(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 235 954 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.10.2017 Bulletin 2017/43

(21) Application number: **17167155.5**

(22) Date of filing: **19.04.2017**

(51) Int Cl.:
E02B 3/12 *(2006.01)* ***B28B 7/00*** *(2006.01)*
B28B 7/42 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **20.04.2016 NL 2016642**

(71) Applicant: **H.H. Martens & Zoon B.V.**
4905 AD Oosterhout (NL)

(72) Inventor: **Martens, Johannes Cornelis Octavianus**
4901 AP Oosterhout (NL)

(74) Representative: **Hylarides, Paul Jacques et al**
Arnold & Siedsma
Bezuidenhoutseweg 57
2594 AC Den Haag (NL)

(54) METHOD AND SYSTEM FOR MANUFACTURING CONCRETE REVETMENT ELEMENTS

(57) The description relates to a method for manufacturing concrete revetment elements, comprising of:
- arranging concrete material in the mould cavity of a mould;
- heating at least a part of the mould at one or more locations so that at least some of the concrete material adjacent to the inner side of the mould is removed;
- removing the mould from the revetment element.

The description also relates to a device for manufacturing a concrete revetment element, comprising:
- a mould (7) with one or more displaceable mould parts (13, 14);
- heating elements (30, 31) configured to heat the wall of the mould (7) for at least partially evaporating concrete material adjacent to the inner side of the mould;
- a displacing unit for displacing the mould part (13, 14) between a closed and opened position.

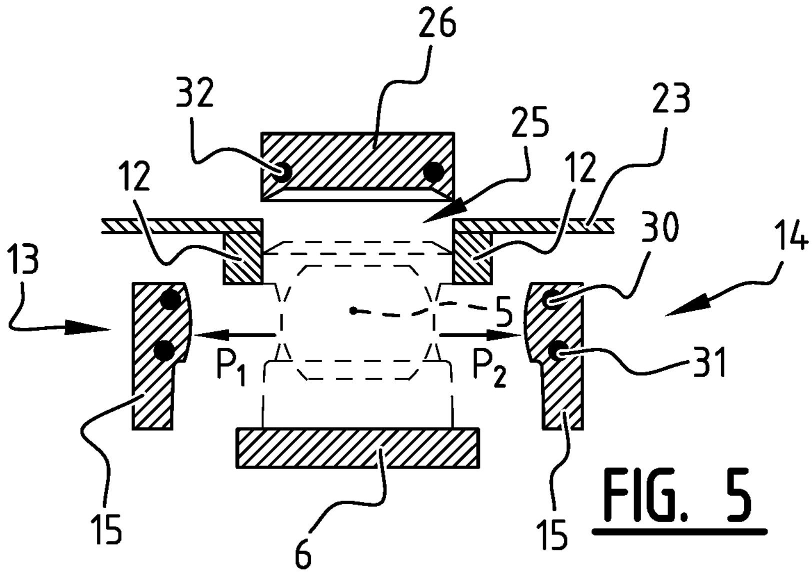

FIG. 5

EP 3 235 954 A1

Description

[0001] The invention relates to a method and a system for manufacturing concrete revetment elements, and to a thus manufactured revetment element.

[0002] For the purpose of revetting slopes of embankments, such as dikes, seawalls and the like, use can be made of concrete paving stones, also referred to as concrete revetment elements. These revetment elements are placed on the ground surface (for instance directly on the slope or on a separate substrate) in a determined pattern and protect the slopes against external influences, for instance against the impact (for instance under the influence of the wave action) of water of a water mass (sea, lake, waterway) present adjacently of the embankment or excavation.

[0003] Different types of paving stone are applied in practice, such as block-like paving stones and column-like paving stones. The different types of paving stone are used to realize different types of revetment, more particularly a closed revetment (also referred to as closed slope) and an open revetment (also referred to as an open slope).

[0004] It is known to make use of a large number of concrete paving stones, which are placed in a pattern of rows such that the sloping side of the embankment or excavation is revetted over at least a part of its surface. The pattern in which the paving stones are placed in combination with the type of paving stone can result in the above stated different types of revetment. The above stated block-like paving stones are used for the purpose of realizing a closed slope, i.e. an inclining surface where the water flows substantially only against the upper side (i.e. side facing toward the water). These paving stones have a cross-section such that they can be placed against each other substantially without intermediate space. In the case of a revetted water defence this means that the water tends not to flow along the sides of the block-like paving stones, or does so only to a very small extent.

[0005] Use can be made of above stated column-like paving stones or column-like revetment elements for the purpose of providing an open slope. These column-like revetment elements are formed such that an intermediate space forms between the revetment elements placed adjacently of each other. Water can flow via this intermediate space, which can result in lower overpressure under the revetment elements as a result of water movements. For the purpose of realizing an open slope use can also be made of a type of revetment element formed with a relatively wide head part, a relatively narrow neck part and then again a relatively wide base part. When the revetment elements are placed adjacently of each other, the neck parts form an intermediate space which forms as it were a laterally extending channel along which water can flow. The head parts have here a cross-sectional surface area such that openings are present between the revetment elements. These openings form a connection to the above stated channel so that water can flow from the water mass, via the openings and into the channel (or the channels), and this water can conversely also flow out of the channel again. Water can further flow in between the base parts.

[0006] The above stated flowing of water subdues the effects of the water on the revetment, which has a positive effect on the defensive capacities of the revetment. An example of such revetment elements is described in the Netherlands patent NL 2004345 C, the content of which should be deemed incorporated herein. It is essential for these known revetment elements that they are embodied as two half elements parts which are placed with their flat sides against each other during use so as to together form an assembled revetment element. Such concrete revetment elements however have the drawback that they are difficult to produce due to their specific form and dimensions.

[0007] Manufacturing the known revetment element with the specific form and dimensions described herein takes place by manufacturing two half part-elements and then placing them against each other so that together, in the situation in which they are placed against each other, they form a single revetment element. The specific method of manufacture of the known revetment elements is shown in figure 5 of said Netherlands patent publication NL 2004345 C, in which two identical part-elements are manufactured in lying position by arranging concrete in a horizontal mould and allowing the concrete to cure therein. After (partial) curing, the part-elements are tilted to an upright position and they can be placed against each other so as to form said single revetment element.

[0008] A drawback of the known revetment element is that, once they have been placed on the bank, the two part-elements sometimes have a tendency to shift or tilt relative to each other. This sometimes does not enhance the appearance of the bank revetted with these revetment elements. The known revetment element has further been found to be susceptible to cracks in the neck as a result of operations performed on the elements during transport. It is possible to envisage here the picking up and placing of the elements in the factory, the placing of the elements in a transport means (truck, ship), the transporting itself and the picking up and placing thereof on the bank. If the two part-elements are for instance gripped with a gripper, a crack can result in the neck of the block as a result of the stresses occurring in the block.

[0009] A further drawback of the revetment element is that the form of the revetment element which can be chosen has determined limitations as a result of the applied method of manufacture, i.e. pouring concrete into a lying mould for the purpose of forming two identical half parts and then placing the two half parts upright and against each other. The form of the known revetment element thus may not be wholly rotation-symmetrical relative to an imaginary vertical rotation axis (i.e. a rotation axis through the centre of the base, neck and head) in practice. This means that the position in which the revetment elements are placed on the bank can be of importance, and that this must be taken into consideration when placing the revetment elements.

[0010] A way of obviating the above stated drawbacks would be to place the part-elements against each other after manufacture thereof and attach them to each other, for instance by glueing them to each other. This however involves an additional manufacturing step, which entails higher manufacturing cost and/or a longer manufacturing time. The revetment elements are moreover subjected to severe and variable conditions (wave action, temperature fluctuations and the like) for many years, and it is therefore difficult to attach the part-elements to each other sufficiently durably. The risk is that the part-elements will nevertheless begin to shift relative to each other in the course of time.

[0011] The revetment elements could also be manufactured in one piece (of concrete). Because such a revetment element consists of one piece and is therefore a monolithic revetment element, the chance of cracking of the neck during transport is generally considerably reduced. Cracks will almost no longer occur in practice. Such a revetment element in one piece is further structurally stronger than a revetment element consisting of two parts. The appearance of a number of revetment elements manufactured in one piece is often also much more uniform and thereby more attractive than when the revetment elements are constructed from two part-elements. Finally, the wave-absorbing and wave-breaking action of such an integrally formed revetment element often remains better preserved, also after prolonged use and/or in the case of settlement in the ground.

[0012] Manufacturing a monolithic revetment element of the form described herein (i.e. with complex external features characteristic for such revetment elements, such as a base and head which are relatively wide in cross-section compared to a relatively narrow neck lying therebetween) is not possible with the above described method of manufacture of NL 2004345 C, since this always requires a multi-part manufacture. The known method of manufacture further limits the form which can be realized, since not all forms can be manufactured with this method of manufacture.

[0013] The revetment elements should for instance be able to take an at least partially rotation-symmetrical form. It is hereby not possible in practice to manufacture the revetment elements in the usual manner in a lying mould. In some situations it is advantageous to manufacture the revetment elements in upright position by placing two (or more) mould parts against each other for the purpose of forming an (almost) wholly enclosed mould cavity and by filling the mould cavity with concrete from the top. Such an upright method of manufacture however entails a number of problems in practice, which have nevertheless resulted in the idea that the upright manufacture of revetment elements was not possible, or in any case could not be readily applied in practice. Such problems entailed, among other things, the concrete which was poured into the mould sticking locally to one or more mould parts, so that the revetment element does not obtain the desired form. When the mould parts are shifted away, some of the concrete material will sometimes for instance remain behind on a mould part, particularly at the position of the peripheral edges of the base and/or the head, because the material sticks.

[0014] It is further difficult to fill the mould cavity properly. The mould cavity is sometimes not completely filled, particularly at the position of said edges of the base and/or the head, so that the resulting raw casting acquires an unsuitable form. This is all the more the case when the concrete material for manufacturing the revetment element in the upright mould is relatively dry, for instance concrete material from the consistency class "dry" (i.e. C_0) or from the consistency class "earth-moist" (i.e. C_1) (also referred to as compacted concrete). The use of concrete material from one of these consistency classes is advantageous, for instance because the drying time (curing time) can be much shorter and the manufacturing speed can therefore be higher than when concrete from a higher consistency class is used, although it does mean that a proper filling of the mould cavity is difficult. This has resulted in application of earth-moist or dry concrete material in a manufacturing process, in which revetment elements of the specific form stated herein are manufactured in upright position, heretofore always being considered impossible or at least not readily applicable in practice.

[0015] The document JP S55 159110 U appears to describe a method and apparatus whereby elements can be manufactured. These elements have a specific form with a head part and a base part which are relatively wide relative to a neck part situated between the head part and base part. The document does not describe the starting material for these elements being formed by dry or earth-moist concrete material. The minimum time required by the concrete material to cure in the mould cavity before the mould can be removed (also referred to here as the minimum demoulding time) without causing damage is further relatively long. A long demoulding time also means a long takt time (i.e. the rhythm in which the elements can be manufactured). The time interval between successive filling, moulding and demoulding operations of the device with which the elements are manufactured is thus relatively great, which has a negative effect on the production capacity of the device.

[0016] It is an object to provide a method and device for manufacturing revetment elements with relatively wide head and base parts relative to a neck part, wherein a short demoulding time can be realized.

[0017] It is also an object to provide a device and a method for manufacturing revetment elements whereby high-quality revetment elements can be realized at relatively low manufacturing cost.

[0018] It is another object of the invention to provide a method whereby concrete revetment elements of the type stated herein can be manufactured in upright position.

[0019] It is a further object to provide a method for manufacturing a monolithic revetment element wherein use can be made of dry or earth-moist concrete material.

[0020] According to a first aspect, at least one of said objects is at least partially achieved in a method for manufacturing a concrete revetment element, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and the head part to each other and wherein the head and base parts are relatively wide and the neck part therebetween is relatively narrow, the method comprising of:

- arranging concrete material in the mould cavity of a mould, wherein the concrete material is dry concrete or earth-moist concrete material;
- heating at least a part of the mould at one or more locations;
- removing the mould from the revetment element;

wherein heating at least a part of the mould at one or more locations comprises of increasing the temperature of the concrete material in a boundary layer adjacent to said part of the mould to a temperature of between 60 and 95 degrees Celsius for a heating period of 10-120 seconds for the purpose of removing at least some of the moisture in the concrete material adjacent to the inner side of the mould through evaporation.

[0021] By evaporating the moisture in the boundary layer in a relatively short period of time, it has unexpectedly been found that the risk of the concrete element sticking to the mould during removal of the mould (which can result in damage to the concrete element) is reduced. This makes it possible to still keep the demoulding time limited, despite the requirements made of the quality of the element. This means that the concrete elements can be demoulded relatively quickly and can be displaced to an area where further curing can take place undisturbed. This enhances the production capacity of the method.

[0022] The method preferably comprises of removing the revetment element from the mould immediately after the heating period (for instance within 1 minute or even within 1 or several seconds) and then allowing it to cure.

[0023] The revetment element is formed directly into the desired final form and can be manufactured in one piece. The revetment element is here also referred to as monolithic since the revetment element forms one whole. No individual parts of the revetment element need be placed against each other, there is no risk of such individual parts shifting relative to each other, and the chance of problems during transport, for instance cracking as a result of the revetment element being gripped with a gripper, is minimal. The local heating of the mould further provides for a corresponding local heating of the boundary layer of concrete material. This boundary layer comprises a relatively large amount of moisture. The inventors have found that it is precisely this moisture which can sometimes cause a mould part to stick to the concrete material, for instance when the mould is opened and the mould part is displaced. Heating the boundary layer and making the moisture partially disappear through evaporation or in other manner (for instance by drying the concrete material in the boundary layer) reduces the chance of sticking.

[0024] In determined embodiments, particularly when dry or earth-moist concrete is used, the revetment element is released by opening the mould immediately after the concrete material has been heated to sufficient extent. In other embodiments, for instance in embodiments in which more moist concrete is used, the method comprises of first allowing the concrete material to (continue to) cure at least partially before the mould is removed from the revetment element.

[0025] The mould cavity in the mould is otherwise wholly or partially closed. In the case of an only partially closed mould cavity, the cavity is only open on the upper side. The bottom of the mould can be formed by a flat support element such as a support plank, but in other embodiments can also be formed by a (steel) mould part. The open upper side forms an inlet opening along which the concrete material can be arranged in the mould cavity.

[0026] The sticking of concrete material to the mould occurs in many cases at the position of the relatively sharp peripheral edges of the revetment element. In a preferred embodiment the mould is therefore heated only or particularly at the position of one or more edges of the mould cavity. This ensures that the amount of moisture decreases as quickly as possible at a relatively critical location, and the manufacturing time can remain limited.

[0027] Because of the specific form of the revetment elements with wide base and head and narrow neck it can be preferred to also heat the concrete material exactly at the transition between the head part and neck part and/or at the transition between the neck part and base part.

[0028] The method comprises of locally heating at least a part of the mould for the purpose of increasing the temperature of the concrete material in a boundary layer adjacent to said part of the mould to a temperature of between 60 and 95 degrees Celsius, preferably about 75 degrees Celsius. It has been found that the chance of sticking decreases rapidly at these temperatures. Heating for between 10 seconds and 2 minutes, for instance for about 20 seconds, often suffices to make the chance of sticking sufficiently small.

[0029] As stated above, the mould cavity is embodied to form a monolithic revetment element with relatively wide head and base parts, and a relatively narrow neck part therebetween. In characteristic revetment elements the smallest diameter of the head part and/or the smallest diameter of the base part is here at least 1.5 times, preferably at least 1.7 times or at least 2.5 times greater than the greatest diameter of the neck part.

[0030] In a determined embodiment the method comprises of:

- only partially filling the mould cavity with a first quan-

tity of concrete material;
- vibrating the first quantity of concrete material;
- further filling the mould cavity with a second quantity of concrete material.

[0031] The above stated steps (i.e. filling the mould cavity and causing the concrete material to vibrate) can be repeated one or more times. After the vibrating, or without vibrating having occurred, a press can be pressed into the mould cavity from the upper side in order to compress the concrete material arranged therein.

[0032] According to a further aspect, a method is provided for manufacturing a concrete revetment element in one piece, wherein the method comprises of:

- providing a concrete arranging unit above a mould which rests on a flat support element and is provided with one or more inlet openings and a mould cavity, wherein the mould comprises one or more mould parts displaceable between a closed position and an opened position;
- having the concrete arranging unit arrange concrete material for forming the revetment element in the mould cavity via the one or more continuous inlet openings when the mould parts are in the closed position;
- having the heating elements remove at least some of the moisture in a boundary layer formed on the inner side of the mould;
- releasing the revetment element by displacing the one or more mould parts of the mould from the closed position to the opened position.

[0033] Displacing of the mould parts can entail shifting of the mould parts in substantially horizontal direction for the purpose of demoulding (shelling) at the position of the narrowed portion formed by the neck part. When the concrete material has cured sufficiently, this in the case relatively moist concrete material is used, or with hardly any curing, this in the case earth-moist or dry concrete material is used, one or more of the mould parts can be shifted away, whereby the revetment element is demoulded.

[0034] In a more specific embodiment, in which the mould comprises a flat support element, a stationary mould part and two mould parts displaceable relative to the stationary mould part and the flat support element between a closed and opened position, the method can comprise of displacing the displaceable mould parts away from each other to the opened position after the concrete material has been arranged. One or more stationary mould parts here hold the revetment element stationary on the flat support element. The revetment element is then ready to be transported further. The stationary part can have the function, among others, of providing support at the location where a press can press the concrete material. The stationary part generally takes a structurally relatively strong form. The movable mould parts are necessary during shelling in respect of the narrowed portion.

[0035] Stationary mould part is otherwise understood to mean a mould part which remains stationary during displacement of a displaceable mould part. This however does not mean that the stationary mould part need therefore be stationary at all times. In determined embodiments the stationary mould part is displaced together with the displaceable mould parts in order to shell the concrete material. In a determined embodiment the displaceable mould parts are for instance first shifted away sideways and the whole of displaceable mould parts and stationary mould part is displaced upward, so that the shelled concrete material remains behind on the flat support element.

[0036] In the above method the mould cavity is in principle open on the underside, but is held closed by the support element. The flat support element, for instance a plank, in fact forms a temporary mould part here.

[0037] When two or more moulds with a shared flat support element are applied and when the displaceable mould parts are embodied to be displaceable by a shared displacing unit, the method can for efficient manufacture of large numbers of revetment elements comprise of:

- having the shared displacing unit displace the displaceable mould parts of each of the moulds collectively away from each other to the opened position after concrete material has been arranged in the moulds and allowed to cure, wherein a stationary mould part simultaneously holds the respective revetment element stably in place on the flat support element.

[0038] According to a further aspect, a device is provided for manufacturing a concrete revetment element with dry concrete or earth-moist concrete material, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and head part to each other, and wherein the head and base parts are relatively wide and the neck part therebetween is relatively narrow, the device comprising:

- a frame;
- a mould arranged on the frame and provided with a mould cavity and with an inlet opening for infeed of concrete material into the mould cavity, wherein the wall of the mould comprises one or more mould parts displaceable relative to the frame;
- one or more heating elements configured to heat at least a part of the wall of the mould for at least partially removing at least some of the moisture in the concrete material adjacent to the inner side of the mould;
- displacing unit for displacing the one or more displaceable mould parts, wherein the displacing unit is configured to displace the mould part between a closed position in which the mould part connects to the rest of the mould and an opened position in which

the mould is opened,

wherein the heating elements are configured to increase the temperature of the concrete material in a boundary layer adjacent to said part of the mould to a temperature of between 60 and 95 degrees Celsius for a heating period of 10-120 seconds at one or more locations, so that at least some of the moisture in the concrete material adjacent to the inner side of the mould is removed through evaporation.

[0039] The heating element is configured (for instance in respect of heating capacity, placing in or on the mould and so on) to evaporate at least a part of the boundary layer of liquid components (moisture) formed against the inner side of the mould.

[0040] In the closed position the mould (optionally in combination with a flat support element) forms a substantially closed mould cavity (with the exception of the inlet opening along which the concrete material is supplied). In the opened position the revetment element can be removed easily and/or the mould can be lifted upward. The displacement between the opened and closed position takes place by utilizing a displacing unit. This can for instance comprise several guides along which the mould parts can be shifted away, as well as one or more actuators, such as hydraulic cylinders, electric motors and the like. The displacing unit contributes to the rapid and efficient production of the revetment elements.

[0041] The heating element is preferably configured to heat in particular the boundary layer of concrete material which is adjacent to the inner side of the mould wall during use, when the mould cavity is filled with concrete material. As described above, this boundary layer consists of aqueous concrete material, i.e. concrete material with a relatively large amount of moisture (particularly water). This moisture forms a boundary layer around the concrete material from which the revetment element is manufactured and in practice may result in adhesion or sticking of the concrete material to the inner side of the mould.

[0042] The one or more heating elements can be arranged in or on the wall of the mould, particularly in or on the displaceable mould parts, and can for instance comprise an electric heater coil. The heating elements can here be in direct contact with the concrete material, or only with the material of the mould itself. In the latter case the wall of the mould is preferably manufactured from heat-conducting material such as steel, so that the heat generated by the heating element can be transferred rapidly to the concrete material.

[0043] A vibrating mechanism can be provided in order to enable compaction of the concrete. This vibrating mechanism sets the mould into vibration. This causes the concrete material present in the mould cavity to be set into vibration. A (compression) press can be provided to enable the concrete to be compressed. This press can be placed in the mould cavity via the inlet opening and is configured to press down on the upper side of the concrete material arranged in the mould cavity. The above stated vibrating mechanism can further be embodied to set the press into vibration as well for the purpose of simultaneously vibrating and compressing the concrete material.

[0044] The inner surface of the mould can be milled and finished in usual manner. In a further embodiment the mould however comprises on the surface facing toward the mould cavity a special layer with non-stick components. This layer can be applied to the inner side of the mould cavity as a coating, and is both hard and smooth. This results in the chance of the concrete material sticking to the mould being reduced further. The non-stick components can comprise a fluoropolymer and/or PTFE particles. Examples of a suitable material are described in the German utility model DE202015006023 (U1), the content of which can be deemed as incorporated herein.

[0045] Because the revetment element is now manufactured in one piece, the usual joint between the part-elements of the known revetment elements which are placed against each other is no longer present. There is thus no longer any visual indication of the orientation of the revetment element, and it is thus more difficult to place the revetment elements on the ground surface in a correct orientation. In the known revetment elements it was necessary to determine the correct orientation, since the method of manufacture in question rendered a rotation-symmetrical form of the element practically impossible and the way in which the element was placed on the ground surface therefore made a difference. The new manufacture with two or more displaceable mould parts, wherein the revetment element can be manufactured upright, has enabled the mould cavity to be embodied, if desired, rotation-symmetrically relative to an imaginary rotation axis through the centre of the base part, neck part and head part. Owing to the symmetry the revetment element can thus no longer be set down in an incorrect orientation. This makes the process for placing the revetment elements on the bank much simpler and less prone to error.

[0046] In an embodiment a mould part which is displaceable relative to the frame takes a substantially U-shaped form in cross-section. This makes it possible to close the mould cavity in simple manner when the outer ends of the displaceable mould part are placed against each other. In a further embodiment the displaceable mould parts are embodied to form the base part and the neck part. One or more stationary mould parts are provided to form the head part. These stationary mould parts are fixedly attached to the frame and thus cannot be displaced relative to the frame (although the frame with the mould parts attached thereto can be displaced in upward and downward direction, as will be further elucidated below). After the revetment element has been formed the displaceable mould parts are shifted away, wherein the revetment element remains held by the one or more stationary mould parts. In a determined embodiment the displaceable moulds can be substantially formed by an upright plate provided on the inner side with a thickened portion at the position of the neck part.

[0047] According to a further aspect, a system is provided for manufacturing a concrete revetment element, the system comprising:

- two or more devices as defined herein, provided on a shared flat support element;
- a shared displacing unit which is configured to shift the displaceable mould parts of each of the moulds collectively over or above the flat support element between a closed and opened position.

[0048] Owing to the shared displacing unit the mould parts can be displaced collectively, optionally simultaneously, between the closed and opened position. The displacing unit can be embodied in numerous ways, but in an advantageous embodiment the shared displacing unit comprises one or more hydraulic cylinders, wherein each of the cylinders is configured to drive the displacement of the mould parts of different moulds.

[0049] When the mould parts have been brought into the closed position, a concrete arranging unit placed above the mould can pour a quantity of concrete material into the mould cavity. The mould cavity can be wholly filled in one operation, although it is also possible to do so in two or more steps, as elucidated above.

[0050] In a further embodiment said displacing unit is configured to displace the displaceable mould parts in transverse direction relative to the frame, for instance for the purpose of locally demoulding only the neck part. The same displacing unit (or a second displacing unit) can be provided for displacing the frame and the stationary and displaceable mould parts attached thereto in upward or downward direction, for instance for the purpose of demoulding the revetment element in its entirety.

[0051] Further advantages, features and details of the invention will be elucidated on the basis of the following description of several embodiments thereof. Reference is made in the description to the accompanying figures.

Figure 1 is a perspective view of a revetment element obtained according to the method;

Figure 2 is a longitudinal section of a revetment element of figure 1;

Figure 3 is a longitudinal section through a system for simultaneously manufacturing a number of revetment elements, with the moulds in closed position;

Figure 4 is a detail drawing of a cross-section of a mould in closed position and with heated zones shown in broken lines;

Figure 5 is a detail drawing of the mould of figure 4 in opened position;

Figures 6 and 7 are cross-sections of figure 3, wherein the middle mould cavity is empty and wherein the left-hand and right-hand mould cavity are cut at different heights (i.e. at the position of respectively the base part and the neck part).

[0052] The system and the method according to aspects of the invention are intended for manufacture of concrete revetment elements of the type as shown in figures 1 and 2. This type of revetment element 1 is characterized by a relatively wide base part 2 with which the revetment element comes to rest on a ground surface during use, a relatively wide head part 4 forming the visible side of a bank revetted with revetment elements during use, and a relatively narrow neck part 3 connecting the base part and head part and forming one or more throughflow channels during use and in combination with adjoining revetment elements. The diameter (d_1) (in cross-section) of a head part can vary, for instance first increasing from top to bottom and then decreasing again in the case of a head part with a convex side. The same is true for the diameter (d_3) of the base part. The diameter (d_2) of the neck part can also vary, for instance first decreasing from top to bottom and then increasing again for a neck part with a concave side. In determined embodiments said type of revetment element is further characterized in that the smallest diameter (d_1) of the head part and/or the smallest diameter (d_3) of the base part is at least 1.5 times, preferably at least 1.7 times or more than 2.5 times, or even more than 5 times greater than the greatest diameter (d_2) of the neck part.

[0053] The head part (and often also the base part) is further formed such that when the revetment elements are arranged on the ground surface in rows, there is sufficient throughflow space between the water mass and the channels formed by the neck parts, so that water can flow into the channels and out of the channels. In other words, the head parts of adjoining revetment elements have to be embodied such, as seen from the visible side, that there is sufficient throughflow area between the water mass and the water discharge channels. A throughflow area of at least 5% of the cross-section of the head part (and preferably a maximum of 20%) can in many cases ensure a correct degree of throughflow of water to and from the channel formed by the neck parts. This throughflow area can for instance be realized by embodying the head part in the form of a polygon in cross-section, wherein the number of corners is greater than or equal to five. An example hereof is for instance a head part with a substantially square or rectangular cross-section, wherein the corners are chamfered such that throughflow openings are realized at the position thereof. Other embodiments are however also possible, for instance embodiments in which the head part has a curved, for instance an oval form.

[0054] Because of the above described specific form of these revetment elements, i.e. with relatively wide base and head parts in relation to a relatively narrow neck part, it has been found difficult to produce them in an efficient and reproducible manner. As stated above, such revetment elements have heretofore always been manufactured by manufacturing two identical half revetment elements and placing these part-elements against each other at a later time. The half part-elements are made by arranging concrete mortar in a mould which is open on the upper side, levelling off the mortar on the upper side and then allowing it to cure. The mould has a form such that the part-elements are made in lying position. This requires a tilting step in which the half part-elements are tilted upward so that they can be placed against each other. In the proposed new method of manufacture the revetment elements are however made in one piece by arranging concrete material in an upright mould and then allowing this concrete material to cure in the mould. This has the advantage, among others, that the step of tilting and the step of placing against each other can be omitted.

[0055] Referring to figures 3- 6, in a first stage of the manufacturing process a row of flat support elements 6 is supplied on a feed conveyor (not shown). The flat support elements can for instance consist of a flat wooden board, although other types of material are of course also possible. A flat support element 6 is then placed under a system 10 for manufacturing the revetment elements. In the shown embodiment system 10 comprises a frame 23 which can be displaced upward and downward and on which are arranged three devices 11 for manufacturing revetment elements. This number can be greater or smaller in other embodiments. Each of the three devices comprises a heatable steel mould 7, 7', 7" and a displacing unit whereby one or more parts of the mould are displaceable relative to frame 23. In this embodiment system 10 is thus embodied to manufacture three concrete revetment elements at the same time. Each of the devices 11 comprises a mould 7 with at least a stationary mould part 12 (i.e. stationary relative to displaceable frame 23) for forming and holding at least a part of head part 4 of revetment element 1 and two mould parts 13, 14, mutually displaceable relative to frame 23, for forming the neck and base parts.

[0056] As shown in figure 3, stationary mould parts 12 are mutually connected via the above stated shared displaceable frame 23. This frame is provided with openings 25 above each of the moulds, this such that concrete material can be poured into the mould cavities of moulds 7 from the top. Figure 3 further shows a schematically shown press 26 whereby the upper side of the concrete material can be pressed down. This press is arranged for displacement in upward and downward direction (P_3) via a known mechanism (not shown). The shown press is provided with a heating element 32, but in other embodiments the heating element in the press is omitted.

[0057] Each of the displaceable mould parts 13, 14 takes a substantially U-shaped form as seen from the upper side. Seen in section (as shown in figures 5 and 6), each mould part 13, 14 has an upright flat part 15 and thereabove an inward protruding thickened portion 16. Thickened portion 16 is embodied to form neck part 3 of revetment element 1 and in the shown embodiment has a substantially convex form in order to be able to form a hollow neck part. In other embodiments thickened portion 16 of displaceable mould part 13, 14 can have a different, for instance more angular, form in order to form a more angular transition between head part or base part 2 and neck part 3.

[0058] Each of the displaceable mould parts 13, 14 is embodied for being shifted in a transverse direction. Mould parts 13 can be shifted in direction P_1 and mould parts 14 in direction P_2, to the opened position. Each of the mould parts 13, 14 can for this purpose be shifted along a number of transverse rods 17, which are embodied as guide for mould parts 13, 14. A guide tongue 18 is further provided at the position of outer mould parts 13, 14, i.e. the first and the last mould parts of the shown row of moulds 7. Mould parts 13, 14 are further attached in longitudinal direction to longitudinal beams 19 and 20. Longitudinal beam 19 is coupled to each of the first mould parts 13 and longitudinal beam 20 is coupled to each of the second mould parts 14 of the row of moulds 7. Longitudinal beams 19, 20 are attached at both their outer ends to extending cylinders 21 and 22. These extending cylinders extend substantially in transverse direction and are embodied to displace longitudinal beams 19, 20 in their respective transverse directions (P_1, P_2) and back. Figure 6 for instance shows the situation in which the two longitudinal beams 19, 20 are in the closed position with retracted extending cylinders 21, 22. In figure 7 extending cylinders 21, 22 are drawn in extended position. In this position longitudinal beams 19, 20 have been displaced in their respective extending directions P_1, P_2 until they are in the opened position. The whole of extending cylinders 21, 22, longitudinal beams 19, 20 and transverse rods 17 together forms a shared displacing unit whereby the mould parts of the different moulds can be operated collectively.

[0059] The figures further show that one or more heating elements are arranged at determined positions in the mould, more particularly in mould parts 13, 14. In the shown embodiment heating elements 31 are situated at the position of the transition between neck part 3 and base part 2 and heating elements 30 at the position of the transition between neck part 3 and head part 4. The heating elements can be situated over the whole periphery, but in other embodiments the heating elements are provided at only one or more positions along the periphery. Heating elements 30, 31 are preferably (only or also) arranged at the position of the relatively sharp edges in displaceable mould parts 13, 14, where the chance of concrete material sticking to the mould during displacing thereof to the opened position is greatest.

[0060] Heating elements 30, 31 for instance comprise electric heater coils arranged inside mould 7, 7', 7" and connected to an electric power source (in a manner not shown). The mould can be heated locally by conducting current through these heating elements. When the mould is manufactured from sufficiently heat-conducting material, the inner surface of the mould wall facing toward the mould cavity will be heated in local heating by the heating elements. This heating of the mould wall can be local or, in the case of sufficient heat conduction in the mould, can also apply to the whole mould.

[0061] The heating elements are embodied and set such that the concrete material adjacent to the mould wall is heated locally to a temperature of between 60 and 95 degrees Celsius, preferably between 70 and 80 degrees Celsius, preferably about 75 degrees Celsius. The heating time may vary, but in practice a heating time of about 20 to 40 seconds suffices to greatly reduce the chance of the concrete material sticking to the inner side of the mould.

[0062] The figures further show that a relatively hard and smooth non-stick layer 35 is arranged against the inner side of the mould facing toward mould cavity 5. This layer 35 is composed such that the surface facing toward the mould cavity takes a very hard and very smooth form. The layer can be manufactured from material provided with one or more non-stick components. Examples of such materials comprise fluoropolymer and/or PTFE particles. The material can be chemically inert, and the material released in the case of wear does not react with the concrete material.

[0063] The operation of system 10 will be further elucidated hereinbelow. Using a concrete arranging unit (not shown) which is positioned above the moulds a quantity of concrete is firstly arranged in each of the mould cavities 5 of the mould by pouring it in via openings 25. When a layer of concrete material has been arranged in the mould cavities, for instance a layer with a height corresponding to that of base part 2 of the revetment element, the pouring is interrupted and the concrete material in the mould cavity is compacted using the vibrating mechanism (not shown).

[0064] A second quantity of concrete material is then arranged in mould cavity 5, and further vibration of the concrete material takes place. After the final quantity of concrete material has been arranged in the mould cavity, the revetment element to be formed is pressed down on the upper side using the above stated press 26 so that a compact and strong whole results. In a subsequent step (simultaneously or subsequently) heating elements 30, 31 are operated so that the mould is locally or wholly heated. At a given moment the concrete material will have cured to sufficient extent and the mould will have heated up to sufficient extent to make the above stated boundary layer between the more solid concrete material and the moisture which accumulates on the inner side of the wall of the mould evaporate.

[0065] When this boundary layer has become sufficiently small, the moisture has at least partially evaporated and/or the concrete material has cured, the extending lifting cylinders 21, 22 are operated so that mould parts 13, 14 are shifted apart in horizontal direction (direction P_1, P_2 in figure 5) until the opened position shown in figure 5 has been reached. Displaceable frame 23 with the whole mould attached thereto, i.e. both the stationary parts 12 and the displaceable parts 15, can then be lifted as one whole by lifting means (not shown) from the starting position shown in figure 4 to and end position in which the revetment element is released from the mould as a whole. The revetment elements now stand unsupported on the support elements and are ready to be transported further. Instead of displacing frame 23 and mould parts 12, 15 upward, in other embodiments support element 6 with the revetment elements present thereon is conversely displaced downward and the mould remains in place. After a support element has been displaced sufficiently far downward, the revetment elements stand unsupported and have therefore been released from the mould. As soon as the revetment elements have been released from the moulds they can be transported further (optionally together with support element 6). As soon as the thus formed revetment elements 1 have been carried away, extending cylinders 21, 22 are once again operated in order to shift mould parts 13, 14 toward each other and close the mould, and frame 23 is once again moved downward until the original starting position has been reached. The process of filling and demoulding of the mould cavities can then be repeated.

[0066] The concrete material arranged in the mould is dry concrete or, preferably, earth-moist concrete, i.e. concrete in a consistency range of zero or one. This consistency can be determined in accordance with the standard NEN 12350-4 "Testing fresh concrete - Part 4: Degree of compactability". Despite the use of such concrete material with relatively low liquid content, elements with the complex forms described herein can still be made by correct heating of the mould.

[0067] The invention is not limited to the embodiments thereof described here. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Method for manufacturing a concrete revetment element, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and the head part to each other and wherein the head and base parts are relatively wide and the neck part therebetween is relatively narrow, the method comprising of:

    - arranging concrete material in the mould cavity of a mould, wherein the concrete material is dry concrete or earth-moist concrete material;
    - heating at least a part of the mould at one or more locations;
    - removing the mould from the revetment element;

    wherein heating at least a part of the mould at one or more locations comprises of increasing the temperature of the concrete material in a boundary layer adjacent to said part of the mould to a temperature of between 60 and 95 degrees Celsius for a heating period of 10-120 seconds for the purpose of removing at least some of the moisture in the concrete material adjacent to the inner side of the mould through evaporation.

2. Method as claimed in claim 1, comprising of removing the revetment element from the mould immediately after the heating period and then allowing it to cure.

3. Method as claimed in claim 1 or 2, wherein the smallest diameter of the head part and/or the smallest diameter of the base part is at least 1.5 times, preferably at least 1.7 times or at least 2.5 times greater than the greatest diameter of the neck part and/or wherein removing the moisture comprises of drying the concrete material adjacent to the mould and/or wherein the concrete element is formed in an upright position, with the head part above the neck part and the neck part above the base part.

4. Method as claimed in any of the foregoing claims, wherein the local heating comprises of heating the mould at the position of one or more edges of the mould cavity and/or heating the mould only at the transition between the head part and neck part and/or at the transition between the neck part and base part.

5. Method as claimed in any of the foregoing claims, comprising of:

- only partially filling the mould cavity with a first quantity of concrete material;
- vibrating the first quantity of concrete material;
- further filling the mould cavity with a second quantity of concrete material,

preferably comprising of repeating the filling of the mould cavity with concrete material and the vibrating of the concrete material one or more times and/or preferably pressing a press into the mould cavity from the upper side in order to press down the concrete material arranged therein.

6. Method for manufacturing a concrete revetment element in one piece, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and head part to each other, preferably a method as claimed in any of the foregoing claims, wherein the method comprises of:

- providing a concrete arranging unit above a mould which rests on a flat support element and is provided with one or more inlet openings and a mould cavity, wherein the mould comprises one or more mould parts displaceable between a closed position and an opened position;
- having the concrete arranging unit arrange concrete material for forming the revetment element in the mould cavity via the one or more continuous inlet openings when the mould parts are in the closed position;
- having the heating elements remove at least some of the moisture in a boundary layer formed on the inner side of the mould;
- releasing the revetment element by displacing the one or more mould parts of the mould from the closed position to the opened position.

7. Method as claimed in any of the foregoing claims, wherein the mould comprises a support element and a frame with a stationary mould part and two mould parts displaceable relative to the frame between a closed and opened position, the method comprising of displacing the displaceable mould parts away from each other to the opened position after the concrete material has been arranged and the revetment element has been formed,
preferably comprising two or more moulds with a shared flat support element, all displaceable mould parts of which are displaceable by a shared displacing unit, the method further preferably comprising of:

- having the shared displacing unit displace the displaceable mould parts of each of the moulds collectively away from each other to the opened position after concrete material has been arranged in the moulds, wherein a stationary mould part simultaneously holds the respective revetment element stably in place on the flat support element.

8. Device for manufacturing a concrete revetment element with dry concrete or earth-moist concrete material, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and head part to each other, and wherein the head and base parts are relatively wide and the neck part therebetween is relatively narrow, the device comprising:

- a frame;
- a mould arranged on the frame and provided with a mould cavity and with an inlet opening for infeed of concrete material into the mould cavity, wherein the wall of the mould comprises one or more mould parts displaceable relative to the frame;
- one or more heating elements configured to heat at least a part of the wall of the mould for at least partially removing at least some of the moisture in the concrete material adjacent to the inner side of the mould;
- displacing unit for displacing the one or more displaceable mould parts, wherein the displacing unit is configured to displace the mould part

between a closed position in which the mould part connects to the rest of the mould and an opened position in which the mould is opened,

wherein the heating elements are configured to increase the temperature of the concrete material in a boundary layer adjacent to said part of the mould to a temperature of between 60 and 95 degrees Celsius for a heating period of 10-120 seconds at one or more locations, so that at least some of the moisture in the concrete material adjacent to the inner side of the mould is removed through evaporation.

9. Device as claimed in claim 8, wherein the displacing unit is configured to remove the revetment element from the mould immediately after the heating and then allow it to cure.

10. Device as claimed in claim 8 or 9, wherein the smallest diameter of the head part and/or the smallest diameter of the base part is at least 1.5 times, preferably at least 1.7 times or at least 2.5 times greater than the greatest diameter of the neck part.

11. Device as claimed in any of the claims 8-10, wherein at least a heating element is arranged at the position of one or more of the edges of the mould cavity and/or wherein at least a heating element is arranged at the transition between the head part and neck part and/or at the transition between the neck part and base part.

12. Device as claimed in any of the claims 8-11, wherein the mould cavity is embodied to form a monolithic revetment element and/or wherein the at least one heating element is arranged in or on the wall of the mould, particularly in or on the displaceable mould parts, and/or wherein the heating element comprises an electric heater coil and/or wherein a heating element is arranged inside the wall and the wall is manufactured from heat-conducting material.

13. Device as claimed in any of the claims 8-12, comprising:

- a press which can be arranged in the mould cavity via the inlet opening and which is configured to press down on the upper side of the concrete material arranged in the mould cavity;
- a layer with non-stick components applied to the surface of the mould facing toward the mould cavity, wherein the non-stick components preferably comprise a fluoropolymer and/or PTFE particles.

14. Device as claimed in any of the claims 8-13, wherein the mould cavity is embodied rotation-symmetrically relative to an imaginary rotation axis through the centre of the base part, neck part and head part and/or wherein a displaceable mould part is substantially U-shaped in cross-section and/or wherein in closed position the outer ends of the displaceable mould part are placed against each other, the device preferably comprising a stationary mould part fixedly attached to the frame, wherein the mould parts which are displaceable relative to the frame are configured to form the base part and the neck part and wherein the stationary mould part is embodied to form the head part.

15. System for manufacturing a concrete revetment element, wherein the revetment element comprises a base part, a head part and a neck part connecting the base part and head part to each other, the system comprising:

- two or more devices as defined in any of the claims 8-14, provided on a shared flat support element;
- a shared displacing unit which is configured to shift the displaceable mould parts of each of the moulds collectively between a closed and opened position,

wherein the shared displacing unit is preferably configured to displace the displaceable mould parts in transverse direction and/or wherein the system preferably comprises a further displacing unit for displacing the frame and the stationary and displaceable mould parts attached thereto in upward or downward direction and/or wherein the system preferably comprises a concrete arranging unit placed above the moulds.

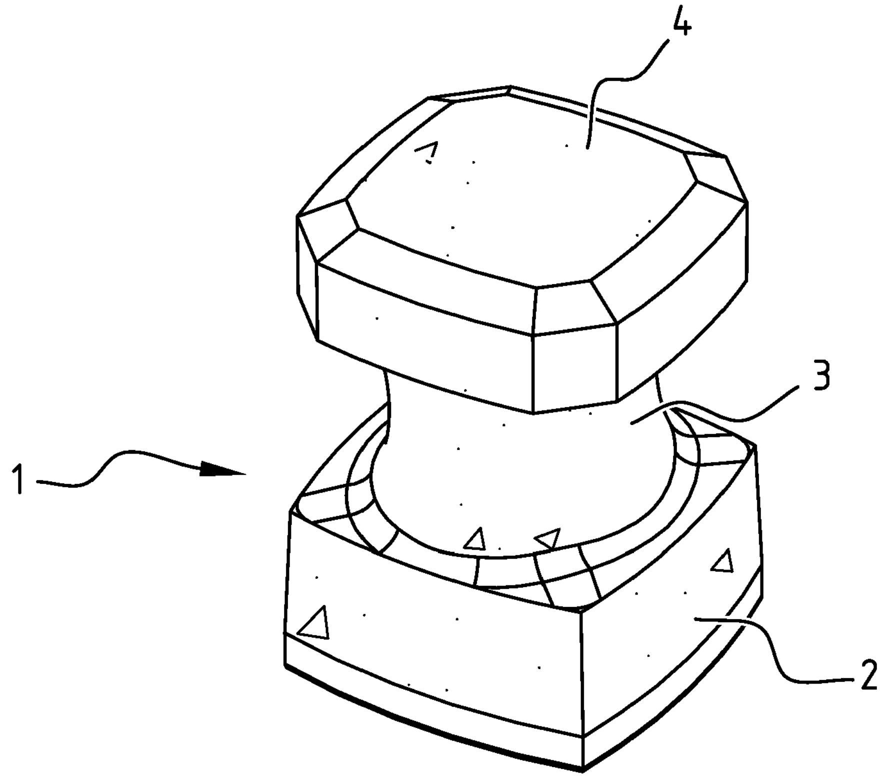

FIG. 1

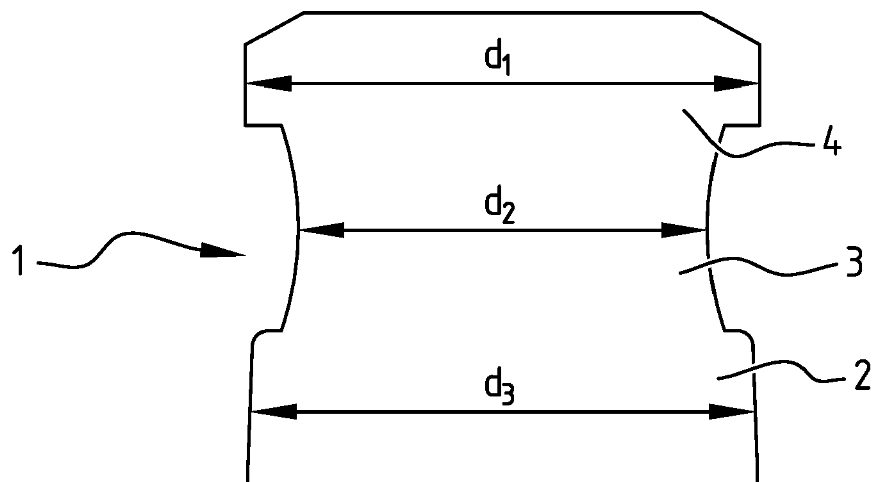

FIG. 2

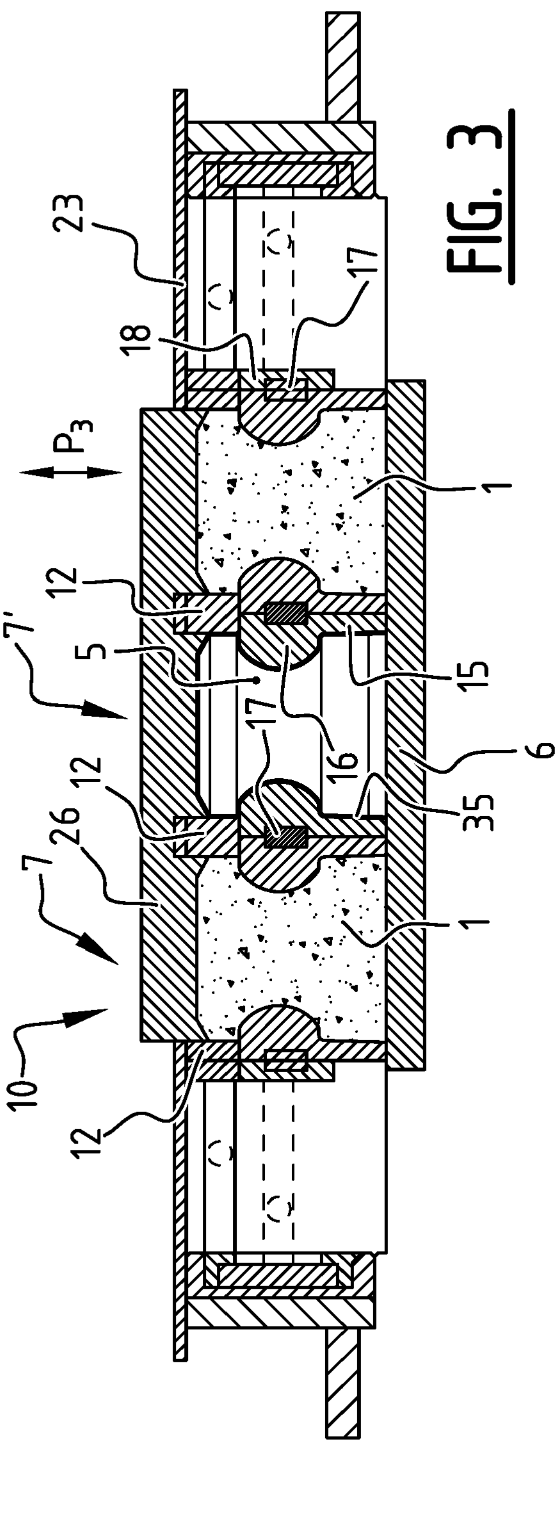

FIG. 3

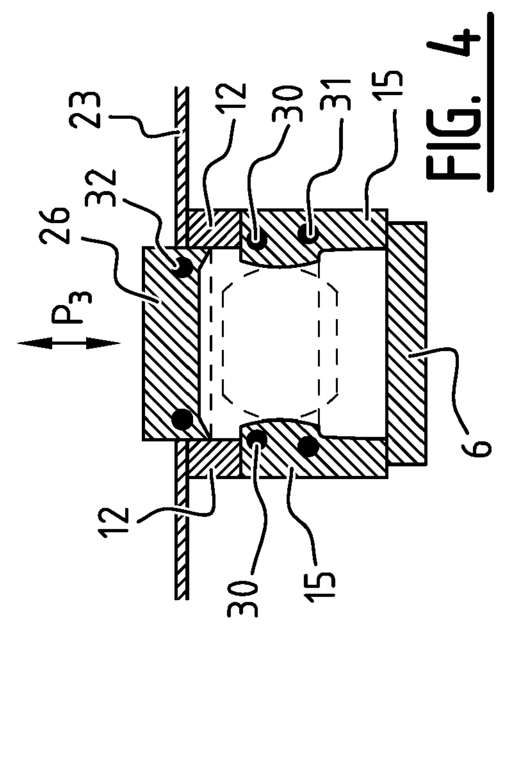

FIG. 4

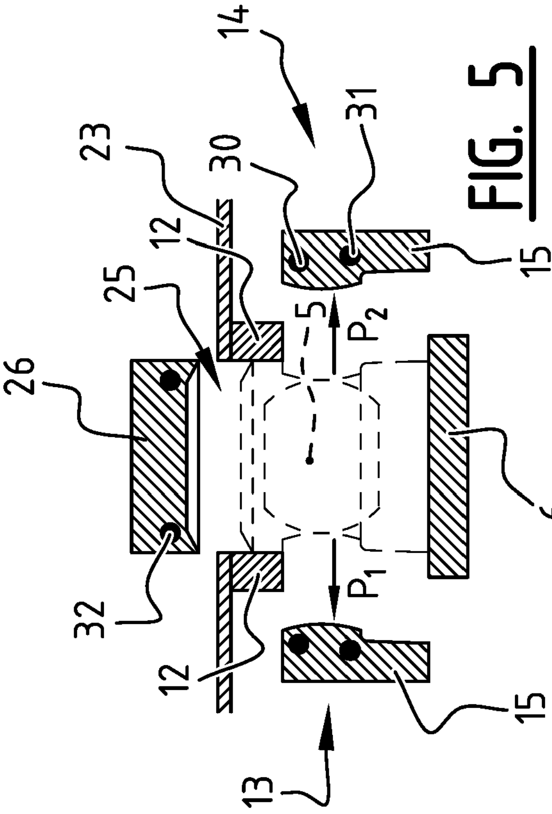

FIG. 5

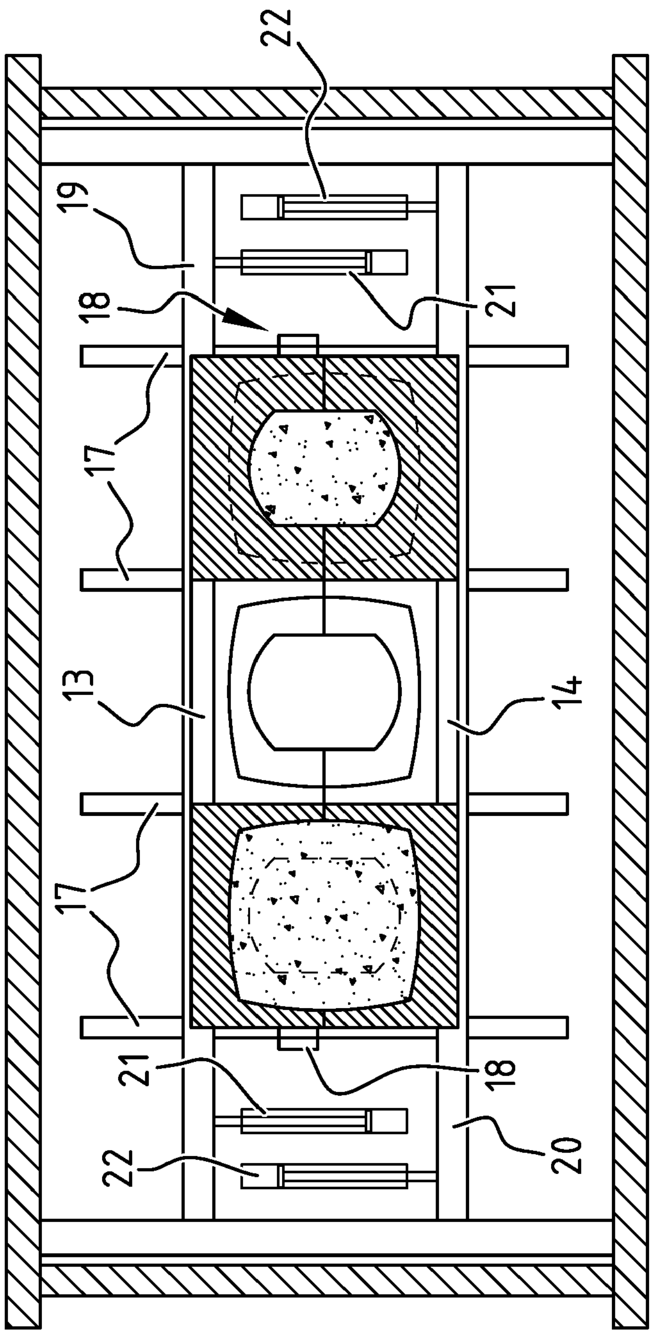

FIG. 6

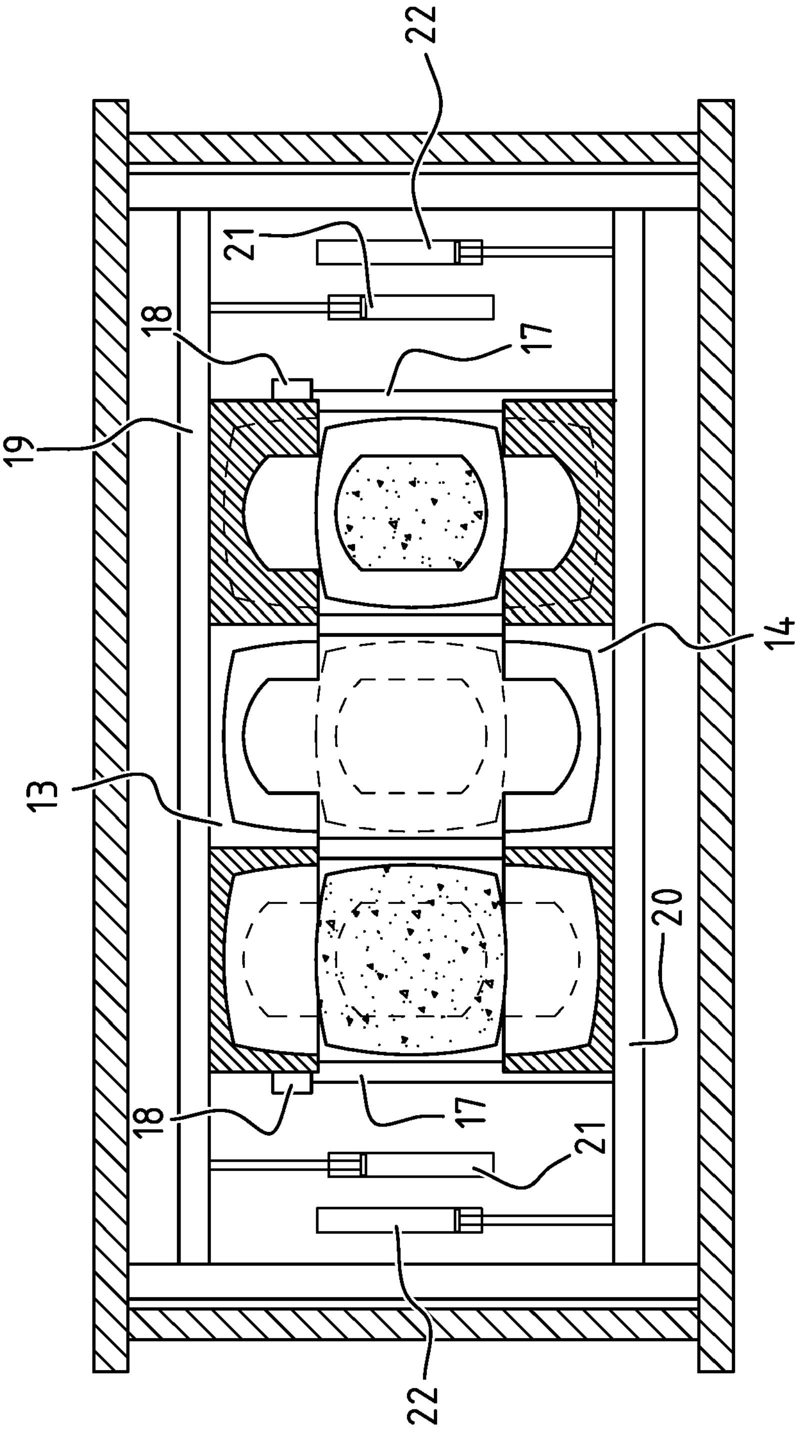

FIG. 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 16 7155

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	JP S55 159110 U (-) 15 November 1980 (1980-11-15) * abstract; figures *	1-15	INV. E02B3/12 B28B7/00 B28B7/42
Y	FR 2 573 337 A1 (GUERIN GABRIEL [FR]) 23 May 1986 (1986-05-23) * page 3; claims 1-6 *	1-15	
Y,D	DE 20 2015 006023 U1 (RAMPF FORMEN GMBH [DE]) 16 October 2015 (2015-10-16) * claims 1,5 *	13	
A	JP H05 337913 A (CHICHIBU CEMENT KK; GOYO KOKI KK) 21 December 1993 (1993-12-21) * abstract; figures *	1-15	
A	DE 24 17 475 A1 (MANNESMANN KLEIBER GMBH) 23 October 1975 (1975-10-23) * page 2, last paragraph - page 4, paragraph 2; claims 1,8,10; figures * * page 6, paragraph 3 - paragraph 4 *	1-15	TECHNICAL FIELDS SEARCHED (IPC)
A	JP S57 185515 U (-) 25 November 1982 (1982-11-25) * abstract; figures *	1	E02B B28B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	17 August 2017	Orij, Jack

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 16 7155

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17-08-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP S55159110 U	15-11-1980	NONE	
FR 2573337 A1	23-05-1986	NONE	
DE 202015006023 U1	16-10-2015	DE 102014012738 A1	03-03-2016
		DE 202015006023 U1	16-10-2015
		EP 3186048 A1	05-07-2017
		WO 2016030014 A1	03-03-2016
JP H05337913 A	21-12-1993	NONE	
DE 2417475 A1	23-10-1975	NONE	
JP S57185515 U	25-11-1982	JP S5940173 Y2	13-11-1984
		JP S57185515 U	25-11-1982

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- NL 2004345 C **[0006] [0007] [0012]**
- JP S55159110 U **[0015]**
- DE 202015006023 U1 **[0044]**