United States Patent [19]

Figari

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[45] **Oct. 21, 1975**

[54] **FLOATING AIRPORT AND METHOD OF ITS CONSTRUCTION**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 198,252, Nov. 11, 1971, abandoned.

[30] **Foreign Application Priority Data**

June 22, 1971 Spain 392545

[52] **U.S. Cl.** ..... **61/46.5;** 61/48; 114/.5 F

[51] **Int. Cl.²** **B63B 35/00**

[58] **Field of Search** ..... 61/48, 46.5, 59; 114/.5 F, 114/43.5; 244/114; 52/445, 586, 723, 379

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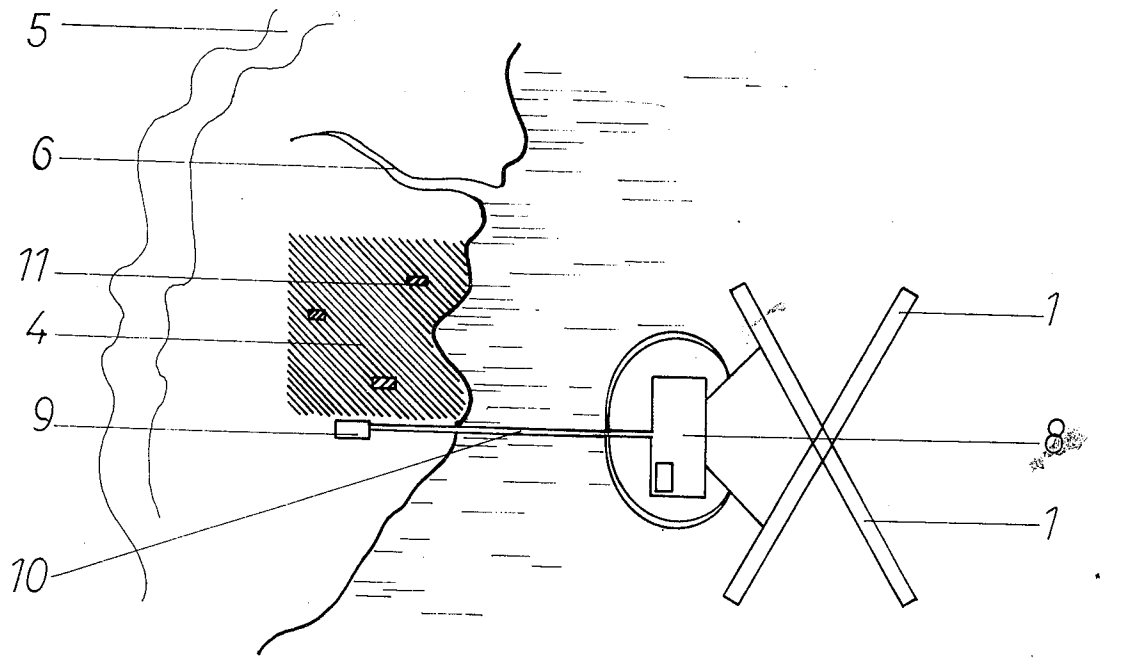
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Primary Examiner—Jacob Shapiro

[57] **ABSTRACT**

An airport constructed on an open body of water, with at least the runway thereof being made up of a plurality of preformed rectangular, hollow, waterproof blocks formed from reinforced concrete and rigidly joined together in side-by-side relation. The blocks have vertically extending undercut grooves in each of their side faces, and are joined together by reinforced concrete locking members which are generally dumbbell shaped in horizontal cross section and which are poured in situ while the blocks to be joined are floating in the open water. The top surface of the individual blocks is a high-strength concrete slab reinforced throughout its expanse by a plurality of steel reinforcing members arranged in a diamond-shaped grid, with the individual reinforcing members extending at an acute angle with respect to the side edges of the slab. The top of the joined blocks is paved with a continuous layer of bituminous material to form the runway surface.

5 Claims, 10 Drawing Figures



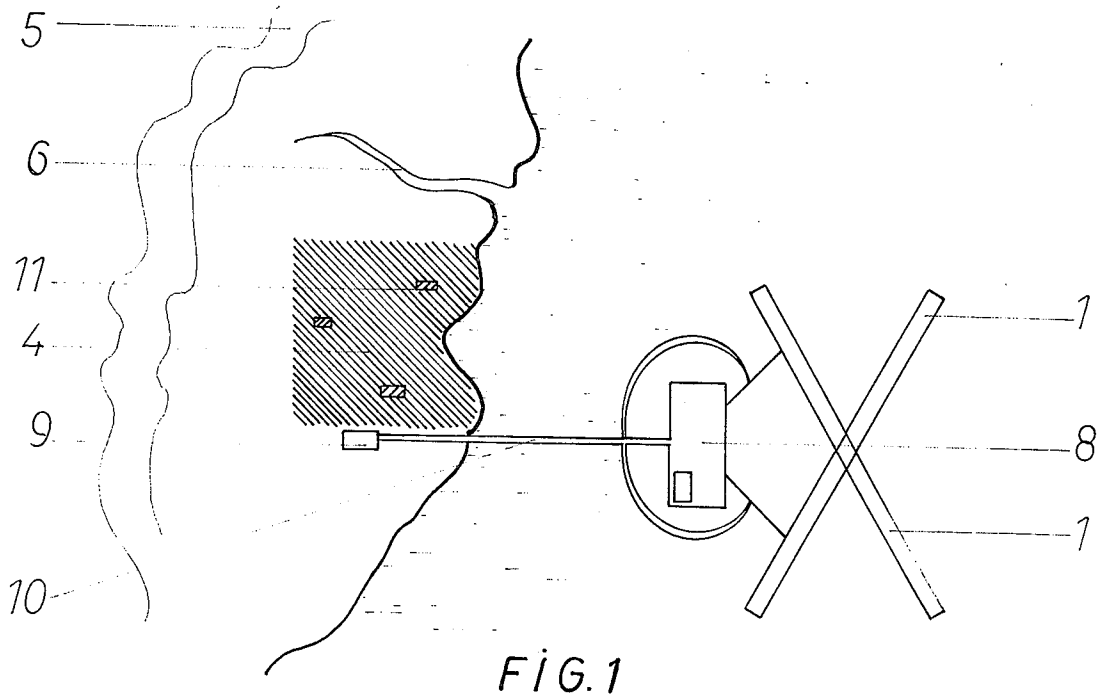


FIG. 1

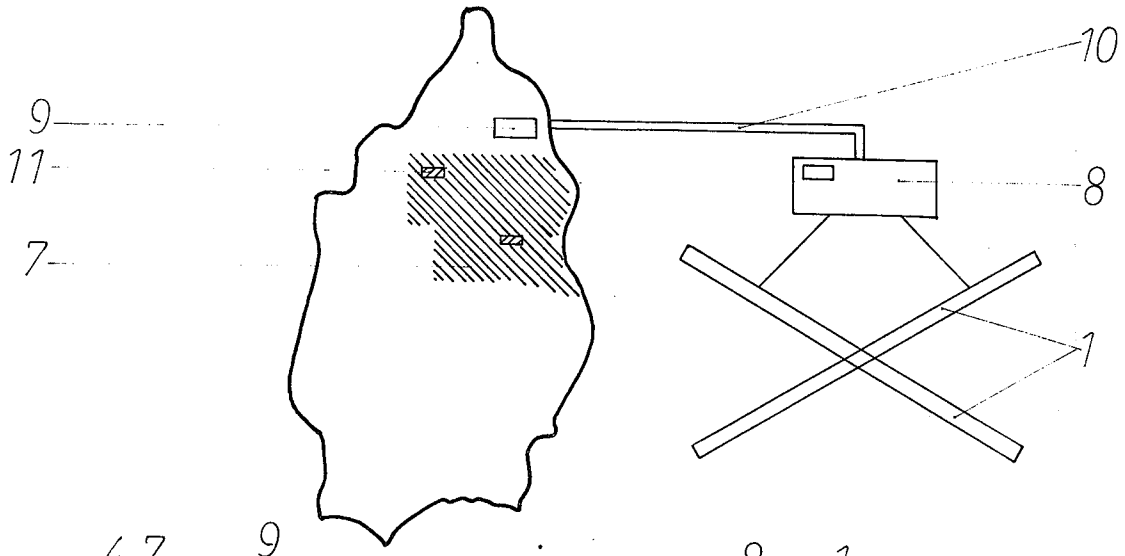


FIG. 2

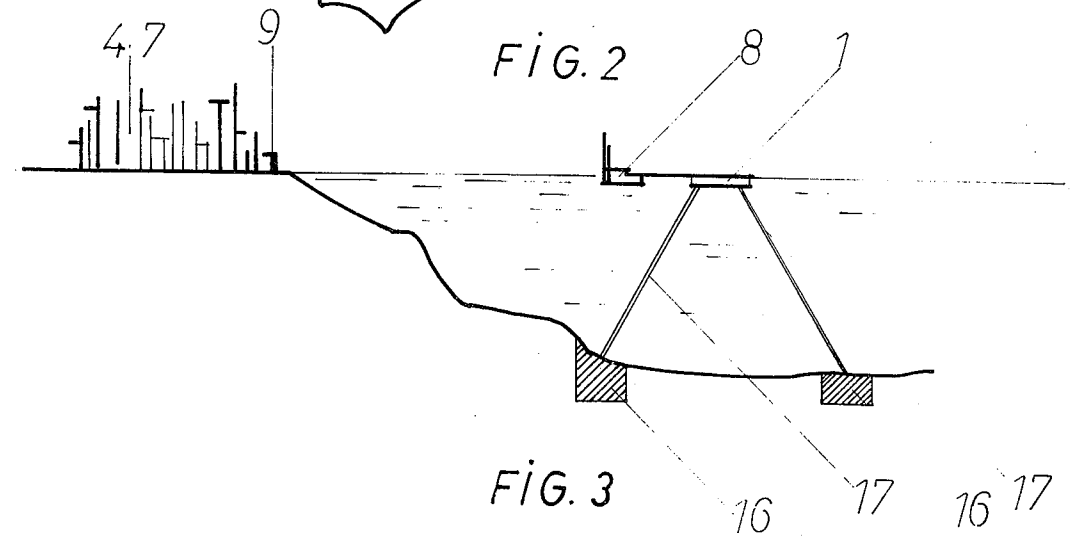


FIG. 3

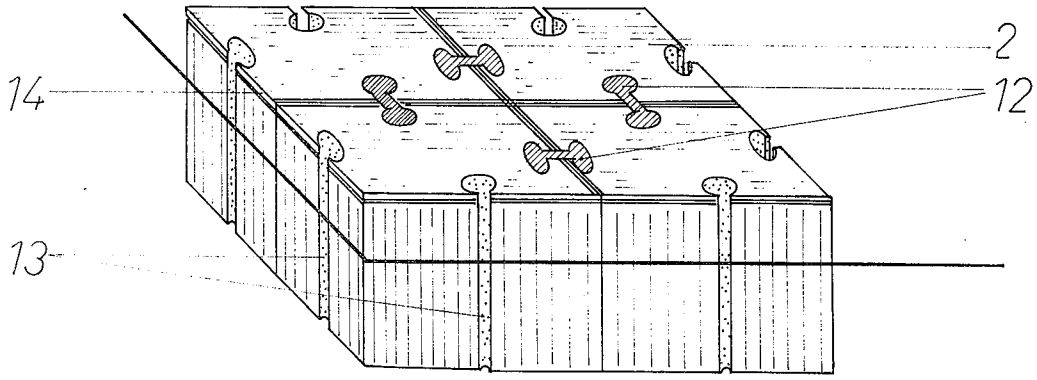


FIG. 4

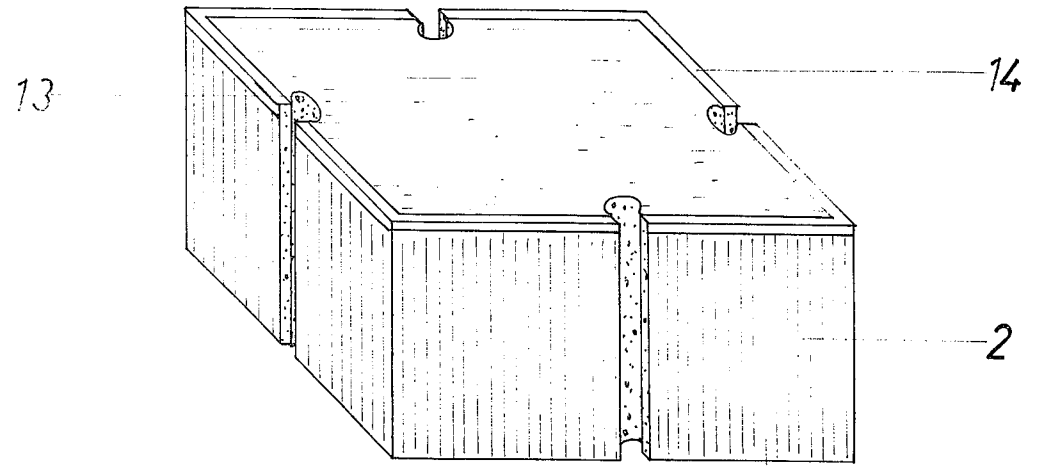


FIG. 5

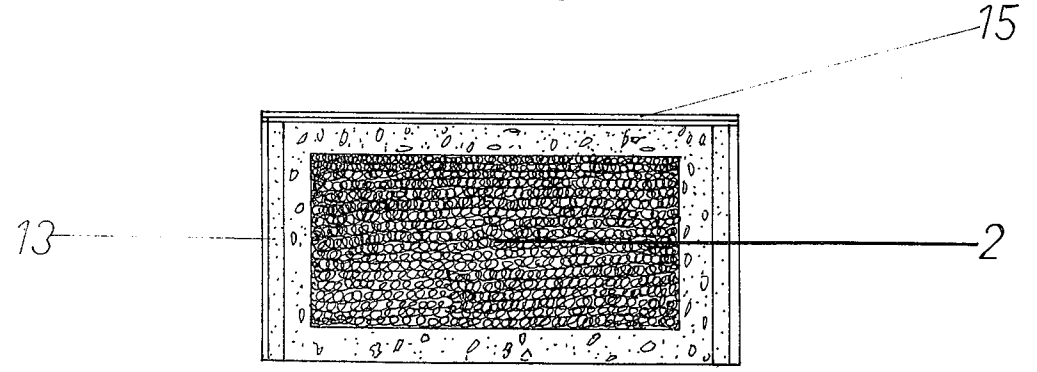


FIG. 6

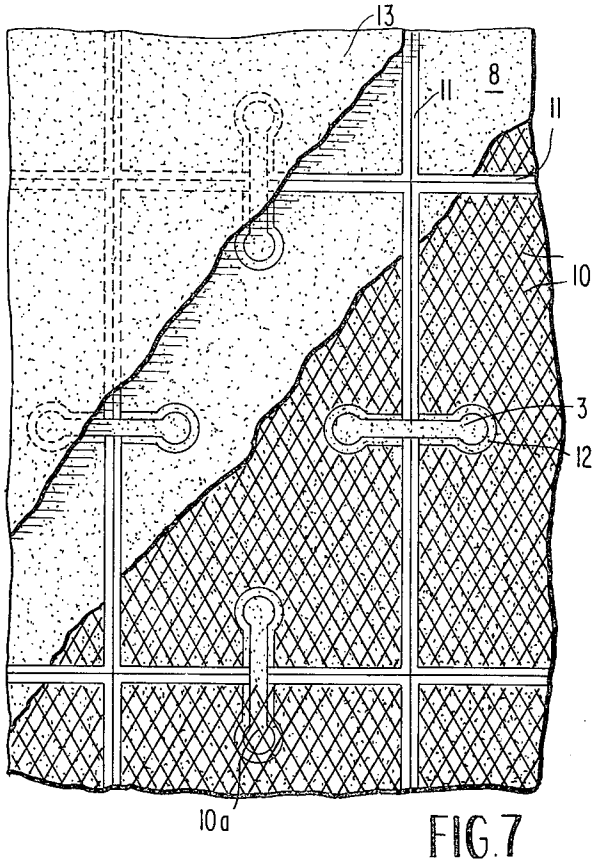


FIG.7

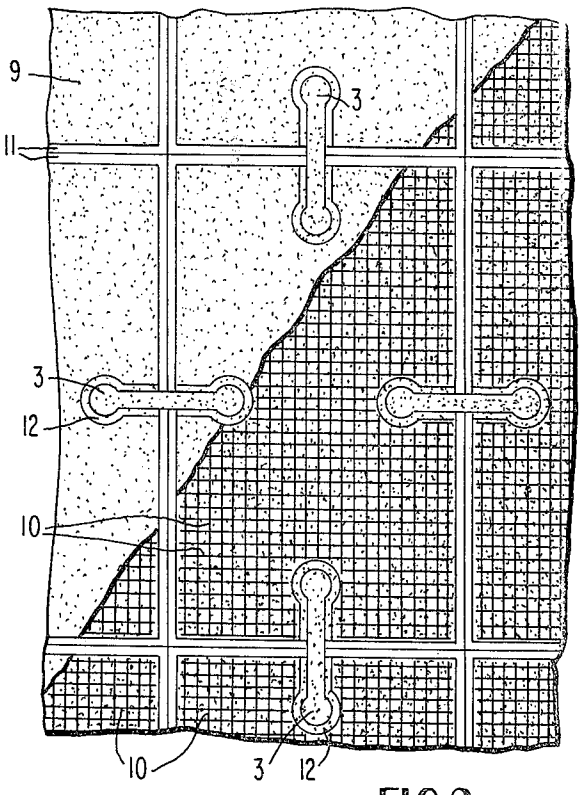


FIG.8

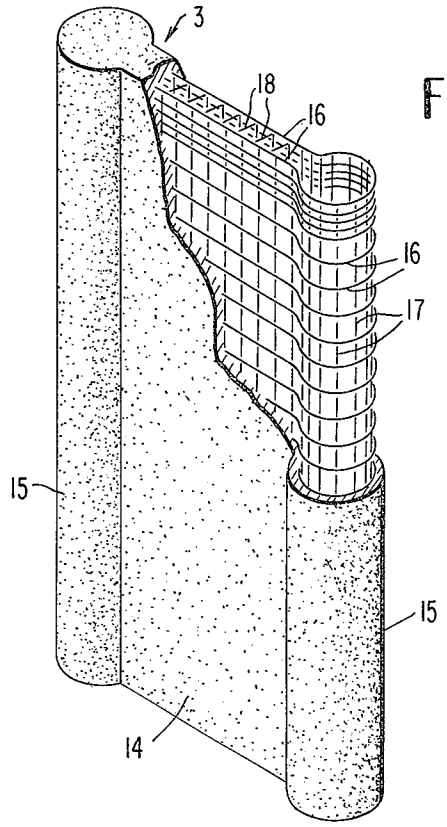


FIG.9

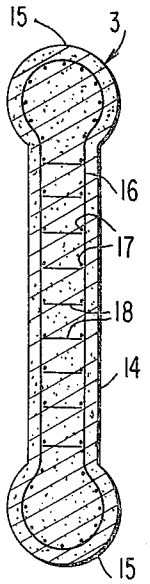


FIG.10

FLOATING AIRPORT AND METHOD OF ITS CONSTRUCTION

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of my application Ser. No. **198,252,** filed Nov. **11, 1971,** and now abandoned, entitled "Systems For Constructing Airports At Sea."

BACKGROUND OF THE INVENTION

This invention relates to a system of constructing airports at sea, its main purpose being to enable the use of coastal areas close to large cities which, due to the topography of the region as, for example, surrounding mountain ranges, lack the necessary space for the installation of a convention airport located on land.

Due to the high cost of land in coastal towns, and particularly those which have a natural barrier to growth and development, it is becoming increasingly desirable to locate the airports for such towns on remote areas of low cost, thereby leaving the available land for economical development within the city. The undesirability of placing the airports for this type of town on land located a great distance away, with the resulting high cost and loss of time required for transportation to and from the airport, has in recent years resulted in many proposals for locating such airports at sea. In accordance with this invention, the airport would be constructed on the water at considerably less expense than would be required either to fill the area to place the airport above sea level, or by draining the area and placing the airport on the bottom below sea level. In some cases, it would only be necessary to build the runways on water, and locate the terminals on solid land or on pilings, or the like. However, the possibility also exists of locating the terminals on the water with the terminals being connected to land by roadways which may be floated on the water in the same way as the runways, or by submerged tunnels, or even by air, with the necessary heliports positioned at strategic points within the city.

SUMMARY OF THE INVENTION

Essentially, the improvements in accordance with this invention consists of constructing large, hollow, waterproof reinforced concrete blocks, adding a waterproofing material to the concrete to accomplish this end, and filling the hollow centers of the blocks with expanded polyethylene or any other suitable lightweight waterproof plastic substance to form a high-strength, low density block which will float on the surface of the water. The necessary runway surfaces would be made by using reinforced concrete links poured in situ to join the rectangular blocks in rigid, side-by-side relation as they float on the surface of the water. For linkage, the blocks are formed with undercut notches in the central portion of the side faces of each block, with the notches cooperating to form keyways for the reinforced concrete links. To provide greater adherence when the concrete link is poured between the blocks and thereby keep the blocks from moving relative to one another with the impact of landing aircraft, the notches are formed with roughened surfaces.

To minimize wear of the blocks due to use of the airport and due to finite movements resulting from wave and tidal action, the concrete blocks are formed with a steel wear plate, preferably in the form of a structural

angle, extending along each edge or corner. Also, the blocks are sealed with a coating of plastic material on their outer surface to reduce wear and to avoid weakening of the concrete from physical, mechanical or chemical effects while floating in the open water.

After the blocks are linked together, a layer of bituminous paving material is applied to their top surface to give the runway the required uniformity. The bituminous material helps to distribute loads and thereby reduce the danger of damage due to high impact of landing aircraft.

The airport, when constructed, is preferably kept in position by anchoring it to the sea bottom as with steel cables which may be replaced when they are eventually corroded, or else by plastic cables which would not be corroded or otherwise effected by the salt water. The cables would be anchored to large reinforced concrete thimbles set on the bottom of the body of water.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent from the detailed description herein below, taken in conjunction with the drawings, in which:

FIG. **1** is a schematic diagram illustrating an airport constructed according to the present invention on the open water adjacent a coastal city;

FIG. **2** is a diagram similar to FIG. **1** and illustrating a floating airport adjacent an island;

FIG. **3** is a sectional view, in elevation, of the airport shown in FIG. **1**;

FIG. **4** is a perspective view of a plurality of reinforced concrete blocks constructed and joined in accordance with this invention to provide the floating support for the airport runways;

FIG. **5** is a perspective view of one of the reinforced concrete blocks shown in FIG. **4**;

FIG. **6** is a sectional view taken on line **6—6** of FIG. **5**;

FIG. **7** is a fragmentary top plan view of a runway constructed according to the invention, with portions broken away to more clearly disclose other parts;

FIG. **8** is a bottom plan view similar to FIG. **7**;

FIG. **9** is a perspective view, on an enlarged scale and with portions broken away, of a reinforced concrete linking member employed to join the blocks shown in FIGS. **7** and **8**; and

FIG. **10** is a sectional view taken on line **10—10** of FIG. **9.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail, an airport according to the present invention is illustrated as including a plurality of runways **1** floating on an open body of water. The runways are constructed from a plurality of large, hollow, reinforced concrete blocks **2** rigidly joined in side-by-side relation by reinforced concrete linking members **3** which are poured in situ in opposed undercut recesses **4** in each of the vertical side faces **5** of the rectangular blocks **2.** As seen in FIG. **6,** the hollow interior **6** of the respective blocks **2** is filled with a substantially rigid mass of foamed thermoplastic material such as polyethylene, polystyrene, or the like. The rigid foam plastic **7** may act as the inner wall of the form for casting the reinforced concrete block, if desired, or may be inserted in a separate form to enable

all the walls of the blocks **2** to be integrally cast as a single unit. Alternatively, the blocks may be cast with a filling opening in its top wall to permit the plastic core to be poured and formed in situ with the opening being subsequently sealed.

The foam plastic **7** is non-absorptive and non-soluble in water, thereby assuring against the block **2** filling with water and losing its buoyancy in the event of a crack or leak in the walls of the blocks. Also, the concrete employed to form the blocks as well as the blocking members **3** is preferably treated in a known manner with a suitable material to render it highly waterproof, and the outer surfaces of the concrete block, except the undercut recesses **4**, are coated with a layer of polymeric material to minimize wear and deterioration as by friction and chemical action, freezing, or the like.

As best seen in FIGS. **7** and **8**, the concrete slabs forming the top wall **8** and the slab forming the bottom wall **9** of the hollow concrete blocks are each reinforced with a plurality of elongated steel reinforcing rods **10**, with the rods reinforcing the top wall **8** being arranged in a diamond-shaped grid pattern, and with the individual rods **10** being positioned at an acute angle with respect to the side edges of the top panel **8**. By arranging the reinforcing rods in this diamond pattern, they provide a high-strength tie from each of the undercut recesses **4** to the recesses in the two adjacent sides of the panel. This arrangement of the reinforcing grid provides for more even distribution of the loads resulting from bending moments in the assembled runway between the linking members **3**, while at the same time providing a slab or panel which has high strength in flexure to provide support for heavy aircraft landing and taxiing thereover. The arrangement of the reinforcing rods is preferably such that at least some of the rods extend between and terminate adjacent two of the adjacent recesses **4**. Also, if desired, some of these rods may have their free ends projecting into the recesses **4** as indicated at **10***a* in FIG. **7** to be embedded in and form a rigid, high-strength joint with the connecting link which is later formed in the recess.

The grid formed by the reinforcing rods **10** employed in the bottom slab or panel **9** may be arranged in the conventional manner with the individual rods being positioned to extend parallel to the side edges of the slab. Since heavy concentrated loads such as result from the landing gear of an aircraft cannot be applied to the bottom panel **9**, the diamond grid pattern is not required to distribute the loads to the locking members **3**.

In order to minimize wear of the reinforced concrete blocks along their edges, they are reinforced with steel wear plates extending completely around the peripheral edges. Preferably, these wear plates are welded together in the form of an open framework of structural steel angles **11** which framework is positioned within the concrete form for the block before molding so that the concrete adheres directly to the surface of the wear plate. Preferably, this angle also extends in a loop **12** around the ends of the recesses **4**.

As indicated in FIG. **7**, the top surface of the top slabs **8** of the joined blocks **2** is covered, or paved, with a layer of bituminous paving material **13** to provide a continuous smooth surface for the runway. The bituminous material, which bridges the joints between the adjacent floating blocks, is sufficiently resilient to avoid cracking. Further, this layer of paving material tends to distribute loads over a wider surface, thereby avoiding or minimizing adverse effects from concentrated or impact loads.

Referring now to FIGS. **9** and **10**, it is seen that the individual linking elements, or keys **3** consist of a flat central wall portion **14** having integrally formed along its two vertical edges an enlarged, generally cylindrical portion **10**. The entire structure is reinforced by a plurality of loops **16** of reinforcing steel which are positioned more closely together adjacent the top and bottom, as indicated at FIG. **9**, and a plurality of vertically extending rod members **17**. Preferably, the horizontal loops **16** and vertical rods **17** are assembled together and tied, as by wires **18**, then positioned within the open-topped cavity formed by the pair of recesses **4** which oppose one another in a pair of the blocks positioned side-by-side. The bottom of the cavity is sealed by any suitable means before the reinforcing steel is placed therein.

After the reinforcing steel is positioned in the recesses, they are filled with concrete which is permitted to set up while the blocks are retained in their adjacent side-by-side relation. By providing roughened surfaces on the interior of the recesses, the concrete is integrally joined to the respective blocks and with the aid of the reinforcing members **16** and **17**, firmly retains the blocks so joined against relative movement even under sever loading conditions.

Referring again to FIGS. **1–3**, the airport terminal **20** may be built on a floating platform constructed from the reinforced concrete blocks joined in the manner described above with respect to the runways **1**. Further, roadways for conventional ground transportation may be provided between a staging point **21** on land by way of roads **22** constructed in the same manner as the runways **1**. Alternatively, the terminal, per se, may be constructed on land, with transportation to the aircraft on the apron **23** adjacent the runways being provided from strategic locations **24** within the city **25** by conventional helicopter buses. The apron **23**, like the terminal **20**, may be constructed on a floating platform or, where water depths are not prohibitive, the terminal and/or apron may be constructed on land fill adjacent the runways and protected by suitable breakwaters or the like. In the case of the terminal being on solid fill, transportation to the terminal may, of course, be provided by conventional highway tunnels.

In order to anchor the floating structure in position, massive reinforced concrete thimbles **26** are positioned at strategic points on the bottom of the body of water and cables **27** extending from the thimbles **26** are employed to firmly retain the floating structure in position. The cables **27** may be of corrosion resistant steel material or alternatively may be of a plastic material which will not be adversely effected by the water. The plastic cables may, in some instances be preferred in that they possess an inherent elasticity which could provide for some limited movement resulting from tides, wave action, and the like whereas special provisions might be required for such movement when steel cables are used.

While I have disclosed and described a preferred embodiment of my invention, I wish it understood that I do not intend to be restricted solely thereto, but that I do intend to include all embodiments thereof which would be apparent to one skilled in the art and which come within the spirit and scope of my invention.

I claim:

1. A floating aircraft runway constructed from a plurality of preformed modules rigidly joined to one another with their top surfaces in a common plane to define the runway, the improvement wherein said modules comprise rectangular blocks having a hollow center and having their top, bottom, and side walls integrally formed from a continuous mass of concrete reinforced with elongaged steel reinforcing members, a mass of low density cellular polymeric material filling the hollow center of said blocks to exclude water therefrom, a vertically extending undercut groove formed in each side wall of said blocks and extending the full height thereof and terminating at the top end in an opening in the top surface of said top wall, said grooves being roughened over substantially the entire surface thereof, a steel bearing plate integrally joined to and extending along the peripheral edges of said blocks, said blocks being joined in said runway in side-by-side relation with said undercut grooves in adjacent sides of joining blocks being disposed opposite one another, a reinforced concrete locking member disposed within and extending between said opposed undercut grooves, said locking members comprising an assembly of steel reinforcing rods positioned within and extending between said opposed grooves, concrete poured into the voids within and joined to the roughened surface of said opposed grooves to rigidly and permanently interlock the adjacent blocks, said reinforcing rods in said top wall being arranged in a diamond pattern with the individual rods being inclined at an acute angle with respect to the side edges of said top wall whereby a portion of the rods effectively extend between said undercut grooves on adjacent side walls of each said block, a coating of waterproof, low friction polymeric material covering at least the side walls and the bottom wall of said rectangular blocks, and a layer of resilient bituminous surfacing material covering the top walls of said blocks and forming a continuous smooth runway surface.

2. The runway as defined in claim 1 wherein at least a portion of said reinforcing members in said top wall extend into said undercut grooves and are integrally bonded into the concrete of said connecting members.

3. The runway as defined in claim 2 wherein said locking member is substantially dumbbell-shaped in horizontal cross section.

4. The method of constructing a floating aircraft runway from a plurality of preformed modules joined to one another, said method comprising the steps of casting said modules from reinforced concrete in the configuration of hollow rectangular blocks with top, bottom and side walls thereof being integrally formed from a continuous mass of concrete reinforced with a plurality of elongated steel reinforcing members, said step of casting said modules including the steps forming an elongated vertically extending undercut groove having roughened surfaces centrally of each said side wall and extending the length thereof, arranging the elongated reinforcing members in said top wall in a diamond patterned grid with the individual members inclined at an acute angle with respect to the side edges of the wall, reinforcing the peripheral edges of said modules by integrally joining a bearing plate thereto extending the full length of said peripheral edges, filling the hollow interior of said modules with a solid mass of low density polymeric material capable of excluding the water from the interior of the modules, coating the exterior surface of said modules with a waterproof coating material, securing a plurality of said modules in side-by-side relation in an open body of water with their top surfaces in a common horizontal plane and with the undercut recesses in the adjacent sides in opposed relationship to define an open-topped cavity, sealing the bottom of the cavity against the water, filling the cavity in situ by initially positioning an assembly of steel reinforcing members into said cavity with said assembly spanning said opposed undercut grooves, and filling the voids in said cavity with concrete and permitting the concrete to harden to rigidly interlock the modules, and covering the top surface of the joined modules with a resilient bituminous surfacing material to form a smooth continuous runway surface.

5. The method as defined in claim 4 further comprising the steps of anchoring selective ones of said modules to submerged weights within the body of water by use of cables.

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