Jan. 14, 1964 STEN-OLOF H. FAGERLUND 3,117,423

METHOD FOR THE PRODUCTION OF UNDERWATER FOUNDATIONS

Filed Jan. 18, 1960 2 Sheets-Sheet 1

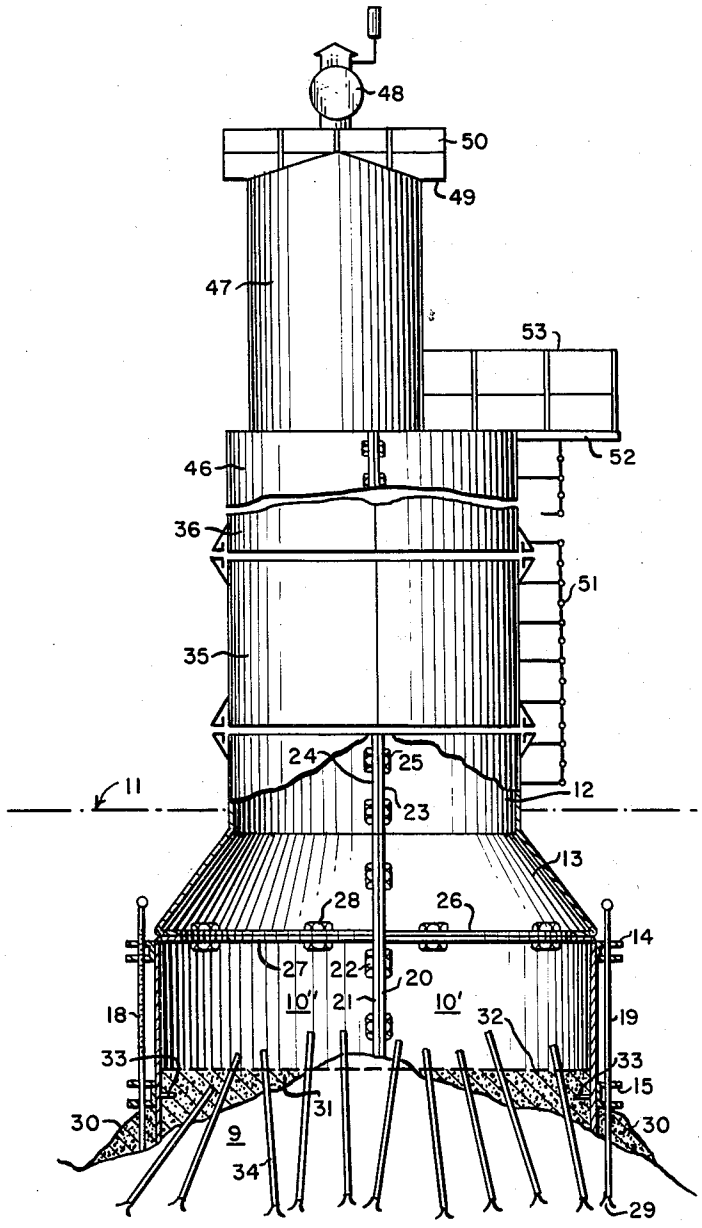


FIG. 1

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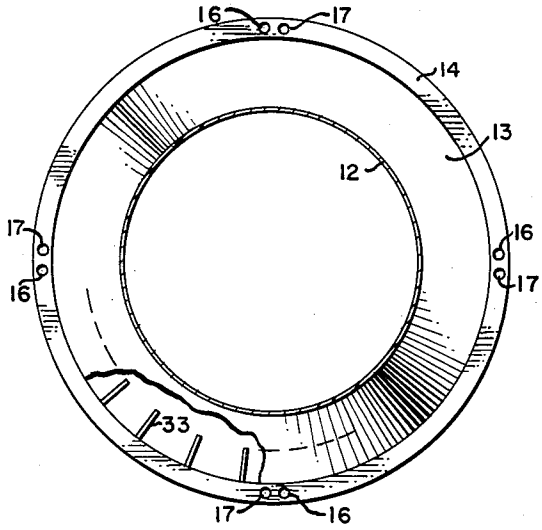


FIG. 2

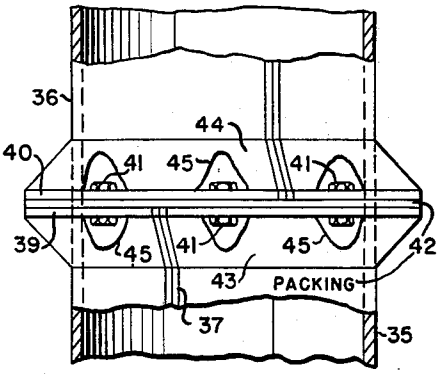


FIG. 4

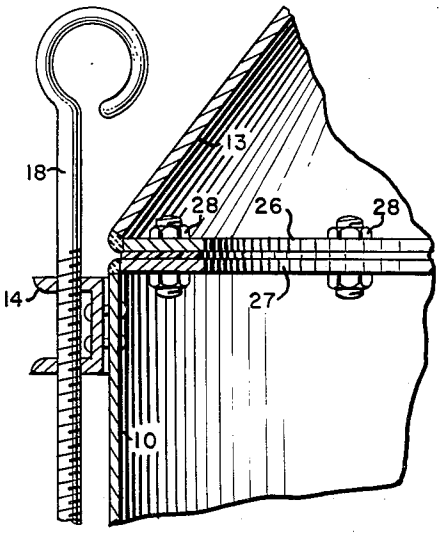


FIG. 3

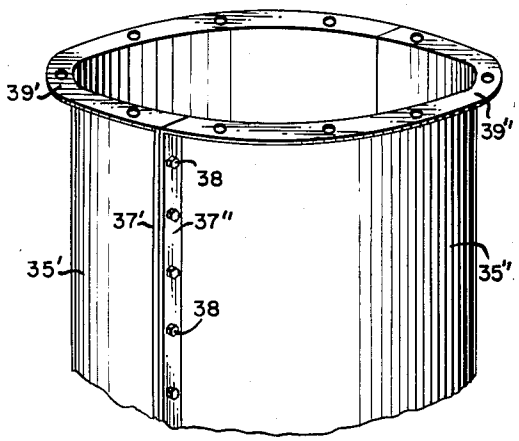


FIG. 5

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METHOD FOR THE PRODUCTION OF UNDERWATER FOUNDATIONS

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3 Claims. (Cl. 61—46)

The present invention refers to a method for the production of foundations, for instance for beacons, bridge supports and similar submarine arrangements, as well as a foundation produced according to this method. Divers structures, such as beacons, bridge piers, certain sea marks, posts for supporting certain kinds of buildings such as boat houses, and so on, are also included in the above indicated conception of foundation. Hitherto, it has been usual to mould the foundation on the place of such a foundation, this moulding taking place in moulds, built on the place. This is, however, a method that is both time-consuming and expensive. The purpose of this invention is, in the first place, to facilitate the building of such foundations as mentioned above, whereby the production of them will be easier, less expensive, and take place more rapidly, without their stability or strength being hazarded or decreased.

The production of foundations according to this invention takes place on basis of shells or outer coverings for the foundation, for instance produced on shore from sheet-iron or similar material, said shells preferably being in several parts which are later on mounted together, after the bottom part has been applied on its place. The bottom part should preferably for this purpose be tubular and open at the top as well as at the bottom.

According to the invention, a shell-formed covering is first made of sheet-iron or similar material, said shell being adapted to the sub-water part of the foundation as well as to a part extending slightly above sea-level, and this shell or covering is lowered in ready-sized state to the sea-bottom and directed in such a way that the upper edge of the covering will be in the horizontal plane, then sand is filled on one or both sides of the lower edge of the covering part, concrete mass rich in cement is filled into the covering part for binding the sand to a tighting mass, then the water is pumped out of the interior of said covering part, then this is anchored to the sea-bottom, and finally, the remaining parts of the foundation are prefabricated and are then mounted on said first part, anchored to the sea-bottom.

Further details of the invention will be evident from the following description in connection with the attached drawings, which show an embodiment of the invention in connection with a foundation, intended for the mounting of a beacon. In the drawings, FIG. 1 shows a section through the foundation and the beacon in vertical direction, while FIG. 2 shows a section in horizontal direction along the waterline in FIG. 1, and FIG. 3 shows a figure for explanation of how certain parts, forming the bottom part of the foundation, are intended to be mutually connected. FIG. 4 shows a corresponding figure for explanation of how certain parts, contained in the upper part of the foundation, are mutually connected. FIG. 5, finally, shows one of these upper parts in a perspective view.

At the embodiment of the invention, shown in the drawing, it is assumed that the beacon should be built on a foundation which shall be moulded in concrete on the bottom of the sea. The bottom of the sea may, principally, be of any kind, but it is preferable that the bottom of the sea is of rock or sand. At the shown embodiment of the invention, it has been assumed, that the foundation of the beacon shall be built on rock-ground, and that the

ground has the profile shown in the drawing, where the bottom is indicated 9. It has further been assumed that the foundation of the beacon shall be built straight above a rise in the bedrock, but it is evident that this is in no way of vital importance, but that the bottom may be of practically any nature.

As illustrated in the drawings, the bottom part of the foundation shall be of a greater diameter at its lower part at 10, in order that the foundation may obtain large contact surface on to the bottom of the sea and thereby a large dumping moment. On the other hand it is assumed that wind resistance and ice-pressure resistance should be made small, and that therefore the diameter of the foundation close above the water-line 11, and preferably also in the proper water-line, and in any case in the upper parts of the foundation, should be essentially smaller, as indicated for instance at 12. The connection part 13 between the parts 10 and 12 is, preferably, conical. One has then to produce in advance, for instance in a workshop on shore, the shell of the bottom parts 10, 12, 13, from sheet iron with the re-inforcements and the adjustment elements, described below.

It is assumed that the foundation shall be essentially of circular cross-section in the horizontal plane, but if the foundation has to be arranged in a place, where there is strong current in given main directions, for instance in a river or at a shore, where the tide may be strong, it may often be suitable instead to give the foundation horizontal spool-form, elliptic form, or oval form.

At the top and at the bottom, the lower, wider part of the bottom part of the shell is re-inforced by bands 14, 15, running around its circumference, said bands for instance being profiled as an L or as a U. Through the flanges of these bands, holes are drilled, preferably two holes 17, 16, see FIG. 2, close to each other and within each quadrant of the circumference of the irons. The holes 16 are threaded for receiving screws 18, FIG. 1, whereas the holes 17 are free-running for receiving anchoring bolts 19.

Depending upon the depth to which the foundation shall extend, the lowermost section, consisting of the parts 10, 12, and 13, will get different size and weight. Under given circumstances, it may be so large that it may be difficult to transport it to the place, where the foundation should be founded, or to lower it on the right place. This part may then, preferably, be made in parts which are either mounted together on board a transport vessel, or even by a lifting-crane in direct connection with the lowering of the part in the way, further described below. The division between the different parts may take place along the limitation line between the part 10 and the part 13, or between the part 13 and the part 12. Irrespective of whether each of said parts or some of them has been made separately, one can further divide one or more parts, forming the bottom part, into two half-parts by a vertical, diametrical section.

In the embodiment of the invention, shown in the drawing, the lower parts 10, 13, 12 of the covering or shell of the foundation has been divided into four parts for simplification of the transportation, in that the lowermost section 10 of greater diameter is divided vertically into two half-parts 10′ and 10″. These are connected, before or during the lowering of the lower part of the covering or shell, by flange connection, directed inwards, while using the flanges 20 and 21 and nuts and bolts 22. Furthermore, the conical part 13 and the upper cylindrical part of smaller diameter 12, contained in this section, has also been divided along a diametrical level, and the two half-parts have been connected in a similar way by means of the flanges 23, 24 and bolt connections 25. Finally, the lowermost, ring-formed part thus connected

has been attached to the upper, also ring-formed, connected part by flange connection, comprising the flanges 26 and 27 and the bolts 28. It should be observed that all of these flanges are preferably directed inwards. The reason for this is that the parts 10, 13 and 12 are not intended to be removed from the foundation after that has been finished, but that they should be allowed to remain as a protection for concrete which is, in a way to be described below, later on founded in the section of the mould shell now described. It is then important that this section of the mould shell shall have no projecting, uneven means, to which ice might possibly adhere, so that there is no undesirable breaking due to the effects of ice.

At the mounting of the bottom part of the foundation shell, one is now proceeding in the following way:

The shell of the lowermost part of the foundation is brought with a vessel to the place where the beacon should be mounted, and is there lowered on to the bottom, if required after connecting its separate parts as described above. The shell should, when being produced, have been given such dimensions that it will, after having been lowered, rest with the upper edge of the part 12 somewhat above the sea level. How much above sea level this upper edge should rest will, of course, depend upon what fluctuations in water-level will occur. In any case, the height should be such that during the erection of the foundation the water-level will never rise above the upper edge of the shell part thus lowered.

Due to unevennesses in the bottom structure, the lowered part may probably assume an inclined position. One is then uprighting it in such a way that it will have its upper edge in the horizontal level. This is made by means of the screws 18 introduced into the threaded holes 16. By adjustment upwards or downwards of each of these screws one may without any difficulty achieve that the shell part of the foundation stands vertically on the sea bottom, so that its upper edge will be in a horizontal plane. The part of the foundation shell now regarded shall now be fixed in this position against side displacements. If the sea bottom consists of sand, one may drive down anchoring bolts in it through the non threaded holes 17 in the flanges of the section bands 14 and 15, until sufficient anchoring has been achieved. If the sea bottom is bedrock, then one introduces drills, for instance pneumatic drills, through the holes in the section bands, and has to drill deep enough in the bedrock to be able afterwards to introduce anchoring bolts 19 in the produced holes, in which they are locked by bottom wedges, as seen from the bolt division 29 at the lower end of the bolt 19. The bottom part of the foundation shell is now, firstly, in horizontal position, and secondly, it is well anchored to the sea bottom so that it cannot be displaced sidewards during the continuous work procedure.

This anchoring thus is sufficient for starting the work with the completion of the foundation, but it cannot be regarded sufficient to resist the strain which may later on arise due to wind and weather, especially under strong ice-pressure conditions. For this purpose, the bottom part of the foundation must therefore be much more strongly anchored. This is done in the following way:

Larger openings due to unevennesses in the bottom between the under edge of the shell part and the sea bottom are tightened by rags or the like, so that any leakage existing is not too substantial. This may, for instance take place by the rags being introduced from above into the interior of the shell part and being packed down into the openings by means of stakes which from above are put down into the interior of the shell part.

Dependent upon the appearance of the sea bottom immediately at the lower edge of the bottom part of the foundation, sand suitable for moulding concrete is thereafter introduced, either in a row 30 outside the lower edge of the foundation bottom part, or in a layer 31 inside the same lower edge, or which as a rule is preferred, inside as well as outside. Thereby, it is suitable that the said inside the bottom part is supplied as a layer with an even upper side that, for instance, may be in a plane with the line 32, FIG. 1.

A number of bolts 33, directed radially inwards, which are attached to the lower re-forcement ring 15, will in this way be embedded in the sand. Hereafter a concrete mixture rich in cement, or even pure cement wash, is added so that cement water therefrom will make its way down into the sand and bind it to a tightening concrete construction. After the concrete has bound, one has to pump out the water from the sheet-iron shell of the lowermost foundation section. Regarding this, one should already when screwing together the shell parts have introduced tightenings or packings in the joints, so that the shell part will be fairly tight. Thereafter, personnel are sent down in the caisson thus formed, in order to drill up a big number of broom-like divided holes through the concrete cake in the bottom and down into the sea bottom by means of available drills, for instance compressed air-driven drills. Through these holes, one is thereafter introducing further anchoring bolts 34 which are locked in their downwards-turned ends by being brought apart over wedges in the usual way.

The bottom part of the foundation can now be regarded to be fixed in its place in a satisfactory way, and one has now to fill this bottom part with some suitable ballast. The safest way is to fill the bottom part with the concrete mixture which is allowed to bind. After the bottom part has been completed this way and has been filled with concrete or other ballast, the foundation is built part for part by adding further elements, which are, as the lowermost element, ready made on shore in the form of shells, for instance in a mechanical workshop, and are transported to the place of building the foundation. Also these further elements may either be fully ringformed or they may consist of two or more sectors which are joined together to form a ring. Likewise, they may either be filled with loose ballast or be moulded together with concrete.

It is especially advantageous to remove the last mentioned elements, after the production of the foundation, and those elements shall thus only serve as shells during the proper moulding procedure. They may then be used for another foundation building. In this case, they should, however, be divided into sectors by outwards directed flange connection, and also they should be combined with adjacent elements by outwards directed flange connection.

The arrangement for this purpose will be evident from FIGS. 4 and 5. One of the upper, cylindrical shells is there indicated by 35 and the shell ring next above is indicated by 36. The shell ring 35 is the one, shown in FIG. 5 partly in perspective view. Both of the shell rings are, in this case, divided into two half-cylindrical parts, as shown in FIG. 5 by 35′ and 35″, as far as regards the shell ring 35. The two ring-half-parts are connected by flange connections and by means of bolts. In FIG. 5, one will see the flange 37′ on the shell-half-part 35′ and the flange 37″ on the shell-half-part 35″, connected by means of bolts 38. The upper shell ring 36 is made in an image-symmetrical way and should, therefore, require no detailed description. The upper edge of the lower shell ring 35 and the lower edge of the upper shell ring 36 are also provided with flanges 39, 40, but, contrary to the flanges 26 and 27, these are directed outwards, in order that one should be able to disconnect and remove the shell rings, after their having been filled with concrete. Connection nuts are indicated by 41. Considering that the shell rings are to be filled with concrete, it is suitable to arrange packings 42 between the flanges 39 and 40.

But the flange arrangement ought not to be subjected to undesired strain during the work, and it may then be

protected by the arrangement of conical mantles **43**, **44**, which are attached to the upper edge of the flanges **39**, **40**, and at the sides of the half-cylindrical shell pieces **35** and **36**, respectively, for instance by welding.

It should be mentioned that in many a case, similar conical mantles may be used with advantage at the inwards-turned flange connections, as shown in FIG. 3. In order that one shall be able to draw and loose the nuts on the bolt heads, small openings **45** are provided in the conical mantles.

After sufficient number of such sections have been moulded, so that the uppermost section **46** has been formed with a plane moulded upper side, the remaining means required for the beacon are mounted. These consist in first place of a beacon shed **47** with a lantern **48** and a platform **49** with a rail **50** as well as a ladder **51** running along the foundation, with the entering platform **52** and a rail **53**. These parts, however, form no part of the present invention.

Executed tests have shown that one may, in the manner now described, build the foundation of a beacon at an essentially lower cost than has been possible according to the earlier used methods. At the same time, one will gain the great advantage that all of the outer parts may be ready-made in advance on shore, so that one has only to bring them on board together with the required building material in the form of sand and material for the production of concrete and the required anchoring bolts. On board the vessel, where the work is done, one need no other machines for the production of the foundation than a lift-crane, the compressor for driving the pneumatic drills and a concrete mixer.

All necessary material may thus be brought to the working place in one single shipload. A complete beacon with a lantern at a height of nine meters above sea-level could under suitable weather conditions be completed according to the method now described during a total time of ony six weeks, which includes the time for hardening of the concrete. This time is figured from the first time the vessel leaves the harbour for proceeding to the place where the beacon is to be located until the beacon is lighted for normal and continuous service. During the time of production of the foundation of this beacon, simultaneous work on other beacon fundations could be made by means of the same vessel, as other beacon foundations could in part be produced during the pauses in the work with the first mentioned beacon for giving the concrete time to bind.

The invention is, of course, not limited to the embodiment described above and shown in the drawings, but different modifications may occur within the scope of the invention. Especially it should be observed that a foundation according to the present invention may be used

for various purposes, for instance, as described above, as a support for a beacon, but also for bridge piers and the like.

What I claim is:

1. A method for the production of underwater foundations comprising lowering an opened end shell-formed covering into the water so that the bottom of the shell-formed covering is supported by the underwater surface upon which the foundation is to be laid and so that the upper end of the shell-formed covering is substantially above the water level, pouring sand into the shell-formed covering so that the bottom of the shell-formed covering is substantially buried in sand and resting upon the surface on which the foundation is to be laid, pouring a cement rich fluid into the shell-formed covering so that the cement rich fluid and the sand set into a cementitious material in sealing contact with the surface upon which the foundation is to be laid and the bottom of the shell-formed covering, pumping the water out of the interior of the shell-formed covering, constructing suitable conventional anchoring and supporting means directly through and upon the accessible cementitious material, and positioning the horizontal levels of the shell-formed covering by attaching outwardly directed horizontal flanges to the shell-formed covering, said flanges being provided with threaded holes, screwing screw bolts through said holes until they rest on the sea-bottom and continuing said screwing action until said shell-formed covering is in the horizontal level.

2. A method according to claim 1 in which the construction of suitable anchoring means consists of drilling holes through the cementitious material into the surface upon which the foundation is to be laid and fixing anchor bolts in the holes.

3. A method according to claim 1 in which the construction of suitable supporting means consists of filling the shell-formed covering with ballast such as concrete.

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