

TRANSFER METHOD AND BARGE FOR USE IN THE METHOD

The present invention relates to a transfer method and barge for use in the method.

Flat top barges are extensively used through the world, both at sea and in rivers, for transport of a wide variety of goods. There are also variants such as submersible barges used for the transport of floating plant and many special purpose craft such as crane barges, work barges, accommodation barges and so on. Typically, submerging of the barge is controlled by ballasting/deballasting of tanks provided in the hull of the barge.

A conventional shiplift, whether, whether operated by winches, hydraulic rams or any other mechanism, is always designed so that the platform is horizontal during the transfer of a vessel between the platform and the onshore transfer system. This in turn means that the whole area utilised for working on or storage of vessels which have been brought ashore must also be horizontal, to avoid high local loads being induced in a ship's hull during the transfer operation.

On-shore sites are very rarely horizontal but

tend naturally to slope down to the water, whether a river bank or a sea coast. Additional cost must then be incurred during the installation of a conventional shiplift, particularly at an existing site. Drainage of a perfectly level site also becomes a problem and the inevitable pools of rainwater, particularly in regions of high rainfall, significantly reduce operational efficiency in ship repair and ship building activities.

In existing sites where it is proposed to install a shiplift workshops will already exist at certain levels. If an entire site has to be raised to this level a large amount of land-fill material will be required or access between a shop and the site will be hampered, particularly for vehicles. When such a site is raised the height of the waterfront above the sea level may well be excessive and in any case will require the shiplift to have a longer vertical travel than is necessary.

Accordingly there is a need for a shiplift barge or other platform which is easily trimmed to a reasonable gradient, such as 1 in 200 to 1 in 50, so that the natural site levels need a minimum of alteration and the seaward limit of the site can be kept as low as possible to make the fullest use of the available buoyancy of the barge.

According to the invention there is provided a method of transferring a load to or from a barge having a submersible hull with floodable ballast tanks and seabed engaging legs the method comprising the steps of

- i. monitoring the forces on the legs while
- ii. transferring the load and
- iii. ballasting or deballasting the ballast tanks to keep the forces on the legs within predetermined limits.

Typically three to six spuds are arranged at the sides of the barge. The spuds may be operated by, for example, hydraulic rams, jacks, screws. The spuds ensure stability during ballasting/deballasting operations during submerging and raising of the barge hull. Control of the movement of the spuds can be synchronised with that of the ballasting system. Means for exerting a controlled and controllable force on the seabed are thus provided. The spuds are not merely locked in position as with some oil rigs. Preferably the total lift available from the spuds exceeds the empty weight of the barge, thereby allowing the hull to be lifted entirely out of the water for maintenance and repair. The spuds may also be used to maintain accurate control of the attitude of the barge during roll-on, roll-off operations, including those associated with

transferring heavy loads such as another vessel, off-shore structures and so on to or from the shore. Preferably the barge hull possesses more than one water ballast tank to allow for adjustment of the attitude of the barge, the total capacity of such water ballast tanks being such as to allow the craft to be completely submerged in order to allow embarkation or disembarkation of other craft or any form of floatable cargo. Ballasting and deballasting of water to or from the tanks may be carried out by pumps or compressed air as appropriate, using suitable valves and piping systems.

The above and other aspects of the present invention will now be illustrated by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates in side elevation a preferred embodiment of the barge in accordance with a first aspect of the present invention;

Figure 2 is a plan view of the embodiment of Figure 1;

Figure 3 is a plan sectional view along line A-A of Figure 1;

Figure 4 illustrates, in views 1 to 13, the sequence of operations followed when using the embodiment of Figure 1 to transfer a vessel from one site to another;

Figure 5 is a diagram showing the centre of

buoyancy and centre of gravity of a vessel.

As shown in Figure 5A a floating vessel can be regarded as having a centre of gravity G through which its weight acts and a counter-balancing upward force acting through its centre of buoyancy. The axes intersect at M the metacentric point. Where M is above G there is a righting arm Z tending to right the vessel. Any heeling of the vessel will shift the centre of buoyancy to a new position B' with a different righting arm as shown in Figure 5B.

When one attempts to sink controllably a barge stability tends to be lost. M moves closer and closer to G reducing the righting arm as buoyancy is lost. When they are coinciding there is no self-righting capability and where G is above M the vessel is inherently unstable.

A result is that it can be extremely difficult to submerge controllably a conventional submersible barge. The barge of the invention does not suffer from these difficulties to such an extent. In accordance with the invention a barge provided with spuds or tension legs is anchored to the sea bed and buoyancy can be lost as required to lower the deck. The sea-bed engaging spud feet substantially reduce any capsizing tendency and

submergence can be readily controlled.

Figure 1 illustrates an embodiment of a barge in accordance with the present invention being the development of a conventional submersible barge with the addition of a "jack-up" capability which increases the versatility of the basic flat top barge without unduly adding to the complexity of the craft. As shown, the barge is non-propelled, but various propulsion systems may be incorporated as desired. The dimensions of the barge, in particular draught, are similar to other flat top barges allowing the barge to operate in shallow rivers and close inshore, being particularly designed for ocean towing and for push-towing in sheltered waters. This barge comprises a hull 10, two pairs of spuds 12, one pair positioned along each of two sides of the hull 10 and an elevated control room 14. The control room 14 is conveniently raised with respect to the upper surface of the hull 10 such that when the hull is submerged below the water level, the control room remains above the water level 11. The interior of the hull 10

is divided into a number of ballast tanks 15 and other areas for machinery, fuel storage and so on. As shown, each spud comprises a power driven such as pneumatically or hydraulically or mechanically driven ram 16. The ram can be extended until the foot 17 of the ram rests on the sea or river bed 12.

The barge may be completely submerged by flooding all the ballast tanks 15 and the attitude of the vessel throughout this operation can be accurately controlled by use of spuds which allow the barge to rest on the bottom 12

The barge may be completely submerged by flooding all the ballast tanks 15 and the attitude of the vessel throughout this operation can be accurately controlled by use of spuds which allow the barge to rest on the bottom 12 or to be halted at a suitable intermediate depth. By use of more than one ballast tank 15 selective flooding allows the attitude of the barge to be varied. The combination of spuds and ballast adjustment allows both the height above or below the water level and the trim of the barge to be accurately adjusted and maintained during transfer of long and heavy items of cargo to and from the barge. Use of the spuds and ballast allows the barge hull to be held at an appropriate depth under water to permit the embarkation/disembarkation of another craft or any other type of floatable cargo. Spud operation also facilitates a fine control of depth and attitude during the initial contact with the keel of a vessel being transported. The barge may also be trimmed so that one

end of the hull 10 is submerged whilst the other end remains above sea level, allowing certain types of cargo such as oil rig jackets to be launched into the sea. This facility may also be used to launch and recover elements of a pontoon bridge to link the barge to the shore where the water depths are too shallow to allow the barge to be berthed alongside a jetty or close to a river bank. Control of the ballasting and spud operation is normally carried out from the elevated platform of the control room 14 which remains above water level throughout the operation.

The length of the spuds and the travel of the hydraulic rams or other systems for control of the spuds may be modified, within reasonable limits to suit for water depths likely to be encountered. The preferred embodiment of the barge is equipped with four spuds which together enable more stable attitude adjustment and enable the barge to be lifted entirely out of the water for maintenance and other applications.

Further, by use of the spuds and ballast tanks the barge may be adapted to serve as a shiplift to transfer vessels undergoing repairs to and from the shore or to launch newly built craft. For this application, the deck of the barge would be equipped with longitudinal rails or

guides on which a sectional transfer carriage is designed to roll. The carriage supports a series of cradles of the appropriate shape to conform to the hull shape of the vessel being lifted, as in the case of a conventional shiplift or slipway. Whereas the conventional shiplift platforms are horizontal, the ability of the barge in accordance with the present invention to be trimmed and held at a precise trim during loading and unloading extends the range of sites which may be utilised and ensures that the minimum amount of earth moving is needed when the new site is being developed to accommodate craft onshore. To ensure that the rails or guides on the barge are precisely aligned with those on the shore, mechanical locks would be incorporated and put into operation during the transfer operation. As the actual loading and unloading of a vessel to or from the barge is carried out independently of shore facilities, these movements may take place in deeper water than is required for barge to shore transfer, reducing the requirement for dredging at the site to a minimum. No fixed jetties are required to operate this barge as a ship lift and hence transfer may take place at any point along an entire site frontage provided that longitudinal rails or guides are installed at a suitable point. This facility eliminates the need

to provide side transfer arrangements at a great majority of onshore locations, saving costs and increasing the space available for ship repair or construction work. Onshore and water front installations are very much simpler and cheaper than those required for a conventional lift or slipway, so if developments necessitate a change of location for a ship repair facility the cost and time required for relocation are minimised.

The barge can perform many of the tasks usually associated with a workbarge and in addition, the spuds main use can be to locate the barge precisely when pile driving or drilling. For certain applications the barge can also operate in the jacked up mode. In the dredging field, the spuds may largely replace anchors for location of the barge. Selective ballasting to give partial or complete submergence allows other craft such as hopper barges to be loaded on deck for a mobilisation voyage and refloated at the destination.

The barge may be deployed as a temporary jetty during construction works. Its roll-on roll-off capability means that cranes or other equipment may easily be embarked and the jetty can be linked to the shore with a pontoon bridge carried on board, or by a

link span as appropriate. The spuds would be used to locate the jetty but during the berthing operation of a large vessel it would be necessary to lift these clear of the sea bed to avoid damage, unless separate mooring dolphins are installed to protect the jetty. The spuds may also jack up the entire jetty to be clear of wave action or to maintain a constant height relative to the shore if this is a requirement. If cargo is to be loaded or unloaded by roll on roll off, the spuds and ballasting capabilities of the barge may be utilised to adjust the relative heights of the ships deck and the jetty level to facilitate this operation.

The spuds may be incorporated into a new barge during fabrication, or may be added to an existing barge.

Figure 4 illustrates the sequence of operations in accordance with the first aspect of the present invention to transfer a vessel or other floating body from a ship repair or construction site, or other suitable water front location, to the water, either immediately adjacent to the site or after being towed to a new location. The example assumes that rails to support some form of transfer carriage are laid directly on the deck of the barge and these conform to tracks ashore, flush with the ground surface. It is

however adaptable to any method of transfer (wheeled, tracked, skates and so on) which may be flush with the ground or deck or raised or possibly inclined relative to these.

Figure 4(1) shows a barge approaching a water front (sea or river wall). It should be possible to ballast and trim the barge such that the deck is level with the water front. If the tracks or rails on land are not horizontal then the barge may be trimmed so that the deck or on board rails are of the same declivity as those ashore. Figure 4(2) illustrates the barge moored at the water front, water having been pumped into various of the ballast tanks to trim the barge hull so that the deck is slightly below the sea wall and at the same declivity as the land site at high water on the chosen date. As shown in Figure 4(3) the spuds are lowered until they contact the sea bed and maximum downward force is then applied to them (typically by hydraulic rams) to bed them in. Typically this will lift the barge by about 50cm. Individual spuds may be moved relative to one another if the sea bed is not uniform and can be adjusted as necessary. At a permanent site, it may be preferable to provide hard points (e.g. pile caps at bed level) to support the spuds and to prevent relative movement.

Final adjustment can then be made to the spud rams and ballasting such that the barge is at the correct height and declivity with each spud about 50% loaded. At some sites it is possible to make a rigid connection to the sea wall via a shelf or horizontal pins. At others there may be a short link span of rails.

Figure 4(4) illustrates a vessel 21 loaded onto transfer carriages 22 rolling onto the barge. At the same time water is pumped out of the ballast tanks to compensate for the additional weight added to the barge. The spuds can accommodate a large variation between the buoyance and weight during this operation, thereby reducing the necessity for exact control of deballasting (typically about one third of the dead weight of a barge can be supported on spuds alone). Load detectors are provided on each spud. The load detected may be displayed continuously in the control room thereby allowing the operator to adjust the pumping or load movement to keep within the limits of spud capacity. This adjustment may be carried out automatically. Once the load has been completely transferred onto the barge, spud rams are used to raise the landward end of the barge slightly to enable the pins, if any, to be withdrawn (Figure 4(5)). If necessary, further deballasting may be done at this time

if water depth at the water front is very restricted. The spuds can then be fully retracted (Figure 4(6)) and the barge moved as required. If the barge is to be towed at sea, final ballasting may now be made to achieve the best towing trim and free board.

The subsequent Figures illustrate discharge of the vessel away from the water front. Figures 4(1) to 4(6) can be followed in reverse if the vessel is to be discharged at another land site.

As shown in Figure 4(7), on arrival at the discharge site ballasting of the barge is commenced to reduce freeboard ready for submergence. When the barge is ballasted down to a few centimetres freeboard, the spuds are lowered, applying maximum load to each (Figure 4(8)). Any relative movement is taken up with the rams and the loading reduced to about 50% on each spud. Ballasting is continued (Figure 4(9)) until the deck is submerged with the spuds held at about half load. Although there is complete loss of inherent stability at this point, stability is assured by the spuds. The pressure of each spud is reduced, control valves ensuring that the flow of hydraulic fluid is the same from each spud so that the barge sinks uniformly (Figure 4(10)). Sinking continues until the hull of the vessel being

carried enters the water and begins to pick up buoyancy. Further ballasting occurs in a selective manner so that the barge takes up approximately the same trim as that of the vessel when fully afloat (Figure 4(11)). Spud ram movements are adjusted to keep the pressure on each spud at about 50% full load, so ensuring that stability is maintained during this phase of the operation. Once the barge has submerged sufficiently, the vessel can float off and may be towed clear (Figure 4(12)). The spare capacity of the spud rams may now be used to return the barge to the surface, which increases the rate of pumping of water ballast (Figure 4(13)). Pumping is continued until buoyancy of the barge is sufficient for the spuds to be retracted and the desired freeboard is reached for the next task. Clearly if the next task is to load a vessel onto the barge, either in a shiplift mode or as a deck cargo, the barge remains submerged rather than returning to the surface, until the new vessel is floated into position overhead. The spuds will then be used to facilitate initial contact between the barge and the keel of this vessel.

Example

By way of example calculations were made to demonstrate the load occurring if a 480 tonne vessel

borne on a 40m cradle were loaded on a spud equipped barge of the invention 54 x 17 x 3.05m. The spuds are situated 10m from the barge ends. The barge has a mass of 520 tonne and a potential buoyancy of 1300 tonne at the assumed draught. The barge and certain key dimensions are shown at Figure 3 and Table 1 and 2. In the initial state each spud provides a thrust of 55 tonne and the ballast tanks filled to 1000 tonne. The barge as a whole thus is in equilibrium and is held firmly but gently in situ by the forces on the spuds. The initial ballasting conditions are shown in Table 2.

The cradle is then rolled 5m onto the barge. The load on the front pairs of spuds P_F increases to a total of 183 tonne and that at the rear P_A decreases to a total of 97 tonne. The centre of gravity will be 41.50m from P_A . 75 tonne ballast is discharged from each of tanks 3P and 35. The load on the front spuds is now a total of 24 tonne and on the rear 106 tonne.

The cradle is rolled on a further 10m resulting in the centre of gravity being 34m from P_A . The load on the aft spuds is unchanged and that on the forward increases to 144 tonne. Tank 3C is deballasted completely i.e. by 104 tonne and the load on the front pair of spuds decreases to 38 tonne and that at the rear increases to

108 tonne.

Loading the cradle a further 10m moves the centre of gravity to 24m from P_A and the load on P_A changes to 143 tonne and on P_F to 123 tonne. No change in ballasting is required. Loading a further 5m moves the centre of gravity to 16.5m from P_A and changes the load to 174 tonne on P_A and 152 tonne on P_F .

Discharge of 50 tonnes of ballast from each of tanks 1P and 1S and 25 tonnes from each of 3P and 3S changes the load on the spuds to 71 tonne on P_A and 105 tonne on P_F . The cradle can be advanced a further 10m so as to place the cradle completely on board. The centre of gravity is then 9m from P_A and the load at P_A 159 tonne and at P_F 137 tonne. It is therefore readily apparent that spuds of relatively low load limit can be used. Clearly during loading in practice deballasting will occur at more frequent intervals or even continuously for example under microprocessor control which would serve to reduce changes in spud load and in some cases the maximum spud load.

The load on the forward spuds could then be increased to allow disengagement from the dock and then all the spuds raised. The barge would then float freely with an estimated aft draught of 2.26m and forward

draught of 1.44m.

Discharge of 109 tonnes from each of tanks 1P and 1S would trim the barge to an estimated aft draught of 1.47m and forward draught of 1.75m. The cradle could be centred on the barge trimming it 89 cm by the stern i.e. draughts of 1.92m at the stern and 1.30m at the bow.

For transport the barge might conveniently be trimmed to about 30 cm by the stern by discharging 61 tonnes from tank 1C giving a draught of 1.71m at the stern and 1.37m at the head.

To discharge the cargo the barge is first brought to an even keel by adding 134 tonne to 3C. The tanks will then be in the state shown in Table 3.

Table 1

Dimension

a	10 m
b	14.89 m
c	2.11 m
d	17.00 m
B (tanks empty)	1300 tonnes
W (Tanks empty)	520 tonnes

Table 3

Tank No	State	Ballast/tonne	Maximum Capacity/tonne
1P	Slack	159	251
1C	Full	261	261
1S	Slack	159	251
2P	Empty	0	225
25	Empty	0	225
3P	Slack	159	251
3C	Slack	104	261
3S	Slack	159	251
		1001	1976

Table 3

Tank No	State	Ballast/tonne
1P	Empty	0
1C	Full	261
1S	Empty	0
2P	Empty	0
2C	Empty	0
2S	Empty	0
3P	Slack	59
3C	Slack	134
3S	Slack	59
		<u>513</u>

If desired the load bearing ability of the ground can be tested by applying a large spud load.

Tanks 1P + 1S are filled with 250 tonne each 3P + 3S are filled with 191 tonne each and 3C filled with 127 tonne. The draught will then be 2.84m on an even keel. A total spud load of 200 tonne is applied and the draught reduces to 2.62m. Tanks 2P and 2S are each filled with 225 tonne. The spud load is monitored during filling. The deck will be awash when about 398 tonne of ballast is taken aboard. The spud pressure is increased to hold the deck awash during filling to a total spud pressure of

about 252 tonne.

The spud load is relaxed back to about 200 tonne. The deck will initially sink rapidly until the buoyancy of the load begins to take effect. The spuds are allowed to rise under control maintaining a total load of about 200 tonne while filling 2C by 269 tonne. The load vessel then has 321 tonne of buoyancy.

The spud pressure is allowed to reduce slowly. When it reaches 159 tonne the load vessel will be afloat. The barge is allowed to sink a little further say 0.3m to enable the load to be towed clear.

The spud load is increased to 200 tonne and the barge will then have a free board of 16.1 cm and a mean draught of 2.89m. 269 tonne is discharged from 1C giving a new draught of 2.6m. The spuds are then retracted to give a stable vessel with a freeboard of about 0.23m.

In a variation of this embodiment, the place of the spuds may be taken by tension legs, each in the form of a wire cable tensioned by, for example, a large concrete block. The cable can be tensioned by a winch.

Each tension leg can include a large mass for example a block of concrete, iron or steel carried on a flexible member such as a chain or hawser. The mass is placed on the sea-bed and the flexible member put under

tension. It is not necessary for the mass to anchor to the seabed by, for example flukes. The mass preferably lies on the seabed or may be slightly buried. The tension leg arrangement operates in a manner similar to that of the spuds except that the tension legs pull the barge down whereas the spuds push the barge up. to raise the tension leg the buoyance of the barge is increased such that the barge and leg have positive buoyance and the leg winched in.

In general terms the spud arrangement is preferred in shallow waters since the mass of a spud is typically less than the mass of a tension leg. A tension leg is however able to operate at greater depths than a spud.



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CLAIMS

1. A method of transferring a load to or from a barge having a submersible hull with floodable ballast tanks and seabed engaging legs the method comprising the steps of
 - i. monitoring the forces on the legs while
 - ii. transferring the load and
 - iii. ballasting or deballasting the ballast tanks to keep the forces on the legs within predetermined limits.
2. A method as claimed in claim 1 wherein the legs are tension legs.
3. A method as claimed in claim 1 or claim 2 wherein the hull is submerged and the load is transferred by raising the submerged hull.
4. A method as claimed in claim 1 or claim 2 wherein the hull is floating with the deck above the waterline and the load is transferred by submerging the floating hull.
5. A method as claimed in any one of the preceding claims wherein the deck of the barge is inclined at between 1 in 200 and 1 in 50 to the horizontal.
6. A method of transferring a load substantially as described herein by reference to any one of the figures.



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7. A barge suitable for use in a method as claimed in claim 1 or claim 6 the barge comprising a submersible hull with ballast tanks and a plurality of stabilising spuds.

8. A barge as claimed in claim 6 wherein each spud is depth adjustable by means of a hydraulic ram independently of any other spud.

9. A barge substantially as hereinbefore described by reference to any one of the figures.

It is to be understood that the above description is given by way of example only and that the invention is not limited to the specific details hereinbefore set forth.