Integrated tug barge system in which the tug is rigidly secured within a barge well at the stern end of the barge by holding and locking the tug deck at both sides against the undersides of respective longitudinally extending, overhanging portions of respective barge wings which define the sides of the barge well. Firm engagement is by a pair of wedge blocks at either side of the tug which engage wedges on the respective stern ends of the barge wings to thus hold tug up at its stern; a tug bow locking device which engages the barge deck and supports tug at forward end of barge well; and a pair of tensioning devices attached on tug deck respectively adjacent barge wing stern ends and which carry standard railroad car couplers connected to similar couplers on barge wing stern ends to hold tug in longitudinal direction within barge well. The tensioning devices are hydraulic rams which also serve to draw tug into barge well when connecting tug and barge, and to quickly push tug out of barge well during disengagement. See specification for further features of connection means and method.

23 Claims, 12 Drawing Figures
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TUG-BARGE SYSTEM AND METHOD

This invention relates to oceangoing ships of the type known as fully integrated tug-barges, and more particularly to apparatus and a method for connecting and disconnecting the tug and barge components of such an integrated unit.

A fully integrated tug-barge system is a virtually unitary ship formed by rigidly connecting an ocean-going tug to a ship-shaped barge, usually in a pusher relationship. The tug is detachable, so that the barge may be "dropped off" for loading and unloading, thus making the tug available for transporting another such barge during such times. In addition, the arrangement facilitates the rebuilding or replacement of either the barge or the power plant component without disturbing the integrity, or interrupting the use of the other.

Perhaps the first successful fully integrated tug-barge system was the CARPORT which was built in 1950-51 for Cargill, Inc. by Christy Shipbuilding Corp. from a basic design prepared by the George G. Sharp organization, and which is pictured and described for example in an article entitled "Seagoing Pusher Tow" which appeared in the January 1951 issue of "The Log" magazine. In that arrangement the tug fitted into a well or opening formed by a bifurcated stern end of the barge, and was wedged within the opening, there to be rigidly secured by turnbuckles extending between the tug and the barge. That is, the bow of the tug was wedged in the vertical plane between a forwardly inclined ramp at the bottom of the barge well opening and the undersides of a pair of overhanging girders or wings respectively along the port and starboard sides of the barge well opening. The bottom of the tug at its bow end was pressed against the barge well ramp, and the deck of the tug at both sides was pressed against the undersides of the overhanging girders. In addition, aft end wedge blocks on the respective sides of the tug were wedged over the respective wedge-shaped stern ends of the barge girders.

The advantages of a fully integrated tug-barge system are many, and are adequately described in published literature so that they need not be recounted here. However, these advantages are predicated upon the attainment of a wholly workable and reliable connection arrangement between the tug and the barge as will hold them rigidly together in a seaway, yet permit prompt release of the tug from the barge within about 4 minutes in the event of an emergency. In addition, the means for connecting and disengaging the vessels should be controllable solely from the tug for obvious reasons, and the arrangement of the vessels and their necessary features and equipment for accomplishing connection and disengagement must not be unduly complicated or expensive and must be completely dependable in operation.

The five manually operated turnbuckles used in conjunction with the CARPORT arrangement cannot effect a quick release of the tug from the barge within the time limits prescribed by present day applicable standards and government regulations. Moreover, several portable hydraulic rams had to be used to push the tug out of its wedged relationship with the barge, and such proved to be a time consuming and inefficient operation.

Thus, since the time of the generally successful CARPORT development, attempts have been made either to improve the wedging arrangement and/or detachment features of that basic design, or to develop wholly new systems. Perhaps the most notable examples of the former are described in United States patents to Garcia, U.S. Pat. Nos. 3,492,964 and 3,613,628, in which specifically designed power operated auxiliary wedges and quick-release devices are used to assist the wedging action, and to promptly push the tug out from its wedged engagement with the barge. Another wedging type system involving the use of powered locking devices is shown in the United States patent to Gainsley U.S. Pat. No. 3,557,742. Prominent examples of entirely new systems are those involving the use of a catamaran type tug, such as shown in the United States patents to Neilson U.S. Pat. No. 3,398,716; Katsumura U.S. Pat. No. 3,494,318; and Stevens U.S. Pat. No. 3,698,349, and those providing for direct locking of the tug to the barge without wedging action as shown, for example, in the United States patent to De Long U.S. Pat. No. 3,345,970. However, these attempts have been entirely satisfactory for one reason or another. For example, they involve the use of specifically designed and fairly complex rams, wedges, and locking equipment, or radically new hull designs, all of which are quite expensive initially and require considerable "de-bugging." Moreover, such complex and non-standard equipment usually requires considerable maintenance.

The present invention provides still another basically different system for connecting and disengaging the tug and barge components, but one which requires neither complex equipment nor any radically new hull design. It is intended to provide a dependable rigid connection between the tug and barge which is easily made, and yet can be very easily and quickly detached. Moreover, and as in the preferred embodiment to be described, it is believed that the system is attained primarily through the use of fairly standard hydraulic or pneumatic equipment. In addition, relatively few operating components are involved, all of which can be remotely actuated from the bridge of the tug.

Briefly describing the invention in its preferred embodiment, the barge component has a bifurcated or notched stern forming a pair of transversely spaced apart barge wings which provide a barge well opening for receiving about three-quarters of the length of the tug component in snugly nestled relationship. The oppositely disposed barge wings have inwardly projecting portions along their lengths which respectively overhang the sides of the main deck of the tug when the latter is within the barge well. However, rather than wedging the forward end of the tug within the barge opening as called for in the above described CARPORT arrangement and in the referred to Garcia patents, the present invention the upwardly facing deck surface portions of the tug are held firmly against the underside surfaces of the referred to overhanging longitudinal portions of the barge wings, and the underside of the hull of the tug does not engage, and therefore does not receive any structural support from any other surface of the barge well.

The firm engagement is effected by providing wedge blocks at either side of the tug which wedge over corresponding wedges formed at the stern ends of the pair of barge wings, and by simply suspending and locking the tug against downward movement at its bow end relative to the barge. The tug is restrained against longitu-
3,837,315

dinal movement out of the barge well and is also rigidly coupled to the barge by a pair of tensioning devices which are mounted on the tug respectively adjacent to the stern ends of the barge wings and which carry couplers by which a rigid but releasable connection is made to corresponding couplers mounted on the barge wings. In the preferred embodiment, the coupler pairs are a standard, self-gathering type of railroad car coupler having known load and other characteristics. The tensioning devices are also used to draw the tug into and to push the tug out of the barge well, and each device is provided with a standard locking device for restraining its piston element from movement. The maximum stroke of the ram is about three feet. In addition, each tensioning device mounts a horseshoe-shaped frame by which the pushing action of the ram in detaching the tug from the barge is by-passed around the coupler elements and transmitted directly to the end of its associated barge wing.

The tug bow locking device to be described in connection with the preferred embodiment is essentially holding device. It is not used to elevate the tug bow to its desired position and, therefore, its arrangement and features are not complex. It essentially comprises an L-shaped lever whose forwardly projecting lower leg is locked in position such that its underside engages the adjacent barge deck after the L-shaped lever has been pivoted about the heel of the L-shape to an upright position. Such pivoting is promoted by extension movement of a hydraulic ram which is mounted horizontally in the fore and aft direction on the tug deck. The ram movement moves the lower end of a vertical pushbar whose upper end is pivotally connected to the upper end of the vertical leg of the L-shaped lever, thus causing the horizontal leg of the lever to move downwardly. This ram is also equipped with a standard locking device to lock it in its extended or retracted position.

The bottom of the barge well is closed at its forward end for the purpose of smoothing the flow of water at the underside of the integrated tug-barge unit when it is underway. The closure is effected by a submerged horizontal structure which extends transversely across the barge well and whose interior surface is inclined in the forward direction so as to conform in shape to the underside of the forward portion of the tug hull. The underside of the structure is faired into the general configuration of the ship-like barge hull. However, a large vent hole is provided through the structure to permit rapid ingress of water into the barge well when the tug is being backed out of the well, thus to reduce power and time requirements when detaching the tug from the barge.

In addition, the tug deck and the coaming under-sides of the overhanging port and starboard barge wing portions slope downwardly in the forward direction along their lengths to facilitate engagement and detachment of the tug and the barge, as will be seen.

Moreover, since the principal operative points of interface between the tug deck and the barge wing overhanging portions are those in the immediate vicinities of the bow of the tug and of the stern of the barge wings, the overhanging barge wing portions need only be disposed at these fore and aft locations along the length of the barge well and need not extend continuously. Alternatively, any wood packing provided at the cofacing tug deck and barge wing overhanging portions might be located at one or both ends of the tug deck or barge wing overhangs, rather than continuously there-along.

In summary, the method of connecting the tug to the barge involves first extending the referred to tug-mounted tensioning device and coupling them respectively to the ends of the barge wings after the tug has been moved into the barge well as far as possible under its own power, and then retracting the tensioning device to pull the tug farther into the barge well such that its referred to stern wedges are brought into wedging relation with the respective ends of the barge wings. The tensioning devices are then locked against further longitudinal movement. The tug and barge being appropriately ballasted and trimmed, it will be found that the deck of the tug is now pressed firmly against the underside of the overhanging barge wings. The tug bow locking device is then actuated as previously described to lock the bow of the tug in position at the forward end of the barge well.

To disengage the tug from the barge, the tug and barge components are appropriately ballasted and the tug bow locking device is disconnected. The tensioning devices at the aft end of the tug are then extended to exert sufficient force against the stern ends of the barge wings to release the wedging pressure of the stern end wedges and thus release the tug from the snug fit of the barge. The couplers are released concurrently, and the tug then floats free of the barge. As soon as detachment has been effected, the tug backs out of the barge well under its own power.

During this time, the barge well rapidly fills with sea water entering through the previously mentioned large hole in the floor of the well, which is adjacent to its forward end. Thus, there are no suction or other hydrodynamic forces to overcome during the backing out operation.

These and other objects, features and advantages of the invention will become more readily apparent from the following detailed description of the invention in which reference is made to the accompanying drawings, in which:

FIG. 1 is a fragmentary inboard profile, partially in cross section, showing an integrated tug-barge system in accordance with a preferred embodiment of the invention;

FIG. 2 is a fragmentary top plan view of the integrated tug-barge system of FIG. 1;

FIG. 3 is a fragmentary transverse section of the integrated tug-barge system as seen from lines 3—3 in FIGS. 1 and 2;

FIG. 4 is a fragmentary transverse section of the integrated tug-barge system as seen from lines 4—4 in FIGS. 1 and 2;

FIG. 5 is a fragmentary side elevation showing, partially in cross section, of the tug-barge system of FIG. 1 prior to any connection being made between the tug and the barge components;

FIG. 6 is an enlarged top view, partially in cross section, of one of the pair of stern end tensioning devices for locking the after part of the tug to the stern of the barge in the tug-barge system of FIG. 1, the device being shown in detached condition;

FIG. 7 is a fragmentary cross-sectional side elevation of the other of the pair of stern end tensioning devices, as it would appear in the attached condition;
FIG. 8 is a fragmentary plan view, partially in cross section, of the tensioning device of FIG. 7;

FIG. 9 is a view similar to FIG. 8, but showing the tensioning device of FIG. 7 in a position thereof during the procedure for disconnecting the tug from the barge;

FIG. 10 is an enlarged fragmentary side elevation, partially in cross section, illustrating a preferred form of locking device mounted on the bow of the tug for locking the tug to the barge in the tug-barge system of FIG. 1;

FIG. 11 is a further enlarged cross-sectional showing of the bow end locking device as seen from lines 11—11 of FIG. 10; and

FIG. 12 is a further enlarged cross-sectional showing of the bow end locking device as seen from lines 12—12 of FIG. 10.

Referring to the drawings, an integrated tug-barge system in accordance with the invention is generally indicated by reference numeral 20. It is formed by a tug 21 and a barge 22, the tug being rigidly secured to the bifurcated stern end of the barge in "pusher" relation when the system is assembled. As best illustrated in FIG. 2, the tug 21 fits closely and is nestled in a stern end opening or barge well 23 of the barge when the tug and the barge are locked together as shown. The barge well 23 is defined by a pair of transversely spaced apart, longitudinally extending stern wings 24 and 25 of the barge, and a bottom structure or ramp 26 extending transversely therebetween. The wings 24 and 25 are faired together at the forward end of the barge well 23, and the submerged ramp 26 spans transversely across and extends longitudinally from the closed forward end of the barge well 23 somewhat more than half the length of the opening between the bottoms of the longitudinal wings 24, 25. As will be understood from a comparison of FIGS. 1 and 2, the interior wall surfaces 23a of the barge well 23, including the interior surface of the ramp 26, conform in shape, both in profile and at the respective waterplane and transverse sections, to those of the shell surface 21a of the hull portion which is received in the barge well even though, as will be understood from FIGS. 1—4, the hull surface 21a of the tug is not in substantial contact with the interior walls of the barge well 23 when the tug and barge are joined. It will also be understood that the outer hull surfaces of the barge formed by the exteriors of the barge wings 24, 25 and the underside of the ramp 26, are faired not only forwardly into the main body of the barge 22 but also generally towards the projecting stern end of the tug 21 when the latter is in engagement with the barge.

Although when the tug is rigidly secured to the barge the hull of the tug 21 does not engage, and is therefore unsupported by the ramp 26, the respective upwardly facing deck surfaces 27a, 27b at opposite sides of the tug deck 27 are pressed tightly against the underside surfaces of the respectively opposite, laterally inwardly projecting barge wing portions 24a, 25a which overhang the barge well 23, as will be best understood from a comparison of FIGS. 1, 3 and 4. From FIGS. 1 and 5 it will be noted that the tug side deck surfaces 27a, 27b and their comating underside surfaces of the overhanging wing portions 24a, 25a slope downwardly in the forward direction, the slope being on the order of 4 percent (i.e., 4 feet per 100 feet of length).

The holding of the tug against the barge wings is achieved by the firm wedging engagement of the respective stern end wedges 28, 29 on the after ends of the barge wings 24, 25 within the respective of the wedge apertures 30, 31 (FIG. 4) at the opposite sides of the tug 21, and by the firm engagement of the bow locking device 32 with the after deck portion 33 of the barge, adjacent the forward end of the barge well 23. The wedge apertures 30, 31 are formed by the vertical spacing between a pair of laterally outwardly projecting wedge blocks 34, 35 and the respective tug deck surfaces 27a, 27b. As seen in FIGS. 2, 3 and 4, the port and starboard vertical sides 21c of the tug deckhouse fit closely, but do not engage, the respective cofacing vertical surfaces 24b and 25b of the barge wings 24, 25.

All, or only a forward end portion and/or an aft end portion of the tug deck surfaces 27a, 27b are formed of or covered with wood planking or packing, and the wedge surfaces of the stern end wedges 28, 29 are covered with wood packing as at 28a, 29a. Moreover, although the wedging provided by the 7\(^{1/8}\)° forward incline of the stern end wedges 28 and 29 and comating downwardly facing surfaces 34a, 35a of the wedge blocks 34 and 35 is shown as being only in the fore and aft direction, the tug deck surfaces 27a and 27b are respectively canted downwardly at an angle of 7\(^{1/8}\)° in the outboard direction, as are the respectively comating underside surfaces of the overhanging barge wing portions 24a, 25a, so that transverse centering and constricting of the tug 21 within the barge well or opening 23 is effected. However, although not illustrated, the tug deck surfaces 27a, 27b need not be so canted but might be flat. Moreover, the stern edge wedges 28, 29 and wedge blocks 34, 35 might be made as compound wedges providing a slope in the athwartship direction as well as in the fore and aft direction.

The tug 21 is locked in engagement with the barge 22 in the position shown in FIGS. 1 and 2 not only by the tug bow locking device 32 but also by a pair of stern end tensioning devices 36 and 37 which are respectively mounted on opposite sides of the tug deck 27. The tensioning devices 36 and 37 carry respective couplers 38, 39 which connect with respectively mating barge couplers 40 and 41 mounted on the stern ends 22a of the respective barge wings 24, 25, as shown. The stern end tensioning devices 36, 37 further include extensible hydraulic rams 42, 43, respectively, by which these devices also serve both to draw the tug 21 firmly into position within the barge opening 23 and as a quick-release mechanism to promptly push the tug 21 out of its snug fit engagement with the stern end wedges 28, 29 of the barge 22, in manner to be more fully described.

The tensioning devices 36 and 37 are located aft of the wedge blocks 34, 35 and are immovably secured to the tug by direct attachment of their cylinder components, as by welding of their respective forward and rearward end supports 36a, 36b, and 37a, 37b. Thus, the required mechanism is simplified by eliminating vertical and lateral hydraulic positioning devices, swivels, and the like for manipulating each device when in use, as would be required if they were deck porters. 38, 39. That is, the respective couplers 38, 39 are mounted
for limited lateral pivotal movement on the vertical pins 44, 45 which are the pivot elements of their respectively associated U-shaped knuckles 46 and 47, and limited vertical pivotal movement of each coupler is permitted by the considerable clearance provided between the coupler and the pin at top and bottom. Side-to-side pivotal movement of each coupler 38, 39 is constrained by respective horizontal spring elements 48 and 49. The springs 48, 49 are respectively attached to and extend across horseshoe-shaped frames 50 and 51 which are respectively adjacent to, and fan around the couplers 38 and 39 and limit their lateral movement as shown, each coupler 38 and 39 being attached to its associated spring 48 and 49 midway along the length of the latter, so that the spring tends to center the coupler and is responsive in both directions of lateral movement. To prevent excessive sagging of the coupler when not attached together, each coupler is provided with a bottom support (not numbered). The frames 50 and 51 are rigidly attached, as by threads 42a, to the respective rams 42 and 43.

Similarly, the couplers 40 and 41, which respectively surface and comate with the couplers 38 and 39, are pivotally mounted on vertical pins 52 and 53, and are centered and constrained in lateral direction by the springs 54 and 55 which respectively extend transversely across the port and starboard coupler housings 56 and 57 formed in the stern ends 22a of the barge wings 24, 25. Couplers 40 and 41 are pivotable vertically, and are provided with supports to prevent excessive sagging, in manner similar to couplers 38, 39. Thus, the pivotal and spring-mounted couplers 38, 39 and 40, 41 have sufficient permissible movement in all directions to compensate for a normally encountered range of misalignment between the tug and the barge as they are being joined.

For a purpose to be described, the vertical pins 52 and 53, on which the barge couplers 40 and 41 are pivotable, are mounted for limited, longitudinal slideable movement in respective elongated slots 58a, 59a of the knuckle elements 58, 59, the latter being rigidly attached within the respective coupler housings 56, 57. The couplers 40 and 41 are normally urged in direction towards the stern end of the barge, to the position shown in any of FIGS. 6-8, by the bias of the longitudinal springs 60 and 61 which are attached between the respective interiors of the housings 56, 57 and the rearward ends of their respectively associated coupler elements 40, 41 as shown.

It will be noted that each of the couplers 38, 39, 40 and 41 is preferably a conventional type "N-2-A" automatic car coupler as made, for example, by WABCO and normally mounted on railroad cars. The coupler is generally described in U.S. Pat. No. 3,280,990 issued to Jeffrey et al. Thus, the couplers have known coupling and holding characteristics, and include as a standard feature provision for making any electrical or hydraulic connections therethrough as may be required to be made between the tug 21 and the barge 22. In addition, it will be noted that each has a funnel-shaped surface surrounding its cylindrical aperture which receives the coupler pin of the coming coupler, and therefore such couplers are characterized as being self-gathering, thus further facilitating the making of the coupler connection in the event of any small misalignment between the parts to be connected. The couplers engage and disengage automatically in response to air pressure actuation of an internal latching device (not shown).

Completing the description of the stern end tensioning devices 36 and 37, reference will be made to FIG. 7 which shows the construction of device 36, and it will be understood that the device 37 is identical. The previously mentioned extensible ram 42, on which the coupler 38 is mounted via the knuckle 46, is actually the piston rod element of a hydraulic piston and cylinder, the ram cylinder being indicated by reference numeral 65. The ram has a maximum length of stroke of 3 feet and is capable of exerting a pulling force of 150 tons in pulling the tug into, and seating the tug in the barge well 23. However, it can effect a pushing force of 800 tons when disengaging the tug from the barge.

At one end, as shown, the piston rod or ram 42 passes through a locking sleeve or barrel 66 which in normal position tightly surrounds and engages the piston rod with an interference fit to prevent piston movement even under very high load conditions on the order of 150 tons. However, when hydraulic pressure is applied via the fluid port 67, the barrel 66 expands radially to relieve the interference and permit the piston rod to slide therebetween in response to fluid pressure on the piston within the ram cylinder 65. Hydraulic fluid is introduced into and discharged from the cylinder 65 via the fluid ports 69 and 70 in a conventional manner. Release of locking pressure through the fluid port 68 permits the locking barrel to radially contract and thereby again lock the piston rod against movement. This locking device is of a known type such as sold under the trademark "Bear-Loc."

Continuing with the description of the overall arrangement, ramp 26 provides a floor 26a of the barge well 23, and is primarily for the purpose of smoothing the flow of water between the undersides of the barge and the tug when the integrated unit is underway. Its interior surface or floor 26a is inclined about 7 percent (i.e., 7 feet per 100 feet of length) in the forward direction of the barge 22, and generally conforms with the drag angle of the bottom of the tug 21. The floor 26a may be covered with wood packing 26b.

Towards its forward end the ramp 26 is provided with a centrally located vent hole 75, as seen in FIGS. 1-3 and 5. The hole has a diameter of approximately 6 feet, and is provided with a plurality of vertical bars or vanes 76 which extend in the fore and aft direction and which minimize hydrodynamic losses. The vent hole 75 allows sea water to rapidly enter the barge well or opening 23 at a rate commensurate with the change of displacement of the tug hull within the barge well when the tug is being disengaged from the barge, which reduces the amount of force required to withdraw the tug. In the absence of the vent hole, all of the water required to fill the barge well would be required to pass through the relatively small clearance areas between the hull surface 21a of the tug and the matching interior surfaces 23a of the barge well 23, and the period of time, as well as the force required to disengage the tug, would be found to increase substantially.

Referring now to the details of the quick-release type bow locking device 32 which is mounted on the tug forecastle 27c, they are best understood from FIGS. 10-12. However, in following the description it should be noted that the device 32 is not used to lift the tug into engagement with the barge but, rather, is used only
to clamp and support the forward end of the tug in its engagement with the barge after the tug is fully within the barge well 23 and after the tug and/or barge have been ballasted such that the forwardmost ends of the tug deck portions 27a, 27b are pressing upwardly against the underside of the overhanging barge wing portions 24a, 25a.

The bow locking device 32 comprises an L-shaped lever 78 providing a horizontal leg portion 78a and a vertical leg portion 78b. At the heel 78c of its L-shape the lever 78 is mounted for vertical pivotal movement on the horizontal pin 79 which extends in athwartship direction within an upwardly projecting U-shaped bracket 80 which is welded to the deck at the foremost 27c of the tug, as shown. A vertical pushbar 81, having lateral stiffeners 81a, is pivotally connected by a crosspin 83 at its upper end to the pivot bracket 82 on the upper end of the vertical leg 78b of the lever. At its lower end the pushbar 81 is pivotally connected by a pin 84 to a slide block 85. The block 85 is mounted for sidewise translation on the longitudinal track 86 attached on the tug deck 27.

A hydraulic ram 87 is attached in fixed position on the tug deck behind the slide track 86 to power reciprocal movement of the slide block 85 to effect both locking and releasing movement of the locking device 32. The extensible ram 87 is attached to the block 85 by a ramrod 88. Thus, and as illustrated by the phantom dotted line showing in FIG. 10, hydraulic powering of the ram 87 (by means not shown) to drive the rod 88 in the forward direction will move the slide block 85 from its dotted line position A, in which the device 32 is released, to its position B as indicated by the full line showing and in which the device 32 is in its locked position. The forward sliding movement of the block 85 pivots and erects the vertical pushbar 81 to pivot the lever 78 to its vertical position in which the downwardly facing foot 89 at the outer end of its horizontal leg 78a, presses downwardly against a pad 90 on the barge deck portion 33.

Although not specifically illustrated, the ram 87 is provided with a normally engaged, radially expansible barrel or sleeve lock similar to that described in connection with the tensioning device 36 and as illustrated in FIG. 7, such that the ram 87 may be locked in its forwardmost position 78 to maintain the locking position of the device 32. When the device 32 is to be released, the ram 87 is hydraulically powered in the opposite direction to withdraw the slide block 85 to its position A, thus restoring the device to its detached position as illustrated by dotted lines.

When connecting the tug 21 to the barge 22 to form the integrated system 20, the tug and barge are ballasted to the relative drafts as shown in FIG. 5, such that the level of the tug deck is slightly lower than the undersurface of the overhanging barge wing portions 24a, 25a, and the bow of the tug will clear the ramp floor 26a (or 26b if wood packing is used). Preferably, neither vessel is trimmed although, as will be understood, the comingling slope of the tug deck side portions 27a, 27b and the underside of the overhanging barge wing portions 24a, 25a, being downward in the forward direction, facilitates the fitting of the vessels together even when the barge lies trimmed by the stern to an extent such that the overhanging portions 24a, 25a are horizontal (in which case the tug would be similarly trimmed). In addition, the comingling slopes assure a very tight fit between the tug and the barge using only one line of interface between the two, as compared with the both top and bottom lines of interference as would be present if the tug were wedged between the stern ramp 26 and the wing portions 24, 25 as in previous known designs. This single line of interface permits proper joining to be effected between the two vessels, even under conditions of considerable variance of the pertinent dimensions as between two different barges which one tug may be expected to fit.

At this time the tug bow locking device is in its detached position, as indicated in FIG. 5.

The tug 21 then moves under its own power into the barge well opening 23 as far as practicable, whereupon its stern end tensioning devices 36, 37 are unlocked and their respective hydraulic rams 42 and 43 are extended so that their forwardly facing couplers 38, 39 are automatically coupled and latched in engagement with the respectively rearwardly facing stern end couplers 40, 41 on the barge wings.

The hydraulic rams 42 and 43 are then retracted contemporaneously so as to draw the tug 21 snugly into the barge well such that the wedge apertures 30 and 31 (FIG. 4) firmly engage the respective barge wedges 28 and 29. The locking sleeves or barrels 66 (FIG. 7) of the tensioning devices 36 and 37 are then engaged to lock the rams 42, 43 in their retracted positions.

The tug 21 may or may not then require further downhill to raise its bow slightly to ensure that the forward ends of its deck side portions 27a, 27b are tightly against the undersides of the barge wing overhanging portions 24a, 25a at their forward ends and that the bottom of the tug is not resting on the barge ramp 26.

The tug bow locking device 32 is then moved to its locked position by hydraulic actuation of its associated deck ram 87, which extends forward and moves the slide block 85 (FIG. 10) to its position B. As previously described, the lever foot 89 is thus pressed downwardly against the barge deck pad 90, which may or may not require that shims (not numbered) be placed therebetween. The ram 87 is then locked in its forward position in the manner previously described.

It is seen that such locking engagement of the bow locking device 32, together with the constraint afforded by the barge stern wedges 28, 29, prevents any downward movement of the tug bow relative to the barge. Of course, no upward movement of the tug relative to the barge can occur because of the engagement of the tug deck side portions 27a, 27b with the overhanging barge wing portions 24a, 25a.

To disengage the tug from the barge after a voyage, the tug bow locking device 32 is first disengaged by unlocking and withdrawing the hydraulic ram 87, thus moving the slide block 85 back to its rearward position A and lifting the lever foot 89 off the barge deck pad 90. The lever 78 is thus pivoted to its detached position as shown in dotted lines in FIG. 10, so that its foot 89 is well clear of the barge end deck portion 33.

Next, the tensioning devices 36 and 37 at the after end of the tug 21 are unlocked in the manner previously described, and their respective rams 42 and 43 are hydraulically powered to extend them contemporaneously in a forward direction to push the tug out of engagement with, and clear of, the barge 22.

Because the very high force required to disengage the tug from the barge might otherwise damage the cou-
The force of the forwardly extending hydraulic rams 42, 43 is applied to the barge ends 22a via the ram coupler frames 50, 51 which directly engage the latter. That is, as shown by a comparison of FIGS. 8 and 9, and appreciating that the operation of the device 37 and couplers on the other side of the tug is identical, with the couplers 38 and 40 in coupled condition the forward movement of the ram 42 in the direction F, from the position shown in FIG. 8 to that of FIG. 9, will initially cause compression of the spring 60 and slidable movement of the barge coupler 40 in the same direction because of the slidable mounting of the coupler pin 52 within the slot 58a of the barge bracket 58. However, the normal location of the forwardly facing pressure surface 50a of the frame 50 behind the barge wing end 22a is a distance less than that of slidable movement of the coupler 40 so that the frame surface 50a will move into pressure engagement against the barge wing end 22a before the coupler pin 52 has reached its fully retracted position at the end of the slot 58a. Thus, the pushing force of disengagement which is exerted by the ram 42 is not transmitted through the couplers 38, 40 but, rather, is transmitted through the horseshoe-shaped frames 50 and 51.

As an alternative for the same purpose, the coupler 38 might be mounted for similar longitudinal slidable movement on the frame 50 by mounting the vertical pin 44 within a longitudinal slot (not shown) of the knuckle 46, and by providing a spring (not shown) normally biasing the coupler 38 to its forward, extended position. In such case, the pressure surface 50a of the frame 50 would be located, in longitudinal direction, within the distance of slidable movement of the forward face of the coupler 38 between its extended and retracted positions.

Of course, the coupler pairs 38, 40 and 39, 41 are unlatched internally so that they will uncouple as the tug 21 rides away from the barge 22 in response to the pushing action of the tensioning devices 36, 37 on the barge ends 22a. When the tug and barge have been disengaged, the tug backs out wholly from the barge opening 23 using its own power. The hydraulic rams 42, 43 are then withdrawn and locked in their rearward positions.

It will be seen that all of the controls necessary to actuate the tensioning devices 36 and 37, the coupler pairs 38, 40 and 39, 41, and the bow locking device 32 may be located on the bridge of the tug 21, and therefore the tug may engage or disengage itself from the barge independently of any activity on the latter.

It will also be seen that the prompt releasing and actuation of the bow locking device 32 and of the tensioning devices 36, 37 as is afforded by remote control of the hydraulic rams 42, 43 and 87 as described, permits very prompt disengagement of the tug from the barge under emergency conditions, as is required under pertinent government regulations.

Thus has been described an integrated tug-barge system, and a method for connecting and disconnecting the tug and barge components thereof, which achieves all of the objects of the invention.

What is claimed is:

1. An integrated tug-barge comprising a barge having a pair of longitudinally extending, transversely spaced apart wings defining a barge well at its stern for receiving a tug in closely nestled relation therein, said wings having respectively laterally inward projecting portions presenting underside surfaces which overhang said barge well on the opposite sides thereof at least adjacent to both the forward end and the aft end of said barge well, a tug having upwardly facing surfaces on opposite sides thereof respectively engaging said overhanging underside surfaces of said barge wing projecting portions, quick-release means providing suspension of the forward end of said tug from said barge and rigidly retaining said engagement between said tug surfaces and said barge wing overhanging surfaces adjacent to said forward end of said barge well, said tug being substantially free of upwardly directed structural support from said barge from any location below said upwardly facing tug surfaces to retain said engagements.

2. An integrated tug-barge according to claim 1 wherein each of said overhanging underside surfaces on said barge wings, and each of said said engaging upwardly facing surfaces on said tug, slopes downwardly in direction towards the forward end of said barge well.

3. An integrated tug-barge according to claim 2 wherein each of said overhanging underside surfaces, and each of their said engaging upwardly facing surfaces, also slopes downwardly in the outboard direction of said tug and said barge.

4. An integrated tug-barge according to claim 1 wherein said suspension and retaining means adjacent to said forward end of said barge well comprises releasable means mounted on said tug and presenting a downwardly facing portion engaging said barge adjacent to the forward end of said barge well to support and prevent downward movement of the bow of said tug relative to said barge.

5. An integrated tug-barge according to claim 4 wherein said releasable means comprises a substantially L-shaped lever providing a horizontal leg portion and a vertical leg portion, the heel of said L-shaped lever being mounted for vertical pivotal movement of the lever on said tug between a substantially horizontal, barge engagement position and a retracted position of its said horizontal leg portion, said horizontal leg portion projecting outboard of said tug to present said downwardly facing portion engaging said barge when in its said barge engagement position, means for pivoting said lever between said positions of its horizontal leg portion, and means for locking said lever in said barge engagement position.

6. An integrated tug-barge according to claim 5 wherein said means for pivoting said lever comprises vertical push bar means having an upper end pivotally connected to the upper end of said vertical leg portion of said lever, a slide block mounted for slidable movement in the fore and aft direction on said tug, said vertical push bar having a lower end pivotally connected to said slide block, and an hydraulic ram mounted on said tug for movement of its extensible element in the fore and aft direction of said tug, said extensible element being connected to said slide block whereby forward movement of said extensible element moves said slide block to pivot said lever thereby moving its said horizontal leg portion to its said barge engagement position, and said means for locking said lever in said posi-
tion comprises means for locking said hydraulic ram against movement of its extensible element.

7. An integrated tug-barge according to claim 1 wherein said suspension and retaining means adjacent to the forward end of said barge well comprises releasable means between said tug and said barge supporting and preventing downward movement of the bow of said tug relative to said barge, and said suspension and retaining means adjacent to said aft end of said barge well comprises wedge means between each of said barge wings and said tug and preventing downward movement of said tug relative to said barge wings, and respective releasable coupler means mounted on the opposite sides of said tug and coupling said tug to each of said barge wings.

8. An integrated tug-barge according to claim 7 wherein each of said coupler means comprises a rearwardly facing coupler mounted on the aft end of one of said barge wings, and a forwardly facing coupling coupler mounted on said tug and coupled to said barge wing coupler.

9. An integrated tug-barge comprising a barge having a pair of longitudinally extending, transversely spaced apart wings defining a barge well at its stern for receiving a tug in closely nested relation therein, said wings having respective laterally inward projecting portions presenting underside surfaces which overhang said barge well on the opposite sides thereof at least adjacent to both the forward end and the aft end of said barge well, a tug having upwardly facing surfaces on opposite sides thereof respectively engaging said overhanging underside surfaces of said barge wing projecting portions, releasable means mounted on said tug engaging said barge adjacent to the forward end of said barge well to support and prevent downward movement of the bow of said tug relative to said barge, wedge means between each of said barge wings and said tug supporting and preventing downward movement of said tug relative to said barge wings at the aft end of said barge well, a rearwardly facing coupler mounted on each of said barge wings, and a tensioning device mounted on each of the opposite sides of said tug to assist in engaging and disengaging said tug and said barge, each of said tensioning devices comprising an extensible ram which is extendable and retractable in the fore and aft direction of said tug and which carries a forwardly facing coupler on the forward end thereof coupled to that one of said rearwardly facing barge wing couplers which is on the same side of said tug, and means for locking said extensible ram in at least a retracted position thereof, said tug being substantially free of structural support from below to retain said engagements.

10. An integrated tug-barge according to claim 9 wherein said coupler is a standard type railroad car coupler.

11. An integrated tug-barge according to claim 10 wherein said car coupler is a type "N-2-A" automatic car coupler.

12. An integrated tug-barge according to claim 9 wherein each of said tensioning devices further comprises a frame attached to said forward end of its said extensible ram and presenting a forwardly facing pressure surface for engaging and exerting pressure against that one of said barge wings which is on the same side of said tug to assist in disengaging said tug and said barge, said frame being adjacent to said forwardly facing coupler carried by said ram, and means providing relative movement in the fore and aft direction between one of said couplers of said coupled pair of couplers and its said associated barge wing whereby said frame is out of engagement with its said associated barge wing when said ram is in its said retracted position and engages its said associated barge wing upon said relative movement in response to extension of said ram to disengage said tug and said barge.

13. An integrated tug-barge according to claim 12 wherein said means providing relative movement comprises means mounting at least one of said couplers of each of said coupled pairs thereof for slidably movement between an extended position and a retracted position thereof, and bias means normally biasing said coupler to its said extended position, said respective ones of said couplers being slidable against its said bias to its said retracted position to permit said engagement of its said adjacent frame with said barge wing associated with the latter.

14. An integrated tug-barge according to claim 9 wherein each of said tensioning devices comprises a conventional fluid driven ram whose cylinder component is rigidly attached on said tug, said extensible ram being essentially the piston rod component thereof, and each of said couplers carried by the respective of said extensible rams being mounted for limited lateral and vertical movement thereon.

15. An integrated tug-barge according to claim 1, wherein said barge well is further defined by a normally submersed ramp structure extending transversely between said barge wings and across said barge well at least adjacent to, and extending rearwardly from its forward end to close said barge well along at least a portion of its length the interior wall surfaces of said barge well, including the interior surfaces of said ramp structure conforming in shape, and at all locations being closely adjacent to the co-facing surfaces of the null portion of said tug which is received in said barge well, and which further comprises means defining an aperture adjacent to said barge well forward end permitting the substantially free flow of sea water into said barge well at a rate providing for filling of the barge well commensurate with the change of displacement of the tug hull within the barge well when said tug is being disengaged from said barge.

16. A tug for use in an integrated tug-barge system, said tug having a hull including upwardly facing, longitudinally extending deck portions on opposite sides thereof, wedge block means on each of said opposite sides of said tug and respectively disposed in vertically spaced relation above each of said deck portions, a tensioning device mounted on each of the opposite sides of said tug rearwardly of said wedge block means, each of said tensioning devices comprising an extensible ram which is extendable and retractable in the fore and aft direction of said tug and which carries a forwardly facing standard railroad car coupler on the forward end thereof and means for locking said extensible ram in at least a retracted position thereof, and locking means mounted on the bow of said tug, said bow locking means comprising means presenting a downwardly facing portion outboard of said tug hull substantially at the elevation of its forecastle.

17. A tug for use in an integrated tug-barge system, said tug having a hull including upwardly facing, longitudinally extending deck portions on opposite sides
thereof, wedge block means on each of said opposite sides of said tug and respectively disposed in vertically spaced relation above each of said deck portions, a tensioning device mounted on each of the opposite sides of said tug rearwardly of said wedge block means, each of said tensioning devices comprising an extensible ram which is extendable and retractable in the fore and aft direction of said tug and which carries a forwardly facing coupler on the forward end thereof and means for locking said extensible ram in at least a retracted position thereof, and locking means mounted on the bow of said tug, said bow locking means comprising means presenting a downwardly facing portion outboard of said tug hull substantially at the elevation of its forecastle, each of said tensioning devices further comprising a frame attached to said forward end of its said extensible ram and presenting a forwardly facing pressure surface, said frame being adjacent to said forwardly facing coupler carried by said ram, means mounting said coupler for slidable movement between an extended position and a retracted position thereof on said ram, and bias means normally biasing said coupler to its said extended position, said pressure surface of the frame means being located, in longitudinal direction, within the distance between said extended and retracted positions of said coupler.

18. A tug according to claim 17 wherein each of said tensioning devices comprises a conventional fluid-driven ram whose cylinder component is rigidly attached on said tug, said extensible ram being essentially the piston rod component thereof, and said coupler is a standard type “N-2-A” automatic railroad car coupler.

19. A tug for use in an integrated tug-barge system, said tug having a hull including upwardly facing, longitudinally extending deck portions on opposite sides thereof, wedge block means on each of said opposite sides of said tug and respectively disposed in vertically spaced relation above each of said deck portions, a tensioning device mounted on each of the opposite sides of said tug rearwardly of said wedge block means, each of said tensioning devices comprising an extensible ram which is extendable and retractable in the fore and aft directions of said tug and which carries a forwardly facing coupler on the forward end thereof and means for locking said extensible ram in at least a retracted position thereof, and locking means mounted on the bow of said tug, said bow locking means comprising means presenting a downwardly facing portion outboard of said tug hull substantially at the elevation of its forecastle, said locking means mounted on the bow of said tug comprising an L-shaped lever providing a horizontal leg portion and a vertical leg portion, the heel of said L-shaped lever being mounted for vertical pivotal movement of the lever between a substantially horizontal, barge engagement position and a retracted position of its said horizontal leg portion, said horizontal leg portion projecting outboard of said tug to present a downwardly facing support surface when in its said barge engagement position, vertical push bar means having an upper end pivotally connected to the upper end of said vertical leg portion of said lever, a slide block mounted for slidable movement in the fore and aft direction on said tug, said vertical push bar having a lower end pivotally connected to said slide block, and an extensible ram which is extendable and retractable in the fore and aft direction of said tug, and comprising a fluid cylinder attached to said tug, and a movable piston within said cylinder and carrying a forwardly projecting rod, the forward end of said forwardly projecting rod being connected to said slide block, whereby forward movement of said slide block pivots said lever to move its said horizontal leg portion of said barge engagement position, and means for locking said lever in said position.

20. A method of rigidly connecting a tug within a barge well formed in the aft end of a barge, said barge well being defined by a pair of laterally spaced apart and longitudinally extending barge wings presenting downwardly facing overhanging surfaces on opposite sides of said barge well at the forward and aft ends thereof, comprising the steps of wedging the aft ends of said barge wings and said tug together by first coupling a pair of extended tensioning devices, mounted respectively on the opposite sides of said tug at a location aft of said barge wings, to the aft ends of said barge wings, respectively, and then retracting said tensioning devices concurrently to pull said tug into said wedging relation with said aft ends of the barge wings, then debalasting the forward end of said tug as necessary to press upwardly facing, forward end surfaces on opposite sides of said tug firmly against the respective of said overhanging forward end surfaces of said barge wings, then locking the forecastle of said tug to the deck of said barge adjacent said barge well to prevent downward movement of the tug bow relative to the barge, and locking said tensioning devices in their said retracted positions to prevent longitudinal movement of said tug out of said barge well, said tug then being substantially free of structural support from below to retain said engagements.

21. A barge for use in an integrated tug-barge system, said barge having a bifurcated stern end providing a pair of longitudinally extending, transversely spaced apart wings defining a barge well which is open at its stern for receiving a tug in closely nested, pusher relation therein, a quick-release standard railroad car coupler mounted on each of said barge wings adjacent to the stern ends of the respective barge wings, each of said couplers facing aft for coupling to a forwardly facing coupling mounting mounted on a tug entering said barge well and means mounting each of said couplers for limited vertical and lateral pivotal movement on its said associated barge wing, and bias means biasing each of said couplers in said aft direction and permitting limited movement of the coupler in said forward direction against the bias of said bias means.

22. A barge according to claim 21 wherein each of said couplers is a type “N-2-A” automatic car coupler.

23. An integrated tug-barge according to claim 15, wherein said aperture is formed through said ramp structure.