 0.5-2 metres with a thickness of approximately 3-10 cm, and is provided with adjusting means for adjusting the height of the concrete slab above a foundation, and for aligning the top surface.

[0054] The invention furthermore relates to a bridge, in particular a bridge having a steel deck, provided with a driving surface comprising concrete slabs as described.

[0055] Such concrete slabs according to the invention have proved to be highly suitable, in particular for driving surfaces of steel bridges, as they, on the one hand, have a surface which is highly suitable therefor, and, in addition, have a stiffness which makes them highly suitable for a bridge deck, in particular for use on a steel bridge deck as also described further in the description.

[0056] The invention will now be described in more detail with reference to an exemplary embodiment illustrated in the figures, in which:

- 5 Fig. 1 shows a concrete element according to the invention;
- Fig. 2 shows an assembly of a steel bridge deck with a series of concrete elements;
- Fig. 3 shows a subseries of concrete elements;
- 10 Fig. 4 shows a cross section at the location where the concrete elements are supported on the steel bridge deck;
- Fig. 5 shows a steel bridge, with a bridge deck according to the invention;
- 15 Fig. 6 shows the underside of a steel bridge;
- Fig. 7 shows a cross section through the bridge deck construction of the bridge according to Fig. 5;
- Fig. 8 shows a first step in the method for moulding a body, in which a mould is shown;
- 20 Fig. 9 shows a subsequent step of the method according to the invention;
- Fig. 10 shows a further step in the method according to the invention;
- Fig. 11 shows a further step, in which the shaped body is released from a mould, in which Fig. 11a shows a cross section through a part of the shaped body;
- 25 Fig. 12 shows a further step of the method, in which a layer of coating material is removed from a shaped body, in which Fig. 12a shows a cross section of the product obtained.

[0057] Fig. 1 shows a concrete element 1 which has a top surface 2 and a bottom surface 3. The top surface 2 has a roughness pattern 4, in such a manner that the concrete element 1 has the desired skid resistance for the road traffic. Each concrete element 1 has a central hole 12, by means of which hole 12, as will be explained below, a filling agent can be applied beneath the concrete element 1. Furthermore, each concrete element 1 has four securing holes 13, which will likewise be explained below, as well as two adjustment holes 14 for use with adjusting means.

[0058] The outline diagram of Fig. 2 shows that two series 5, 6 of such concrete elements 1 are arranged next to one another on a steel cover plate 7. Each series 5, 6 can have at least the width of one traffic lane, so that the wheel load of a lorry can be distributed over a large area of the steel cover plate 7. In order to be able to attach the series 5, 6 to the edges 8 of the steel cover plate 7, liquid asphalt 9 is used as filling.

[0059] In order to be able to place the concrete elements 1 in an efficient manner, they can be joined together to form subseries 10, as illustrated in Fig. 3. Such subseries 10 composed of concrete elements 1 are held together by the strips 11. These strips 11 in turn have openings 15, into which securing means 16 have been inserted which are accommodated in the securing holes

13 (see Figs. 1 and 4) of the concrete elements 1. The strips 11 furthermore have adjustment openings 17, which are aligned with respect to the adjustment holes 14 in the concrete elements 1.

[0060] As can be seen with reference to Fig. 4, the adjusting elements, which are accommodated in the adjustment holes 14 of the concrete elements 1, comprise a nut 18 which is fixedly connected to the concrete elements 1, as well as a bolt 19 which can be rotated therein. The head 28 of the bolt 19 can be accessed via the adjustment hole 14 and the adjustment opening 17, in such a manner that the concrete elements 1 can be brought to the desired height with respect to the steel cover plate 7 at each of their transverse ends. The cross section of Fig. 4 also shows that the concrete elements 1 are sealed with respect to one another by means of a compressed rubber strip 20, and are attached to the strips 11 by means of bolts 16 which are screwed into nuts 27 which are embedded in the top surface of the concrete elements 1.

[0061] In the perspective view of Fig. 5, a steel bridge is shown in its entirety, with the usual arches 29, tension rods 22 from which the bridge deck construction is suspended, as well as the transverse connections 23 between the arches 29. On the steel bridge deck (not visible in this case), the elements 1 are visible, accommodated between the edges 8.

[0062] The bottom view of Fig. 6 shows the underside of the steel cover plate 7, with the usual longitudinal stiffeners 24 and cross members 25. The cross members 25 are attached to the edge beams 28, to which the tension rods 22 of the arches 21 are connected. The cross sections of Figures 4 and 7 also show that there is a filling 21 of polyurethane between the elements 1 and the steel cover plate 7, which filling 21 is introduced via the holes 12. The polyurethane is introduced after the subseries 10 have been placed in the correct position with respect to the cover plate 7 by means of the bolts 19. The openings 14, which contain the bolts 19, are then filled with a plug 26, in order to completely seal the road surface.

[0063] Fig. 8 shows a mould 101 with which a tile can be produced in the form of a shaped body. In this case, the mould 101 is provided with a layer of coating material, in this case a layer of a thermoplastic film material 102, which is introduced into the mould. Furthermore, Fig. 8 shows a container 103 filled with particles of granular material 104, in this case road metal material, which is heated, here diagrammatically indicated by means of the heating 105.

[0064] Fig. 9 shows a subsequent step of the method of Fig. 8. In this case, the mould 101 with the coating layer 102 is already provided with the granular material 104 which has been introduced. Due to the fact that the latter has a temperature which is sufficiently high to partially incorporate the material in the coating layer, the particles of granular material will partially penetrate into this layer. The amount of granular material is sufficient for a single layer with a small distance between the particles of granular material to be formed. When used as a

road surface, water is quickly drained away as a result thereof.

[0065] Subsequently, a further container 106 is supplied, in this example filled with fluid concrete material 107. This fluid concrete material is poured into the mould and results in the mould being filled. In Figs. 9-12, the coating layer 102 is shown as being thicker with respect to the road metal 104 than will be the case in most applications. In most applications, the coating layer will have a thickness which is such that the particles extend through almost the entire layer so that they rest against the wall of the mould, but are held in position by the coating layer. The particles will in this case protrude from the layer to a great extent so that they will be incorporated in the concrete mass to a large degree.

[0066] Thereafter, as is shown in Fig. 10, a pressure element is arranged on the concrete mass 107, by means of which pressure is exerted on the concrete so that the concrete spreads itself well between the particles of granular material and there are as few gaps as possible between the granular material and the mould is filled as efficiently as possible. If desired, the mould can also be made to vibrate.

[0067] Fig. 11 shows a shaped body which has been released from a mould, as illustrated in Fig. 10. In this embodiment, the coating layer has remained stuck to the shaped body and thus been removed from the mould as well.

[0068] Fig. 11 a shows a cross section through the shaped body provided with the plastic layer 102. In this case, it can clearly be seen that the particles of granular material, such as road metal 104, are partly incorporated in the coating material and thus have also acquired an orientation, with flat parts being slightly aligned with respect to one another, originally against the mould wall. It can also be seen that the plastic material has partly ended up between the granular material, but in such a manner that the granular material is only partly surrounded by this coating layer. Furthermore, it can be seen that the concrete 107 has flowed between the granular material and surrounds the remainder of it, in such a manner that the granular material is either surrounded by concrete or partly surrounded by the coating material and for the remainder by the concrete material.

[0069] Fig. 12 shows the manufacturing step of an example of the method, in which the coating material 104 is peeled from the shaped body. Fig. 12a shows a detailed cross section of the final shaped body. In this case, it can clearly be seen that the particles of granular material 104 partly protrude from the concrete layer 107 and for the remainder are incorporated in and retained by the concrete material. It can also be seen that a reasonably uniform surface is formed by the road metal material which partly protrudes from the concrete material 107 and is partly retained therein.

[0070] Using the method according to the invention, it is readily possible to produce slabs with a surface which is highly suitable as a driving surface for roads. Such

slabs are excellent for use as reinforcement or as driving surface on bridges, in particular bridges with a steel structure. Such bridges and slabs are described with reference to Figs. 1-7 above.

Claims

1. Method for improving a bridge provided with a bridge deck construction which comprises a steel cover plate (7) as well as stiffeners (24) attached to the underside of the steel cover plate (7), comprising the step of:

- covering the upper side of the steel cover plate (7) with a prefabricated concrete deck (1).

2. Method according to claim 1, comprising the step of:

- adjusting the concrete deck (1) in the vertical direction with respect to the steel bridge deck (7).

3. Method according to claim 1 or 2, comprising the step of:

- filling an open space between the upper side of the steel bridge deck (7) and the underside of the concrete deck (1) with a filling agent (21), such as polyurethane.

4. Method according to one of the preceding claims, comprising the steps of:

- providing a number of prefabricated concrete elements (1),
- placing a series of concrete elements (1) one behind the other on the steel cover plate (7),

in one embodiment furthermore comprising the step of:

- sealing neighbouring concrete elements (1) with respect to one another,

in a further embodiment furthermore comprising the steps of:

- connecting a number of concrete elements (1) to one another to form a subseries (10),
- placing a number of subseries (10) one behind the other on the steel cover plate (7),

in a further embodiment furthermore comprising the step of:

- connecting a number of concrete elements (1) to one another to form a subseries (10) by means

of at least one strip (11) which extends over the upper side of the concrete elements (1).

5. Method according to claim 3 and 4, comprising the step of:

- removing each strip (11) after the subseries (10) has been placed and the filling agent (21) has cured or set.

6. Method according to claim 4 or 5, comprising the step of connecting the subseries (10) to one another.

7. Method according to one of claims 4-6, comprising the use of concrete elements (1), whose dimension transverse to the longitudinal direction of the bridge is greater than the dimension in the longitudinal direction of the bridge.

8. Bridge provided with a bridge deck construction which comprises a steel cover plate (7) as well as longitudinal stiffeners (24) provided on the underside of the steel cover plate (7), **characterized in that** a prefabricated concrete deck (1) is arranged on the upper side of the steel cover plate (7).

9. Bridge according to claim 8, in which the concrete deck (1) comprises a series of prefabricated concrete elements (1) connected to one another, in which, in one embodiment at least part of the concrete elements (1) are connected to one another by means of at least one strip (11) extending in the longitudinal direction of the bridge deck.

10. Bridge according to claim 8 or 9, in which the concrete elements (1) are sealed with respect to one another and are connected to the bridge deck in a watertight fashion.

11. Bridge according to one of claims 9-10, in which the dimension of the concrete elements (1), viewed in the longitudinal direction of the bridge, is smaller than the dimension in the transverse direction of the bridge.

12. Bridge according to one of claims 9-11, in which each concrete element (1) is provided with an adjusting means (19) for adjusting the height of the concrete element (1) with respect to the steel cover plate (7).

13. Bridge according to one of claims 9-12, in which each concrete element (1) is in each case provided at its ends, viewed in the transverse direction of the bridge, with an adjusting means (19) for adjusting the height of the concrete element (1) with respect to the steel cover plate (7).

14. Bridge according to claim 12 or 13 to the extent that it is dependent on claim 9, in which the adjusting means (19) each comprise a nut (18) provided in an adjustment hole (14), as well as a bolt (19) which is screwed into the nut and the bottom end of which rests on the steel cover plate (7). 5
15. Bridge according to one of claims 9-14, in which the space between each concrete element (1) and the steel cover plate (7) is filled with a filling agent (21), such as polyurethane. 10
16. Bridge according to one of claims 8-15, in which the surface (4) of the concrete deck (1) is roughened. 15
17. Bridge according to one of claims 8- 16, in which steel cross members (25) are provided on the underside of the steel cover plate (7). 20
18. Bridge according to one of claims 8-17, comprising a bridge deck construction with edge beams (28), in which steel arches (21) are provided from which the edge beams (28) are suspended, and in which steel cover plate (7) extends between the edge beams (28). 25
19. Concrete element (1) for a bridge according to one of claims 9-18.
20. Concrete element according to claim 19, in which at least three adjustment holes (14) are provided, in which adjustment holes (14) at least one part (28) of an adjustment means (18, 19) is provided. 30
21. Subseries (10) for use with the method according to one of claims 4-7, comprising at least two concrete elements (1), as well as a securing means (11) by means of which the concrete elements are connected to one another. 35
22. Subseries (10) according to claim 21, in which the securing means comprises at least one strip (11) which extends over the upper side of the concrete elements (1). 40

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Fig 1

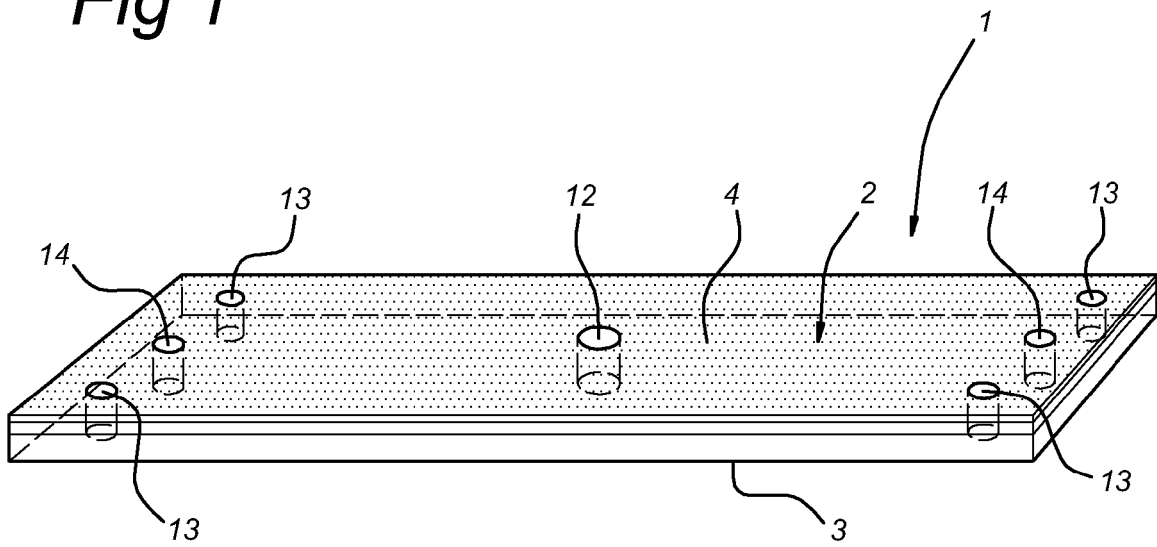


Fig 2

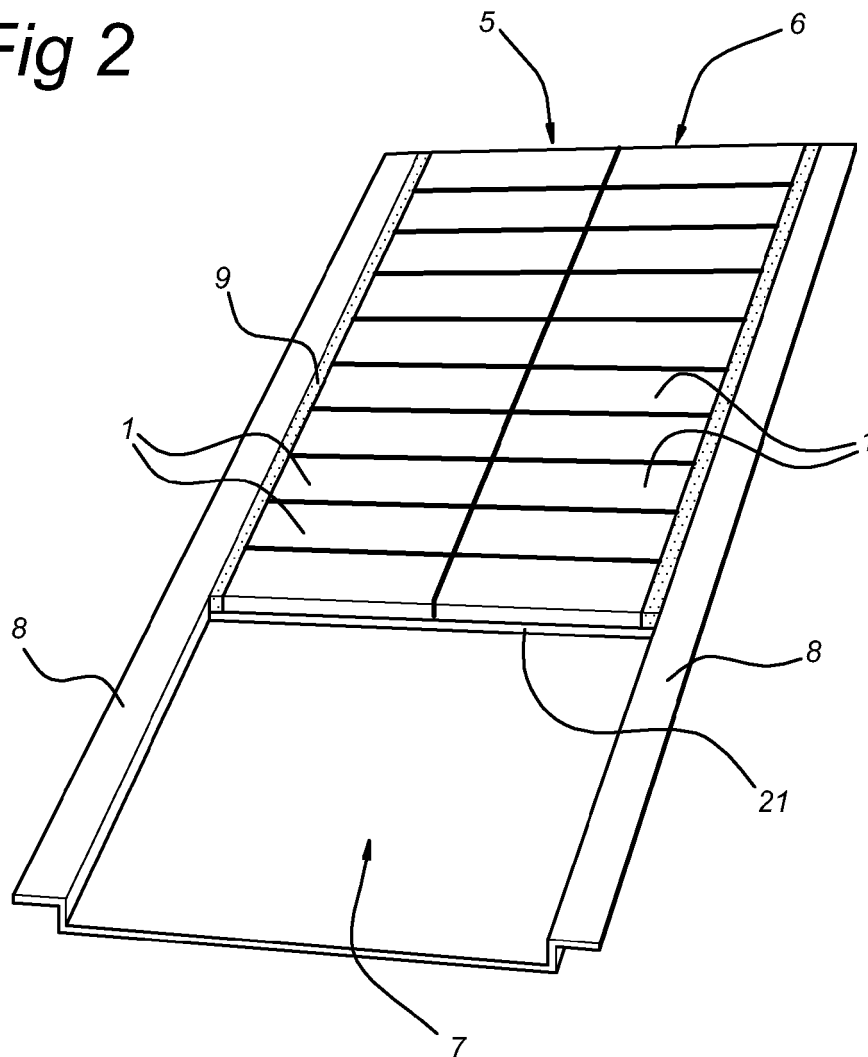


Fig 3

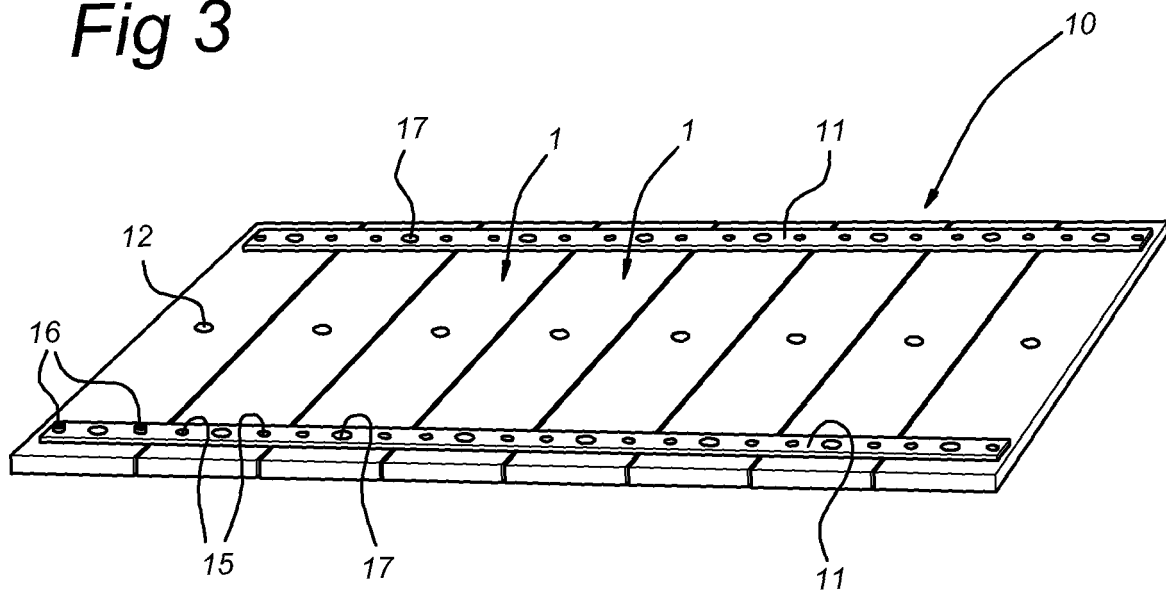


Fig 4

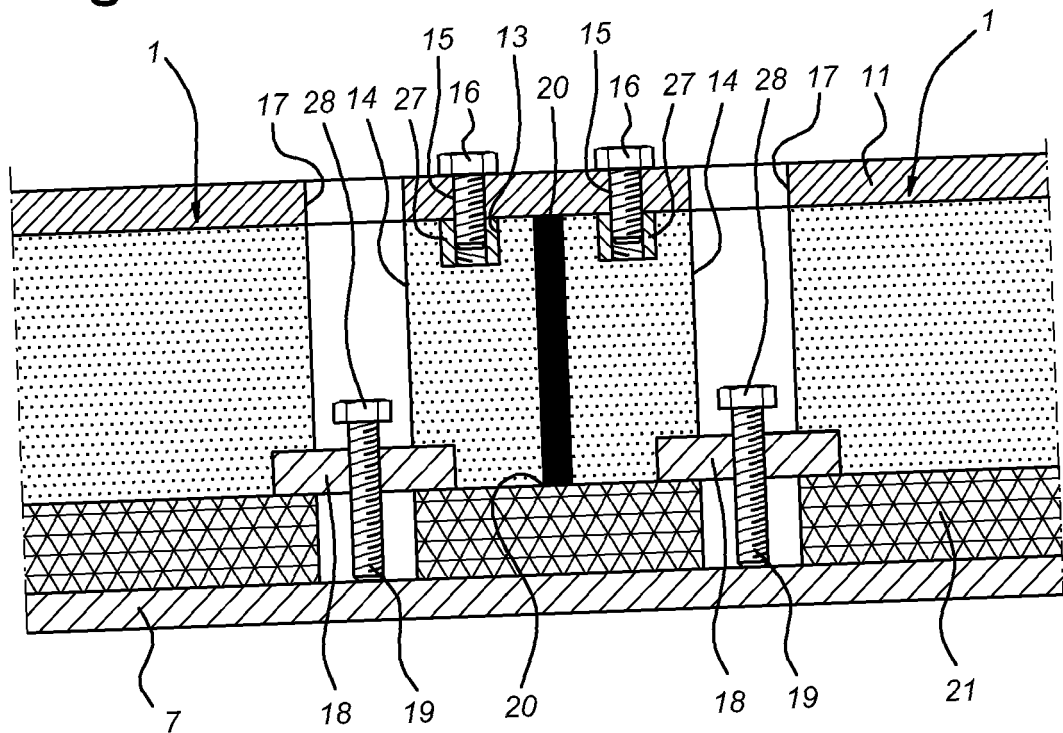


Fig 5

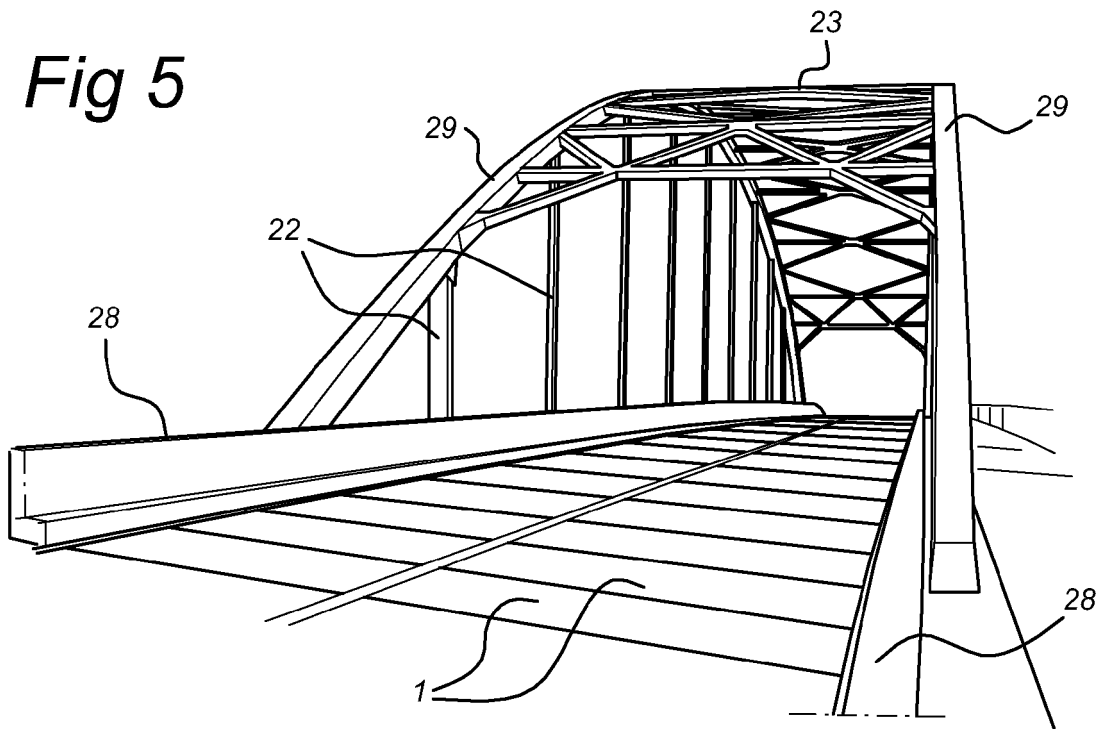


Fig 6

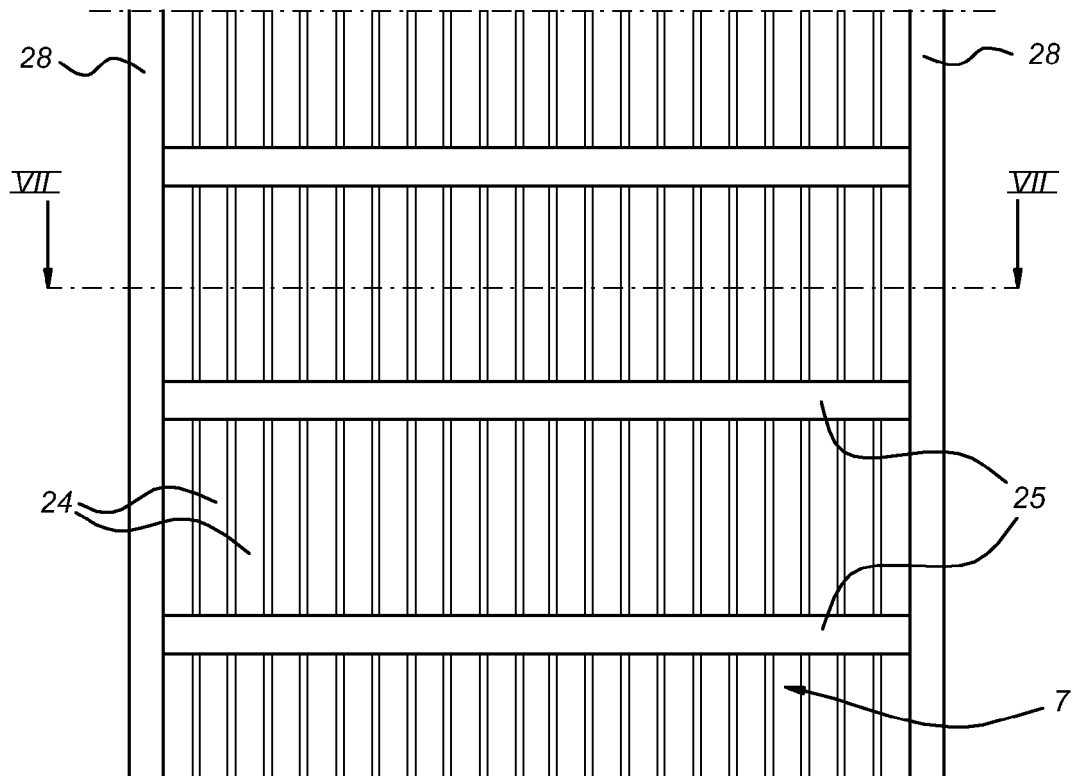


Fig 7

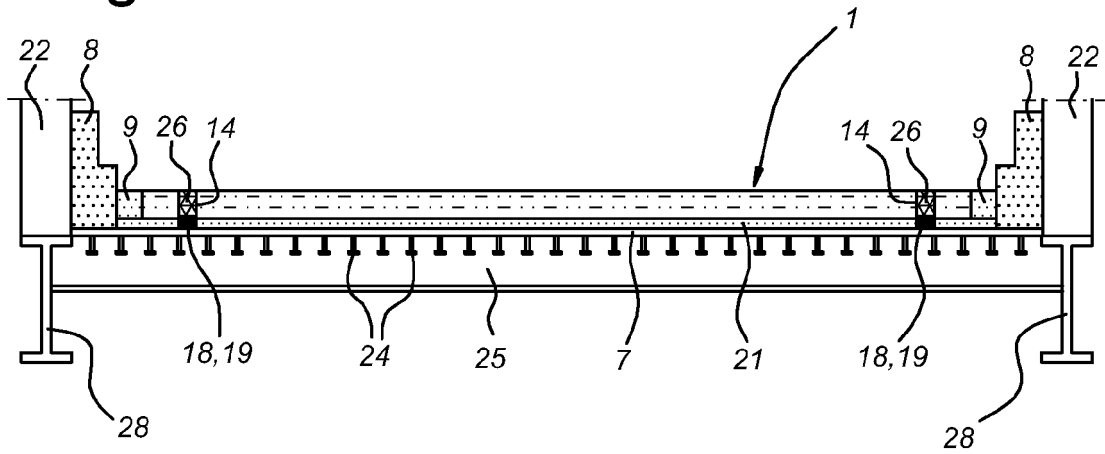


Fig 8

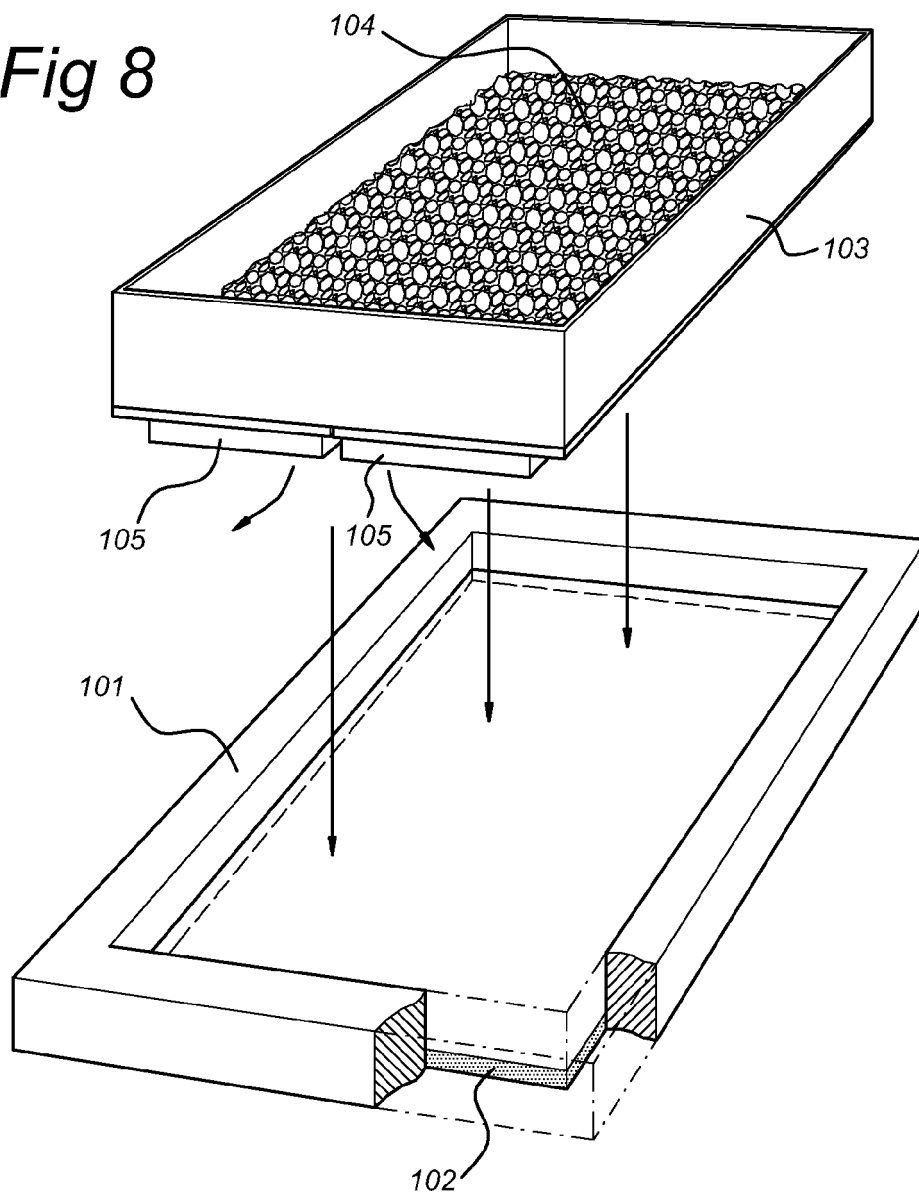


Fig 9

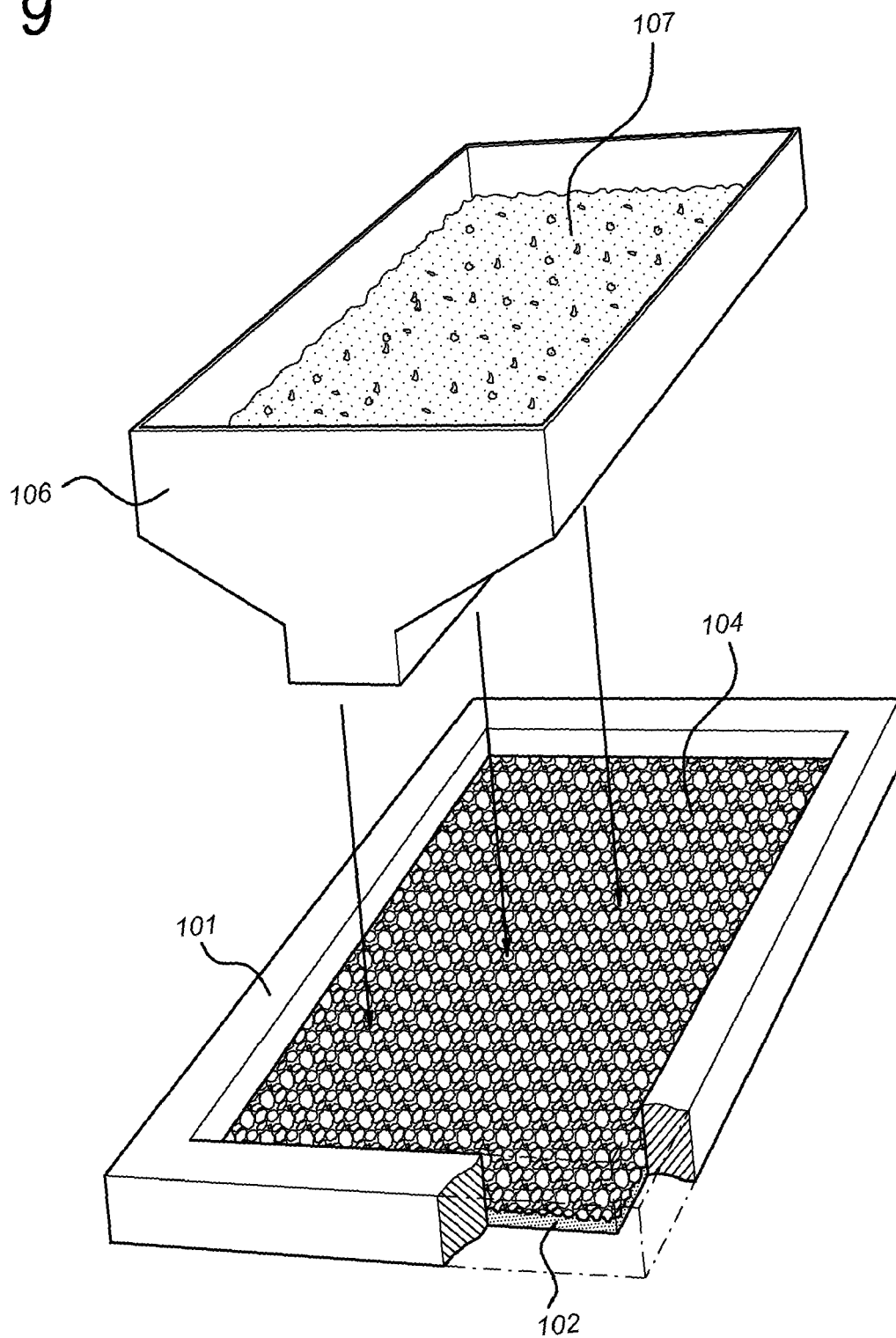


Fig 10

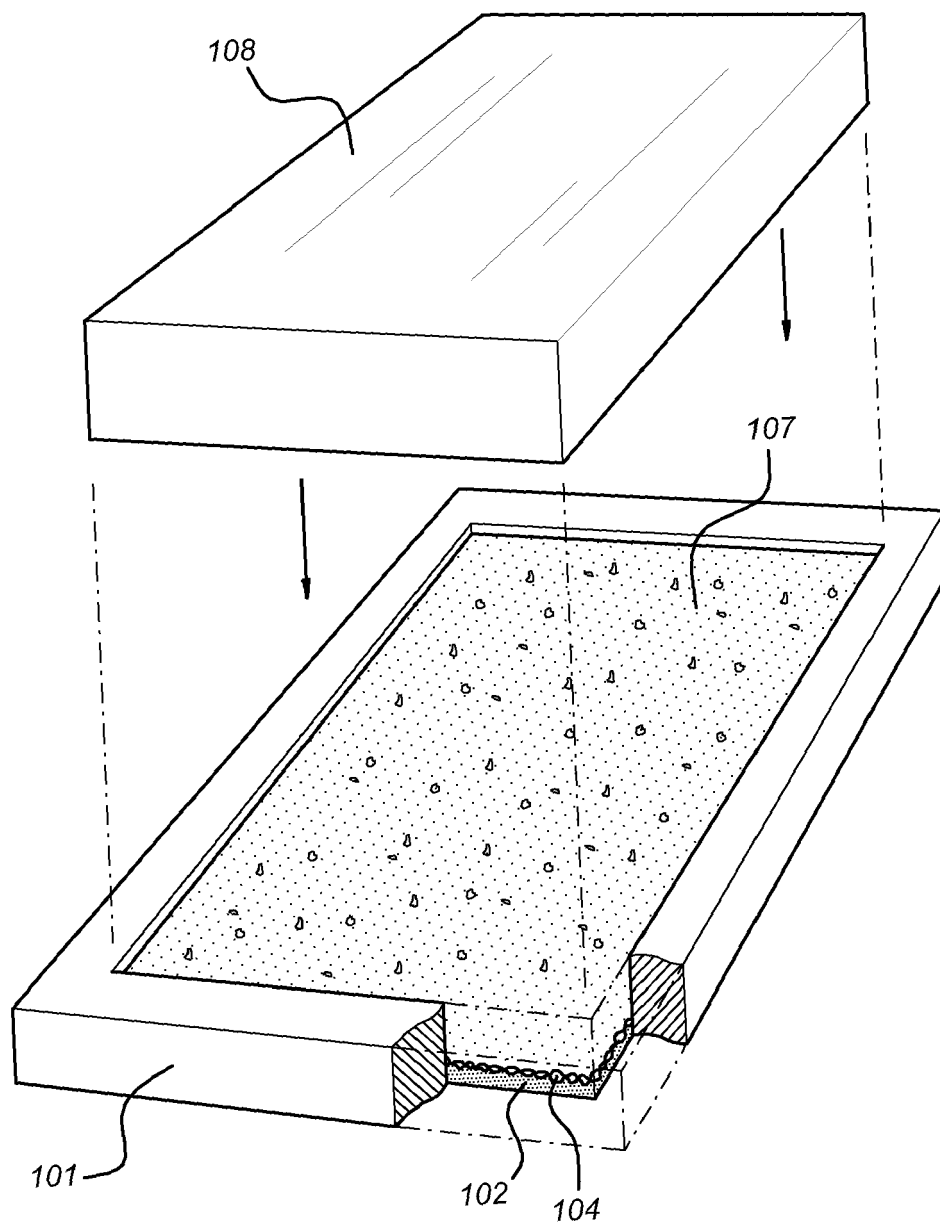


Fig 11

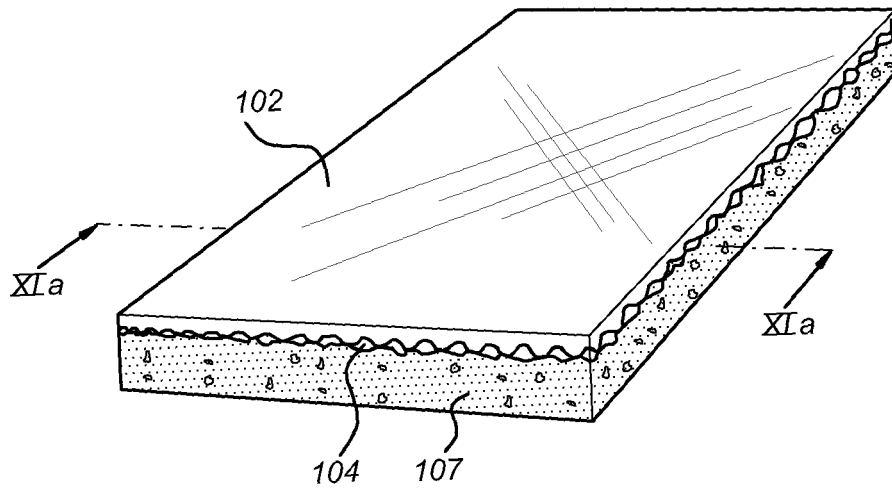


Fig 11a

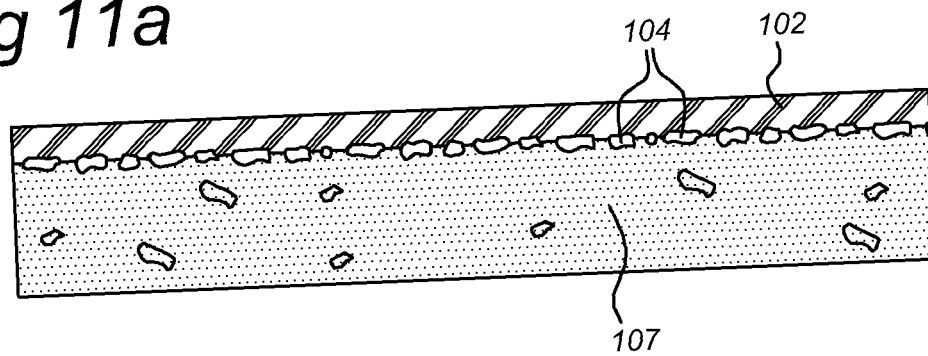


Fig 12

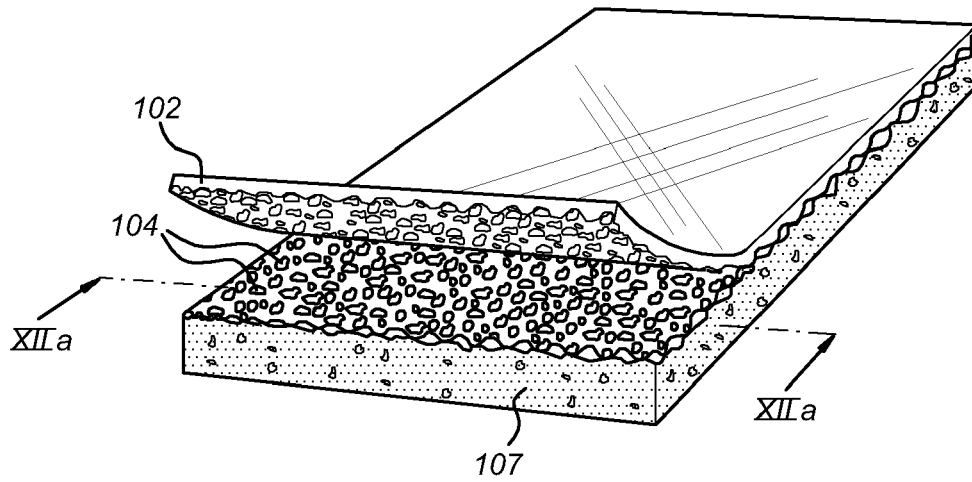
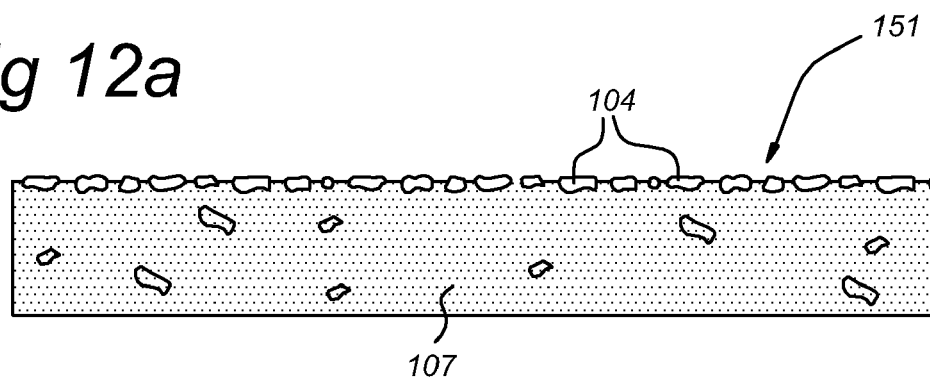


Fig 12a



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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