Sept. 29, 1959 L. B. DE LONG ET AL 2,906,100

METHOD OF OPERATING PORTABLE MARINE STRUCTURE

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FIG. 1.

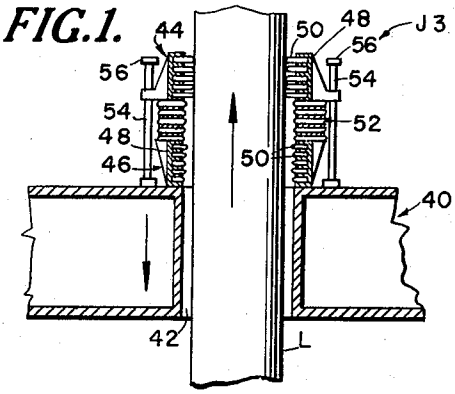


FIG. 2.

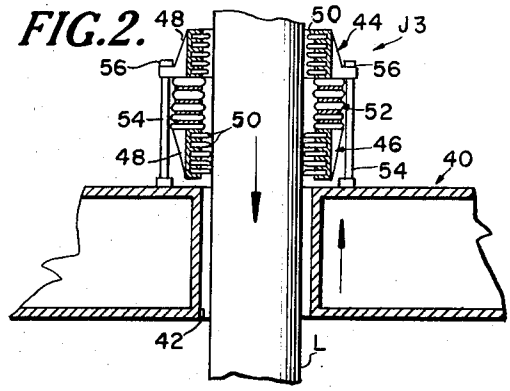


FIG. 4.

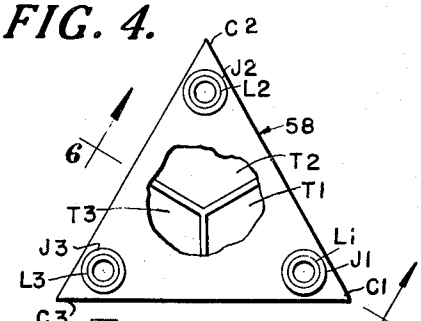


FIG. 5.

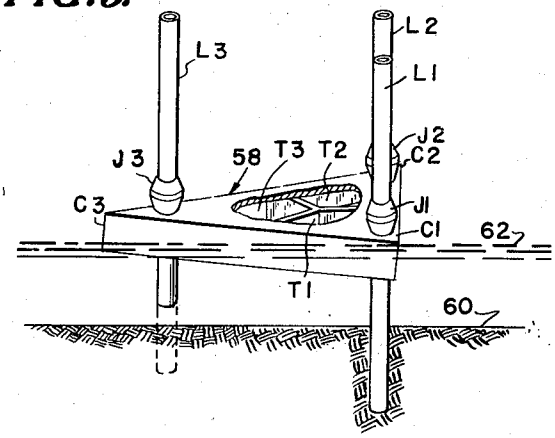


FIG. 3.

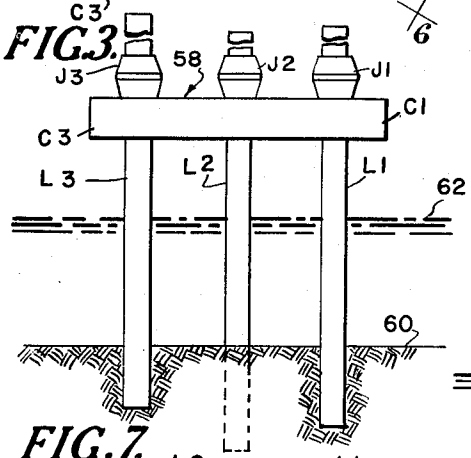


FIG. 6.

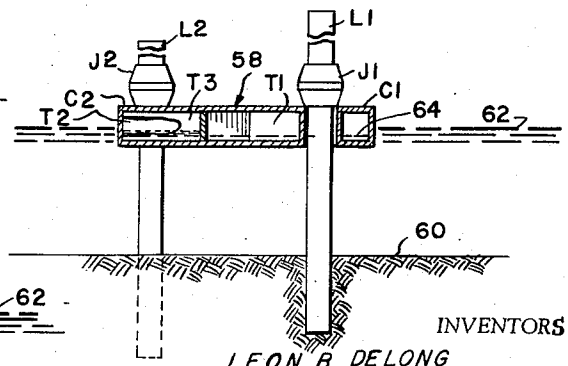
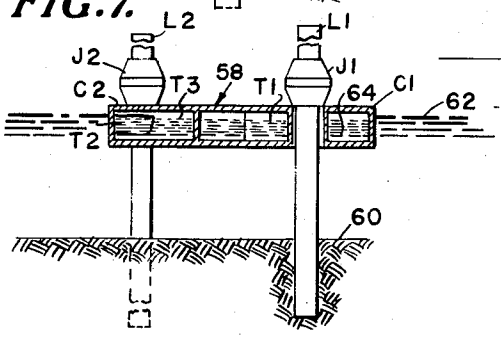


FIG. 7.



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FIG. 9.

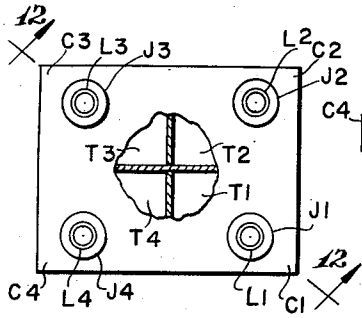


FIG. 8.

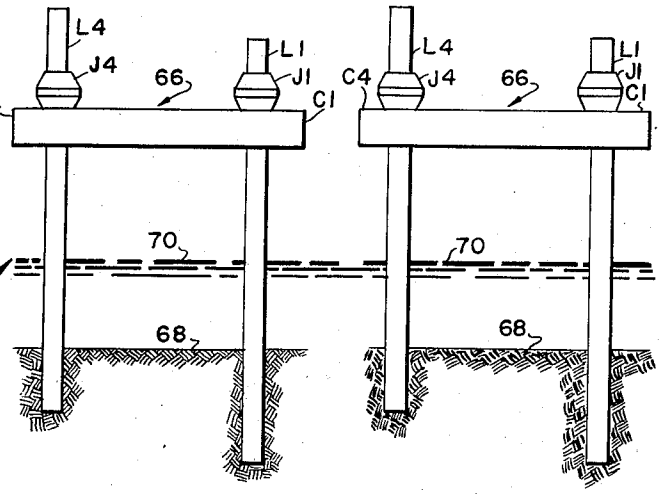


FIG. 10.

FIG. 11.

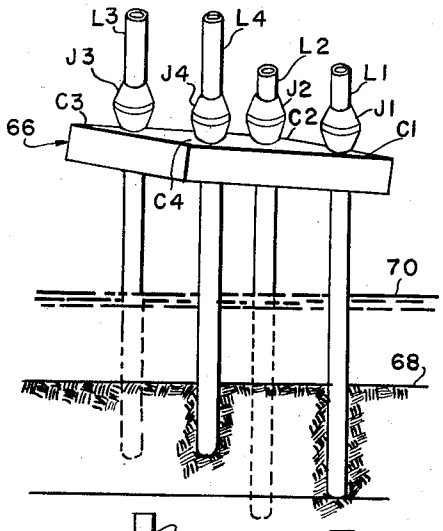


FIG. 12.

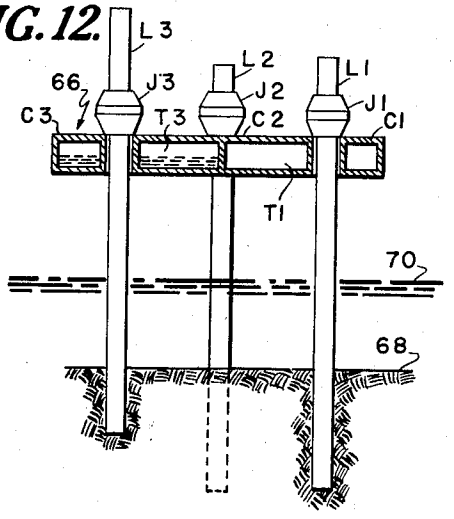
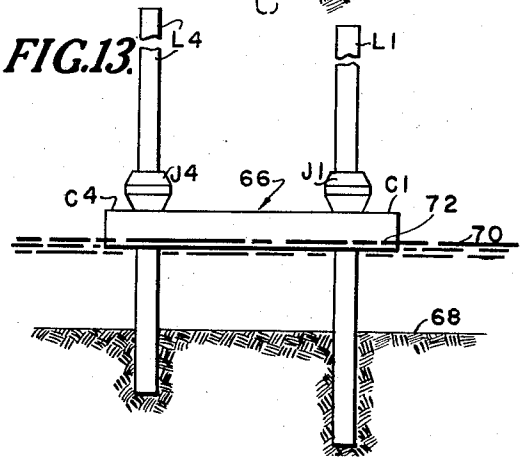


FIG. 13.



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FIG. 16.

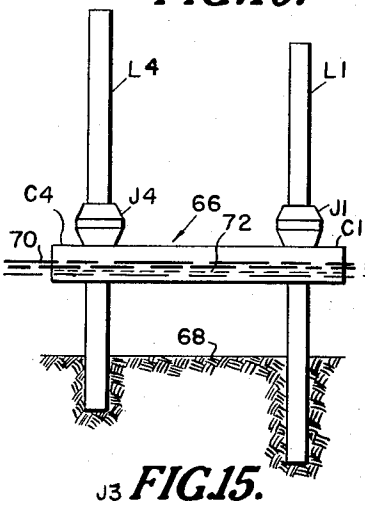


FIG. 18.

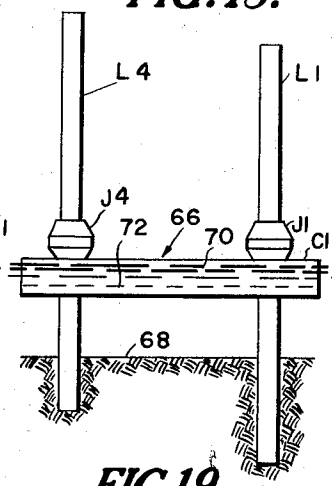


FIG. 14.

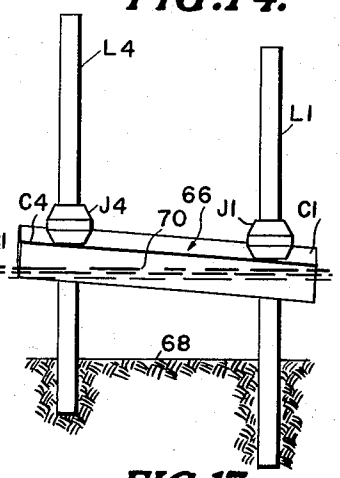


FIG. 15.

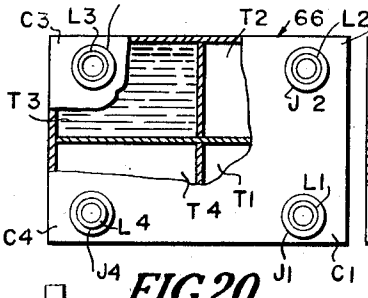


FIG. 19.

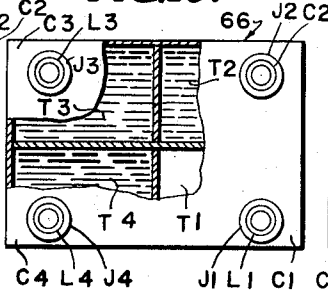


FIG. 17.

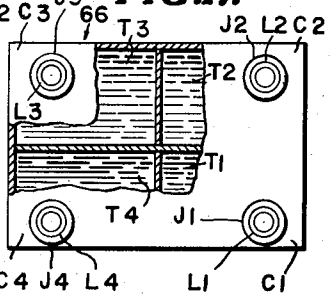


FIG. 20

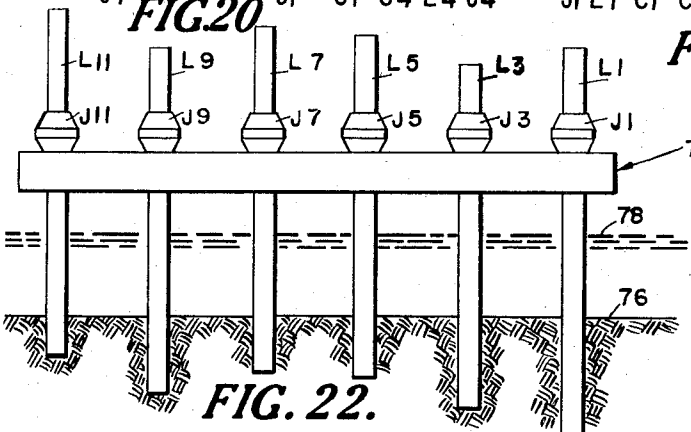


FIG. 21.

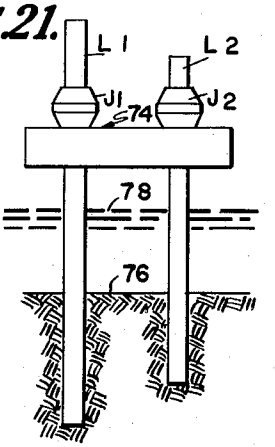
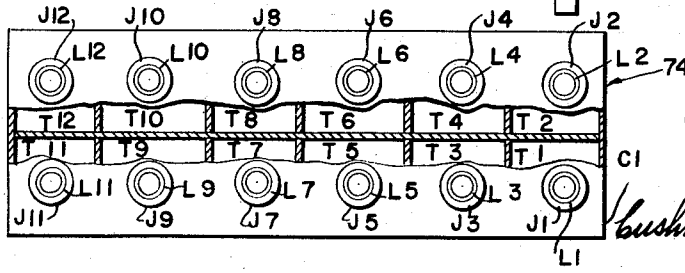


FIG. 22.



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United States Patent Office 2,906,100 Patented Sept. 29, 1959

2,906,100

METHOD OF OPERATING PORTABLE MARINE STRUCTURE

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Application May 16, 1955, Serial No. 508,762

13 Claims. (Cl. 61—46.5)

This invention relates to portable, above-water marine platforms, which may be in the nature of a dock or in the nature of an offshore installation. More particularly, this invention relates to methods of operating and manipulating apparatus which can be erected at any selected site as an above-water marine platform, and at any subsequent time moved to another location for erection thereat, such apparatus generally embodying the teachings of the co-pending application of Robert W. Pointer, Serial No. 283,567, filed April 22, 1952.

In the aforementioned application, there is disclosed a barge having a buoyant hull equipped with a plurality of extensible upright supporting elements or legs. Such legs are there disclosed as caissons which are loosely mounted for vertical movement relative to the hull in corresponding guiding means in the form of wells in the latter. Jacks are mounted on the hull and are releasably engageable with each caisson for forcefully effecting relative vertical movement in either direction between each caisson and the hull, that is, such jacks can extend or retract the caissons. The jacks also can be operated to prevent such relative vertical movement. In use of this apparatus, the barge can be floated to any selected marine location and the caissons moved down to engage with the marine bottom while the hull is still afloat. Thereafter, by operation of the jacks, the hull can be raised to any desired elevation on the caissons and supported thereon, to thus provide a stable marine platform which can be used as a dock, as a base for drilling operations, or for any other appropriate purpose. When it is desired to move the platform to another location, the hull is lowered by the jacks back down into the water until the hull is again afloat. Thereupon, the caissons are pulled up by their jacks out of engagement with the marine bottom and the entire apparatus floated to another erection site.

Certain problems are encountered in the operation of the aforementioned type of portable, above-water marine platform. In particular, such apparatus is presently in use for oil drilling in the Gulf of Mexico, and the marine bottom in certain areas of the Gulf of Mexico, as well as in other locations, is composed for the most part of a deep layer of alluvial mud, that is, a mixture of silt and water overlying harder understrata. In its upper portions, the mud layer may contain as much as 80 percent water, while its deeper parts have small water content. Because of the nature of this type of marine bottom, the supporting legs of the aforementioned type of above-water marine platform tend to sink deeply into the mud when supporting the weight of the platform and the supplies and equipment carried thereby. In fact, when the platform is being erected, each supporting leg is deliberately driven to refusal into the marine bottom in order to prevent settling of any one of the supporting legs deeper into the mud after a prolonged bearing therein. Methods for so driving the supporting legs are described with particularity in the co-pending application of Showalter et al, Serial No. 461,454, filed October

11, 1954. In actual practice, supporting legs in the form of tubular steel caissons of the order of 6 feet in diameter have been driven to depths of the order of 70 feet into the marine bottom of the Gulf of Mexico by the methods described in the aforementioned Showalter et al application.

Because the supporting legs of above-water marine platforms of the aforedescribed type are driven deeply into a soft marine bottom, there are problems involved in pulling the legs out of the mud before the platform can be moved to another location. When a supporting leg penetrates deeply into a soft marine bottom, the lower portions of the leg tend to become substantially rigid in the mud, so that the latter tends to pack and settle around the legs and substantially freeze the leg in the bottom. Hence, in many cases the mud exerts a gripping action on the legs that can be overcome only by a pulling force in excess of the maximum force that can be exerted by a single jack on a stuck leg. This situation can also exist even when a supporting leg is equipped with a spread footing. When apparatus of the aforedescribed type is erected in locations where the marine bottom is not particularly soft, a force in excess of that exertable by a single jack may still be required to pull a leg out of the marine bottom. A leg may become so stuck in a relatively hard bottom because the leg has been driven thereinto with a pile-driving hammer, or the like. Furthermore, even in an ordinary mud bottom, wherein a leg does not penetrate very deep, the force required to pull a leg therefrom may become excessive.

Additional problems exist in the pulling of a stuck leg other than those encountered by the inherent limitation of the pulling force of any one jack. In particular, the imposition of a pulling force on a leg creates an equal and opposite reaction force on the barge or platform. In many instances, such reaction force is sufficient to cause the platform to tilt. When such a tilting action occurs, the resulting angularity, though small, between the stuck leg and its guide means on the platform tends to cause a binding action between the guide means and the leg. Such a binding action renders the pulling of a stuck leg even more difficult. Furthermore, the continued application of a pulling force on a stuck leg, when the latter is at the limit of its possible angularity with respect to its guiding means on the platform, imposes a strong bending force on the leg. Such a bending force in many instances may become large enough to actually bend and damage the supporting leg, whether it is in the form of a caisson as described heretofore or in the form of an openwork tower. It also is pointed out that the large force sometimes needed to pull a stuck leg also can impose dangerously high stresses in the barge hull. Such stresses can be particularly severe when the stuck caisson is located adjacent a corner of a generally rectangular hull, so that the danger of breaking off the corner actually can arise.

Consequently, an object of this invention is to provide novel methods for pulling stuck supporting legs of a portable, above-water marine platform of the type under consideration.

It is another object of this invention to provide novel methods for pulling such stuck legs which will avoid a binding action between the legs and their guiding means on a platform.

It is still another object of this invention to provide methods for pulling a stuck leg of a portable marine platform of the type under consideration which will prevent the imposition of excessive bending forces on the stuck leg.

It is another object of this invention to provide methods for pulling a stuck leg of a portable marine platform of

the type under consideration which will prevent the imposition of excessive stresses on the platform.

It is a further object of this invention to provide novel methods for pulling stuck legs of a marine platform of the type described which will enable the imposition of a pulling force in excess of the maximum force exertable by the corresponding pulling instrumentality.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawings, in which:

Figure 1 is an enlarged, fragmentary, vertical sectional view illustrating jack mechanism of the type which can be utilized for practicing methods involving this invention. The jack is shown mounted on a marine platform and exerting an upward force on a platform supporting leg.

Figure 2 is a view corresponding to Figure 1 but showing the jack mechanism exerting a downward force on a platform-supporting leg.

Figure 3 is an elevational view of an erected, generally triangular, marine platform having three supporting legs, the platform being of the type to which the methods embodying this invention are applicable.

Figure 4 is a plan view of the platform shown in Figure 3, with parts broken away to illustrate details.

Figure 5 is a perspective view of the platform shown in Figure 3 illustrating the normal result of an attempt to pull one of the platform-supporting legs free of the grip of the marine bottom.

Figure 6 is a vertical sectional view taken substantially on line 6—6 of Figure 4 and illustrating a step in one of the methods embodying this invention.

Figure 7 is a view corresponding to Figure 6 but illustrating a step in another of the methods embodying this invention.

Figure 8 is a view corresponding to Figure 3 but illustrating a rectangular platform having four supporting legs.

Figure 9 is a plan view of the platform shown in Figure 8, with parts broken away to illustrate details.

Figure 10 is a view corresponding to Figure 8 but illustrating a step in a method embodying this invention.

Figure 11 is a perspective view of the platform illustrated in Figure 8 showing the normal result of an attempt to pull one of the supporting legs free of the grip of the marine bottom.

Figure 12 is a vertical sectional view taken substantially on line 12—12 of Figure 9 and illustrating a step of one of the methods embodying this invention.

Figure 13 is a view corresponding to Figure 8 but showing the platform lowered back down into the water and afloat before the supporting legs are pulled up from their engagement in the marine bottom.

Figure 14 is a view corresponding to Figure 13 but illustrating the normal effect of an attempt to pull up one of the supporting legs free of the grip of the marine bottom.

Figure 15 is a plan view of the platform shown in Figure 13 with parts broken away to illustrate details and showing a step in one of the methods embodying this invention.

Figure 16 is an elevational view of the platform shown in Figure 15.

Figure 17 is a plan view of the platform shown in Figure 13 with parts broken away to illustrate details, and showing a step in one of the methods embodying this invention.

Figure 18 is an elevational view of the platform shown in Figure 17.

Figure 19 is a view corresponding to Figure 17 and illustrating a step in one of the methods embodying this invention.

Figure 20 is a side elevational view of an erected platform having more than four supporting legs, the platform being of the type to which the methods embodying this invention are applicable.

Figure 21 is an end view of the platform shown in Figure 20.

Figure 22 is a plan view of the platform shown in Figure 20, with parts broken away to illustrate details.

Referring now to Figures 1 and 2 of the drawings, there is shown a jack J of the type disclosed in the aforementioned Pointer application mounted on a platform 40, which may be in the nature of a barge having a buoyant hull, for releasable engagement with a platform supporting element or leg L. The leg L in this instance is illustrated as a hollow circular steel caisson that is somewhat loosely slidably guided for substantially vertical linear movement relative to the platform 40 in a guiding well 42 that extends vertically therethrough. The guiding well 42 is of a diameter slightly greater than that of the caisson mounted therein so as to somewhat loosely receive and linearly guide the latter. In an actual operating embodiment, the caisson is of the order of six feet in diameter uniformly throughout that section of the length thereof receivable in its well, while the latter is about six feet, one inch in diameter. Consequently, it will be seen that it is possible for the leg L to cant slightly in its well 42. In Figures 1 and 2 of the drawings, the clearance between the caisson L and its well 42 has been greatly exaggerated for illustrative purposes only.

Although all of the supporting legs shown herein have been illustrated as caissons, it is to be understood that this invention is applicable to and may be practiced with hulls or platforms having upstanding, supporting legs of any type, whether of an openwork tower-like construction or of the caisson-like construction shown herein. Furthermore, it will be realized that the invention can be practiced with supporting elements or legs of any suitable configuration in cross section.

The jack J is secured to the platform at the well and is disposed in surrounding relation to the leg L. Since a detailed description of such jack J is given in the aforementioned Pointer application, a detailed description here would be unnecessarily repetitious. It is sufficient to point out that the jack shown in Figures 1 and 2 includes vertically spaced upper and lower gripper sections 44 and 46, each comprising a caisson-surrounding rigid collar or sleeve 48 having a plurality of inner circumferential channels within which are disposed hollow fluid-pressure-constrictable resilient rings 50 for positively yet releasably gripping the caisson L. Between the upper and lower sections 44 and 46 is a caisson-surrounding fluid-pressure-expansible bellows-like section 52 capable of exerting a powerful but controllable force to move the upper and lower jack sections apart, while several pressure-cylinder retractors (not shown) are spaced about and connected to both the upper and lower jack sections to draw them toward each other when the bellows 52 is exhausted.

Abutment means are provided on the platform 40 to limit both downward movement of the lower jack section 46 relative to the platform and upward movement of the upper jack section 44 relative to the platform. In the embodiment of the jack shown herein, the lower gripper section 46 is engageable against the deck of the barge 40, while the upper gripper section 44 is fastened to the barge by a plurality of tie rods 54, usually about four such rods being arranged circumferentially about the jack J. The upper gripper section 44 is slidable on the rods 54, but upward movement of such section relative to the rods is limited by heads 56 on the latter engageable by the upper gripper section. The connection between the upper gripper section 44 and the rods 54, or the connection of the rods to the platform 40, is such that the entire jack J can move slightly in any transverse direction relative to the guiding well 42 and also can cant with the leg L as the latter cants in its well.

As described more in detail in the aforementioned Pointer application, even jack J can be operated to impart step-by-step vertical linear relative movement in either

direction between the leg L and the platform 40. Thus, for example, in order to move the leg L upwardly relative to the platform 40, as shown by the upwardly pointing arrow in Figure 1, the lower jack section 46 engages the deck of the platform, the upper jack section 44 is engaged with or grips the leg L, and the bellows 52 is inflated. It further will be realized that if the leg L is stuck in a marine bottom and the jack J is operated, as shown in Figure 1, in an attempt to pull the leg, there will be a reaction force on the platform 40, equal to the force being exerted by the jack on the leg L in an attempt to pull the latter. Such reaction force is indicated by the downwardly pointing arrow in Figure 1.

When the jack J is being operated to exert a downward force on the leg L to move the latter downwardly relative to the platform 40, as indicated by the downwardly-pointing arrow in Figure 2, it will be seen that the upper jack section 44 is engaged against the heads 56 of the tie rods 54 while the lower jack section 46 is engaged with or grips the leg, so that by inflating the bellows 52 the leg will be formed downwardly relative to the platform. Again, there is an opposite reaction force on the platform 40 as indicated by the upwardly-pointing arrow in Figure 2. This operation normally will be carried out only when the leg L is engaged with a marine bottom, and by operating the jack J in the manner shown in Figure 2, the leg will continue to be driven deeper into the marine bottom until the resistance to further penetration of the leg thereinto becomes substantially equal to the force exertable on the leg by the jack without lifting the platform. When a plurality of legs are engaged with a marine bottom and have been so driven to refusal, continued operation of the jacks in the manner shown in Figure 2 will serve to raise the platform on the legs.

It also will be seen that the jack J can be operated to prevent any relative vertical movement between the leg L and the platform 40. In this operation the upper section 44 is engaged with the tie rod heads 56 and the leg L and the lower section 46 is engaged with the deck of the platform 40 and the leg. Normally, the bellows 52 will be fully inflated to so position the jack sections 44 and 46. As is also described in detail in the aforementioned Pointer application, controls (not shown) are provided for a plurality of jacks to enable their selective individual operation or their operation in unison.

It also is pointed out that other types of jacks which operate on somewhat the same general principles as the Pointer jack can be employed for practicing this invention. Additionally, the methods of this invention can be practiced with other types of mechanisms for forcefully moving upright supporting legs vertically in either direction relative to the platform or for restraining such movement, so that the practice of this invention is not necessarily limited to the employment of a jack type of apparatus for forcefully effecting relative vertical movement between a supporting leg and a platform. It is pointed out, however, that the amount of movement-effecting force developed by any moving instrumentality is inherently limited by the size of the moving instrumentality and that economy dictates a limitation on the size of any moving instrumentality.

Platform having three supporting legs

Referring now to Figures 3 and 4 of the drawings, there is shown a portable marine platform of the type with which this invention is concerned. In this instance, the apparatus is shown as a generally triangular buoyant platform 58 having three supporting legs L1, L2, and L3, in the form of caissons, extending through corresponding guiding wells in the platform and operated by corresponding jacks J1, J2, and J3 of the aforedescribed type. The supporting legs L are located at the corner portions C1, C2, and C3 of the platform 58 in order to provide stable support for the latter when it is in its erected position shown in Figure 3 wherein the supporting legs L have engaged and penetrated at various depths into a marine bottom 60 and the platform has been elevated above the surface 62 of the water by operation of the jacks J. As stated heretofore, certain marine bottom conditions, such as those existing in the Gulf of Mexico, require the legs L to penetrate quite deeply into a marine bottom before they reach a bearing sufficient to support the weight of the platform when the latter has been elevated out of the water sufficiently to eliminate or substantially eliminate its buoyancy support, and such deep penetration is shown in Figure 3.

When it is desired to move the erected platform 58 to another location, the problem arises of pulling the supporting legs L loose from the marine bottom 60. As previously described, no upward pull can be exerted by a jack J on its corresponding supporting leg L without exerting an equal and opposite downward reaction force on the platform 58. In the present instance, when the platform 58 is elevated out of the water, as shown in Figure 3, and an upward pull is exerted on any one leg L by its jack J, the resulting downward reaction force on the platform will be substantially unopposed, because the platform is supported at only two other locations, i.e., by the other two legs. The result will be to tilt the platform 58. Hence, if a platform is of generally triangular configuration and has only three supporting legs, i.e., one at each corner, the platform must be lowered back down into the water for buoyancy support before the supporting legs can be pulled up.

When the platform 58 has been so lowered by the jacks J and is afloat, the normal manner of pulling up all of the legs L from the marine bottom is to operate all of the jacks in unison. Before this is done, however, it is desirable to assure that each leg L can be pulled loose from the marine bottom 60 without the use of an excessive pulling force. Hence, the first step is to operate each jack J in succession in a direction to pull its corresponding leg L slightly. If each leg L can be moved up slightly by its jack J, without the corresponding reaction force causing the platform 58 to tilt excessively, the next operation preferably will be to operate all of the jacks individually until the lower ends of the deeper penetrating legs, i.e., L1 and L2 as shown in Figure 3, are on substantially the same level as the lower end of the shallowest penetrating leg, i.e., L3. All of the jacks usually are then operated in unison to pull up all of the legs L at the same rate so that the lower ends of the latter will clear the marine bottom 60 at substantially the same time. Hence, the platform 58 can float free without being pinned to the bottom 60 by any one leg L. Thereafter, the entire apparatus can be floated, as by a tug (not shown) to another erection site.

In many instances, however, it will be found that a leg, e.g. L1, will be gripped so tightly in the marine bottom 60 that the reaction force developed by independent operation of its jack J1 in an effort to pull it loose will merely force the corresponding corner portion C1 of the platform 58 lower into the water, as is shown in Figure 5. This forceful tilting of the platform 58, if continued, not only eventually will cause all the legs L to become tightly bound in their wells or other equivalent guides, but also obviously will exert a strong bending force on all the legs. Hence, as previously pointed out, continued efforts to pull a stuck leg by its jack might possibly severely damage all the legs as well as impose dangerous stresses on all the guiding wells and those portions of the platform adjacent thereto.

The aforedescribed difficulties can be avoided, however, by the methods embodying this invention. One of such methods involves counterbalancing the platform 58 so that it will remain on an even keel, i.e., substantially level in the water, while a strong upward pull is being exerted upon the stuck leg L1 by its jack J1. This leveling of the platform 58 can be accomplished by releasing the jacks J2 and J3 on the legs L2 and L3, and slowly

adding weight to that portion of the platform remote from the leg L1, i.e., the portion between the legs L2 and L3, in a manner to cause that portion to sink deeper in the water and maintain the platform substantially level as the corner C1 tends to be pulled down while the jack J1 is being operated to pull the stuck caisson L1. This added weight may take the form of heavy equipment, e.g., a crawler crane, portable air compressors, or the like (not shown), carried in some instances upon such a platform, which can be shifted to the general area between the two legs L2 and L3 to counteract the tilting effect caused by the reaction force of the jack J1 on the platform 58. In the event that such heavy equipment will not be available or will not be heavy enough, the platform 58 can be prefabricated with a number of interior buoyance tanks, such as the three tanks T1, T2, and T3 shown in Figure 4, and by controllably flooding the tanks T2, and T3, sufficient weight can be added slowly to that portion of the platform 58 opposite the corner C1 to maintain the platform level, as shown in Figure 6, while the jack J1 is being operated with increasing force in an attempt to free the stuck leg L1.

When the stuck leg L1 starts to come loose, all of the jacks J are immediately actuated to grip their legs L and restrain relative vertical movement between the latter and the platform 58 to hold the platform in a stationary position. That is, the jacks J are operated to prevent the corner portion C1 of the platform from bobbing up unduly and thus tilting the platform sufficiently to cause possible damage to the legs L and/or their wells. While the platform 58 is held in such a stationary position, the water ballast is then unloaded from the tanks T2 and T3 or evenly distributed among all the tanks T and the jacks are then operated to level the platform if it is out of level. Thereupon, all of the jacks J are operated in unison to control the rise of the platform 58 to its normal draft, as indicated, for example, by the dotted line 64 in Figure 6, as the tanks T are pumped dry. After its normal draft 64 has been reached, the jacks J are operated to pull all the legs L clear of the marine bottom 60 as described hereinbefore in order to float the apparatus to another erection site.

During the course of the foregoing operation of freeing the leg L1 from the grip of the marine bottom 60 thereon, it will be seen that the pulling force exerted by the jack J1 is opposed primarily by the buoyancy of the corner tank T1. As stated heretofore, however, the pulling force exertable by any one jack J on its leg L is inherently limited by the size of the jack. Consequently, the maximum pulling force exertable by the jack J1 on the leg L1 may be insufficient to loosen the latter in the marine bottom 60. Additionally, this force normally is not great enough to force the corner C1 of the platform 58 down into the water to any great extent below the normal draft 64 of the platform 58. In this connection, the tilt-down of the corner C1 shown in Figure 5 has been greatly exaggerated for illustrative purposes only. Of course, as the corner C1 is forced deeper and deeper into the water, more and more of the latter is displaced so that the buoyancy force opposing the pulling force of the jack J1 correspondingly increases. Hence, at the maximum pulling force exertable by the jack J1 without loosening the stuck leg L1, normally there still will be a considerable amount of freeboard at the corner of the platform 58.

In such an event, wherein the maximum pulling force of the jack J1 is insufficient to free the leg L1 by the aforedescribed procedure, this invention also provides a method whereby a pulling force in excess of that exerable by the jack J1 may be imposed upon the stuck leg L1 in an effort to loosen the latter from the marine bottom 60. For this purpose, all of the jacks J are disengaged from their respective legs L and all of the tanks T are slowly flooded substantially equally to sink the platform 58, while maintaining it level, deeper in the water until a substantially minimum uniform freeboard is obtained as shown in Figure 7. At this point, the jack J1 is engaged with the stuck leg L1 to restrain any relative vertical movement between the latter and the platform 58, and water is slowly pumped from the tank T1. As the tank T1 is slowly emptied of water, the corner portion C1 of the platform becomes more and more buoyant, and eventually a buoyancy force will be obtained in excess of the maximum pulling force exertable by the jack J1. This buoyancy force normally will be sufficient to loosen the leg L1 from the marine bottom 60. In this connection, it will be seen that water is allowed to remain in the tanks T1 and T2 so that the platform 58 will not tilt during the deflooding of the corner tank T1. Such tilting possibly would occur even if the jacks J2 and J3 were engaged with their legs L2 and L3 because the latter are assumed to be loose, i.e., not stuck, in the marine bottom 60.

As soon as the leg L1 starts to break loose in the marine bottom 60, the tanks T2 and T3 are started to be de-flooded to prevent tilting of the platform 58. Additionally, at this time, all of the jacks J are appropriately operated to exert opposed forces between their respective legs L and the platform 58 to control the latter while it is rising due to its increased buoyancy. In other words, as the tanks T2 and T3 are being deflooded, all the jacks J must be operated to maintain the barge 58 substantially level, until all of the tanks T have been de-flooded and the barge is at its normal draft 64 and in a level position. Were the platform 58 allowed to tilt appreciably during the foregoing procedure, possible damage to the legs L or to the structure of the platform obviously could occur.

It will be seen that in some instances, more than one of the legs L might be stuck quite tight in the marine bottom 60. In the event that it is found that all of the legs are so stuck, after the platform 58 has been lowered back down into the water until it is afloat, all of the jacks J can be operated in unison to the maximum extent of their pulling force in an effort to free the stuck legs. This simultaneous pulling operation of all of the jacks J obviously will force the entire platform 58 deeper into the water while maintaining it substantially level. Consequently, if one of the stuck legs L starts to break loose, all of the jacks J must be operated in a manner to maintain the platform 58 on an even keel, while the jacks J are being operated to allow the platform to rise on the legs to its normal draft 64.

If the foregoing procedure does not loosen any or all of the three stuck legs L, the jacks J can be disengaged from the legs and all three tanks T evenly flooded until the platform 58 has sunk to a minimum freeboard, as shown in Figure 7. Thereupon, the jacks J are re-engaged with the legs L to restrain any relative vertical movement between the latter and the platform and all the tanks T are evenly and slowly de-flooded. By this procedure a buoyancy pulling force can be developed on each of the three stuck legs normally greatly in excess of the pulling force exertable by any one of their jacks J. Again, if any one of the three stuck legs L starts to break loose in the marine bottom 60, all the jacks J must immediately be operated in a manner to maintain the platform 58 level.

Assuming that one of the three stuck legs L has been loosened so that it can be pulled up readily by the operation of its jack J, there will remain two legs stuck in the mud. Thus, for example, assuming that leg L1 has been loosened and that legs L2 and L3 remain stuck, the latter two legs can be loosened by procedures similar to those outlined hereinbefore. First of all, an attempt can be made to free either or both of the two stuck legs L2 and L3 by exerting simultaneous pulling forces thereon by their respective jacks J2 and J3. To avoid tilting of the platform 58, the jack J1 is released and weight slowly added to the corner portion C1 of the

platform, as by flooding the tank T1, to cause such portion to sink deeper into the water and thus maintain the entire platform 58 substantially level as the two corner portions C2 and C3 are being forced deeper into the water by the reaction force exerted thereon by the jacks J2 and J3 in their efforts to pull the two stuck legs L2 and L3. If either or both of the two legs L2 and L3 are loosened in the marine bottom 60 by this procedure, the tank T1 is immediately started to be de-flooded to prevent tilting of the platform. Also, as the corner C1 tends to rise because of its increasing buoyancy, all of the jacks J are operated in a manner to cause the platform 58 to rise to its normal draft 64 without becoming appreciably out of level.

If the aforedescribed procedure fails to loosen the two stuck legs L2 and L3, all of the jacks J can be released, and all of the tanks T flooded substantially equally to thus sink the platform 58 deeper in the water until it has substantially minimum freeboard. At this time, the jacks J2 and J3 are operated to restrain relative vertical movement between the platform 58 and the legs L2 and L3 and the two tanks T2 and T3 are slowly de-flooded. Thus, the buoyancy of the two corner portions C2 and C3 will slowly increase until an upward pulling force is exerted on the two stuck legs L2 and L3 in excess of the maximum pulling force exertable thereon by their respective jacks J2 and J3. As previously stated, such force normally will be sufficient to loosen either or both of the stuck legs L2 and L3 in the marine bottom 60. Again, when either or both of the two stuck legs L2 and L3 start to break loose in the marine bottom, the tank T1 is started to be de-flooded and all of the jacks are operated to maintain the platform 58 substantially level while it rises to its normal draft 64.

Platform having four supporting legs

Referring now to Figures 8 and 9 of the drawings, there is shown another type of portable marine platform embodying apparatus with which this invention is concerned. In this instance, the apparatus is shown as a generally rectangular buoyant platform 66 having four supporting legs L1, L2, L3, and L4, one located adjacent each corner portion C1, C2, C3, and C4, in the form of caissons extending through corresponding guiding wells in the platform and operated by jacks J1, J2, J3, and J4 of the aforedescribed type. The platform 66 is shown erected in Figure 8 wherein the supporting legs L have engaged and penetrated at various depths relatively deeply into a soft marine bottom 68, and the platform has been elevated above the surface 70 of the water on the legs by operation of the jacks J.

As hereinbefore described with reference to a three-legged triangular platform, when the platform 66 is to be moved to another location, it is desirable to assure that each leg L can be pulled up easily out of the marine bottom 68 before all the legs are raised in unison as described hereinbefore. When a platform is supported by more than three leg, such initial procedure can be accomplished before the platform is lowered back down into the water into its floating condition. This is highly desirable since it shortens the time of transition of the apparatus after the platform is in the water from its bottom-pinned to its free floating condition, which shortened transition time is greatly advantageous if heavy seas are running. Hence, before the platform 66 is lowered back down into the water by operation of the jacks J, each jack can be operated in succession in a direction to pull its corresponding leg L slightly because the platform will be substantially stably supported by the other three legs. In other words, the reaction force of any one jack J, if not excessive, will not force down the corresponding corner C of the platform 66 because of the counterbalancing weight of the diagonally opposite corner portion and the weight and bottom-grip on the leg thereat when the jack of the latter restrains vertical movement of the same relative to the platform.

If a leg L can be moved up slightly by its jack J, as indicated, for example, by the dotted line showing of leg L4 in Figure 10, the leg will be able to be pulled up completely by its jack when the platform 66 is lowered back down into the water. Frequently, however, the aforedescribed testing procedure will reveal that one, or possibly more, of the legs L is gripped tightly by the marine bottom 68, so that the aforedescribed testing procedure merely serves to force down the corresponding corner C of the platform 66 when the leg-pulling force of the jack J begins to overcome the aforedescribed counterbalancing effect of the diagonally opposite corner portion and leg thereat. In such an event, the following procedure may first be attempted in order to try to free a stuck caisson.

First of all, all of the loosened legs L are driven back down to a firm bearing into the marine bottom 68 by operation of their jacks J. Thus, for example, assuming that leg L1 is stuck and the remaining legs L2, L3, and L4 are loose, after the aforedescribed testing procedure the latter legs L2, L3, and L4 are driven back to a firm bearing, i.e., their original bearing, in the marine bottom by their respective jacks J. Thereupon, the jacks on the legs L2, L3, and L4 are engaged with their legs in a manner so that no relative vertical movement can occur between the three legs L2, L3, and L4 and the platform 66. The jack J1 for the stuck leg L1 then is operated to exert a pulling force on the latter, with the consequent development of an equal downward reaction force on the corner portion C1 of the platform 66. This reaction force, which obviously urges the corner portion C1 downwardly, is opposed primarily by the support afforded by the two legs L2 and L4, so that the reaction force also tends to raise the diagonally-opposite corner portion C3 of the platform 66. If the leg L3 holds fast in the marine bottom 68, the platform 66 will not tilt, but if the leg L3 pulls loose from the marine bottom, and it is assumed to be loose therein, the corner C1 will drop and the corner C3 will rise, and thus tilt the platform as shown in Figure 11. As aforedescribed, such a condition is highly undesirable, because all the legs L will immediately start to bind in their wells as soon as the limit of angularity between each leg and its well is reached. This binding action serves to reduce the effective pulling force exertable on the leg L1 by its jack J1 and also to impose strong and possible damaging bending forces on all the legs and possibly damaging stresses on their wells and associated platform structure.

In order to eliminate the aforedescribed tendency of the platform 66 to tilt if the leg L3 pulls loose, weight is added slowly to the opposite corner portion C3 of the platform, as the pulling force of the jack J1 is increased, in order to counterbalance such tilting effect. As described before, such weight can take the form of heavy equipment (not shown) which can be shifted to the corner C3. In the event that the weight of such equipment is not sufficient to counterbalance the tilting tendency or such equipment is not available or shiftable, it is desirable for the platform to be provided with interior compartments or tanks T, as shown in Figure 9, into which water can be pumped for adding weight thereto. Hence, as is shown in Figure 12 of the drawings, sufficient water has been added to the tank T3 to counteract the tendency of the platform 66 to tilt when the jack J1 is being operated in a direction to pull the stuck leg L1. Thereupon, a large pulling force can be exerted effectively by the jack J1 in an effort to loosen the leg L1 in the marine bottom 68.

It is obvious that the foregoing procedure will exert large stresses in the platform 66, and if the latter does not possess sufficient structural strength, there actually may be a danger of breaking off the corner portion C1. Hence, if the platform 66 cannot safely absorb the stresses

imposed therein when the jack J1 is operated with its maximum pulling force, the latter must be operated with a reduced force.

Even when the jack J1 is operated with its maximum pulling force in an effort to loosen the stuck leg L1 by the foregoing procedure, in some instances such procedure will not serve to loosen the stuck leg. In that event, the following procedure may next be employed, assuming that the platform 66 has sufficient structural strength to enable the employment of such procedure.

The jack J1 is engaged with the leg L1, to prevent relative vertical movement between the latter and the platform 66, and simultaneously the jacks on the other three legs L2, L3, and L4 are operated in a manner to lift the platform 66 on such legs. By means of this procedure, it will be seen that the combined forces of all three jacks J2, J3, and J4 can be utilized in an effort to loosen the stuck leg L1. If the combined lifting forces of the jacks J2, J3, and J4 fail to loosen the stuck leg L1, the jack J1 of the latter is operated to exert a pulling force on the leg L1 while the other three jacks are being operated to exert lifting forces on the platform 66. Thus, the combined efforts of all four jacks can be employed to loosen the leg L1. It will be realized, however, that the upward forces so exertable on the leg L1 through the platform 66 by the jacks J2, J3, and J4 are limited by the weight of the platform. Of course, both of these precedures exert tremendous stresses in the platform 66 so that due regard must be had to its structural strength. Additionally, the platform 66 may also have a tendency to tilt downwardly at the corner C1 and to rise at the opposite corner C3 during such procedures. Such a tendency also can be restrained by the hereinbefore described counterbalancing steps, e.g. by pumping sufficient water into the tank T3 to counterbalance the pulling force on the leg L1.

The aforedescribed procedure of utilizing the combined force of all of the jacks J to loosen a single leg can also be employed if all, or any lesser number, of the legs are stuck in the marine bottom 68 by operating on each stuck leg in succession. Although the foregoing procedure of utilizing the combined force of all of the jacks J to loosen a single stuck leg L is possible, marine platforms of the type under consideration normally are not designed to withstand such extreme stresses. The imposition of such extreme stresses can be avoided, however, by lowering the platform 66 back down into the water until it is afloat at normal draft 72, as shown in Figure 13, and then utilizing the following procedures in an effort to free stuck legs.

Assuming that leg L1 is stuck in the marine bottom 68 and that the remaining legs L2, L3, and L4 are loose therein, the exertion of a pulling force by the jack J1 on the stuck leg L1, with the remaining jacks J2, J3, and J4 disengaged from their respective legs, serves to force the corner C1 deeper into the water with a resulting undesirable tiling of the platform 66, as exaggeratedly shown in Figure 14. The tendency of the platform 66 to so tilt can be avoided, however, by the hereinbefore described procedures of adding sufficient weight to the diagonally opposite corner C3, as by slowly flooding the tank T3 as shown in Figure 15, to maintain the platform level as shown in Figure 16 as the pulling force of the jack J1 is increased and forces the corner C1 deeper in the water. It will be seen that during this procedure, the platform 66 is supported in the water by the uniform pressure of the latter thereagainst, and that the downward reaction force of the jack J1 is opposed primarily by the buoyancy of the corner portion C1 of the platform so that no concentrated and damaging stresses are imposed on the latter by such procedure. During this procedure, the tanks T2 and T4 can be flooded selectively and partially, if need be, in order to counteract any tendency of the platform to tilt down at the opposite corner C4 or C2, respectively.

If by this procedure, the leg L1 starts to pull loose, the remaining jacks J2, J3, and J4 are immediately operated to restrain vertical movement between the legs L2, L3, and L4 while the tank T3 is deflooded, and also the tanks T2 or T4, if also flooded. Thereupon, the jacks J are operated to level the platform 66, if necessary, and to control the rise of the platform to its normal draft 72.

If all or more than one of the legs L is stick in the marine bottom, attempts can be made to free such legs by operating on them in succession in accordance with the foregoing procedure. Still another procedure can be utilized, however. When the platform is afloat, the jacks for such stuck legs can be operated in unison to exert pulling forces on the stuck legs while counterbalancing any tilting tendencies of the platform 66 by adding weight to appropriate portions of the platform as described hereinbefore with reference to a three-legged platform. Thus, for example, if the legs L1 and L2 are stuck, while their jacks J1 and J2 are being operated in unison to pull them, the tanks T3 and T4 are flooded sufficiently to maintain the platform 66 level as that side of the platform extending between the corner C1 and C2 sinks deeper in the water.

As aforedescribed, the maximum pulling force exertable by a single jack on its leg in many instances will be insufficient to loosen a leg that is stuck in a marine bottom. Accordingly, if the foregoing procedure is unsuccessful, the following procedure may be utilized in an attempt to free a stuck leg, e.g., L1. All of the jacks J are disengaged from their legs L and all of the tanks T are slowly and uniformly flooded as shown in Figure 17 until the platform 66 has sunk into the water to a minimum freeboard, as shown in Figure 18. At this point the jack J1 is operated to grip or engage its leg L1 in a manner to prevent relative vertical movement between the latter and the platform 66. The tank T1 then is slowly de-flooded, as shown in Figure 19, so that the increased buoyancy of the corner portion C1 of the platform 66 will exert an upward pulling force on the stuck leg L1 in excess of that exertable thereon by the jack J1. In the event that this buoyancy force is insufficient to loosen the leg L1, the tanks T2 and T4 may be slowly and controllably de-flooded, in a manner to prevent tilting of the platform 66 toward either of the corners C2 or C4, to resultingly increase the upward buoyant force on the leg L1. If necessary, additional water can be pumped into the tank T3 to prevent upward tilting of the corner C3 because of the increasing buoyancy of the tanks T2 and T4.

The foregoing procedure, i.e., first de-flooding tank T3 and then de-flooding tanks T2 and T4, if necessary, usually will be quite sufficient to loose the stuck leg L1. As soon as the leg L1 starts to loosen in the marine bottom, the tank T3, and T2 and T4 if flooded, is controllably de-flooded and all of the jacks J are operated on their legs to maintain the platform 66 level while it is rising due to its increasing buoyancy.

Similar procedures can be employed to free more than one stuck leg, either by operating on them in succession, or in unison as described hereinbefore with reference to a three-legged platform. Thus, for example, if the legs L1 and L2 are stuck, after the platform 66 has been sunk to a minimum freeboard, the jacks J1 and J2 are operated to restrain downward movement of their legs relative to the platform, while the tanks T1 and T2 are slowly de-flooded.

Platform having more than four supporting legs

Substantially all of the foregoing procedures are likewise applicable to marine platforms of the type under consideration having more than four supporting legs. Thus, for example, as shown in Figures 20 to 22, a generally rectangular marine platform 74 may have twelve such supporting legs L1 to L12 arranged in two rows extending along both longitudinal sides of the platform.

When the platform 74 is in its erected position, as shown in Figures 20 and 21, with the legs L penertating at various depths into the marine bottom 76, each leg is first tested by its jack J to see if it can be loosened in the marine bottom before the platform is lowered back down into the water. Such testing procedures were outlined hereinbefore with reference to the platform shown in Figure 8.

In this connection, it will be seen that the maximum pulling force of each jack J can be exerted on its corresponding leg L with substantially no possibility whatever of causing the platform 74 to tilt because of the geometrical arrangement of the legs on the platform. Even if the maximum pulling force of the jack J is exerted on a corner leg, such as leg L1, it will be seen that any tendency of the corresponding corner of the platform 74 to be pulled down, because of the resulting reaction force on the platform, will be completely counteracted by the weight of those portions of the platform on the opposite side of a line, connecting the legs L2 and L3, from the leg L1.

In the event, however, that a leg L is stuck so fast in the marine bottom 76 that the maximum pulling force of its jack J is insufficient to loosen the leg, the following procedure can be used to exert a pulling force on the stuck leg in excess of the pulling force exertable thereon by its jack.

Thus, for example, assuming that the leg L1 cannot be freed from the marine bottom 76 by its jack J1, the latter jack is engaged with its leg L1 to prevent downward movement of the latter relative to the platform 74 and then all of the other jacks J2 to J12 are operated to lift the platform on the legs L2 to L12, thus utilizing the combined force of eleven of the jacks J in an effort to free the stuck leg L1. Of course, as heretofore mentioned, the combined force of the aforementioned eleven jacks J2 to J12 effective to pull the stuck leg L1 is limited somewhat by the weight of the platform 74 and the equipment carried thereon and therein. Nevertheless, the aforementioned combined force normally is greatly in excess of the pulling force of any single jack J. If the foregoing procedure is not successful in freeing the stuck leg L1, the jack J1 on the stuck leg can be operated to pull the leg L1 while all of the other eleven jacks J2 to J12 are being operated in a manner to lift the platform.

Of course, the employment of the foregoing procedure is limited by the structural strength of the platform 74, and in particular if a corner leg L1, L2, L11, or L12 is stuck, there may be some danger of actually damaging the structure of the platform by any of the foregoing procedures. Accordingly, if any of the foregoing procedures do not succeed in freeing a stuck leg by exterting pulling forces thereon to the maximum extent permitted by the structural strength limitations of the platform 74, the platform should be lowered back down into the water 78 until it is afloat, and the following procedures employed.

Again, assuming that leg L1 is stuck in the marine bottom 76, the jacks J2 to J12 are released and the jack J1 is operated to exert a pulling force on the stuck leg. As the pulling force of the jack J1 is increased, the resulting reaction force will tend to force the corner portion C1 of the platform 76 deeper into the water. To counteract this tilting of the platform 74 and to maintain it on an even keel while the jack J1 is being operated in an effort to free the stuck leg L1, weight is added or shifted to the opposite side of the platform. Thus, for example, the ballast tanks T2 and T4 may be partially flooded sufficiently to mtintain the platform on an even keel athwartship. If necessary, the tanks T11 and T12 may also be sufficiently partially flooded in order to maintain the platform on an even keel fore and aft or longitudinally.

Much the same procedures may be followed in the event that a leg remote from a corner of the platform is stuck. Thus, for example, assuming that leg L6 is stuck in the marine bottom, while the jack J6 is being operated in an effort to free the stuck leg L6 weight must be shifted or added to the other side of the platform in order to maintain the latter on an even keel athwartship. Hence, the tank T5 may be sufficiently partially flooded to maintain such an even keel. It is obvious that when a stuck leg is located at a position remote from the ends of the platform 74, there usually will be no necessity for flooding any of the end tanks to maintain the platform 74 on an even keel longitudinally. When a stuck leg starts to pull loose, all of the jacks are immediately operated to engage their corresponding legs in order to hold the platform 74 stationary while the interior tanks which were flooded are de-flooded and then all of the jacks are operated to maintain the platform on an even keel while it rises to its normal draft.

If any of the foregoing procedures do not succeed in freeing a stuck leg, the following procedure may then be followed. A number of symmetrically disposed tanks, such as the tanks T1, T2, T11, and T12 are slowly and evenly flooded until the platform sinks levelly into the water to a minimum freeboard. If necessary, additional tanks, such as tanks T3, T4, T9, and T10 may also have to be flooded in order to obtain such a minimum freeboard. After such a minimum freeboard is had, the jack for the stuck leg is then operated to engage therewith. Thus, for example, assuming that leg L1 is stuck in the marine bottom, the jack J1 is engaged therewith, while the other jacks are disengaged from their respective legs, and the tank T1 then is slowly de-flooded so that the increasing buoyancy of the corner C1 of the platform exerts a progressively increasing upward force on the stuck leg L1. Additional tanks, such as T2 and T3, also can be slowly de-flooded in the event that the buoyancy force of the tank T1 is insufficient to free the stuck leg L1 from the grip of the marine bottom 76. In the event that the platform tends to tilt in any direction during the foregoing operation, other tanks may be flooded or de-flooded as necessary in order to maintain the platform level. As before, when the stuck leg L1 starts to break loose from the marine bottom, all of the jacks are operated to grip their respective legs L in order to hold the platform stationary while the tanks T which had been flooded are deflooded. Thereupon, all of the jacks are operated to control the rise of the platform to its normal draft.

If more than one leg is found to be stuck in the marine bottom, they can be freed by operating on them in succession in accordance with the foregoing procedure, or in unison in accordance with comparable procedures hereinbefore with reference to three-legged and four-legged platforms.

It will be realized that all of the foregoing methods can be practiced with non-buoyant platforms that are detachably carried, for example, on a barge and have the supporting legs of the platform disposed outboard of the peripheral outline of such barge for effective operation of such legs. Those methods described above wherein the platform is afloat while a stuck supporting leg is being pulled, still can be practiced with a non-buoyant barge-carried platform by securely fastening the latter to the barge. Of course, in all of those methods wherein a stuck leg is being pulled while the platform is up in the air, so to speak, the platform can be non-buoyant and the barge used only for installation and transportation of the platform.

It thus will be seen that the objects of this invention have been fully and effectively accomplished. It will be realized, however, that various changes may be made in the methods described and illustrated herein for the purpose of illustrating the principles of this invention without departure from such principles. Accordingly, this

invention includes all modifications encompassed within the spirit and scope of the following claims.

We claim:

1. The method of pulling loose from a gripping marine bottom a supporting leg of a portable above-water marine platform which includes a platform-like buoyant body having at least three substantially upright marine-bottom-engageable supporting legs extensibly mounted on the body for only substantially perpendicular movement relative thereto, and further having means for selectively and forcefully extending and retracting the legs or restraining the latter against movement relative to the body, and starting with the legs engaged with the marine bottom, at least a portion of the weight of the body supported on the legs, and at least one of the legs stuck against pullout in the marine bottom, the steps comprising: lowering the body on the legs and buoyantly supporting the body in the water substantially perpendicular to the one stuck leg; exerting opposed forces between the body and the one marine-bottom-stuck leg in a direction to raise the latter relative to the body while rendering the remaining legs freely extensible or retractable relative to the body; and counteracting the tilting effect of such forces on the body and maintaining the latter substantially perpendicular to the stuck leg during the exertion of such forces by adding weight to portions of the body remote from the one leg.

2. The method defined in claim 1 in which the weight is added by shifting weight from other portions of the body.

3. The method defined in claim 1 in which the weight is added by adding water ballast.

4. The method defined in claim 1 in which the body is generally triangular and has three supporting legs, one located adjacent each apex of the body, and the weight is added at a location generally adjacent that side of the body opposite the one leg.

5. The method defined in claim 1 in which the body is generally rectangular and has four supporting legs, one located adjacent each corner of the body, and the weight is added at a location generally adjacent that corner of the body diagonally opposite the one leg.

6. The method defined in claim 1 in which the body is generally rectangular and has more than four supporting legs arranged generally in two rows extending along the opposite longitudinal sides of the body, and the weight is added to that side of the body opposite the row in which the one leg is located.

7. The method defined in claim 1 in which the body is generally rectangular, has more than four supporting legs arranged generally in two rows extending along the opposite longitudinal sides of the body; the one leg is located between one end of the body and the transverse center line thereof; and the weight is added to that side of the body opposite the row in which the one leg is located in order to maintain the body substantially at right angles to the one leg athwartship and the weight is also added at a location adjacent the other end of the body to maintain the latter substantially at right angles to the one leg fore and aft.

8. The method of pulling loose from a gripping marine bottom a supporting leg of a portable above-water marine platform which includes a platform-like body having at least three substantially upright marine-bottom-engageable supporting legs extensibly mounted on the body for only substantially perpendicular movement relative thereto, and further having means for selectively and forcefully extending and retracting the legs or restraining the latter against movement relative to the body, and starting with the legs engaged with the marine bottom, at least a portion of the weight of the body supported on the legs, and at least one of the legs stuck against pullout in the marine bottom, the steps comprising: lowering the body on the legs and buoyantly supporting the body in the water while freely permitting relative movement between the legs and the body; decreasingly the buoyancy support of the body to lower the latter relative to the surface of the water into a position substantially perpendicular to the one stuck leg; fixing the one marine-bottom-stuck leg against extensible movement relative to the body; increasing the buoyancy support of that portion of the body adjacent the one stuck leg to thereby impose an upward force on the latter; and maintaining the body substantially perpendicular to the one stuck leg during the step of increasing the buoyancy support by adjusting the buoyancy support of other portions of the body.

9. The method of pulling loose from a gripping marine bottom a supporting leg of a portable above-water marine platform which includes a platform-like body having at least four substantially upright supporting legs extensibly mounted on the body for only substantially perpendicular movement relative thereto at locations outlining at least a quadrilateral geometric figure, and further having means for selectively and forcefully extending and retracting the legs or restraining the latter against movement relative to the body, and starting with the legs engaged with the marine bottom, at least a portion of the weight of the body supported on the legs, and at least one of the legs stuck against pullout in the marine bottom, the steps comprising: exerting opposed forces between the body and the one marine-bottom-stuck leg in a direction to raise the latter relative to the body while stably supporting the latter on the other legs; and counteracting the tilting effect of such forces on the body and maintaining the latter substantially perpendicular to the one stuck leg during the exertion of the opposed forces by adding weight to portions of the body remote from the one leg.

10. The method defined in claim 9 in which the weight is added by shifting weight from other portions of the body.

11. The method of pulling loose from a gripping marine bottom a supporting leg of a portable above-water marine platform which includes a platform-like body having at least four substantially upright supporting legs extensibly mounted on the body at locations outlining at least a quadrilateral geometric figure, and further having means for selectively and forcefully extending and retracting the legs or restraining the latter against movement relative to the body, and starting with the legs engaged with the marine bottom, a least a portion of the weight of the body supported on the legs, and at least one of the legs stuck against pullout in the marine bottom, the steps comprising: fixing the one marine-bottom-stuck leg against extensible movement relative to the body; and exerting opposed forces between the body and the other legs in a direction to raise the body on the latter.

12. The method defined in claim 11 including the additional step, carried out simultaneously with the force exerting step, of exerting opposed forces between the body and the stuck leg in a direction to raise the latter relative to the former.

13. The method defined in claim 11 wherein the legs are mounted for only substantially perpendicular movement relative to the body and including the additional step of maintaining the body substantially perpendicular to the one stuck leg during the force exerting step by adding weight to portions of the body remote from the one stuck leg.

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