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O'Brien et al.

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[45] **Feb. 20, 1973**

[54] METHOD AND APPARATUS FOR CONSTRUCTING AND CONNECTING UNDERWATER RISERS

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[21] Appl. No.: **121,788**

[52] **U.S. Cl.** **61/72.3**, 166/.5, 166/.6, 269/47, 285/18, 285/24

[51] **Int. Cl.** **F16l 35/00**, E02b 17/00, B23q 1/08

[58] **Field of Search** ....61/72.3, 72.1, 63, 43; 285/24, 285/18; 166/.5, .6

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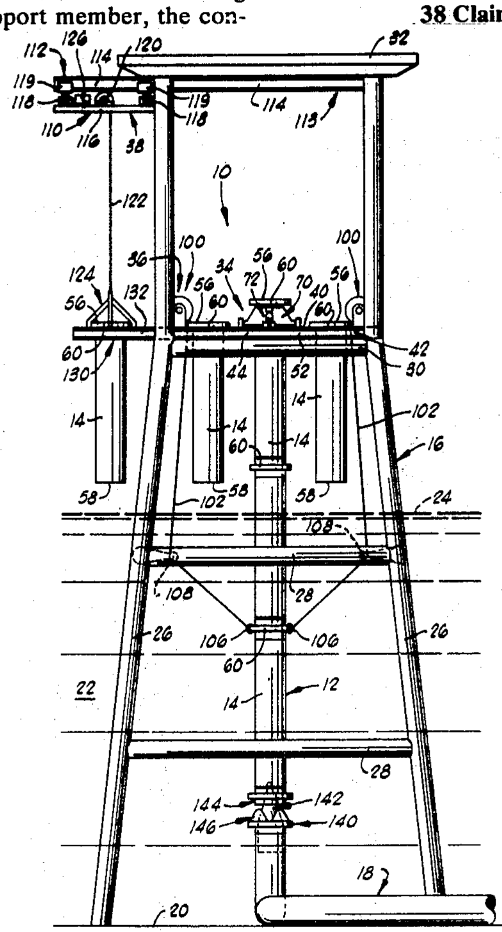
[57] **ABSTRACT**

An improved method and apparatus for constructing an underwater riser from a support member, the constructed riser being formed from a plurality of interconnected riser-sections, and for moving the lowermost end of the constructed riser into an interconnecting relationship with one end of an underwater pipeline, wherein one end of each riser-section is rigidly supported by a riser support assembly, in one position of each riser-section and in a support position of the riser support assembly, and another riser-section is positioned in a connecting relationship with respect to the riser-section being supported in the riser support assembly by a positioning assembly. In this position, the two riser-sections are secured in an interconnecting relationship. The connecting end portions of each riser-section are constructed such that two riser-sections can be quickly and guidingly positioned in an interconnecting relationship, and to facilitate a more sealingly secure interconnection therebetween. The riser-sections thus interconnected are lowered generally through the riser support assembly to a position wherein the uppermost end portion of the last connected riser-section is supported in the riser support assembly in a position to be interconnected to another riser-section. A predetermined number of riser-sections are thus interconnected to form the constructed riser, and the constructed riser is then lowered to a position wherein the lowermost end thereof is aligned with one end of the underwater pipeline. The lowermost end of the constructed riser is guided into an interconnecting relationship with the end of the underwater pipeline generally aligned therewith by a guide coupling assembly which is removably secured in the underwater pipeline.

38 Claims, 16 Drawing Figures



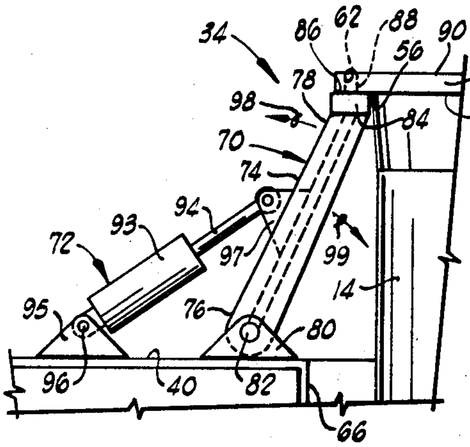


FIG. 3

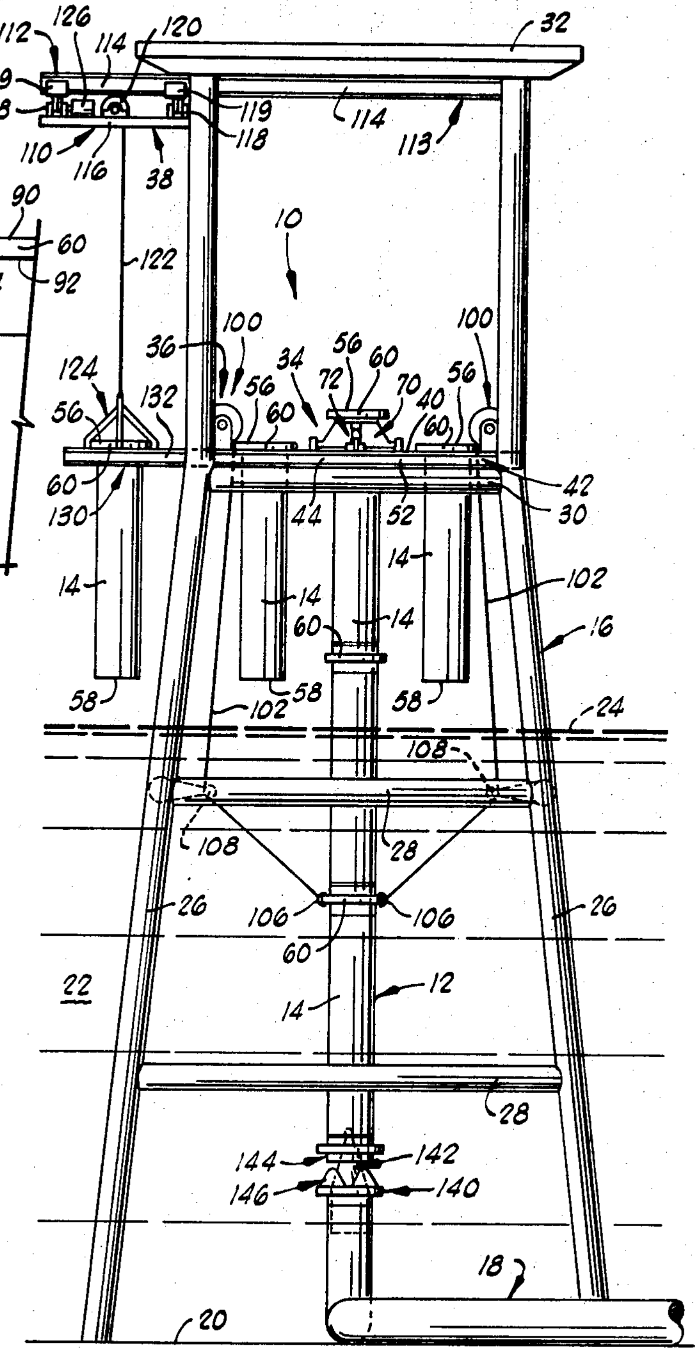


FIG. 1

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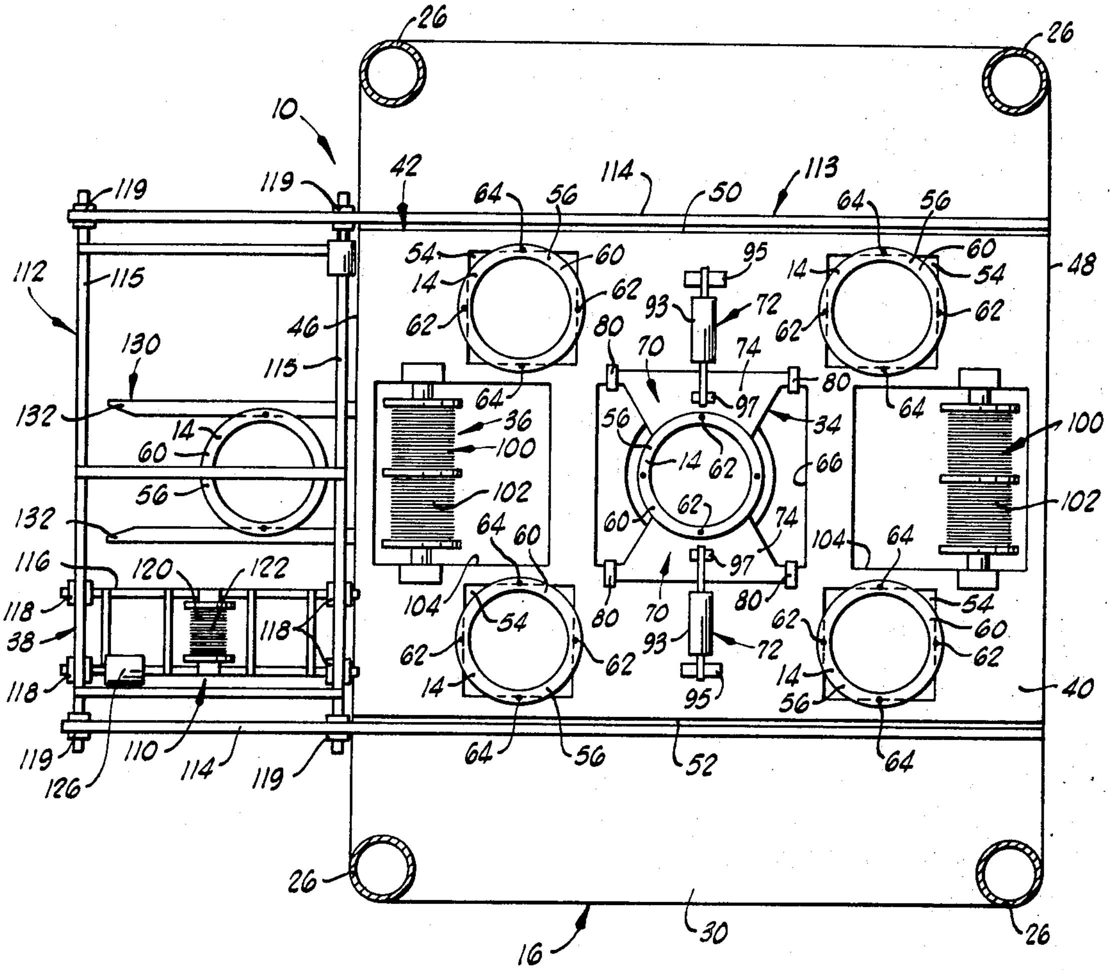

FIG. 2

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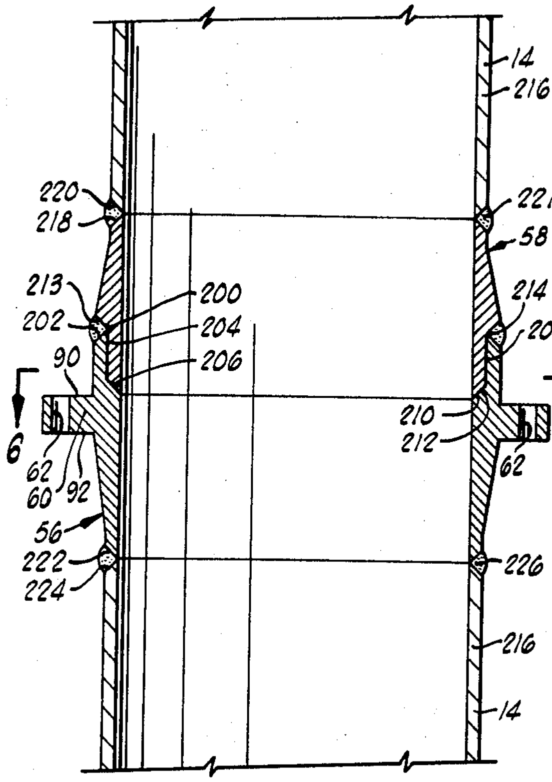

FIG. 5

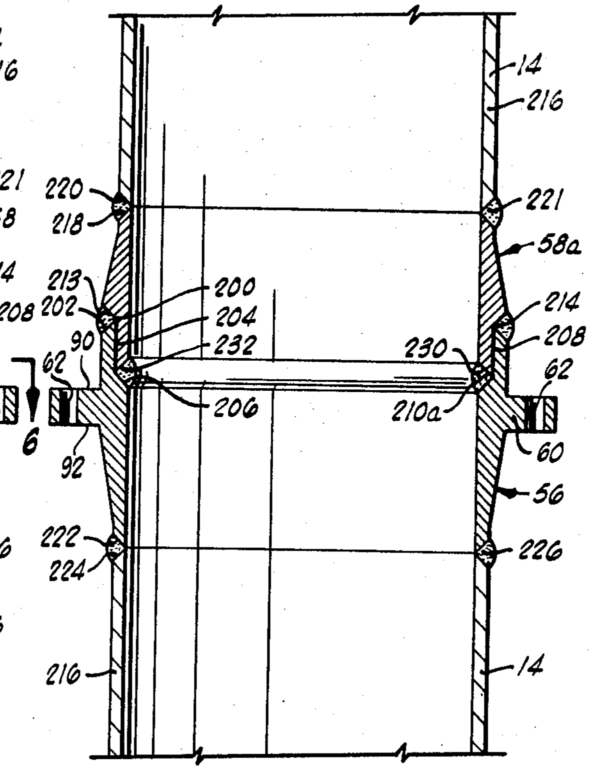

FIG. 7

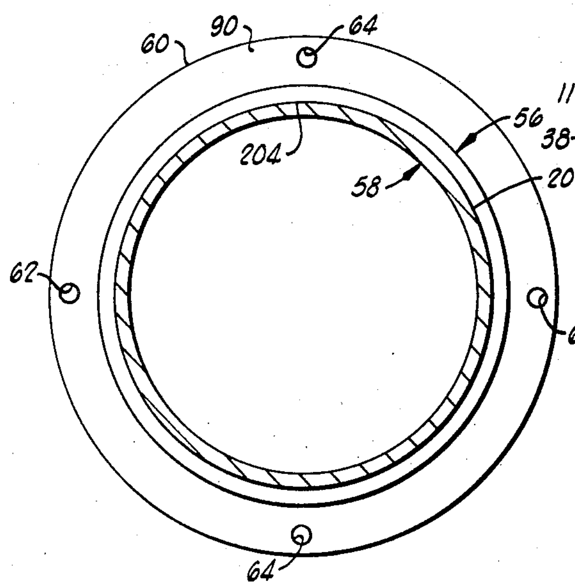

FIG. 6

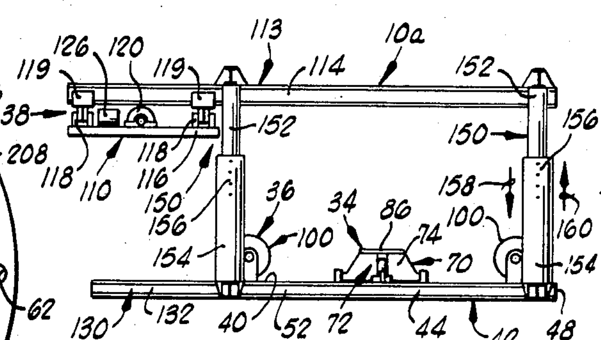

FIG. 4

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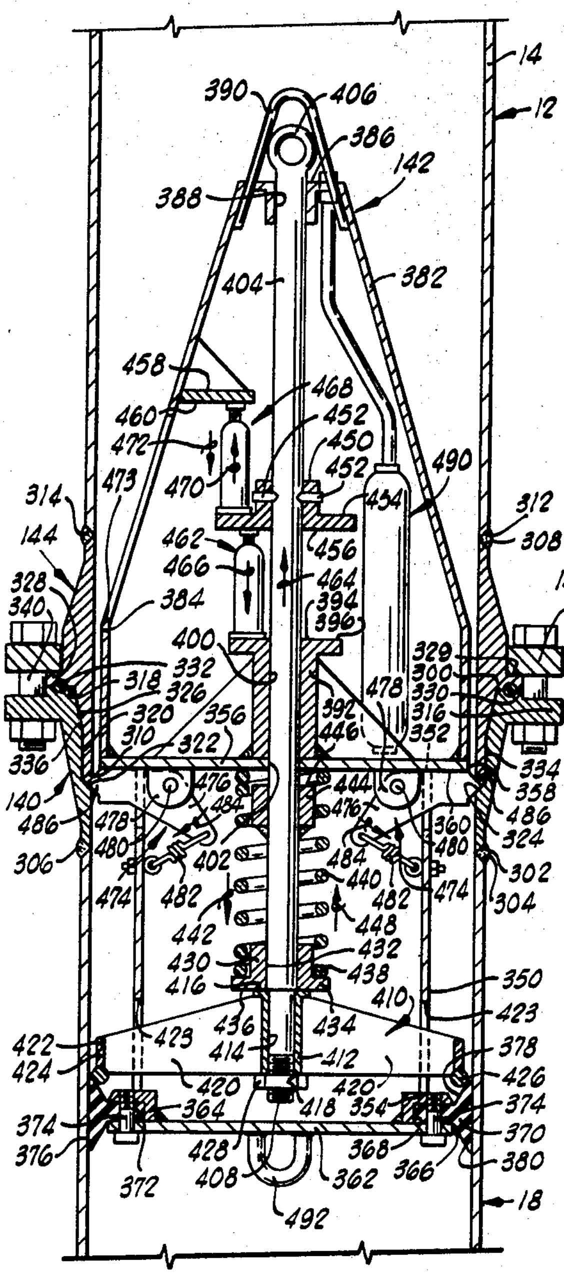

FIG. 8

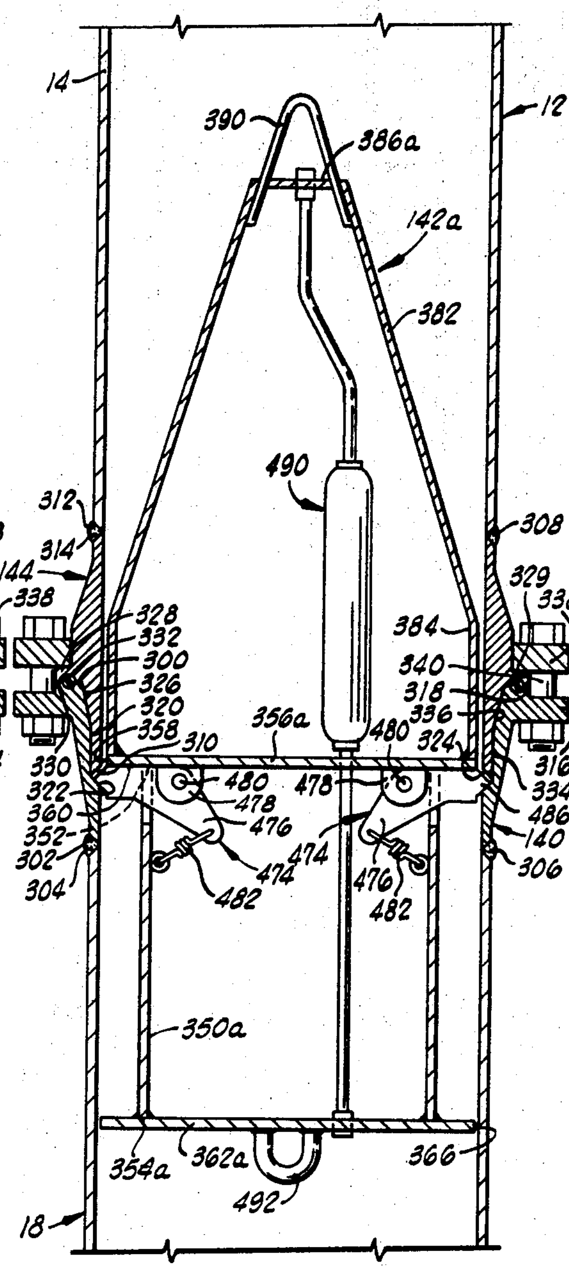

FIG. 10

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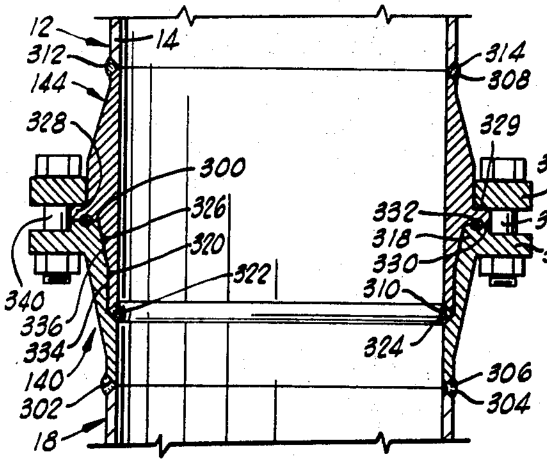

FIG. 9

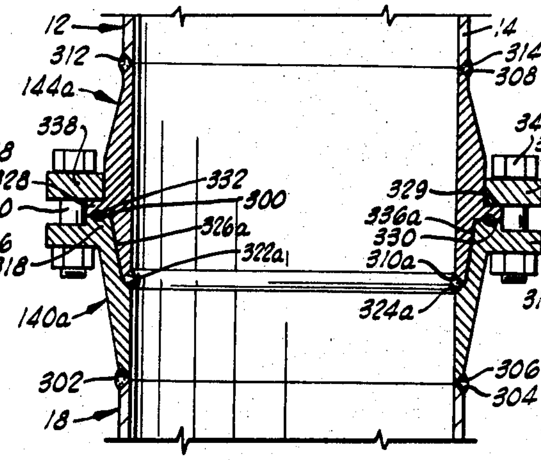

FIG. 11

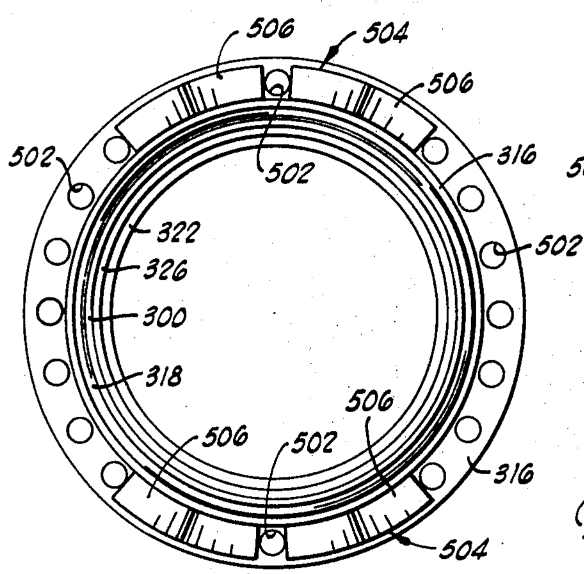

FIG. 13

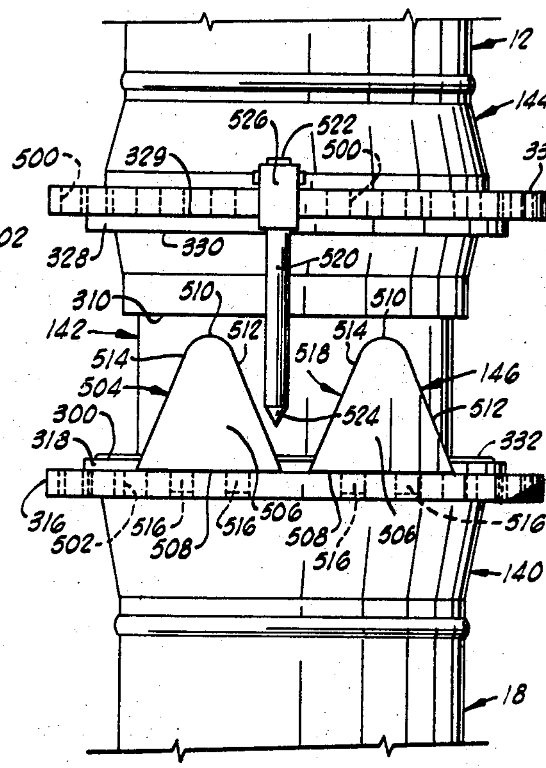

FIG. 12

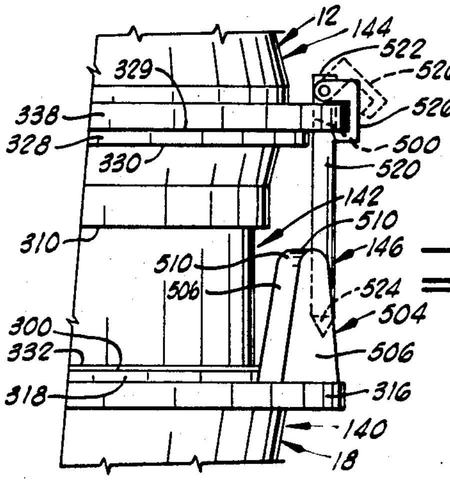

FIG. 14

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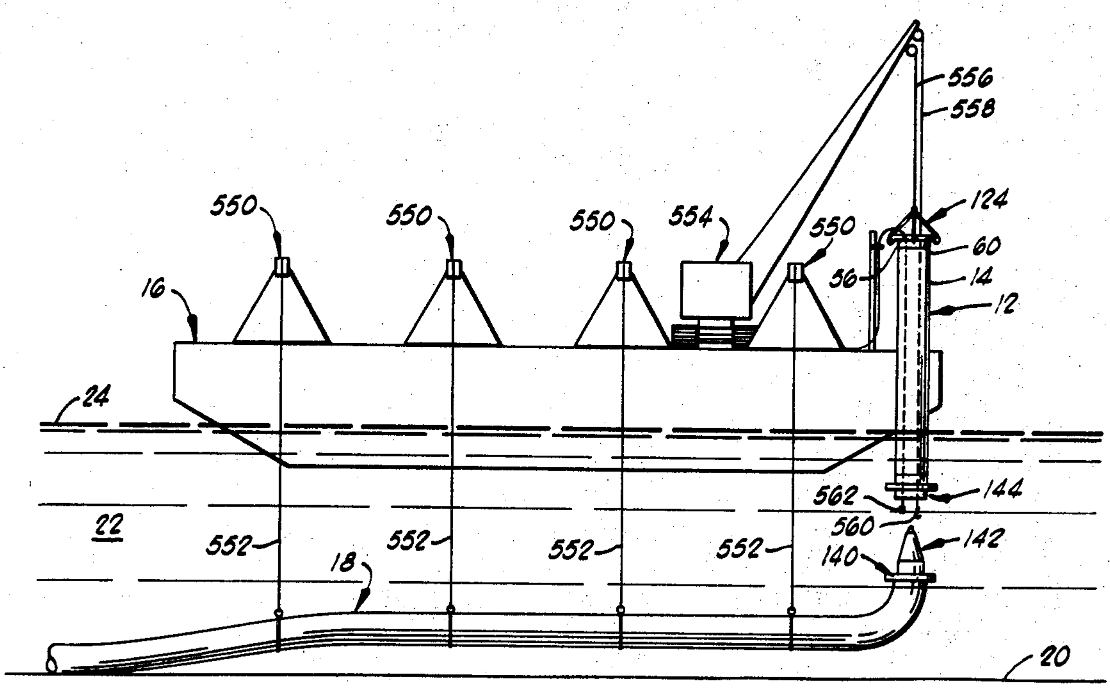

FIG. 15

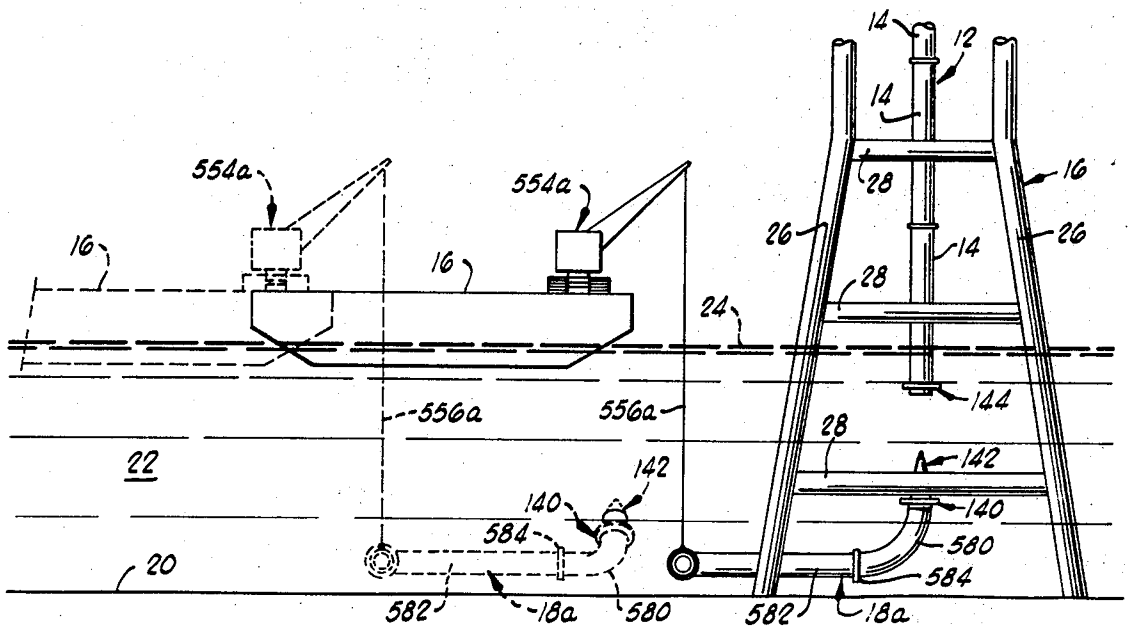

FIG. 16

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METHOD AND APPARATUS FOR CONSTRUCTING AND CONNECTING UNDERWATER RISERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to improvements in methods and apparatus for constructing and installing underwater pipelines and, more particularly, but not by way of limitation, to a method and apparatus for constructing an underwater riser and an underwater pipeline to facilitate the underwater interconnection therebetween.

2. Description of the Prior Art

Offshore marine structures, commonly referred to in the art simply as "platforms" are installed in a marine environment, and are generally utilized to support structures and equipment during various offshore operations. In the past, one of the most common usages of such platforms has been with respect to the offshore drilling and production of an oil and gas well.

In connection with such platforms, various underwater pipelines are commonly utilized to transport a fluid to or from various remote locations with respect to the platform. These pipelines generally include an underwater pipeline, which is disposed on the water-body floor, and a pipeline, which is commonly referred to in the art as a "riser," vertically disposed, generally adjacent or near the offshore platform. The lowermost end of the riser is generally connected to one end of the underwater pipeline, in an assembled position of the riser and underwater pipeline.

Various methods and apparatus have been proposed in the past for constructing and installing the underwater pipelines and the risers, and for making the underwater connection between the riser and the underwater pipeline. One such method utilized in the past, basically comprised the bending of a portion of the underwater pipeline in a generally upward direction, the portion of the underwater pipeline extending upwardly from the bend thereby forming the pipeline riser. This particular method, although adequate for extremely small sizes of pipe, is not of a nature that it could be successfully utilized to construct underwater pipelines and risers which are of a relatively large size, as commonly associated with the offshore production of oil and gas.

In the past, the underwater pipeline has been constructed of various pipeline sections which were interconnected aboard a support member or, more particularly, a barge, and the interconnected pipeline sections were then laid on the water-body floor from the barge. The pipeline riser was basically constructed of the plurality of riser-sections which were also interconnected aboard the barge and "stovepiped" or, in other words, lowered into an interconnecting relationship with one end of the underwater pipeline. The riser-sections were supported by cables generally on one side of the barge in a somewhat interconnecting relationship, and the riser-sections were then welded together at the interconnection therebetween while being thus supported.

Not only was this procedure, generally described above, for constructing and connecting an underwater riser hazardous with respect to the various operating personnel involved, but it has also been found that when utilizing such a method it was virtually impossible to assure a good, substantially **100** percent X-ray weld, with respect to the welded interconnections between the various riser-sections. Although the inability to achieve an adequate welded connection between the various riser-sections was generally due to the relative movement of the two riser-sections being connected during the welding or connecting procedure, it has also been found that the construction of the riser-sections per se made a sealingly secure, welded interconnection substantially difficult to achieve. In practice, it was the general operating procedure to secure a sufficient amount of weld material generally about the interconnection between the riser-sections to merely assure a connection therebetween. The weld material was then ground-down, and the interconnection re-welded, in an effort to achieve a maximum security weld. It should also be noted that even in those instances where the riser-sections were bolted together and a gasket interposed therebetween to provide the sealing security, it has been found that in many instances the gasket was completely or partially destroyed during the interconnection of the two riser-sections, utilizing the connecting procedure, as generally described above.

Since a portion of one of the riser-sections being interconnected was generally partially disposed in the water-body during the connecting procedure, it has been found that, in many instances, full crews of men and machinery were idled during a high-tide or a generally rough water condition. Thus, not only were the procedures for constructing and installing underwater risers hazardous and the interconnections between the various riser sections relatively unsecure, but also these procedures were extremely inefficient and costly.

SUMMARY OF THE INVENTION

An object of the invention is to provide a method and apparatus for constructing an underwater riser wherein the sealing integrity between the interconnected riser-sections is substantially increased.

Another object of the invention is to provide a method and apparatus for constructing an underwater riser in a manner assuring the safety of the various operating personnel and which is economical in construction and operation.

One other object of the invention is to provide a method and apparatus for constructing an underwater riser and connecting one end of the constructed riser to one end of an underwater pipeline, wherein the alignment of the riser with the end of the underwater pipeline is accomplished in a faster, more efficient and more positive manner.

A further object of the invention is to provide a method and apparatus for constructing an underwater riser wherein the required construction time is substantially reduced.

A still further object of the invention is to provide a method and apparatus for constructing an underwater riser and for connecting one end of the constructed riser to one end of an underwater pipeline which is economical in construction and operation.

Another object of the invention is to provide a guide coupling for aligning the ends of two pipelines to be interconnected in a more efficient and positive manner.

One further object of the invention is to provide a guide coupling for guidingly aligning the ends of two pipelines to be interconnected, which is economical in construction and operation.

One other object of the invention is to provide a guide coupling apparatus to guide one end of a pipeline into an interconnecting relationship with one end of another pipeline particularly useful in effecting underwater connections.

Another object of the invention is to provide a riser-section constructed to be economically and efficiently connected to another riser-section.

A still further object of the invention is to provide a method and apparatus for positioning an underwater pipeline in an interconnecting alignment with a riser in a faster, more efficient and more economical manner.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawings which illustrate the various embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a marine support member, more particularly, a platform having a riser construction apparatus supported thereon for constructing a riser and for connecting the constructed riser to one end of an underwater pipeline.

FIG. 2 is a top plan view of the riser construction apparatus of FIG. 1.

FIG. 3 is an enlarged, side elevational view showing a preferred embodiment of a portion of a riser support assembly constructed to be utilized in cooperation with the riser construction apparatus of FIG. 1.

FIG. 4 is a side elevational view of a modified riser construction apparatus, similar to the riser construction apparatus of FIG. 1, but having an insertable, removable support structure.

FIG. 5 is a partial, enlarged sectional view showing a pair of interconnected riser-sections constructed to be utilized in cooperation with the riser construction apparatus of FIG. 1.

FIG. 6 is a sectional view of the riser-sections of FIG. 5, taken substantially along lines 6—6 of FIG. 5.

FIG. 7 is a sectional view, similar to FIG. 5, but showing a modified pair of interconnected riser-sections.

FIG. 8 is an enlarged, sectional view showing a preferred embodiment of the guide-coupling apparatus of FIG. 1.

FIG. 9 is an enlarged, sectional view showing a portion of the riser and a portion of the underwater pipeline of FIG. 8 in an interconnected position.

FIG. 10 is a sectional view, similar to FIG. 8, but showing a modified guide-coupling apparatus.

FIG. 11 is an enlarged sectional view, similar to FIG. 9, but showing a modified riser and underwater pipeline interconnection.

FIG. 12 is an enlarged, elevational view showing a flange alignment apparatus utilized to align the bolt holes in the riser and the underwater pipeline for bolting interconnection therebetween.

FIG. 13 is a top elevational view of the end of the underwater pipeline of FIG. 12 having the guide coupling apparatus removed therefrom, and a portion of a pin guide assembly positioned therein.

FIG. 14 is a partial, side elevational view of the flange alignment apparatus of FIG. 12.

FIG. 15 is a diagrammatical, side elevational view showing a riser construction and connection apparatus for constructing a riser and connecting the riser to an underwater pipeline from a barge type support member.

FIG. 16 is a partial diagrammatical, side elevational view showing a portion of an underwater pipeline and apparatus for moving the underwater pipeline into an interconnecting position with respect to an underwater riser being constructed from a platform.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in general, and to FIGS. 1, 2 and 3 in particular, shown therein and designated by the general reference 10 is a riser construction apparatus for constructing a riser 12 by securedly interconnecting a predetermined number of riser-sections 14 from a support member 16, and connecting one end of the constructed riser 12 to an underwater pipeline 18. The riser construction apparatus 10 is supported in an assembled position upon the support member 16 which is, more particularly, an offshore platform or, in other words, a platform which is supported on a floor 20 of a body of water 22, a portion of the platform 16 being disposed in a body of water 22 generally below a surface 24 thereof. The platform 16 may be of the type commonly utilized with respect to various offshore operations relating to the drilling and production of oil and gas, for example, and basically comprises: a plurality of support legs 26, which are anchored in the floor 20 of the body of water 22; and a plurality of brace members 28, which are securedly interconnected to the support legs 26 (only two of the brace members 28 and only two of the support legs 26 are shown in FIG. 1, for the purpose of clarity of description).

As shown more clearly in FIG. 1, the platform 16 includes a first operating deck 30 supported thereon generally above the surface 24 of the body of water 22. A portion of the first operating deck 30 is secured to a portion of each of the support legs 26, and is generally supported on the platform 16 thereby. A second operating deck 32 is supported by the support legs 26 on the platform 16, a distance generally above the first operating deck 30. The first and the second operating decks 30 and 32 may be of the type generally adapted to support various well-drilling and servicing equipment and, in some installations, the second operating deck 32 may be removable for temporary utilization during certain portions of the overall construction operation. The construction and utilization of various offshore support members, such as the platform 16, generally described above, is well known in the art and a detailed description thereof is not required herein.

As shown more clearly in FIGS. 1 and 2, the riser construction apparatus 10 generally includes: a riser support assembly 34 and a riser lowering assembly 36, each being supported on a portion of the first operating deck 30; and a positioning assembly 38 supported on a lower side portion of the second operating deck 32, generally between the first operating deck 30 and the second operating deck 32. Although the riser construction apparatus 10 can be securedly connected directly to various portions of the support member 16 and supported thereby, in a preferred form, and as shown in

FIGS. 1, 2 and 3, the support assembly **34** and the riser lowering assembly **36** are, more particularly, securedly supported on a base plate **40** which is connected to a support frame **42**, in a manner to be described in more detail below.

The support frame **42** is securedly connected to and supported upon a portion of the first operating deck **30**, and basically comprises a plurality of structural members **44** (one of the structural members **44** being shown in FIG. 1), such as, for example, I-beams, which are interconnected to form a generally rectangularly shaped support structure. The base plate **40** has opposite ends **46** and **48** and opposite sides **50** and **52**. In actual practice, additional structural members may be interconnected and secured generally between the opposite ends **46** and **48** and the opposite sides **50** and **52** to provide additional supporting strength for the support frame **42**. In view of the detailed description of the riser construction apparatus **10** below, the precise construction of a support frame and the precise interconnection of the various structural members will be apparent to those skilled in the art and a detailed description thereof is not required herein.

As shown more clearly in FIG. 2, the base plate **40** includes a plurality of support apertures **54** formed therethrough. It should be particularly noted that the first operating deck **30** also has apertures formed therethrough (not shown) aligned with the support apertures **54** in the base plate **40** or, at least, the first operating deck **30** has an opening therethrough positioned such that riser-sections **14** can be positioned through the support apertures **54**. Each support aperture **54**, more particularly, is sized to receive one of the riser-sections **14** such that a portion of the base plate **40** supportingly engages a portion of the riser-section **14** to storingly support the riser-section **14** disposed therein in a stored position for subsequent utilization in the construction of the riser **12**, for reasons and in a manner to be described in greater detail below.

As generally shown in FIGS. 1, 2 and 3, each riser-section **14** has a connecting upper end **56** and a connecting lower end **58** formed thereon. The connecting upper end **56** of each riser-section **14** is shaped to interconnectingly mate with the connecting lower end **58** of another riser-section **14**, in such a manner that the riser-sections **14** can be securedly joined to form the riser **12**. In a preferred form, the connecting lower end of one of the riser-sections **14** is, more particularly, an underwater connecting end and is positioned or interconnected to the other riser-sections **14** to form an underwater connecting end of the constructed riser **12** in a manner to be described in greater detail below.

A support ring **60** is formed about the outer periphery of each riser-section **14**, generally near the connecting upper end **56** thereof, as shown in FIGS. 1, 2 and 3. Each support ring **60** extends a distance generally radially from one of the riser-sections **14**. More particularly, each support ring **60** is shaped and sized to extend a sufficient distance from one of the riser-sections **14**, such that when one of the riser-sections **14** is lowered into a stored position through one of the support apertures **54**, a portion of the support ring **60** engages a portion of the base plate **40**, generally adjacent the support aperture **54**, the riser-section **14** being thus supported in a stored position therein. It should also be noted that the support ring **60** of each riser-section **14** is also shaped and disposed to engagingly contact a portion of the riser support assembly **34**, in one position of the riser support assembly **34**, during the construction of the riser **12**, in a manner and for reasons which will be described in greater detail below.

In a preferred form and as shown more clearly in FIG. 2, a pair of position apertures **62** are formed through a portion of each support ring **60**. The position apertures **62** are spaced approximately 180° apart and are sized and positioned on each support ring **60** to cooperate with the riser support assembly **34** such that one of the riser-sections **14** is securedly positioned and supported therein in one position of the riser support assembly **34**, as will be described in greater detail below.

A pair of support apertures **64** are also formed through a portion of each support ring **60**, as shown in FIG. 2. The support apertures **64** are spaced approximately 180° apart, and each support aperture **64** is spaced approximately 90° from each position aperture **62**. The support apertures **64** are sized and positioned on each support ring **60** to cooperate with the lowering assembly **36** such that the interconnected riser-sections **14** can be lowered through the riser support assembly **34**, in one position of the riser support assembly **34** and in one position of the lowering assembly **36**, in a manner to be described in greater detail below.

As shown more clearly in FIGS. 2 and 3, the riser opening **66** is formed through a central portion of the base plate **40**, and the riser opening **66** is also centrally disposed with respect to the riser support assembly **34**. The riser opening **66** is sized such that the interconnected riser-sections **14** can be passed therethrough, more particularly, the riser opening **66** has a diameter larger than the largest radial diameter of any portion of any of the riser-sections **14**, for reasons which will be made apparent below. It should be particularly noted that the first operating deck **30** also has apertures (not shown) formed therethrough or, at least, an opening therethrough positioned such that interconnected riser-sections **14** can be passed through the riser opening **66** during one portion of the operation of the riser construction apparatus **10**, for reasons and in a manner to be described in more detail below.

As shown in FIGS. 1, 2 and 3, the riser support assembly **34** is secured to and supported upon a portion of the base plate **40**, generally about or near the riser opening **66**. The riser support assembly **34** has a support position, and is constructed to securedly position and to supportingly engage one of the riser-sections **14** or, more particularly, a portion of the support ring **60** of one of the riser-sections **14**, in a support position of the riser support assembly **34**. The riser support assembly **34** also has a release position, and is constructed to non-engagingly pass the interconnected riser-sections **14** therethrough, in a release position thereof, in a manner to be described in greater detail below.

The riser support assembly **34** includes a pair of support arm assemblies **70** secured to a portion of the base plate **40**, generally adjacent the riser opening **66**, and a pair of actuator assemblies **72** which are secured to a portion of the base plate **40**. Each actuator assembly **72** is connected to one of the support arm assemblies **70** to move the support arm assemblies **70** to a support position and a release position, in a manner to be described in detail below.

Each support arm assembly **70** includes a support arm **74**, as shown more clearly in FIGS. **2** and **3**. Each support arm **74** has a pivot end **76** and a support end **78**. The pivot end **76** of each support arm **74** is pivotally secured to the support member **16** and, more particularly, each pivot end **76** is pivotally secured to a flange **80** via a pin **82**, as shown more clearly in FIG. **3**. Each flange **80** is secured to the base plate **40**, and positioned thereon such that, in the assembled position of the riser support assembly **34**, the support arms **74** are spaced approximately 180° apart, for reasons which will be made apparent below.

In a preferred form, each support arm **74** has a base **84** formed on the support end **78** thereof, and each base **84** has an upper supporting surface **86** formed thereon. Each upper surface **86** is arcuately shaped and sized to supportingly engage a portion of the support ring **60** of one of the riser-sections **14**, in a support position of the riser support assembly **34**.

A locating pin **88** is formed or, more particularly, secured to a portion of the upper surface **86** of each base **84**. Each locating pin **88** extends generally perpendicularly from the upper surface **86**, and is sized to positioningly extend through a portion of one of the position apertures **62** of the riser-section **14** being supported by the riser support assembly **34**, to position each riser-section **14** in a support position of the riser support assembly **34**, and in one position of each riser-section **14**. It should be noted that each support arm assembly **70** could, in one form, include additional locating pins **88**; however, in a preferred form, each support arm assembly **70** does include at least one locating pin **88**, and each support arm assembly **70** is disposed generally on opposite sides of the riser-section **14** being supported thereby such that the locating pins **88** on the support arm assemblies **70** are spaced approximately 180° apart, in a support position of the riser support assembly **34**, as shown in FIGS. **1, 2** and **3**.

As shown more clearly in FIG. **3**, the support ring **60** of each riser-section **14** has an upper surface **90** and a lower surface **92**. The lower surface **92** of each support ring **60** is shaped to engage a portion of the upper surface **86** of each support arm **74**, in a support position of one of the riser-sections **14** with respect to the riser support assembly **34**, as shown in FIGS. **1, 2** and **3**.

Each actuator assembly **72**, more particularly, includes a cylinder actuator **93**, having a piston arm **94** reciprocatingly disposed therein. The end of each cylinder actuator **93**, opposite the piston arm **94** end thereof, is pivotally secured to a flange **95**, which is secured to a portion of the base plate **40** via a pivot pin **96** (the pivotal interconnection between one of the cylinder actuators **93** and one of the flanges **95** being shown in greater detail in FIG. **3**). The end of each piston arm **94** opposite the end thereof reciprocatingly disposed in one of the cylinder actuators **93** is pivotally secured to a flange **97**, formed on a portion of each support arm **74** and extending generally perpendicularly therefrom.

The support arms **74** and the cooperating cylinder actuators **93** are thus each pivotally connected to the support member **16** or, more particularly, to a portion of the base plate **40**, and interconnected such that as each piston arm **94** is reciprocated into the respective cylinder actuator **93**, each support arm **74** is pivotally moved in a general direction **98** to a release position, and such that as each piston arm **94** is reciprocated generally toward the support arm **74** connected thereto, each support arm **74** is pivotally moved in a general direction **99** to a support position. Each cylinder actuator **93** is thus actuatable to move the support arm **74** connected thereto to a support position and a release position, in a manner as generally described above. Such cylinder actuators are well known in the art, and a further detailed description of the construction and operation thereof is not required herein.

In the support position of the riser support assembly **34** and one of the riser-sections **14**, the locating pin **88** of each support arm **74** is disposed through one of the position apertures **62**. In this position, the locating pins **88** of each support arm **74** thus cooperate with the support ring **60** of the supported riser-section **14** to securedly position the supported riser-section **14** in the riser support assembly **34**. Thus, the base **84** securedly supports the riser-section **14** in the riser support assembly **34** in a stationary vertical position, and the locating pins **88** cooperate with the position apertures **64** to securedly support the riser-sections **14** in the riser support assembly **34** in a stationary axial position, in the support position of the riser support assembly **34**.

It should be particularly noted that the term vertical as used herein to denote a direction or a plane represents a direction or a plane which extends generally parallel to a direction of plane extending perpendicularly from the base plate **40**, and the term horizontal as used herein to denote a direction or a plane represents a direction or plane which extends generally parallel to the base plate **40**. In this regard, the terms axially and radially are used herein to denote a direction or a plane extending generally axially or radially with respect to the constructed riser **12** which is vertically disposed in the body of water **22**.

The riser lowering assembly **36** is constructed and positioned to guidingly lower the constructed riser **12** in a direction generally toward the underwater pipeline **18** to a position wherein the riser **12** connectingly engages the underwater pipeline **18**. As shown in FIGS. **1** and **2**, the riser lowering assembly **36** includes a pair of winch assemblies **100**, each winch assembly **100** being supported on the support member **16** and spaced approximately 180° apart. More particularly, one of the winch assemblies **100** is supported on the base plate **40** generally near the end **46** thereof, and one of the winch assemblies **100** is supported on the base plate **40** generally near the end **48** thereof. A winch cable **102** is connected to each winch assembly **100**.

As shown in FIG. **2**, a pair of winch apertures **104** are formed through the base plate **40**. More particularly, each winch aperture **104** is formed through the base plate **40** generally between one of the winch assemblies **100**, and the riser aperture **66**, for reasons which will be made more apparent below.

One end of each wench cable **102** is secured to one of the winch assemblies **100** and the opposite end of each winch cable **102** is removably connected to a portype support member for temporary storage, for reasons to be made more apparent below.

The underwater pipeline **18** is constructed of a plurality of interconnected pipe-sections and, in a preferred form and as shown in FIG. **1**, an underwater connecting end **140** is connected to one end of the underwater pipeline **18**. The underwater connecting end **140**, referred to sometimes below as the pipeline underwater connecting end **140**, is constructed to interconnectingly engage one end of the constructed riser **12**, in one position of the constructed riser **12** and the underwater pipeline **18**, as will be described in greater detail below.

A guide coupling assembly **142** is removably disposed in a portion of the underwater pipeline **18** generally near the end of the underwater pipeline **18** having the underwater connecting end **140** connected thereto, as shown in FIG. **1**. A portion of the guide coupling assembly **142** is shaped and disposed to guidingly engage a portion of the constructed riser **12**, generally near an underwater connecting end **144** thereof, to guide the constructed riser **12** to a position wherein the underwater connecting end **144** of the constructed riser **12** connectingly engages a portion of the underwater connecting end **140** of the underwater pipeline **18**, in a manner to be described in greater detail below.

As mentioned before, each of the riser-sections **14** has a connecting upper end **56** and a connecting lower end **58**; however, in a preferred form and as shown in FIG. **1**, one of the riser-sections **14** has an upper end **56** and the underwater connecting end **144** is connected to the end thereof opposite the upper end **56** thereof. The riser-sections **14** are interconnected to form the constructed riser **12** such that the underwater connecting end **144** connected to the one riser-section **14** forms the lowermost end or the underwater connecting end **144** of the constructed riser **12**. It is apparent from the foregoing that the constructed riser **12** is formed from a predetermined number of riser-sections **14** wherein one of the riser-sections **14** has an upper end **56** and an underwater connecting end **144**, and each other riser-section **14** has an upper end **56** and a lower end **58**. The riser-sections **14** are interconnected such that the connecting upper end **56** of some of the riser-sections **14** is interconnected to the connecting lower end **58** of one other riser-section **14** to form the constructed riser **12**, as will be made more apparent below.

As shown in FIG. **1**, the riser construction apparatus **10** also includes a flange alignment assembly **146** which is supported generally between the underwater connecting end **144** of the one riser-section **14** and the underwater connecting end **140** connected to the underwater pipeline **18**. The flange alignment assembly **146** is constructed to align the bolt holes (not shown in FIG. **1**) of the underwater connecting end **140** connected to the underwater pipeline **18** with the bolt holes through a portion of the underwater connecting end **144** of the one riser-section **14** for bolting interconnection therebetween, in a manner and for reasons which will be described in greater detail below.

OPERATION OF FIGURES 1, 2 AND 3

The riser construction apparatus **10** described above, is constructed and positioned to facilitate the construction of the riser **12** from the support member **16**, and to position the lowermost end of the constructed riser **12**, that is the underwater connecting end **144** thereof, in an interconnectingly engaging position with the underwater connecting end **140** of the underwater pipeline **18**, so that the constructed riser **12** can be safely and securedly joined to the underwater pipeline **18**.

After the platform **16** has been constructed, the support frame **42**, having the base plate **40** secured thereto is initially positioned upon and secured to a portion of the first operating deck **30** of the platform **16**. In one form, the various assemblies and components of the riser construction apparatus **10** are then secured in an assembled position to the base plate **40** and to a portion of the second operating deck **32**. In another form, the various assemblies and components of the riser construction apparatus **10** could be secured to the first operating deck **30**, the first operating deck **30**, in this form, providing the support structure for the riser construction apparatus **10**.

A plurality of riser-sections **14** are then storingly disposed in the support apertures **54** for subsequent utilization in the construction of the riser **12**. It should be noted that, in one form, the riser construction apparatus **10** could be assembled on the base plate **40** prior to inserting the support frame **42** onto the support member **16**. In this form, if the riser-sections **14** are storingly disposed in the support apertures **54** prior to inserting the unit onto the platform **16**, the first operating deck **30** will be constructed or modified to provide an access opening or a clearance for the stored riser-sections **14** to pass through, as the unit is being initially positioned onto the first operating deck **30**.

In those applications where the riser-sections **14** are not initially positioned in the various support apertures **54** prior to installing the riser construction apparatus **10** on the platform **16**, the riser-sections **14** to be storingly supported through the riser-section apertures **54** are initially unloaded from a barge, temporarily positioned in the riser section receiving assembly **130**, and then positioned in the support apertures **54** by the positioning assembly **38**. In this instance, the positioning assembly **38** is positioned generally over the riser-section **14** temporarily stored in the riser section receiving assembly **130**, and actuated to a lowering position, thereby lowering the crane cable **122**. The crane cable **122** is lowered to a position wherein the riser section connector **124** can be securedly connected to the riser-section **14** stored in the riser section receiving assembly **130**. The positioning assembly **38** is then actuated to a raising position, thereby raising the crane cable **122** and the riser-section **14** connected thereto via the riser-section connector **124**. The positioning assembly **38** will raise the riser-section **14** to a position wherein the connecting lower end **58** of the riser-section **14** is disposed in a horizontal plane generally above the base plate **40**. The positioning assembly **38** is then moved transversely and laterally over the base plate **40** to a position wherein the riser-section **14** connected thereto is spaced generally over one of the support apertures **54**. The positioning assembly **38** is then again actuated to a lowering position, thereby lowering the riser-section **14** connected thereto through the support aperture **54** and to a position

tion of the interconnected riser-sections **14**, more particularly, a connecting end **106** of each winch cable **102** is removably connected to the support ring **60** of one of the riser-sections **14** via the support apertures **64** therethrough. Each winch cable **102** is disposed through one of the winch apertures **104**, and is disposed in guiding engagement with a guide pulley **106**. Each guide pulley **108** is secured to a portion of the platform **16**, and is disposed thereon to guide one of the winch cables **102** into a guidingly, engaging position with the constructed riser **12**, for reasons which will be described in detail below.

Each winch assembly **100** has an actuated raising and an actuated lowering position, and is constructed such that in the actuated raising position, each winch assembly **100** retrieves a portion of the winch cable **102** connected thereto, thereby raising the constructed riser **12** connected thereto, and such that in the actuated lowering position, each winch **100** releases a predetermined length of the winch cable **102**, thereby lowering the constructed riser **12** connected thereto. Winch assemblies constructed to retrieve and release a winch cable connected thereto, such as generally described above with respect to the winch assemblies **100**, are well known in the art and a detailed description of the construction and operation of the various components thereof is not required herein.

As shown in FIGS. **1** and **2**, the positioning assembly **38** includes an overhead crane assembly **110** which is rollingly connected to a transverse track assembly **112**. The transverse track assembly **112** is rollingly connected to a lateral track assembly **113**. The track assemblies **112** and **113** are each supported in a horizontal plane generally above the riser support assembly **34** and the stored riser-sections **14**, which are storingly disposed in the support apertures **54**. More particularly, the lateral track assembly **113** includes a pair of lateral track members **114** which extend generally laterally over the riser support assembly **34** and the stored riser-sections **14**, and the transverse track assembly **112** includes a pair of transverse track members **115** which extend generally transversely with respect to the lateral track assembly **113**.

The overhead crane assembly **110** includes a crane support frame **116** which is rollingly connected to the transverse track assembly **112** via a plurality of interconnecting roller assemblies **118**, as shown more clearly in FIG. **2**. The crane support frame **116** is thus transversely positionable on the transverse track assembly **112** or, more particularly, rollable on the transverse track assembly **112** to predetermined positions over the stored riser-sections **14** and over the riser support assembly **34**.

As shown in FIGS. **1** and **2**, the overhead crane assembly **110** also includes a crane winch **120** which is supported on a portion of the crane support frame **116**, and a crane cable **122** having one end thereof connected to the crane winch **120**. A riser section connector **124** is secured on the end of the crane cable **122**, opposite the end thereof connected to the crane winch **120**.

The transverse track assembly **112** is, more particularly, rollingly connected to the lateral track assembly **113** via a plurality of roller assemblies **119**, as shown more clearly in FIG. **2**. The transverse track assembly **112** is thus laterally positionable on the lateral track assembly **113**.

It is apparent from the foregoing, that the crane assembly **110** is positionable on the track assemblies **112** and **113** to predetermined positions over the stored riser-sections **14** and over the riser support assembly **34**, during the operation of the positioning assembly **38**. In one form, a position control apparatus (not shown) is connected to the overhead crane assembly **110** and a control portion thereof is disposed near the base plate **40** so that an operator can transversely and laterally position the overhead crane assembly **110**, for reasons and in a manner to be made more apparent below.

The riser section connector **124** is constructed to be removably secured to a portion of a riser-section **14**. In a preferred form, the riser section connector **124** is, more particularly, constructed to be securedly and removably connected to the support ring **60** of one of the riser-sections **14** via the support apertures **64** therethrough, in an operating position of the riser section connector **124**, so that the riser-section **14** connected thereto can be positioningly raised and lowered by the positioning assembly **38**, in a manner and for reasons to be described in detail below.

The crane winch **120** is driven by a winch drive **126** which, as shown in FIG. **1**, is also supported on a portion of the crane support frame **116**. The winch drive **126** has an actuated raising position and an actuated lowering position, and is connected to the crane winch **120** such that, in an actuated raising position of the winch drive **126**, the crane winch **120** retrieves a portion of the crane cable **122** thereby raising the riser-section **14** connected thereto via the riser section connector **124** in a generally vertical direction toward the track assemblies **112** and **113**, and such that, in an actuated lowering position of the winch drive **126**, the crane winch **120** releases a portion of the crane cable **122** thereby lowering the riser-section **14** connected thereto via the riser section connector **124** in a generally downwardly direction toward the stored riser-sections **14** and the riser support assembly **34**. In a preferred form, the control apparatus (not shown) for the winch drive **126** is connected to the winch drive **126** and movably disposed near the base plate **40** so that an operator can control the actuated position of the winch drive **126** to raise or lower a riser-section **14**, in a manner and for reasons to be made more apparent below.

In one form, and as shown in FIGS. **1** and **2**, the riser construction apparatus **10** also includes a riser section receiving assembly **130** which is supported on the support member **16**. The riser section receiving assembly **130**, as shown more clearly in FIG. **2**, basically includes a pair of support beams **132**, one end of each support beam **132** being secured to the end **46** of the support frame **42**. The support beams **132** are spaced a distance apart, and each support beam **132** extends a distance generally perpendicularly from the support frame **42**. More particularly, the support members **132** are spaced a sufficient distance apart and disposed with respect to the platform **16** to receivingly and supportingly engage a portion of the lower surface **92** of the support ring **60** of one of the riser-sections **14**, which is supportingly positioned therein from a barge winch drive **126** of the positioning assembly **38** is then actuated to a raising position, and the overhead crane assembly **110** is then moved laterally and transversely on the track assemblies **112** and **113** to a position wherein the overhead crane assembly **110** is disposed generally above another or a subsequent riser-section **14**. The winch drive **126** is then actuated to a lowering position, thereby lowering the riser section connector **124** to a position for interconnection thereof to the subsequent riser-section **14**.

After the riser section connector **124** is secured to the support ring **60** of the riser-section **14**, the winch drive **126** is then actuated to a raising position, thereby raising the riser-section **14** connected thereto. The riser-section **14** is raised in a generally upwardly direction and removed from the support aperture **54**. The overhead crane assembly **110** is then laterally and transversely positioned over the base plate **40** to a position wherein the riser-section **14** connected thereto is disposed generally over the riser support assembly **34**, in a manner as described above.

After the subsequent riser-section **14** has been positioned over the riser support assembly **34**, as described above, the overhead crane assembly **110** is actuated to a lowering position, thereby lowering the riser-section **14** connected thereto generally toward the riser support assembly **34** or, more particularly, generally toward the supported riser-section **14** which is securedly supported in the riser support assembly **34**. The riser-section **14** supported by the positioning assembly **38** is lowered to a position wherein the connecting lower end **58** thereof is positioned in a mating, interconnecting relationship with respect to the connecting upper end **56** of the riser-section **14**, which is supported in the riser support assembly **34**.

After the connecting lower end **58** of the riser-section **14** supported by the positioning assembly **38** is then moved into a mating, interconnecting relationship with respect to the connecting upper end **56** of the riser-section **14** supported in the riser support assembly **34**, the two riser-sections **14** are then secured together such as, for example, by welding or bolting two riser-sections **14** together. It should be noted that, in the preferred form, the two riser-sections **14** are welded or, at least, partially welded in an interconnecting relationship to form a portion of the constructed riser **12**. In this form of the invention, that is where the two riser-sections **14** are welded or partially welded in an interconnecting relationship, the connecting upper end **56** and the connecting lower end **58** of each riser-section **14** is formed and constructed to facilitate not only the interconnecting, mating relationship, described above, but also to facilitate the welding interconnection of the two riser-sections **14**. It should also be noted that preferred embodiments of the connecting upper end **56** and the connecting lower end **58** of the riser-sections **14** will be described in greater detail below.

The riser support assembly **34** maintains the riser-section **14**, supported therein, in a firm and secure position, such that the movement of the supported riser-section **14** is substantially reduced or virtually eliminated, as described before. The positioning assembly **38** cooperates to maintain the position of the riser-section **14** connected thereto in a manner relatively free of movement, and connecting upper end **56** and connecting lower end **58** of each riser-section **14** is also shaped in a preferred form, to cooperate with the riser support assembly **34** and the positioning assembly **38** to maintain the interconnecting disposition of the riser-sections **14** during the welding or other interconnecting operation to assure a sealingly secure interconnection between the two riser-sections.

After the two riser-sections **14** have been secured in an interconnected relationship, as described above, the winch drive **126** of the positioning assembly **38** is actuated to a raising position, thereby raising the two interconnected riser-sections **14** in a generally upwardly, vertical direction. The two interconnected riser-sections **14** are raised upwardly by the positioning assembly **38** to a position wherein the riser support assembly **34** is disengaged from the supported riser-section **14** supported thereby or, more particularly, to a position wherein the locating pins **88** of the riser support assembly **34** are removed from the position apertures **62** of the supported riser-section **14**.

After the two interconnected riser-sections **14** have been raised by the positioning assembly **38**, as described above, each connecting end portion **106** of the riser lowering assembly **36** is removably, securedly connected through one of the support apertures **64** of the support ring **60** of the riser-section **14** first supported in the riser support assembly **34**. The riser lowering assembly **36** is thus connected in an assembled position to a portion of the partially constructed riser **12**, in a manner as described above.

The riser lowering assembly **36** is constructed and the guide pulleys **108** are disposed and positioned on the support member **16** to maintain each winch cable **102** taut at all times during the construction of the riser **12**, after the riser lowering assembly **36** has been connected to the first supported riser-section **14** and, more particularly, is constructed to lower the interconnected riser-sections **14** of the constructed riser **12** to a position wherein the underwater connecting end **144** of the constructed riser **12** is interconnectingly disposed with respect to the underwater connecting end **140** of the underwater pipeline **18**, as will be described in greater detail below.

After the interconnected riser-sections **14** have been disengaged from the riser support assembly **34**, as described above, the riser support assembly **34** is actuated to a release position, that is a position wherein each support arm **74** is pivoted in a release direction **98** away from the riser opening **66**. The support arm assemblies **70** and the actuator assemblies **72** are each constructed such that, in the release position of the riser support assembly **34**, each support arm **74** is pivoted in a release direction **98** to a position wherein the interconnected riser-sections **14** can be lowered through the riser support assembly **34** and through the riser opening **66** without engaging either support arm assembly **70**.

After the riser support assembly **34** has been positioned in the release position, the overhead crane assembly **110** is actuated to a lowering position, thereby lowering the two interconnected riser-sections **14** through the riser support assembly **34** through the riser opening **66**, to a position wherein the connecting upper end **56** of the last connected riser-section **14** is disposed in a horizontal plane generally above the riser support wherein the riser-section **14** is storingly supported therein, in a manner as described before.

The positioning assembly **38** is utilized, in a manner as described above, to remove a predetermined number of riser-sections **14** from the riser section receiving assembly **130** and to position those riser-sections **14** in a stored position through the support apertures **54**. It should also be noted that, in those applications where the riser-sections **14** are storingly disposed in the support apertures **54** prior to inserting the riser construction apparatus **10** onto the platform **16**, the riser section receiving assembly **130** and the positioning assembly **38** can be utilized to obtain additional riser-sections **14** which may be required during the construction of the riser **12**, in some of the applications, in a manner similar to that described above.

Whether the riser section receiving assembly **130** and the positioning assembly **38** are utilized to initially position the riser-sections **14** in the support apertures **54**, or to position additional riser-sections **14** in the support apertures **54**, in either event, the riser-sections **14** can be initially positioned in the riser section receiving assembly **130** and subsequently positioned in the support apertures **54** by the positioning assembly **130** during a slack tide. In this manner, the stored riser-sections **14** can be subsequently utilized to construct the riser **12** regardless of the water condition, and thus various operating personnel and equipment are not idled due to a rough water condition, thereby reducing the amount of non-productive time and substantially increasing the efficiency and reducing the cost of the riser construction operation.

After the riser construction apparatus **10** has been securedly positioned on the platform **16** and the riser-sections **14** have been storingly disposed through the support apertures **54**, the riser support assembly **34** is then actuated to a support position, that is a position wherein the riser support assembly **34** is positioned to securedly and supportingly receive and engage a riser-section **14**. More particularly, each actuator assembly **72**, shown more clearly in FIG. 3, is actuated to pivotally move each support arm assembly **70** in a support direction **99**.

The positioning assembly **38** and, more particularly, the overhead crane assembly **110** supported thereon, is then transversely and laterally positioned on the transverse track assembly **112** and the lateral track assembly **113**, respectively, such that the overhead crane assembly **110** is positioned generally over or above one of the riser-sections **14** which is storingly disposed in one of the support apertures **54** or in the riser section receiving assembly **130**. In this position of the positioning assembly **38**, the winch drive **126** is then actuated to a lowering position, thereby lowering the crane cable **122** in a downwardly direction generally toward the base plate **40**. The crane cable **122** is lowered, in a manner as described above, to a position wherein the riser section connector **124** is disposed generally near the connecting upper end **56** of one of the riser-sections **14**. The operator will then secure the riser section connector **124** to the riser-section **14** or, more particularly, to the support ring **60** of the riser-section **14**.

After the riser section connector **124** is secured to one of the riser-sections **14**, the winch drive **126** is then actuated to a raising position wherein the crane cable **122** is retrieved on the crane winch **120** or, in other words, wherein the crane cable **122** is moved in an upwardly direction generally toward the positioning assembly **38**, thereby raising the riser-section **14** connected thereto via the riser section connector **124**. The overhead crane assembly **110** will continue to move the riser-section **14** connected thereto in an upwardly direction to a position wherein the connecting lower end **58** of the riser-section **14** is disposed a distance vertically above the base plate **40** and thus removed from the support apertures **54**.

The operator will then move the overhead crane assembly **110** transversely across the transverse track assembly **112** and move the transverse track assembly **112** laterally across the lateral track assembly **113** to a position wherein the riser-section **14** connected thereto is disposed generally above the riser support assembly **34** or, more particularly, generally above the riser opening **66** through the base plate **40**. The overhead crane assembly **110**, or more particularly, the winch drive **126** thereof is then actuated to a lowering position, thereby lowering the riser-section **14** connected thereto in a generally downwardly direction toward the base plate **40**.

The riser-section **14** is lowered by the overhead crane assembly **110**, as described above, through the space between the support arm assemblies **70** and through the riser opening **66** to a position wherein the lower surface **92** of the support ring **60** is supportingly engaged by the upper surface **86** of each support arm assembly **70**. In a preferred form, the riser-section **14** being lowered through the riser opening **66** is also positioned such that each locating pin **88**, disposed on the support arms **74**, is partially disposed through one of the position apertures **62** in the support ring **60**, as shown more clearly in FIG. 3.

The supported riser-section **14**, that is the particular riser-section **14** supported in the riser support assembly **34**, is thus secured in a predetermined horizontal plane via the engagement between a portion of the lower surface **92** of the support ring **60** and the supporting surface **86** of each support arm **74**. The supported riser-section **14** is also securedly supported in a predetermined axial position via the locating pins **88**, each of which is disposed through one of the position apertures **62** in the support ring **60**. The locating pins **88**, more particularly, engage a portion of the support ring **60** and cooperate to limit or virtually prevent any rotational movement of the supported riser-section **14**, about an axial axis, for reasons which will be made more apparent below.

It should be noted that, in a preferred form, the first riser-section **14** supported in the riser support assembly **34** is, more particularly, that one riser-section **14** having the underwater connecting end **144** connected thereto. It will be apparent from the foregoing that, in this manner, the lowermost end of the constructed riser **12**, as shown in FIG. 1, will be the underwater connecting end **144**.

After one of the riser-sections **14** has been securedly supported in the riser support assembly **34**, the operator will then release and remove the riser section connector **124** from the support ring **60** of the supported riser-section **14**, thereby disconnecting the supported riser-section **14** from the positioning assembly **38**. The assembly 34. The riser support assembly 34 is then actuated to a support position, as described before, and the interconnected riser-sections 14 are further lowered to a position wherein the connecting upper end portion 56 of the last connected riser-section 14 is securedly and supportingly engaged by the riser support assembly 34, in a manner similar to that described in detail before with respect to the riser-section 14 first supportingly positioned in the riser support assembly 34.

The riser-section connector 124 is then disconnected from the riser-section 14, and the two interconnected riser-sections 14 are then securedly supported and positioned in a predetermined horizontal plane by the riser support assembly 34, in a manner similar to that described before. The positioning assembly 38 is then utilized to remove another riser-section 14 storingly disposed in one of the support apertures 54, and to move that riser-section 14 to a position wherein the connecting lower end 58 of that riser-section 14 is matingly and interconnectingly disposed with respect to the connecting upper end 56 of the riser-section 14 supported in the riser support assembly 34, in a manner similar to that described above. The connecting lower end 58 of the riser-section 14 supported by the positioning assembly 38 is then secured to the connecting upper end 56 of the riser-section 14 supported in the riser support assembly 34, in a manner similar to that described above. The positioning assembly 38 is actuated to disengage the supported riser-sections 14 from the riser support assembly 34, and to lower the interconnected riser-sections 14 through the riser support assembly 34 and through the riser opening 66 to a position wherein the connecting upper end 56 of the last connected riser-section 14 is securedly and supportingly engaged by the riser support assembly 34.

A predetermined number of riser-sections 14 are interconnected in a manner as described above to form the constructed riser 12. The precise number of riser-sections 14 utilized to form the constructed riser 12 will, of course, depend upon the desired overall length of the riser 12 and the length of each riser-section 14.

After the riser-sections 14 have been securedly interconnected to form the constructed riser 12, the riser lowering assembly 36 is actuated to a raising position, thereby raising the constructed riser 12 to a position wherein the last connected riser-section 14 is disengaged from the riser support assembly 34. The riser support assembly 34 is then actuated to a release position.

In a release position of the riser support assembly 34, the riser lowering assembly 36 is actuated to a lowering position thereby lowering the constructed riser 12 in a generally downwardly direction toward the underwater connecting end 140 connected to the underwater pipeline 18. The riser lowering assembly 36 is, more particularly, utilized to lower the constructed riser 12 to a position wherein the underwater connecting end 144 thereof is positioned in mating and interconnecting engagement with the underwater connecting end 140 of the underwater pipeline 18, as will be described in greater detail below.

In one form, the riser lowering assembly 36 can be utilized solely to lower the constructed riser 12, and the positioning assembly 38 can be utilized to provide a stationary, augmenting support for the interconnected riser-sections 14 during the lowering thereof. In another form, the riser lowering assembly 36 and, more particularly, the winch cables 102 thereof can be utilized solely to lower the constructed riser 12.

In a preferred form, and as will be described in greater detail below, the guide coupling assembly 142 and the flange alignment assembly 146 are each disposed in a portion of the underwater pipeline 18 generally near the underwater connecting end 140 thereof. The guide coupling assembly 142 and the flange alignment assembly 146 each cooperate to position the underwater connecting end 144 of the constructed riser 12 in an interconnecting relationship with respect to the underwater connecting end 140 of the underwater pipeline 18. More particularly, the guide coupling assembly 142 guidingly engages the underwater connecting end 144 of the constructed riser 12 to guide the underwater connecting end 144 in an interconnecting relationship with respect to the underwater connecting end 140 of the underwater pipeline 18, as the constructed riser 12 is lowered in a generally downwardly direction toward the underwater connecting end 140 of the underwater pipeline 18. The flange alignment assembly 146, more particularly, cooperates to align the bolt holes of the underwater connecting end 144 with the bolt holes of the underwater connecting end 140 for bolting interconnection therebetween in a manner which will be described in more detail below.

The riser lowering assembly 36 will be actuated to initially lower the constructed riser 12 to a position wherein the underwater connecting end 144 thereof is disposed in a horizontal plane generally above the underwater connecting end 140 of the underwater pipeline 18. The riser lowering assembly 36 is then utilized to maintain the constructed riser 12 in a predetermined horizontal plane until such time as the underwater interconnection between the constructed riser 12 and the underwater pipeline 18 can be effected by a diver. The diver will position himself generally near the underwater connecting ends 140 and 144 of the pipeline 18 and the constructed riser 12, respectively, and then, in a preferred form, the riser lowering assembly 36 will be actuated to further lower the constructed riser 12 to a position wherein the underwater connecting end 144 of the riser 12 interconnectingly and matingly joins the underwater connecting end 140 of the underwater pipeline 18. The diver will then secure the constructed riser 12 to the underwater pipeline 18 such as, for example, by bolting or by bolting and welding the underwater connecting end 144 of the riser 12 to the underwater connecting end 140 of the underwater pipeline 18.

It will be apparent from the foregoing, that the riser construction apparatus 10, shown in fIGS. 1, 2 and 3 and described above, thus provides an apparatus and a method for constructing an underwater riser in a safe and efficient manner, and a manner assuring a sealingly secure interconnection between the various riser-sections 14 and between the underwater interconnecting ends of the riser and the underwater pipeline. The two riser-sections 14 which are being interconnected during any one portion of the operation of the riser construction apparatus 10 are securedly positioned in an interconnecting relationship by the riser support assembly **34** and the riser positioning assembly **38**, thereby substantially reducing or virtually eliminating relative movement between the two riser-sections **14** being thus interconnected. In those instances where the interconnection between the two riser-sections must be effected while relative movement between the two riser-sections is occurring, as in the past, the interconnecting weld material or the seal element disposed between the end of the two riser-sections being interconnected will be continually fractured, cracked or damaged, thus making it virtually impossible to assure a sealingly secure interconnection.

The riser construction apparatus **10** is particularly adapted to be supported by a marine support structure **16**, such as the platform **16**, shown in FIGS. **1**, **2** and **3**, thereby permitting the various technical personnel responsible for the construction of the riser **12** to perform their various responsibilities and functions from a stable supporting structure, and further since the relative movement between the two riser-sections **14** being interconnected is virtually eliminated, their various functions and responsibilities can be effected under safer, overall working conditions. It should also be noted that since the two riser-sections **14** are securedly positioned and supported in a mating and interconnected relationship during the interconnecting operation, in a manner as described above, the various riser-sections **14** can be interconnected to form the constructed riser **12** independent of the particular condition of the body of water **22** into which the constructed riser **12** will ultimately be disposed. More particularly, the interconnection between the various riser-sections **14** can be effected utilizing the riser construction apparatus **10** even during those times when a high tide or a rough water condition exists with respect to the body of water **22** generally about or near the marine support structure **16**, thereby effecting the construction of the riser **12** in a more efficient manner.

As shown in FIGS. **1** and **2** and as described in detail before, a plurality of riser-sections **14** are storingly disposed through a portion of the riser construction apparatus **10** to be subsequently utilized during the construction of the underwater riser **12**. The riser-section receiving assembly **130** allows a plurality of additional riser-sections **14** to be unloaded from a barge and storingly disposed in the riser construction apparatus **10** during slack tide water conditions, thereby permitting an overall more efficient riser construction operation. More particularly, utilizing the riser construction apparatus **10**, the various technical and operating personnel associated with the construction of the riser **12** are not idled during rough water conditions.

EMBODIMENT OF FIGURE 4

The riser construction apparatus **10*a***, shown in FIG. **4**, is constructed similar to the riser construction apparatus **10**, shown in FIGS. **1**, **2** and **3**, the salient difference being that the support frame **42** is rigidly and adjustably connected to the transverse track assembly **112** and the lateral track assembly **113** by a plurality of telescoping connectors **150**. The riser construction apparatus **10*a*** is thus constructed such that the support frame **42** provides a portable supporting structure for the riser support assembly **34**, the riser lowering assembly **36**, the positioning assembly **38** and the riser section receiving assembly **130**, such that the riser construction apparatus **10*a*** can be constructed as a complete, single, unitary unit, and subsequently transported to the various offshore locations, and inserted as a unit onto the support structure, such as the platform **16** shown in FIGS. **1** and **2**.

Each telescoping connector **150** has opposite ends, and one end of each telescoping connector **150** is connected to a portion of the base plate **40**. The positioning assembly **38** is supportingly connected to the end of each telescoping connector **150**, opposite the ends thereof secured to the base plate **40**. Each telescoping connector **150** is positionable in predetermined horizontal planes to position the positioning assembly **38** in a transport position and an assembled position.

More particularly, each telescoping connector **150** (two of the telescoping connectors **150** are shown in FIG. **4**), basically includes a first structural support member **152**, which is secured on one end thereof to a portion of the lateral track assembly **113**, and a second structural member **154**, which is secured on one end thereof to the support frame **42**. Each second structural member **154** is hollow, and the hollow portion thereof is sized to telescopingly receive a portion of one of the first structural members **152**. It will be apparent to those skilled in the art from the foregoing, that the vertical distance generally between the base plate **40** and the transverse track assembly **112** and the lateral track assembly **113** is thus adjustable in a vertically, downwardly direction **158** and in a vertically, upwardly direction **160** by moving the positioning assembly **38** in a vertically downwardly direction **158** or in a vertically upwardly direction **160**, respectively, thereby telescoping each first structural member **152** a greater distance into the hollow portion of one of the second structural members **154** or telescoping each first structural member **152** in a direction generally out of the hollow portion of one of the second structural members **154**. It should be noted that although only two of the telescoping connectors **150** are shown in FIG. **2**, that in a preferred form, a plurality of telescoping connectors **150** are connected to the base plate **40** and positioned thereon generally about the support frame **42** such as, for example, positioning one telescoping connector **150** at each corner of the support frame **42**, in such a manner that the transverse track assembly **112** and the lateral track assembly **113** is securedly positioned in a horizontal plane generally above the base plate **40** via the telescoping connectors **150**.

In one form, after the first structural member **152** of each telescoping connector **150** has been telescopingly disposed to a predetermined position in the hollow portion of one of the second structural members **154**, the first structural member **152** and the second structural member **154** of each telescoping connector **150** can be secured in this predetermined position by welding interconnection therebetween. In a preferred form, and as indicated in FIG. **4**, a plurality of apertures **156** are formed through a portion of each of the second structural members **154** and a plurality of holes, similar to the holes **156**, are also formed through a portion of each of the first structural members **152**. In this latter form, after the positioning assembly **38** has been moved to a predetermined horizontal position above the base plate **40**, a securing pin (not shown) can then be disposed through one of the apertures **156** and through an aligned aperture in the first structural member **152** of each telescoping connector **150**, the pin thereby removably securing the first structural member **152** in a predetermined position with respect to the second structural member **154** of each telescoping connector **150**.

OPERATION OF FIG. 4

As mentioned before, the riser construction apparatus **10***a*, shown in FIG. **4**, is particularly constructed to provide portable support for the various components and assemblies of the riser construction apparatus **10***a*, so that the riser construction apparatus **10***a* can be conveniently transported to a remote location and disposed in an assembled position on a particular marine support structure, such as the first operating deck **30** of the platform **16**, shown in FIGS. **1** and **2**. The riser construction apparatus **10***a* is positionable in a transport position, that is a position wherein the first structural member **152** has been telescoped in a vertically, downwardly direction **158** to the full extent, or more particularly, to the position wherein the end of each first structural member **152** either abuts the end of one of the second structural members **154** connected to the support frame **42** or to a position wherein a portion of the positioning assembly **38** engages a portion of the end of each second structural member **154** opposite the ends thereof secured to the support frame **42**.

After positioning the riser construction apparatus **10***a* in a transport position, as described above, the riser construction apparatus **10***a* is then transported to a predetermined remote location for installation on a particular marine support structure. The riser construction apparatus **10a** is then disposed in an operating position on the marine support structure and the support frame **42** is secured and positioned thereto such as by bolting or welding.

After the support frame **42** has been securedly positioned on the particular marine support structure, the positioning assembly **38** is then raised in a vertically, upwardly direction **160** to an assembled position wherein the positioning assembly **38** is disposed in a predetermined horizontal plane above the base plate **40** of the support frame **42**. In an assembled position of the positioning assembly **38**, the first structural member **152** and the second structural member **154** of each telescoping connector **150** are then interconnected such as, for example, by welding or by utilizing a pin disposed through one of the apertures **156**, in a manner as described above.

It will be apparent to those skilled in the art that after the riser construction apparatus **10***a* has been inserted and secured in an operating position on the particular marine support structure, that the riser construction apparatus **10***a* will then be utilized to construct the riser **12** and to guidingly position the underwater connecting end **144** thereof in an interconnecting relationship with respect to the underwater connecting end **140** of the underwater pipeline **18**, in a manner as described before with respect to FIGS. **1**, **2** and **3**. The riser construction apparatus **10***a* thus retains all of the advantages of the riser construction apparatus **10**, and in addition provides a portable structure which can be transported to various locations in an assembled position.

EMBODIMENT OF FIGS. 5 AND 6

One preferred embodiment of each riser-section **14** having the connecting upper end **56** and the connecting lower end **58** is shown in detail in FIGS. **5** and **6**. More particularly, the connecting upper end **56** of a riser-section **14** is shown in FIGS. **5** and **6** in an interconnected relationship with respect to the connected lower end **58** of another riser-section **14**. The two riser-sections **14**, shown in FIGS. **5** and **6**, have been sealingly secured in an interconnecting relationship by welding a portion of the connecting upper end **56** of one of the riser-sections **14** to a portion of the connected lower end **58** of the other riser-section **14**.

Although, the following description will relate particularly to the two riser-sections **14**, as shown in FIGS. **5** and **6**, it is contemplated in this embodiment of the invention that each of the riser-sections **14** utilized to construct the riser **12**, in a manner as described before with respect to FIGS. **1**, **2** and **3**, includes a connecting upper end **56** and a connecting lower end **58** constructed in a manner as particularly described below with respect to the riser-sections **14**, shown in FIGS. **5** and **6**. As mentioned before, one of the riser-sections **14** includes the underwater connecting end **144**, and with respect to that one riser-section **14**, only the description of the connecting upper end **56** below is applicable, in a preferred form.

Referring more particularly to the connecting upper end **56**, as shown more clearly in FIG. **5**, an uppermost end **200** thereof is beveled, thereby forming a beveled surface **202** extending about the outer periphery of the riser-section **14**, generally adjacent the uppermost end **200** thereof. A groove **204** is formed in the inner periphery of the connecting upper end **56**, extending a distance axially along the inner periphery thereof, and intersecting a portion of the uppermost end **200** thereof. The groove **204** terminates with a beveled end **206**. The beveled end **206**, more particularly, forms an annular beveled surface **206** which extends about the inner periphery of the connecting upper end **56**, and is positioned therein to matingly abut a portion of the connecting lower end **58** of an adjoining riser-section **14**, in a manner which will be made more apparent below.

As shown in FIGS. **5** and **6**, the support ring **60** is formed on a portion of the outer periphery of the connecting upper end **56**, and extends a distance generally radially therefrom. The support ring extends about the entire outer periphery of the connecting upper end **56**, generally near the uppermost end **200** thereof.

As shown more clearly in FIG. **5**, a groove **208** is formed in a portion of the outer periphery of the connecting lower end **58**, the groove **208** intersecting a portion of a lowermost end **210** of the connecting lower end **58**. More particularly, the lowermost end **210** of the connecting lower end **58** is beveled, thereby forming an annular beveled surface **212** which extends about the outer periphery of the connecting lower end **58**, generally adjacent the lowermost end **210** thereof. The beveled surface **212** matingly and positioningly engages the beveled surface **206** formed in the connecting upper end **56** of an adjoining riser-section **14**, in an interconnecting position of the two riser-sections **14**, as shown in FIG. **5**.

The groove **208**, as shown in FIG. **4**, also extends a distance axially along the outer periphery terminating with an annular end surface **213** which intersects a portion of the outer periphery of the connecting lower end **58**. The annular end surface **213** is beveled, thereby forming a beveled surface **213** extending about the outer periphery of the connecting lower end **58**. In an assembled or interconnecting position of two riser-sections **14**, the uppermost end **200** of the connecting upper end **56** engages a portion of the end surface **213** and, in this position, the beveled surface **202** formed on the connecting upper end **56** cooperates with the beveled surface **213** formed on the connecting lower end **58** of the adjoining riser-section **14** to form a V-shaped groove **214** which extends about the outer periphery of the interconnected riser-sections **14**, as shown more clearly in FIG. **5**. The V-shaped groove **214** provides a space wherein weld material is disposed so that the two riser sections **14** can be weldingly joined in an interconnected relationship, during the construction of the riser **12**, as described before.

In a preferred form, and as shown in FIG. **5**, the connecting upper end **56** and the connecting lower end **58** of the riser-sections **14** is constructed as a separate component, and subsequently secured to a pipe-section **216** to form each riser-section **14**. The connecting upper end **56** and the connecting lower end **58** will therefore be sometimes used below to refer to the separate, individual components which are secured to the pipe-section **216** to form the riser-sections **14**.

In this embodiment of the invention, that is where the connecting upper end **56** and the connecting lower end **58** are constructed as separate, individual components, each connecting lower end **58** includes an upper end **218** which is secured, or more particularly, welded to a lower end **220** of one of the pipe-sections **216**. As shown in FIG. **5** and, in a preferred form, the upper end **218** of the connecting lower end **58** is beveled, and the lower end **220** of the pipe-section **216** is also beveled. The beveled surfaces **218** and **220** of the connecting lower end **58** and the pipe-section **216**, respectively, form a V-shaped groove **221** in an interconnected position of the connecting lower end **58** and one of the pipe-sections **216** to facilitate the welding interconnection therebetween, as shown in FIG. **5**. Each connecting upper end **56**, in this embodiment of the invention, includes a lower end **222** which is secured or, more particularly, welded to an upper end **224** of one of the pipe-sections **216**. The lower end **222** and the upper end **224** of the connecting upper end **56** and the pipe-section **216**, respectively, are beveled, and form a V-shaped groove **226** in an interconnected position of the connecting upper end **56** and one of the pipe-sections **216** to facilitate the welding interconnection therebetween, as shown in FIG. **5**.

It should be noted that the salient reason for forming the connecting lower end **58** and the connecting upper end **56** as separate, individual components, and subsequently securing each connecting end **56** and **58** to the pipe-sections **216** is to facilitate the manufacture of the riser-sections **14**. Since each connecting end **56** and **58**, in a preferred form, requires a certain amount of machining to form the various beveled and tapered surfaces thereon, the forming of the connecting ends **56** and **58** as a separate, individual component reduces the cost of manufacture of the constructed riser-sections **14**, and with respect to a riser-section **14** having an extremely large diameter, it should be noted that, in some instances, it may be extremely difficult to accurately machine the connecting ends **56** and **58** on the pipe-sections **216**.

OPERATION OF FIGS. 5 AND 6

The connecting upper end **56** and the connecting lower end **58**, described in detail above, not only facilitate the effecting of the interconnection between two riser-sections **14**, but also are constructed to facilitate the guiding of the connecting lower end **58** of one of the riser-sections **14** into an adjoining and mating relationship with respect to the connecting upper end **56** of another riser-section **14**, during the construction of the riser **12**, as described in detail above with respect to FIGS. **1**, **2** and **3**. More particularly, utilizing the riser-sections **14**, constructed as shown in FIGS. **5** and **6**, one of the riser-sections **14** is securedly and supportingly positioned in the riser support assembly **34** such that the connecting upper end **56** of the riser-section **14** thus supported is disposed generally above the support arm assemblies **70** of the riser support assembly **34**.

The positioning assembly **38** is then utilized to move another riser-section **14** to a position wherein the connecting lower end **58** of the riser-section **14** supported thereby is disposed in a horizontal plane generally above the supported riser-section **14**. The operator will then actuate the positioning assembly **38** to a lowering position, thereby lowering the riser-section **14** connected thereto in the direction generally toward the connecting upper end **56** of the supported riser-section **14**.

As the riser-section **14** is lowered by the positioning assembly **38**, the beveled surface **212** of the connecting lower end **58** will initially engage a portion of the upper-most end **200** of the connecting upper end **56** of the supported riser-section **14** to guide the connecting lower end **58** into an interconnecting and mating relationship with respect to the connecting upper end **56** of the supported riser-section **14**. More particularly, the connecting lower end **58** is guided into an interconnecting and mating position wherein the surface formed by the groove **204** of the connecting upper end **56** engagingly and slidingly receives the surface formed in the connecting lower end **58** by the groove **208** therein. The riser-section **14** supported by the positioning assembly **38** is further lowered to a position wherein the beveled surface **212** formed on the connecting lower end **58** positioningly engages the beveled surface **206** formed about the inner periphery of the connecting upper end **56**.

The connecting lower end **58** and the connecting upper end **56** cooperate to maintain the riser-section **14** supported in the riser support assembly **34** in an interconnecting and adjoining relationship with respect to the riser-section **14** supported by the positioning assembly **38** while the interconnecting weld is effected by the various operating personnel, the interconnecting and adjoining weld between the two riser-sections **14** being made generally in the area between the two riser-sections **14** formed by the V-shaped groove **214**.

EMBODIMENT OF FIG. 7

Shown in FIG. **7**, is a modified embodiment of the connecting lower end **58***a* which may be preferred in some applications. The connecting lower end **58***a* is constructed similar to the connecting lower end **58**, shown in FIGS. **5** and **6**, the salient difference being that a beveled surface **230** is formed about the inner periphery of the connecting lower end **58***a*, generally adjacent the lowermost end **210***a* thereof.

The beveled surface **230** extends about the inner periphery of the connecting lower end **58***a* and is shaped and positioned to cooperate with the beveled surface **206** formed about the inner periphery of the connecting upper end **56**, such that when two riser-sections **14** are placed in an interconnecting and adjoining relationship, as described before, the beveled surfaces **206** and **230** form a V-shaped groove **232**, as shown in FIG. **7**. The V-shaped groove **232** extends about the inner periphery of the two adjoining riser-sections **14**, and is positioned therebetween to facilitate an additional welding interconnection between the two adjoining riser-sections **14** about the inner periphery thereof, generally adjacent the interconnection therebetween.

OPERATION OF FIG. 7

The connecting upper end **56** and the connecting lower end **58***a*, as shown in FIG. **7**, will operate similar to the connecting upper end **56** and the connecting lower end **58**, as shown in FIGS. **5** and **6**. The salient difference resulting from utilization of the connecting lower end **58***a* being that an additional interconnecting weld may be effected between the two adjoining riser-sections **14**.

This particular embodiment of the invention, as shown in FIG. **7**, may be particularly useful when constructing a riser **12**, wherein the riser-sections **14** have a relatively large inner diameter. In this embodiment of the invention, the various riser-sections **14** are preferably interconnectingly joined in a manner similar to that described before. The underwater connecting end **144** of the constructed riser **12** is then secured to the underwater connecting end **140** of the underwater pipeline **18**. The accumulated water in the constructed riser **12** is then removed, in a manner to be described below, and a welder on a supporting platform is lowered downwardly through the constructed riser **12**, in such a manner that the welder can effect each additional welding interconnection in the area formed by the V-shaped grooves **232**.

It will be apparent to those skilled in the art from the foregoing, that the embodiment of the riser construction apparatus **10** retains all of the advantages described before with respect to the embodiment shown in FIGS. **5** and **6**, and in addition, provides riser-sections **14** which can be more securedly bonded or welded in an interconnecting relationship to form the completed, constructed riser **12**.

EMBODIMENT OF FIGS. 8 AND 9

In one form, the underwater connecting end **144** of the riser **12**, could be constructed substantially the same as the connecting lower end **58**, described in detail above. In that form of the invention, the underwater connecting end **140** of the underwater pipeline **18** should be constructed substantially the same as the connecting upper end **56**, described in detail above, with the exception of the support ring **60** which would not be necessary, as will be apparent to those skilled in the art. However, in a preferred form, the underwater connecting end **140** of the underwater pipeline **18** and the underwater connecting end **144** of the lowermost riser-section **14** of the constructed riser **12** are constructed in a different manner to facilitate the underwater interconnection therebetween. A preferred embodiment of the underwater connecting end **140** connected to the underwater pipeline **18** and the underwater connecting end **144** connected to the constructed riser **12**, and a preferred embodiment of the guide coupling assembly **142** are shown in FIGS. **8** and **9**.

As shown more clearly in FIG. **9**, the underwater connecting end **140** of the underwater pipeline **18** and the underwater connecting end **144** of the constructed riser **12** are each, in a preferred form, constructed as a separate, individual component, the underwater connecting end **140** being secured to one end of one of the pipe-sections forming the underwater pipeline **18** and the underwater connecting end **144** being secured to the lowermost end of the first connected or the lowermost riser-section **14**. The underwater connecting end **140** is thus sometimes referred to below as the pipeline underwater connecting end **140**, and the underwater connecting end **144** is sometimes referred to below as the riser underwater connecting end **144**.

Referring more particularly to the underwater connecting end **140**, as shown more clearly in FIG. **9**, the underwater connecting end **140** has an uppermost end **300** and a lower end **302**. The lower end **302** of the underwater connecting end **140** is secured to an upper end **304** of the underwater pipeline **18** and, in a preferred form, the lower end **302** of the underwater connecting end **140** and the end **304** of the underwater pipeline **18** are each beveled such that when the underwater connecting end **140** is placed in an interconnecting relationship with respect to the underwater pipeline **18**, the beveled ends **302** and **304** form a V-shaped groove **306** which extends about the periphery of the interconnection therebetween. The V-shaped groove **306** is provided to facilitate the welding interconnection between the underwater connecting end **140** and the underwater pipeline **18**, as shown in FIGS. **8** and **9**.

The underwater connecting end **144** has a beveled upper end **308** and a beveled lowermost end **310**. As shown more clearly in FIG. **9**, the upper end **308** of the underwater connecting end **144** is secured to a beveled lowermost end **312** of the lowermost riser-section **14** of the constructed riser **12**. In an assembled position of the underwater connecting end **144**, the upper end **308** thereof and the lowermost end **312** if the constructed riser **12** cooperate to provide or form a V-shaped groove **314** to facilitate the welding interconnection between the one riser-section **14** and the underwater connecting end **144**.

An annular flange **316** is formed on the outer periphery of the underwater connecting end **140**. The flange **316** extends generally radially from the outer periphery of the underwater connecting end **140**, and has a plurality of bolt-holes (not shown) formed therethrough and spaced circumferentially thereabout, for reasons which will become more apparent below.

An annular raised face **318** is formed on a portion of the flange **316**, the uppermost end of the raised face **318** forming the uppermost end **300** of the underwater connecting end **140**. The raised face **318** extends circumferentially about the underwater connecting end **140**, and cooperates with the flange **316** to provide what is generally referred to in the art as a raised face flange connection on the underwater connecting end **140** of the underwater pipeline **18**.

A groove **320** is formed in a portion of the inner periphery of the underwater connecting end **140**, extending a distance axially along the inner periphery thereof, terminating with a beveled end **322**. The beveled end **322** formed in the underwater connecting end **140**, more particularly, forms a beveled surface **322** which extends about the inner periphery of the underwater connecting end **140**. The beveled surface **322** of the underwater connecting end **140** cooperates with the beveled end **310** of the underwater connecting end **144** to form a V-shaped locking groove **324** in an interconnected position of the underwater connecting ends **140** and **144**. The V-shaped locking groove **324** is provided to facilitate the welding interconnection and to cooperatingly engage a portion of the guide coupling assembly **142** to position the guide coupling assembly **142** in the underwater pipeline **18**, as will be described in greater detail below.

As shown more clearly in FIG. **9**, a radially outwardly tapering surface **326** is formed in a portion of the groove **320**, thereby forming an annular tapered surface **326** extending about the inner periphery of the underwater connecting end **140**. A portion of the tapered surface **326** intersects the uppermost end **30** of the underwater connecting end **140**. The surface formed by the groove **320**, and the annular tapered surface **326** of the underwater connecting end **140** is shaped to guidingly and contactingly engage a portion of the underwater connecting end **144**, as will be described in more detail below.

An annular flange **328** is formed about a portion of the outer periphery of the underwater connecting end **144**, generally between the upper end **308** and the lower end **310** thereof. The annular flange **328** extends a distance generally radially from the underwater connecting end **144**, thereby forming an annular upwardly facing surface **329** and an annular downwardly facing surface **330**, each extending about the outer periphery of the underwater connecting end **144**. The downwardly facing surface **330** formed by the flange **328** is positioned on the underwater connecting end **144** to contactingly engage a portion of the uppermost end **300** of the underwater connecting end **140**, in an interconnected position of the constructed riser **12** and the underwater pipeline **18**.

As shown in FIGS. **8** and **9**, the uppermost end **300** of the underwater connecting end **140** and the downwardly facing surface **330** of the underwater connecting end **144** are each shaped to receive a seal gasket **332** which is sealingly disposed therebetween. In one form, the seal gasket **332** could provide the sealing integrity between the constructed riser **12** and the underwater pipeline **18** and, in another form, the seal gasket **332** provides a temporary fluid seal between the constructed riser **12** and the underwater pipeline **18** to sealingly prevent the leakage of fluid therebetween until such time as the welding interconnection can be effected. In this latter form, the seal gasket **332** remains in position to augment the primary sealing integrity provided by the welding interconnection formed between the constructed riser **12** and the underwater pipeline **18**.

As shown in FIGS. **8** and **9**, a groove **334** is formed in a portion of the outer periphery of the underwater connecting end **144** of the constructed riser **12**, extending a distance axially along the outer periphery thereof. A radially outwardly tapering surface **336** is formed in a portion of the groove **330**, thereby forming annular tapered surface **336** extending about the outer periphery of the underwater connecting end **144** and intersecting a portion of the outer periphery thereof. The surfaces formed in the underwater connecting end **144** by the groove **334** and the tapered surface **336** are each shaped to guidingly and matingly engage the surfaces formed in the underwater connecting end **140** by the groove **320** and the tapered surface **326**, respectively, to position the constructed riser **12** in an interconnecting relationship with respect to the underwater pipeline **18**.

As shown in FIGS. **8** and **9**, an annular slip ring **338** is disposed about the underwater connecting end **144** of the one riser-section **14**. More particularly, the upwardly facing surface **329** of the flange **328** is shaped to slidingly and supportingly engage the slip ring **338**, thereby supporting the slip ring **338** on the underwater connecting end **144** in one direction. A plurality of bolt-holes (not shown) are formed through the slip ring **338**, and the bolt-holes formed therethrough are spaced circumferentially about the slip ring **338** to cooperatingly align with the bolt-holes (not shown) formed through the flange **316**, such that in the interconnecting and assembled position of the constructed riser **12** and the underwater pipeline **18**, shown in FIG. **9**, the bolt-holes of the slip ring **338** and the bolt-holes of the flange **316** receive a plurality of interconnecting bolts **340**.

It should be noted that, in an alternate form, a flange could be formed on the outer periphery of the underwater connecting end **144** having the bolt-holes formed therethrough in lieu of the slip ring type of connecting end described above. Although this alternate form may, in some instances be less expensive to manufacture, the slip ring type of connecting end is preferred, since it does facilitate a quicker, more efficient alignment of the bolt-holes for the underwater bolting interconnection.

Referring more particularly to the guide coupling assembly **142**, as shown in FIG. **8**, the guide coupling assembly **142** is constructed to be securedly, removably, and sealingly positioned in a portion of the underwater pipeline **18** to sealingly prevent fluid from entering the underwater pipeline **18** via one end thereof and to guidingly contact a portion of the constructed riser **12** as the constructed riser **12** is being lowered into an interconnecting relationship with respect to the underwater pipeline 18, in a manner which will be described in more detail below.

The guide coupling assembly 142 includes a hollow tubular shaped support base 350 having an upper end 352 and a lower end 354. The support base 350 is disposed in a portion of the underwater pipeline 18 generally near the underwater connecting end 140 connected thereto, in an assembled position of the guide coupling assembly 142, as shown in FIG. 8.

A circular shaped plate 356 is secured to the upper end 352 of the support base 350. The circular shaped plate 356 is sized to encompass the upper end 352 and, more particularly, the diameter of the plate 356 is larger than the diameter of the support base 350 and thus a portion of the plate 356, generally adjacent an outer periphery 358 thereof, extends beyond the outer periphery of the support base 350. The portion of the plate 356 extending beyond the outer periphery of the support base 350 provides an annular downwardly facing surface 350 extending generally radially from the support base 350 and about the entire outer periphery thereof, for reasons which will be made more apparent below.

A circular-shaped, lower end plate 362 is connected to the lower end 354 of the support base 350, as shown in FIG. 8. More particularly, the lower plate 362 is secured to the lower end 354 of the support base via an L-shaped, annular ring 364. A portion of the L-shaped ring 364 is secured to a portion of the lower plate 362, and another portion of the L-shaped ring is secured to the lower end 364 of the support base 350, thereby providing the interconnection therebetween. As shown in FIG. 8, the lower plate 362 has a larger diameter than the diameter of the support base 350, and a portion of the lower plate 362, generally adjacent an outer periphery 366 thereof, cooperates with the L-shaped ring 364 to provide an annular space 368 therebetween.

An annular seal member 370 is connected to the support base 350 and, more particularly, the seal member 370 has an annular ring shaped portion 372 which is disposed generally in the space 368, in an assembled position of the seal member 370. The ring shaped portion 372, in a preferred form, is larger than the space 368, and the seal member 370 is thus compressingly and sealingly secured in an assembled position generally in the space 368 by a plurality of bolts 374 (only two of the bolts 374 are shown in FIG. 8).

The seal member 370 has an annular seal end 376 which extends radially beyond the outer periphery 366 of the lower plate 362, and is sized to slidingly engage an adjacent portion of the inner periphery of the underwater pipeline 18, in one position of the guide coupling assembly 142. A pair of annular, tapered surfaces 378 and 380 are formed on the seal member 370, generally adjacent the seal end 376 thereof. The tapered surface 378 is sized and disposed to be engaged by fluid entering the underwater pipeline 18 via the underwater connecting end 140 thereof such that the fluid biases the seal end 376 of the seal member 370 into sealing engagement with an adjacent portion of the inner periphery of the underwater pipeline, thereby forming a fluid seal between the guide coupling assembly 142 and the underwater pipeline 18, in one position of the seal member 370. The tapered surface 378 is also sized and disposed to be cooperatingly engaged by a portion of a bias assembly, the bias assembly augmenting the sealing engagement between the seal member 370 and the adjacent portion of the inner periphery of the underwater pipeline 18, in a manner to be described in more detail below.

The tapered surface 380 is sized such that, in an assembled position of the guide coupling assembly 142, any pressure which might exist in the underwater pipeline 18, generally below the guide coupling assembly 142, will act on the tapered surface 380 in such a manner that such pressure augments the sealing engagement between the seal member 370 and the adjacent portion of the inner periphery of the underwater pipeline 18.

A cone-shaped guide 382, having a cylindrically shaped base portion 384 is secured to the upper plate 356 of the guide coupling assembly 142. More particularly, one end of the cylindrically shaped base 354 is secured to an upper portion of the upper plate 356, and the opposite end of the cylindrically shaped base 354 is secured to a lower, circular-shaped end of the cone-shaped guide 382. The cylindrically shaped base 384 of the cone-shaped guide 382 has an outer periphery 385, and the outer surface formed by the cone-shaped guide 382 and the outer periphery 385 of the base 384 are each sized and positioned on the guide coupling assembly 142 to provide a guiding surface which guidingly engages a portion of the underwater connecting end 144 to guide the underwater connecting end 144 of the one riser-section 14 into an interconnecting engagement with the underwater connecting end 140 connected to the underwater pipeline 18, in a manner to be made more apparent below.

As shown in FIG. 8, a flat surface 386 is formed on the apex or upper end of the cone-shaped guide 382, and an aperture 388 is formed through a central portion of the flat end 386. In a preferred form and as shown in FIG. 8, the rod 390 is secured in a portion of the flat end 386 of the cone-shaped guide 382, the rod 390 forming the apex of the cone-shaped guide 382. The rod 390 is also positioned to guidingly engage a portion of the underwater connecting end 144 of the constructed riser 12.

A cylindrically shaped support member 392 is secured to a central portion of the upper surface of the upper plate 356. The support member 392 extends generally axially from the upper plate 356, terminating with an uppermost end 394. A portion of the support member 392, generally adjacent the uppermost end 394 thereof, is flanged radially outwardly, thereby providing an extended, substantially flat support surface 396, for reasons which will be made more apparent below.

An aperture 400 is formed through a central portion of the support member 392, and extends axially therethrough through-intersecting the opposite ends thereof. As shown in FIG. 8, an aperture 402 is formed through a central portion of the upper plate 356 and, in an assembled position of the guide coupling assembly 142, the aperture 400 through the support member 392 is aligned with the aperture 402 through the upper plate 356. The apertures 400 and 402 are also axially aligned with the aperture 388 through the end 386 of the cone-shaped guide 382, for reasons which will be made apparent below.

As shown in FIG. 8, an elongated rod 404 is reciprocatingly supported in the guide coupling assembly 142. A portion of the elongated rod 404 extends through the aperture 386 and through the apertures 400 and 402. The rod 404 has an eyelet 406 formed on one end thereof, the eyelet 406 being sized larger than the aperture 388, as shown in FIG. 8. A portion of the rod 404 generally adjacent the lowermost end 408 thereof, is threaded, for reasons which will be made apparent below.

A seal bias assembly 410 is supported in a portion of the base 350 or, more particularly, on the rod 404, generally adjacent the lower end 408 thereof. The seal bias assembly 410 is constructed to biasingly engage a portion of the seal member 370, in one position thereof, to bias the seal end 376 of the seal member 370 into sealing engagement with an adjacent portion of the inner periphery of the underwater pipeline 18.

As shown in FIG. 8, the seal bias assembly 410 has a cylindrically shaped base 412, having an aperture 414 formed through a central portion thereof, and opposite ends 416 and 418. The aperture 414 of the base 412 is sized to receive a portion of the elongated rod 404, generally adjacent the lower end 408 thereof, in an assembled position of the guide coupling assembly 142. A predetermine number of flanges 420 (only two of the flanges 420 are shown in FIG. 8) are connected on one end thereof to a portion of the rod 404 or, more particularly, secured on one end thereof to a portion of the outer periphery of the base 412. Each flange 420 extends radially from the base 412 terminating with an outermost end portion 422 thereof. As shown in FIG. 8, a plurality of openings 423 (only two of the openings 423 are shown in FIG. 8) are formed through a portion of the support base 350, and each flange 420 extends through one of the openings 423.

An annular ring 424 is secured to the outermost end 422 of each flange 420. The annular ring 424 is, more particularly, cylindrically shaped, and is supported in an assembled position, shown in FIG. 8, by each of the flanges 420, each flange 420 being secured to a portion of the ring 424. An annular bias ring 426 is secured to a lowermost end portion of the cylindrically shaped ring 424, as shown in FIG. 8.

The seal bias assembly 410 and, more particularly, the bias ring 426 secured thereon is disposed in the guide coupling assembly 142 and constructed to biasingly engage a portion of the tapered surface 378 of the annular seal member 370, thereby biasing the seal end 376 of the seal member 370 into sealing engagement with an adjacent portion of the underwater pipeline 18, in one position of the seal bias assembly 410.

The seal bias assembly 410 is secured in an assembled position on the rod 404 via a nut 428 which is threadedly secured to the threaded portion 408 of the rod 404. The nut 428, more particularly, engages a portion of the end 418 of the base 412 to limit the movement of the base 412 in one direction on the rod 404.

The seal bias assembly 410 also includes a bias plate 430 having an aperture 432 formed through a central portion thereof. As shown in fIG. 8, and in an assembled position of the guide coupling assembly 142, the rod 404 extends through the aperture 432 of the bias plate 430. A flange 434 is formed on one end of the bias plate 430 and extends radially a distance therefrom, thereby providing a downwardly facing surface 436 and an upwardly facing surface 438 each extending annularly about one end of the bias plate 430.

In an assembled position as shown in FIG. 8, the downwardly facing surface 438 engages the upwardly facing surface 416 of the base 412, and a bias spring 440 is disposed generally between the upper plate 356 secured to the support base 350 and the bias plate 430 of the seal bias assembly 410. More particularly, one end of the bias spring 440 is in engagement with a portion of the upper plate 356 and the opposite end of the bias spring 440 biasingly engages the portion of the upwardly facing surface 438 of the bias plate 430. The bias spring 440 is disposed generally about a portion of the elongated rod 404, and is sized to biasingly engage the bias plate 430, and thus the flanges 420, thereby biasingly moving the bias plate 430 and the flanges 420 in a biasing direction 442, generally toward the lower end plate 362 of the support base 350.

A stop 444 is secured to a portion of the elongated rod 404, and the stop 444 is positioned on the rod 404 generally below the upper plate 356 of the support base 350. The stop 444 has an upwardly facing surface 446 formed thereon which is shaped and positioned to engage a portion of the upper plate 356 to limit the movement of the rod 404 in a non-biasing direction 448, for reasons and in a manner to be described in greater detail below.

A guide coupling assembly 142 also includes a support 450 which is secured to a portion of the rod 404, generally between the eyelet 406 end thereof and the upper plate 356 via a pair of pins 452. The support 450 has a flange formed on one end thereof extending generally radially therefrom, thereby forming an upwardly facing support surface 454 and downwardly facing surface 456 extending generally about the support 450. As shown in FIG. 8, a flange 458 is secured on one end thereof to a portion of the inner periphery of the cone-shaped guide 382, thereby providing a downwardly facing surface 460 in the guide coupling assembly 142, for reasons which will be made more apparent below.

As shown in FIG. 8, a first jack assembly 462 is disposed generally between the support surface 396 of the support member 392 and the downwardly facing surface 456 of the support member 450. More particularly, the base of the first jack assembly 462 is supported on the support surface 396 of the support member 392, and the reciprocating element of the first jack assembly 462 engages a portion of the downwardly facing surface 456 of the support member 450, in one position of the first jack assembly 462. The base of the first jack assembly 462 is thus positioned in the guide coupling assembly 142 and the reciprocating element of the first jack assembly 462 engages the elongated rod 404 via the engagement thereof with the support member 450 to move the elongated rod 404, in a manner to be described in greater detail below.

The first jack assembly 462 is constructed such that the first jack assembly 462 may be actuated to move the reciprocating element therein in a generally upward direction 464 or in a generally downwardly direction 466. Jack assemblies of a nature generally described above are well known in the art and may be hydraulically or pneumatically operated, for example, and a detailed description of the construction and operation thereof is not required herein.

A second jack assembly **468**, constructed similar to the first jack assembly **462**, is disposed generally between the upwardly facing surface **454** of the support member **450** and a downwardly facing surface **460** of the flange **458**. More particularly, the base of the hydraulic jack assembly **468** is supported on the upwardly facing surface **454** of the support member **450** and the reciprocating element of the second jack assembly **468** is in engagement with a portion of the downwardly facing surface **460** of the flange **458**. The second jack assembly **468** is constructed to be actuated to a position wherein the reciprocating element thereof is moved to a generally upwardly direction **470** and to a position wherein the reciprocating element thereof is moved in a generally downwardly direction **472**.

An access opening **473** is formed through a portion of the cone-shaped guide **382**, as shown in FIG. **8**. The access opening **473** is shaped to permit the first and the second jack assemblies **462** and **468** to be inserted therethrough and removed therefrom, during the operation of the guide coupling assembly **142**, for reasons which will be made apparent below.

As shown in FIG. **8**, the guide coupling apparatus **142** also includes a pair of clamp assemblies **474** which are partially disposed in the hollow portion of the support base **350**. Each clamp assembly **474** includes a jaw member **476** with is pivotally secured to a flange **478** via a pin **480**. The flange **478** is secured to a portion of the lower end of the upper plate **356**.

The clamp assemblies **474** also include a jaw bias spring **482**, one jaw bias spring **482** being biasingly secured to each jaw member **476**. More particularly, one end of each jaw bias spring **482** is secured to one end portion of one of the jaw members **476** and the opposite end of each jaw bias spring **482** is secured to a portion of the support base **350**, as shown in FIG. **8**. Each jaw biasing spring **482** is sized and connected to one of the jaw members **476** to bias the jaw members **476** in a bias direction **484** to a position wherein a portion of each jaw member **476** extends radially from the support base **350** through an opening in the support base **350**, and engages a portion of the underwater connecting end **140**, for reasons to be made more apparent below.

As shown in FIG. **8**, one end portion of each jaw member **476** has a V-shaped flange tip **486** formed thereon. Each flange tip **486** is sized and positioned to engage a portion of the beveled surface **324** formed about the inner periphery of the underwater connecting end **140** to securedly position the guide coupling assembly **142** in an assembled position in the underwater pipeline **18**.

It should also be noted that although only two clamp assemblies **474** have been shown in FIG. **8**, that in actual practice a plurality of jaw assemblies **478** may be pivotally secured to the upper plate **356** and circumferentially spaced thereabout. This latter form, that is where the guide coupling assembly **142** includes a plurality of clamp assemblies **474** may be particularly desirable in a guide coupling assembly constructed to be utilized with a constructed riser and the underwater pipeline having relatively large inner diameters.

The guide coupling assembly **142**, as shown in FIG. **8**, also includes a submergable pump assembly **490** which is supported within a portion of the cone-shaped guide **382** generally above the upper plate **356**. The submergable pump assembly **490** is, more particularly, constructed and disposed in the guide coupling assembly **142** to pump-out any fluid existing in the constructed riser **12** and the underwater pipeline **18** generally above the seal member **370** of the guide coupling assembly **142**, so that the guide coupling assembly **142** can be more easily removed from an assembled position in the underwater pipeline **18** after the constructed riser **12** has been secured to the underwater pipeline **18**. Submergable pumps constructed to function in a manner generally as described above with respect to the submergable pump assembly **490** are well known in the art, and a detailed description of the construction and operation thereof is not required herein.

An eyelet **492** is secured to a central portion of the lower plate **362**, as shown in FIG. **8**. The eyelet **492** is provided to facilitate the transportation of the guide coupling assembly **142**.

OPERATION OF FIGS. 8 AND 9

The guide coupling assembly **142** is constructed to guide the underwater connecting end **144** of the constructed riser **12** into a mating and interconnecting engagement with the underwater connecting end **140** of the underwater pipeline **18**, and is constructed to sealingly prevent fluid from entering into the underwater pipeline **18** to maintain a maximum buoyancy of the underwater pipeline **18**. In practice and in a preferred form, the underwater pipeline **18** is constructed from a marine support member such as, for example, a barge, and as each pipe-section is secured in an interconnecting relationship aboard the barge, the interconnected pipe-sections are lowered and eventually disposed on the floor of the body of water, in a manner well known in the art. Thus, the underwater pipeline **18** is finally disposed in the water only after a sealing interconnection has been effected between the various pipe-sections, thereby substantially eliminating the buildup of water within the hollow portion of the underwater pipeline **18**. The last pipe-section interconnected to the underwater pipeline **18** generally includes at least one 90° turn and, in some instances, will include more than one 90° turn, so that the end of the underwater pipeline **18** to be interconnected to the riser **12** will be disposed in a substantially vertical position, in an assembled position of the underwater pipeline **18**, on the waterbody floor. In a preferred form, after the last pipe-section has been secured to the underwater pipeline **18**, the guide coupling assembly **142** will be placed and secured in an assembled position generally through the underwater connecting end **140** of the underwater pipeline **18**.

Prior to inserting the guide coupling assembly **142** through the underwater connecting end **140** of the underwater pipeline **18**, the second jack assembly **468** is actuated to a position wherein the reciprocating element disposed therein is disengaged from the downwardly facing surface **460** of the flange **458**. The first jack assembly **462** is actuated such that the reciprocating element therein engages and moves the support member **450** in an upwardly direction **464**, thereby moving the elongated rod **404** in a generally upwardly direction **464**.

The elongated rod **464** is moved by the first jack assembly **462** in an upwardly direction **464** to a position wherein the stop **444** secured on the elongated rod **404** engages the upper plate **356**, thereby limiting the upward movement of the elongated rod **404**. It will be apparent to those skilled in the art, that when the first jack assembly is actuated to move the elongated rod **404** in an upwardly direction **464** against the bias tension of the bias spring **440**, the flanges **420** will also be moved in a generally upwardly direction **464**, thereby disengaging the bias ring **426** from the annular seal member **370**.

In this position of the seal bias assembly **410**, that is a position wherein the bias ring **426** is disengaged from the annular seal member **370**, the seal member **370** is in what may be referred to as a relaxed position, and in that position, the seal member **370** will slidingly engage the inner periphery of the underwater pipeline **18**. In this position the guide coupling assembly **142** is positioned to be inserted through the underwater connecting end **140** and disposed in an assembled position in the underwater pipeline **18**.

The guide coupling assembly **142** is then inserted through the underwater connecting end **140** of the underwater pipeline **18**. As the guide coupling assembly **142** is being inserted downwardly through the underwater connecting end **140** of the underwater pipeline **18**, the seal end **376** of the seal member **370** will slidingly engage the inner periphery of the underwater pipeline **18**. Since the seal member **370** slidingly engages the inner periphery of the underwater pipeline **18** during the insertion of the guide coupling assembly **142** therein, the possibility of the seal member **370** being damaged or destroyed during the insertion of the guide coupling assembly **142** in the underwater pipeline **18** is substantially reduced.

The guide coupling assembly **142** will be lowered through the underwater pipeline **18** to a position wherein the V-shaped flange tip **486** of each jaw member **476** engages a portion of the beveled surface **322** formed about the underwater connecting end **140**. The engagement of each flange tip **486** with the beveled surface **322** tends to bias each jaw member **476** in a bias direction **484**. The engagement of each jaw member **476** with a portion of the upper plate **356** limits the movement of each jaw member **476** in a bias direction **484**, thereby maintaining the engagement of each flange tip **486** with a portion of the beveled surface **322**, and positioning the guide coupling assembly **142** in an assembled position in the underwater pipeline **18**.

In the assembled position of the guide coupling assembly **142**, shown in FIG. **2**, the seal member **370** is disposed in a horizontal plane generally below the upper end **300** of the underwater connecting end **140**, and the cone-shaped guide **382** extends a distance axially above the upper most end **300** of the underwater connecting end **140**.

After the guide coupling assembly **142** has been positioned in the underwater pipeline **18**, as described above, the first jack assembly **462** is actuated to move the reciprocating element therein in a vertically downward direction **466**, to a position wherein the reciprocating element is disengaged from the downwardly facing surface **456** off the support member **450**. The first jack assembly **462** may then be removed via the access opening **473** from the guide coupling assembly **142**.

It will be apparent from the foregoing that as the first jack assembly **466** is disengaged from the support member **450**, that the elongated rod **404** will be biased in a downwardly direction **482** via the bias spring **440**. The bias spring **440** will thus bias the elongated rod **404** to a position wherein the bias ring **426** biasingly engages a portion of the tapered surface **378** of the seal member **370**. The seal member **370** will be biased by the bias ring **426** in a radially outwardly direction into a sealing engagement with the adjacent portion of the inner periphery of the underwater pipeline **18**.

In some applications, it may be desireable to augment the biasing action of the bias spring **440** to create an even tighter or more sealingly secure engagement between the seal member **370** and the inner periphery of the underwater pipeline **18**. In those applications, the second jack assembly **468** is then actuated to move the reciprocating element therein in an upwardly direction **470** and into engagement with the downwardly facing surface **460** of the flange **458**.

The second jack assembly **468** will thus bias the rod **404** in a downwardly direction, thereby augmenting the biasing force of the bias spring **440**. In this manner, the bias ring **426** is moved into further engagement with the tapered surface **378** of the seal member **370**, thereby increasing the sealing integrity between the seal member **370** and the underwater pipeline **18**. The downward movement of the rod **404** is limited by the position of the lower plate **362** which will engage the lower end **408** of the rod **404**.

After the guide coupling assembly **142** has been sealingly positioned in the underwater pipeline **18**, the underwater pipeline **18** can be lowered into the body of water and positioned therein to receive and be connected to the constructed riser **12**. In one form, for example, the underwater pipeline **18** including the portion thereof adjacent the underwater connecting end **140** thereof is lowered into the body of water and positioned substantially as shown in FIG. **1** with respect to the platform **16**.

After the underwater pipeline **18** has been positioned in the body of water to receive the constructed riser **12**, the constructed riser **12** is then lowered, the underwater connecting end **144** thereof being lowered downwardly toward the underwater connecting end **140** of the underwater pipeline **18**. The guiding surface formed by the cone guide **382**, including the outer periphery **385** of the base **384** thereof, will initially guidingly contact the underwater connecting end **144**, and guide the underwater connecting end **144** generally toward an interconnecting relationship with respect to the underwater connecting end **140** of the underwater pipeline **18**.

As the constructed riser **12** is being guided by the cone-shaped guide **382** and the cylindrically shaped base **384**, the lower end **310** of the underwater connecting end **144** will initially engage the tapered surface **326** of the underwater connecting end **140**. A portion of the underwater connecting end **144** generally adjacent the lower end **310** thereof will move along the tapered surface **326** of the underwater connecting end **140**, and ultimately will engage and move along the surface of the underwater connecting end **140** formed by the groove **320** therein. The downwardly facing surface **330** formed on the underwater connecting end **144** will engage the upwardly facing surface formed on the underwater connecting end **140** by the upper end **300** thereof, thereby limiting the downward movement of the constructed riser **12** into the underwater pipeline **18**.

It should be noted that in a preferred form, a diver will position himself generally near the underwater connecting end **140** of the underwater pipeline **18** prior to the constructed riser **12** being finally lowered into a mating and interconnecting relationship therewith. The diver, in this form, will initially position the underwater connecting end **144** generally above the guide coupling assembly **142**, such that as the constructed riser **12** is lowered, the underwater connecting end **144** thereof will be positioned in guiding contact with the guide surface formed by the cone guide **382** and the guide surface formed by the cylindrically shaped base **384**.

The diver, in a preferred form, will deactuate the second jack assembly **468** prior to the constructed riser **12** being lowered into engagement with the underwater pipeline, connect a cable (not shown) to the eyelet **406** of the elongated rod **404**, and connect the proper hydraulic lines (not shown) to the submergable pump assembly **490**. Thus, during that period of time while the constructed riser **12** is being lowered over the guide coupling assembly **142**, the bias spring **440** provides the only biasing force acting upon the seal member **370** to bias the seal member **370** into a sealing engagement with the underwater pipeline **18**.

After the underwater connecting end **144** has been positioned in interconnecting engagement with the underwater connecting end **140**, the diver will then secure the constructed riser **12** to the underwater pipeline **18** by securing the bolts **340** about the interconnection therebetween. Since the slip ring **338** is in sliding engagement with the flange **328**, the slip ring **338** can be easily and quickly positioned by the diver to a position wherein the bolt holes therethrough align with the bolt holes through the flange **316**.

After the constructed riser **12** has been boltingly secured to the underwater pipeline **18**, the submergable pump assembly **490** is actuated, and the fluid in the underwater pipeline **18** generally between the seal member **370** and the underwater connecting end **140** thereof and the fluid in the constructed riser **12** will be pumped out via the submergable pump assembly **490**.

After the fluid in the constructed riser **12** and the underwater pipeline **18** has been removed therefrom by the submergable pump assembly **490**, the guide coupling assembly **142** is removed by raising the cable which has been connected to the eyelet **406** of the rod **404**. It will be apparent from the foregoing that as the rod **404** is pulled in an upwardly direction by the cable, the rod will be moved or reciprocated upwardly against the biasing force of the bias spring **440**, thereby disengaging the bias assembly **440** from the seal member **370**. The seal end **376** of the seal member **370** is thus in sliding engagement with the inner periphery of the underwater pipeline **18**, as the guide coupling assembly **142** is being removed from the underwater pipeline **18** in the constructed riser **12**.

As the guide coupling assembly **142** is initially pulled in an upward direction, a portion of the flange tip **486** will initially engage the lower end **310** of the underwater connecting end **144**, the underwater connecting end **144** thereby biasing each jaw member **476** in a direction generally opposite the bias direction **484** and against the biasing force of the springs **482**. The flange tip **486** will thus be removed from the V-shaped groove **324**, and will engage the inner periphery of the constructed riser **12** as the guide coupling assembly **142** is being removed from the underwater pipeline **18** and the constructed riser **12**.

After the guide coupling assembly **142** has been removed, the underwater connecting end **140** and the underwater connecting end **144** can be welded in an interconnecting position, the weld being effected generally in the groove **324** formed therebetween. In this manner, an additional sealing securedness is provided between the constructed riser **12** and the underwater pipeline **18**.

It will be apparent from the foregoing to those skilled in the art that the guide coupling assembly **142**, not only provides a guiding surface so that the constructed riser **12** can be quickly and efficiently guided into an interconnecting and mating engagement with the underwater pipeline **18**, but also sealingly prevents fluid from entering the underwater pipeline **18**, thereby maintaining the buoyancy of the underwater pipeline **18**. This latter feature of the guide coupling assembly **142** is particularly important with respect to underwater pipelines and risers having relatively large diameters, since the buoyant effect resulting from the absence of water in the underwater pipeline **18** is necessary to maintain a maneuverability of the underwater pipeline **18** so that the underwater pipeline **18** can be more quickly, efficiently and safely maneuvered to a proper position to be connected to a riser. The guide coupling assembly **142** also provides the support structure for the submergable pump assembly **490**, thereby enabling the constructed riser **12** to be connected to the underwater pipeline, and the fluid accumulated in the connected riser **12** to be more efficiently pumped therefrom.

It should also be noted that the underwater connecting end **140** and the underwater connecting end **144**, described above, cooperate with the guide coupling assembly **142** to guide the constructed riser **12** into a mating and interconnecting engagement with the underwater pipeline **18** in such a manner that the possibility of damage occuring to the seal member **332** is minimized.

EMBODIMENT OF FIG. 10

Shown in FIG. **10**, is a modified guide coupling assembly **142*a*** which is constructed similar to the guide coupling assembly **142**, shown in FIG. **8**, described in detail before. The salient difference between the guide coupling assembly **142*a***, shown in FIG. **10**, and the guide coupling assembly **142**, described before, is that the guide coupling assembly **142*a*** does not include the various components, assemblies and apparatus to provide the fluid seal between the guide coupling assembly and the underwater pipeline **18**.

OPERATION OF FIG. 10

The guide coupling assembly **142**a, shown in FIG. **10**, will operate substantially the same as the guide coupling assembly, shown in FIG. **8**, described in detail before, to guide the underwater connecting end **144** of the constructed riser **12** into interconnecting and mating engagement with the underwater connecting end **140** of the underwater pipeline **18**. After the underwater connecting end **140** has been securedly connected to the underwater connecting end **144** via the bolts **340**, the guide coupling assembly **142** is removed from the underwater pipeline **18** in the constructed riser **12** via a cable which, in this form of the invention, is secured to the rod **390**.

The modified guide coupling assembly **142**a provides a guide coupling to guide the constructed riser **12** into interconnecting and mating engagement with the underwater pipeline **18**, which is less expensive to manufacture, which may be useful in some applications where a presence of fluid in the underwater pipeline **18**, and thus the reduced maneuverability of the underwater pipeline **18** will not detrimentally affect the overall construction operation.

EMBODIMENT OF FIG. 11

Shown in FIG. **11** is a modified underwater connecting end **140**a and a modified underwater connecting end **144***a*, which may be utilized in cooperation with the underwater pipeline **18** and the constructed riser **12**, respectively, in some applications. The salient difference between the underwater connecting end **140***a*, shown in FIG. **11**, and the underwater connecting end **140**, shown in FIGS. **8** and **9**, is that the tapered surface **326***a* formed in the underwater connecting end **140***a* extends downwardly from the upper end **300**, terminating with the beveled surface **322***a* formed about the inner periphery of the underwater connecting end **140***a*. The salient difference between the underwater connecting end **144***a*, shown in FIG. **11**, and the underwater connecting end **144**, shown in FIGS. **8** and **9**, is that the tapered surface **336***a* formed on the outer periphery of the underwater connecting end **144***a* extends downwardly along the outer periphery of the underwater connecting end **144***a*, intersecting the lower end **310***a* thereof. In other words, the underwater connecting end **144***a* and the underwater connecting end **140***a* have single tapered mating surfaces to form the guiding interconnection therebetween.

OPERATION OF FIG. 11

The underwater connecting end **144***a* and the underwater connecting end **140***a*, shown in FIG. **11**, will operate substantially the same as the underwater connecting end **144** and the underwater connecting end **140**, shown in FIGS. **8** and **9**, described in detail before. The tapered mating surfaces **326***a* and **336***a* cooperate to position the underwater connecting end **144***a* of the constructed riser **12** in mating and interconnecting engagement with the underwater connecting end **140***a* of the underwater pipeline **18**.

The additional sealing securedness of a welded interconnection between the underwater connecting end **144***a* and the underwater connecting end **140***a* is still effected generally in the groove **324***a*, which is also sized to cooperate with the jaw members **476** to position the guide coupling assembly **142** in the underwater pipeline **18**, in a manner similar to that described before.

It is apparent from the foregoing, that the underwater connecting end **144***a* and the underwater connecting end **140***a*, shown in FIG. **11**, each retain most of the advantages of the underwater connecting end **144** and the underwater connecting end **140**, described before, and yet provide a single tapered surface which may be less costly to manufacture, in some instances.

EMBODIMENT OF FIGS. 12, 13 AND 14

A preferred embodiment of the flange alignment assembly **146** is shown in detail in FIGS. **12**, **13** and **14**. As mentioned before, the salient purpose or function of the flange alignment assembly **146** is to properly align the bolt holes formed through a portion of the underwater connecting end **144** with the bolt holes formed through a portion of the underwater connecting end **140**, so that a diver can more quickly, safely and efficiently secure the bolting interconnection between the constructed riser **12** and the underwater pipeline **18**.

As mentioned before and shown in FIG. **12**, the slip ring **338** has a plurality of bolt holes **500** formed therethrough and spaced circumferentially thereabout, and the flange **316** of the underwater connecting end **140** also has a plurality of bolt holes **502**, shown in FIGS. **12** and **13**, formed therethrough and spaced circumferentially thereabout.

In a preferred form, and as shown in FIGS. **12**, **13** and **14**, the flange alignment assembly **146** includes at least two pair of pin guide assemblies **504**. Each pin guide assembly **504** includes a pair of removable guide members **506** which are generally triangularly shaped in one cross-section, as shown more clearly in FIG. **12**, and arcuately shaped in another cross-section, as shown more clearly in FIG. **13**.

Each guide member **506** has a base **508**, an upper end **510** and guide sides **512** and **514**, as shown more clearly in FIG. **12**. In an assembled position of the pin guide assemblies **504**, each base **508** is removably supported on the upwardly facing surface of the flange **316**.

Each guide member **504** includes a pair of cylindrically shaped plugs **516**, one end of each plug being secured to a portion of the base **508** of each guide member **506**. The plugs **516** are secured and position on the base **508** of each guide member **506** such that, in the assembled position thereof, as shown in FIGS. **12**, **13**, and **14**, each plug **516** is partially disposed through one of the bolt holes **502** in the flange **316**. In the assembled position, each guide member **506** is positioned on the flange **316** so that one of the bolt holes **502** through the flange **316** is positioned generally between each pair of guide members **506**, for reasons which will be made apparent below.

In the assembled position of each pin guide assembly **504**, described above, the side **512** of one of the guide members **506** and the side **514** of the other guide member **506** of each pin guide assembly **504** cooperate to provide a generally funnel-shaped guide path **518** therebetween. As shown more clearly in FIG. **12**, the guide path **518** is wider generally adjacent the upper ends 510 of the guide members 506 with respect to the width of the guide path 518 generally near the bases 508 of the guide members 506. In other words, the guide path 518 generally funnels toward one of the bolt holes 502 formed in the flange 316, as shown more clearly in FIG. 13, for reasons which will be made more apparent below.

The flange alignment assembly 146 also includes one pin 520 to cooperate with each pin guide assembly 504. As shown more clearly in FIGS. 12 and 14, each pin 520 has an upper end 522 and a lower end 524, and each pin 520 is removably disposed through one bolt hole 500 in the slip ring 338 to a position wherein a portion of each pin 520 generally near the upper end 522 thereof is disposed above the upwardly facing surface of the slip ring 338.

A C-shaped clamp 526 is connected to each pin 520, generally near the upper end 522 thereof, as shown more clearly in FIG. 14. Each C-shaped clamp 526 is more particularly, pivotally secured to each pin 520 by a pivot pin 528, such that the C-shaped clamp 526 can be pivoted to a locking position wherein each C-shaped clamp 526 engages a portion of the slip ring 338 to secure the pin 520 connected thereto in an assembled position, as shown in FIGS. 12 and 14. Each C-shaped clamp 526 is also pivotable to a detached position, as shown in dashed-lines in FIG. 14.

OPERATION OF FIGS. 12, 13 AND 14

As mentioned before, the flange alignment assembly 146 is particularly constructed to align the bolt holes of the underwater connecting end 144 with the bolt holes of the underwater connecting end 140 as the constructed riser 12 is lowered into mating and interconnecting engagement with the underwater pipeline 18.

In one form, the pin guide assemblies 504 and, more particularly, each guide member 506 thereof can be positioned in an assembled position on the flange 316 prior to the lowering of the underwater pipeline 18 into the water. Each pin 520 can also be secured through one of the bolt holes 500 of the slip ring 338 prior to the lowering of the constructed riser 12 into the water.

In a preferred form, however, each pin guide assembly 504 and, more particularly, each guide member 506 is disposed on the flange 316 and each pin 520 is disposed through one of the bolt holes 500 by the diver immediately subsequent to the lowering of the constructed riser 12 into mating and interconnecting engagement with the underwater pipeline 18. Since each guide member 506 is removably positioned on the flange 316 via the plugs 516, the pin guide assemblies 504 can be easily, quickly and efficiently placed in an assembled position by the diver. After each pin 520 is inserted through one of the bolt holes 500 to an assembled position, the C-shaped clamp 526 associated therewith is moved to a locking position, shown in FIGS. 12 and 14, thereby securedly positioning each pin 520 in an assembled position.

As the constructed riser 12 is lowered generally toward the underwater pipeline 18, the pin 520 and, more particularly, the cone-shaped end 524 thereof will be disposed generally within the guide path 518 formed by the surfaces 512 and 514 of the two guide members 506 of each pin guide assembly 504. Each guide side 512 and 514 will alternately and guidingly engage a portion of the pin 520 generally adjacent the lower end 524 thereof to guide the pin 520 into the particular bolt hole disposed between the two guide members 506 of each pin guide assembly 504.

As each pin 520 is guidingly engaged by the sides 512 and 514 of the two guide members 506, the slip ring 338 will be slidingly rotated on the upper surface 329 of the flange 328 on the underwater connecting end 144. The lower end 524 of the pin 520 will ultimately then be guided into the bolt hole 502 disposed between the two guide members 506, thereby assuring an alignment between the bolt holes 500 of the slip ring 338 and the bolt holes 502 through the flange 316.

After the constructed riser 12 has been lowered a sufficient distance such that a portion of each pin 520 generally adjacent the cone-shaped end 524 thereof has been disposed through the bolt hole 502 between the guide members 506, the constructed riser 12 will be held stationary while the diver removes the guide members 506 from their assembled position on the flange 316. The constructed riser 12 will then be lowered into a mating and interconnecting relationship with respect to the underwater pipeline 18.

After the constructed riser 12 has been matingly and interconnectingly positioned in the underwater pipeline 18, the diver will then pivot each C-shaped clamp 526 to a detached position (dashed-lines in FIG. 14), and remove each pin 520. The diver can then effect the bolting interconnection between the underwater connecting end 144 and the underwater connecting end 140.

It will be apparent to those skilled in the art, that the flange alignment assembly, shown in FIGS. 12, 13 and 14, and described in detail above, cooperates with the underwater connecting end 144 and the underwater connecting end 140 so that the underwater interconnection therebetween can be effected in a quicker, easier, more efficient and safer manner.

EMBODIMENT OF FIG. 15

Diagrammatically shown in FIG. 15 is an alternate method and apparatus for lowering the constructed riser 12 into a mating and interconnecting engagement with the underwater pipeline 18, that is alternate with respect to the utilization of the platform 16, as shown in FIGS. 1, 2 and 3. As shown in FIG. 15, the constructed riser 12 is lowered from a support member or, more particularly, from a barge type marine support member 16 into an interconnecting and mating engagement with the underwater pipeline 18.

In this embodiment of the invention, a predetermined length of the underwater pipeline 18 is supported generally above the floor 20 of the body of water 22 by a plurality of davits 550 which are connected at predetermined positions to the underwater pipeline 18 by a plurality of cables 552.

As shown in FIG. 15, the guide coupling assembly 142 has been secured in the underwater pipeline 18, generally through the underwater connecting end 140 thereof. Since the guide coupling assembly 142 provides a fluid seal to prevent water from entering the pipeline 18 in a manner as described in detail before with respect to FIG. 8, the buoyancy of the pipeline 18 is maintained. The pipeline 18 can thus be more easily and efficiently supported by the davits 550 above the floor 20 of the body of water 22.

In this embodiment of the invention, positioning assembly **554** is utilized which is, more particularly, a movable crane assembly having a cable **556** supported and controlled thereby which is connected to the constructed riser **12** via the riser section connector **124**. The positioning assembly **554** also has a coupling cable **558** which is controllingly supported thereon.

As shown in FIG. **15**, a hook **560** is secured to one end of the coupling cable **558**. In this embodiment of the invention, the hook **560** is particularly constructed to be connected to the eyelet **406** of the guide coupling assembly **142**. The positioning assembly **554** can thus be utilized to pull the guide coupling assembly **142** through the constructed riser **12**, after the constructed riser **12** has been securedly interconnected to the underwater pipeline **18** via the coupling cable **558**.

As diagrammatically shown in FIG. **15**, a hydraulic line assembly **562**, including the necessary pump drive connectors and fluid discharge lines, is also disposed through the constructed riser **12** and a portion thereof extends beyond the underwater connecting end **144** thereof. The hydraulic line assembly **562** is particularly constructed to be connected to the submergable pump assembly **490** by the diver, in a manner similar to that mentioned above with respect to the operation of the guide coupling assembly **142** shown in FIG. **8**.

In this embodiment of the invention, the positioning assembly **554** is utilized to lower the constructed riser **12** to a position generally above the underwater connecting end **140** of the underwater pipeline **18**, and a diver will position the guide coupling assembly **142** in a position to be removed through the constructed riser **12**, in a manner as described before with respect to FIGS. **8** and **9**, and will connect the cable assembly **562** to the submergable pump assembly **490**. The constructed riser **12** will then be lowered by the positioning assembly **554** into interconnecting engagement with the underwater pipeline **18**. Although the riser **12** is shown in FIG. **15** as being constructed of a single riser-section **14**, more particularly, of the one riser-section **14** having the connecting end **144**, it will be apparent that the riser **12** could be constructed of a plurality of riser-sections **14** interconnected in a manner as described before with respect to FIGS. **1, 2** and **3**. In this instance, the riser support assembly **34** would also be supported on the barge type support member **16** and utilized in cooperation with the positioning assembly **554** to securedly interconnect the riser-sections **14**.

It will be apparent to those skilled in the art that, since the underwater pipeline **18** is supported at various predetermined positions by the davits **550** on the barge **16**, that the movement of the underwater pipeline **18** and the movement of the constructed riser **12** will each be relative to the movement of the barge **16**, thereby reducing the relative movement occuring between the constructed riser **12** and the underwater pipeline **18**. The reduction of relative movement between the constructed riser **12** and the underwater pipeline **18** permits the constructed riser **12** to be lowered into interconnecting and mating engagement with the underwater pipeline **18** in a quicker and more efficient manner, and in a manner wherein the possibility of damage occuring to the underwater connecting end **144** of the constructed riser **12** and the underwater connecting end **140** of the underwater pipeline **18** or to a seal element disposed therebetween, is substantially reduced. After the constructed riser **12** has been securedly connected to the underwater pipeline **18**, the riser **12** and the underwater pipeline **18** may then be moved by the barge support member **16** to a position generally near a platform, such as the platform **16**, shown in FIG. **1**, for permanent installation.

EMBODIMENT OF FIG. 16

Diagrammatically shown in FIG. **16** is a portion of a modified underwater pipeline **18*a***, which more particularly has a 90° turn segment **580** which is coupled to a pipeline segment **582** via a slip coupling interconnection **584**. The slip coupling interconnection **584** is particularly constructed such that the 90° turn segment **580** can be rotated with respect to the pipeline segment **582**, generally about the slip coupling interconnection **584**. In one form, the slip coupling interconnection **584** is constructed similar to the underwater connection between the underwater connecting end **140** and the underwater connecting end **144**, described in detail before with respect to FIGS. **12, 13** and **14**.

The 90° turn segment **580** includes the underwater connecting end **140** connected to one end thereof. The guide coupling assembly **142** is positioned through the underwater connecting end **140** of the underwater pipeline **18*a***, as shown in FIG. **16**.

OPERATION OF FIG. 16

The apparatus shown in FIG. **16** is particularly constructed to facilitate the moving of the underwater pipeline **18*a*** into an assembled position within an offshore platform **16** to matingly and connectingly receive the constructed riser **12**. More particularly, the underwater pipeline **18*a*** provides an apparatus wherein the underwater pipeline **18*a*** can be moved into an assembled position within the offshore platform **16**, as described above, wherein the offshore platform **16** is constructed and the underwater pipeline **18*a*** is of such a size that the underwater pipeline **18*a*** cannot be moved or centrally disposed within the offshore platform **16** in a completely assembled position.

In this embodiment of the invention, the 90° turn segment **580** is rotated to a position wherein the 90° turn segment **580** is disposed in a horizontal plane with respect to the floor **20** of the body of water **22**, as indicated in dashed-lines in FIG. **16**. The underwater pipeline **18*a*** is supported by the marine support member or, more particularly, the barge **16** via a cable **556*a***, which is secured on one end thereof to the underwater pipeline **18*a*** and on the opposite end thereof to the positioning assembly **554*a***. In this position of the underwater pipeline **18*a*** (as shown in dashed-lines in FIG. **16**), the barge **16** is then moved generally toward the offshore platform **16** to a position wherein the 90° turn segment **580** of the underwater pipeline **18*a*** is generally centrally disposed within the offshore platform **16**.

After the underwater pipeline **18*a*** has been positioned within the offshore platform **16**, as described above, a diver can then rotate the 90° turn segment **580** to a position wherein a portion thereof generally near the underwater connecting end **140** is vertically disposed or, in other words, to a position wherein the underwater connecting end **140** of the underwater pipeline **18*a*** generally faces the underwater connecting end **144** of the constructed riser **12**. The diver will then secure the slip coupling **584**, thereby securing the 90° turn segment **580** in an assembled position within the offshore platform **16**.

After the underwater pipeline **18**a has been positioned within the offshore platform **16**, as described above, the constructed riser **12** can then be lowered into mating and interconnecting engagement with the underwater pipeline **18***a*, in a manner similar to that described in detail before.

It will be apparent from the foregoing, to those skilled in the art, that the method and apparatus described in detail above provides a safer and more efficient means for constructing an underwater riser and connecting the constructed riser to an underwater pipeline. The method and apparatus are also such that the various interconnections, that is the interconnection between the various riser-sections **14** and the interconnection between the constructed riser **12** and the underwater pipeline are effected in a safer and more efficient manner, and in a manner assuring a sealingly secure interconnection.

Changes may be made in the construction and the arrangement of the parts or the elements of the various embodiments, or in the steps of the method as described herein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. Apparatus for constructing a riser from a marine support member and connecting one end of the constructed riser to an underwater pipeline, the apparatus comprising:
   a predetermined number of riser-sections, interconnected to form the constructed riser, an underwater connecting end formed on one end of one riser-section connectingly engaging a portion of the underwater pipeline in one position of the constructed riser, support means formed on at least one riser-section;
   an underwater connecting end connected to one end of the underwater pipeline connectingly engaging the underwater connecting end of the constructed riser in one position of the constructed riser;
   positioning means supported on the marine support member, a portion of the positioning means being removably connected to the support means formed on the riser-section, to support the constructed riser in one position of the positioning means, the positioning means lowering the constructed riser connected thereto in a direction generally toward the underwater pipeline in one position of the positioning means; and
   guide coupling means removably disposed in a portion of the underwater pipeline generally near the end of the underwater pipeline having the underwater connecting end connected thereto, a portion of the guide coupling means guidingly engaging a portion of the constructed riser generally near the underwater connecting end thereof to guide the constructed riser to a position wherein the underwater connecting end thereof connectingly engages a portion of the underwater connecting end of the underwater pipeline.

2. The apparatus of claim 1 further defined to include:
   means supported on the support member connected to a portion of the underwater pipeline to support a predetermined length of the underwater pipeline and the underwater connecting end connected thereto in a horizontal plane generally above the floor of the body of water, thereby maintaining the movement of the underwater connecting end of the underwater pipeline and the movement of the constructed riser relative to the movement of the support member.

3. The apparatus of claim 1 wherein the guide coupling means is defined further to include, a portion sealingly engaging a portion of the underwater pipeline generally near the end thereof having the underwater connecting end connected thereto, said portion sealingly preventing the entry of fluid into the underwater pipeline via the end thereof having the underwater connecting end connected thereto.

4. Apparatus for constructing a riser from a marine support member to be connected to an underwater pipeline, comprising:
   a predetermined number of riser-sections, each riser-section having a connecting upper end and a connecting lower end, each connecting upper end of some of the riser-sections interconnected to the connecting lower end of one other riser-section, the interconnected riser-sections forming the constructed riser, support means formed on a portion of each riser-section;
   riser support means supported on the marine support member to securedly position and support one of the riser-sections in one position thereof, the riser support means, including:
      support arm means supported on the marine support member, having a support position and a release position, a portion of the support arm means supportingly engaging a portion of support means of one of the riser-sections in a support position of the support arm means and in one position of one of the riser-sections, the support arm means passing the interconnected riser-sections therethrough in a release position of the support arm means; and
      actuator means connected to the support arm means to position the support arm means in a support position and in a release position; and
   positioning means supported on the marine support member, a portion of the positioning means removably connected to a portion of the support means of one of the riser-sections in one position of the positioning means, the positioning means movable to a position wherein the connecting lower end of the riser-section removably connected thereto interconnectingly engages the connecting upper end of a riser-section supported in the riser support means in one position of the positioning means.

5. Apparatus for constructing a riser from a marine support member and connecting one end of the constructed riser to an underwater pipeline, the apparatus comprising:
   a predetermined number of riser-sections, one riser-section having a connecting upper end and an underwater connecting end, each other riser-section having a connecting upper end a connecting lower end, each connecting upper end of some of the

riser-sections interconnected to the connecting lower end of one other riser-section, the interconnected riser-sections forming the constructed riser, the underwater connecting end of the one riser-section being the underwater connecting end of the constructed riser, support means formed about a portion of each riser-section generally near the connecting upper end thereof;

riser support means supported on the marine support member to support one riser-section therein in one position thereof, the riser support means including:

support arm means supported on the marine support member having a support position and a release position, a portion of the support arm means supportingly engaging a portion of the support means of one of the riser-sections in a support position of the support arm means and in one position of one of the riser-sections, the support arm means passing the interconnected riser-sections therethrough in a release position of the support arm means; and

actuator means connected to the support arm means to position the support arm means in a support position and in a release position; and

positioning means supported on the marine support member, a portion of the positioning means being removably connected to the support means of one of the riser-sections in one position of the positioning means, the positioning means movable to a position wherein the connecting lower end of the riser-section removably connected to the positioning means interconnectingly engages the connecting upper end of the riser-section supported in the riser support means in one position of the positioning means;

an underwater connecting end connected to one end of the underwater pipeline, a portion of the underwater connecting end of the underwater pipeline interconnectingly engaging the underwater connecting end of the constructed riser in one position of the constructed riser and the underwater pipeline; and

guide coupling means removably disposed in a portion of the underwater pipeline generally near the end of the underwater pipeline having the underwater connecting end connected thereto, a portion of the guide coupling means guidingly engaging a portion of the constructed riser generally near the underwater connecting end thereof to guide the constructed riser to a position wherein the underwater connecting end of the constructed riser connectingly engages a portion of the underwater connecting end of the underwater pipeline.

6. The apparatus of claim **5** defined further to include:

riser lowering means supported on the marine support member, a portion of the riser lowering means removably connected to a portion of the support means of one of the riser-sections in one position of the riser lowering means, the riser lowering means guidingly lowering the constructed riser in a direction generally toward the underwater connecting end of the underwater pipeline, to a position wherein the underwater connecting end of the constructed riser connectingly engages the underwater connecting end of the underwater pipeline.

7. The apparatus of claim **5** wherein the support means formed on the riser-sections is defined further as being a support ring formed on the outer periphery of each riser-section, generally near the connecting upper end thereof and extending generally radially therefrom, thereby forming an annular upper surface and an annular lower surface extending circumferentially about the outer periphery of each riser-section.

8. The apparatus of claim **7** wherein the support ring is defined further to include a predetermined number of position apertures formed therethrough.

9. The apparatus of claim **7** wherein the support ring is defined further to include a predetermined number of support apertures formed therethrough.

10. The apparatus of claim **8** wherein the support arm means is defined further to include:

at least two support arms, each support arm having a pivot end and a support end, the pivot end of each support arm pivotally secured to a portion of the marine support member, the support arm of each support arm supportingly engaging a portion of the lower surface of the support ring of each riser-section in a support position of the support arm means and in one position of each riser-section; and

wherein the actuator means is defined further to include:

at least two cylinder actuator means, each

cylinder actuator means pivotally connected to the marine support member and having a piston arm reciprocatingly disposed therein, one end of each piston arm pivotally connected to a portion of one of the support arms, each cylinder actuator means actuable to move the support arm means connected thereto to a support position and a release position.

11. The apparatus of claim **10** wherein the support end of each support arm is defined further to include:

a base having an upper surface formed thereon, the upper surface being arcuately shaped and supportingly engaging a portion of the lower surface of the support ring of each riser-section in one position of each riser-section; and

a predetermined number of locating pins, each locating pin secured to a portion of the upper surface of the base and extending a distance generally perpendicularly therefrom, each locating pin extending through a portion of one of the position apertures of each riser-section in one position of each riser-section, to position each riser-section in a support position of the riser-support means and in one position of each riser-section.

12. The apparatus of claim **11** defined further to include at least one locating pin secured to the base of each support arm, and wherein the support arms are further defined as being generally disposed on opposite sides of the riser-section supported in the riser support means, the locating pins being spaced approximately 180° apart, in a support position of the riser support means.

13. The apparatus of claim **5** defined further to include:

means to support a plurality of riser-sections in a stored position on the marine support member, for subsequent utilization in the construction of the riser; and

wherein the positioning means is defined further to include:

a track means supported in a horizontal plane generally above the riser support means and the stored riser-sections; and

a crane support frame rollingly connected to the track means, the crane support frame rollable on the track means to predetermined positions over the stored riser-sections and over the riser support means;

a crane winch means supported on a portion of the crane support frame, having an actuated raising and an actuated lowering position;

a crane cable means, having opposite ends, one end of the crane cable means being connected to the crane winch means; and

a riser section connector secured to the end of the crane cable means opposite the end thereof secured to the crane winch means; and the riser section connector securedly engaging one of the supported riser-sections in one position thereof, the riser-section connected to the riser section connector being raised in a generally vertical direction toward the track means in the actuated raising position of the crane winch means, the riser-section connected to the riser section connector being lowered in a generally downwardly direction toward the riser support means in an actuated lowering position of the crane winch means.

14. The apparatus of claim **13** wherein the track means is defined further to include:

a lateral track means disposed in a horizontal plane generally above the riser support means and the supported riser-sections, the lateral track means extending generally laterally over the riser support means and the supported riser-sections; and

a transverse track means extending generally transversely with respect to the lateral track means, the transverse track means rollingly connected to the lateral track means, the transverse track means being laterally positionable on the lateral track; and

wherein the crane support frame is more particularly connected to the transverse track means, the crane support frame being positionable transversely on the transverse track means.

15. The apparatus of claim **6** wherein the riser lowering means is defined further to include:

at least two winch means, each winch means supported on a portion of the marine support member and spaced approximately 180° apart, each winch means having an actuated raising and an actuated lowering position; and

a winch cable connected to each winch means, each winch cable having opposite ends, one end of each winch cable secured to one of the winch means and the end of each winch cable opposite the end thereof secured to one of the winch means removably connected to a portion of the interconnected riser-sections, the interconnected riser-sections being lowered via the winch cables in an actuated lowering position of each winch means, and the interconnected riser-sections being raised by each winch cable in an actuated raising position of each winch means.

16. The apparatus of claim **5** defined further to include:

a riser section receiving means supported on the marine support member, a portion of the riser section receiving means receivingly and supportingly engaging a portion of one riser-section for temporarily storing one riser-section therein

17. The apparatus of claim **5** defined further to include:

a portable support frame removably connected to a portion of the marine support member in as assembled position thereabove;

a base plate means secured to the support frame, a riser opening formed through a portion of the base plate having a diameter larger than the largest radial diameter of any portion of any of the riser-sections, the riser support means connected to the base plate generally near the riser opening therethrough; and

a plurality of telescoping connectors, each telescoping connector having opposite ends, one end of each telescoping connector being connected to a portion of the base plate, the ends of the telescoping connectors opposite the ends thereof secured to the base plate being positionable in predetermined horizontal planes above the base plate to a transport position and to an assembled position; and

wherein the riser positioning means is further defined as being supportably connected to the end of each telescoping connector opposite the end thereof secured to the base plate, the horizontal disposition of the positioning means with respect to the base plate thereby adjustable to a transport position and an assembled position following the positioning of the telescoping connectors.

18. The apparatus of claim **17** wherein the base plate is defined further to include a plurality of support apertures formed therethrough, a portion of the base plate generally adjacent each support aperture supportingly engaging a portion of the support means of one riser-section to storingly support the riser-section in a stored position.

19. The apparatus of claim **5** wherein the connecting upper end of each riser-section is defined further to include an uppermost end and a groove formed in the inner periphery of each riser-section intersecting a portion of the uppermost end thereof and extending a distance axially along the inner periphery thereof terminating with a beveled end, the beveled end of the groove forming an annular beveled surface in the connecting upper end of each riser-section; and wherein the connecting lower end of each riser-section is defined further to include a lowermost end and a groove formed in the outer periphery of each riser-section intersecting a portion of the lowermost end thereof extending a distance axially along the outer periphery thereof terminating with an annular end surface formed about the outer periphery of the connecting lower end of each riser-section, the annular end surface formed about the connecting lower end of each riser-section engaging a portion of the uppermost end of the connecting lower end of one other riser-section in an interconnecting position of two riser-sections, the lowermost end of the connecting lower end of each riser-section engaging a portion of the annular beveled surface formed in the connecting lower end of one other riser-section in an interconnecting position of two riser-sections.

20. The apparatus of claim **19** wherein the support means formed about each riser-section is defined further as being a support ring formed on the outer periphery of the connecting upper end portion of each riser-section generally near the uppermost end thereof, extending a distance radially therefrom.

21. The apparatus of claim **19** wherein the lowermost end of the connecting lower end of each riser-section is formed on a bevel, thereby providing an annular beveled surface extending about a portion of the outer periphery of the lowermost end of each connecting lower end, the annular beveled surface of each connecting lower end matingly and connectingly engaging the annular beveled surface formed about the inner periphery of the connecting upper end of one other riser-section in an interconnecting position of two riser-sections.

22. The apparatus of claim **19** wherein the lowermost end of the connecting lower end of each riser-section is formed on a bevel, thereby providing an annular beveled surface extending about a portion of the outer periphery of the lowermost end of each connecting lower end, the annular beveled surface of each connecting lower end and the annular beveled surface of each connecting upper end forming an annular V-shaped groove in an interconnecting position of two riser-sections to facilitate the welding interconnection therebetween.

23. The apparatus of claim **5** wherein the underwater connecting end of the one riser-section is defined further to include, a lowermost end and a radially outwardly tapering groove formed in the outer periphery of the underwater connecting end of the one riser-section intersecting a portion of the lowermost end thereof thereby forming an annular tapered surface extending about the outer periphery of the underwater connecting end of the one riser-section; and wherein the underwater connecting end connected to the underwater pipeline is defined further to include, an uppermost end and a radially inwardly tapering groove formed in the inner periphery thereof, intersecting a portion of the uppermost end thereof, forming an annular tapered surface extending about a portion of the inner periphery of the underwater connecting end connected to the underwater pipeline, the annular tapered surface of the underwater connecting end connected to the underwater pipeline guidingly and matingly engaging the annular tapered surface of the underwater connecting end of the one riser-section in an interconnected position of the constructed riser and the underwater pipeline.

24. The apparatus of claim **5** wherein the underwater connecting end of the one riser-section is defined further to include, a lowermost end and a groove formed in the outer periphery thereof extending a distance axially along the outer periphery thereof, a portion of the groove tapered radially outwardly thereby forming an annular tapered surface extending about the outer periphery of the underwater connecting end of the one riser-section, a portion of the tapered surface intersecting a portion of the outer periphery of the underwater connecting end of the one riser-section; and wherein the underwater connecting end connected to the underwater pipeline is defined further to include, an uppermost end and a groove formed in the inner periphery thereof extending a distance axially along the inner periphery thereof, a portion of the groove tapered radially outwardly thereby forming an annular tapered surface extending about the inner periphery of the underwater connecting end connected to the underwater pipeline, a portion of the tapered surface intersecting a portion of the uppermost end of the underwater connecting of the underwater pipeline, the surface formed by the groove and the annular tapered surface of the underwater connecting end connected to the underwater pipeline guidingly and matingly engaging the surface formed by the groove and the annular tapered surface, respectively, of the underwater connecting end of the one riser-section in an interconnected position of the constructed riser and the underwater pipeline.

25. The apparatus of claim **5** wherein the underwater connecting end connected to the underwater pipeline is defined further to include; an annular flange formed on the outer periphery thereof, extending generally radially therefrom and an annular raised face formed on a portion of the flange extending generally axially from the annular flange terminating with an uppermost end, the uppermost end of the annular raised face forming the uppermost end of the underwater connecting end connected to the underwater pipeline; and wherein the underwater connecting end of the one riser-section is defined further to include, an annular flange formed on the outer periphery thereof, extending generally radially therefrom, thereby forming an annular downwardly facing surface and an annular upwardly facing surface, each extending about the outer periphery of the underwater connecting end of the one riser-section, the annular downwardly facing surface engaging the uppermost end of the underwater connecting end connected to the underwater pipeline in an interconnected position of the constructed riser and the underwater pipeline.

26. The apparatus of claim **25** wherein the underwater connecting end of the one riser-section is defined further to include:

an annular slip ring disposed about the underwater connecting end of the one riser-section, a portion of the annular slip ring slidingly engaging the upwardly facing surface formed by the flange about the outer periphery of the underwater connecting end of the one riser-section, the slip ring being supported in one direction thereby, a plurality of bolt holes being formed through a portion of the slip ring and spaced circumferentially thereabout; and

wherein the flange formed about the underwater connecting end connected to the underwater pipeline, is defined further to include a plurality of bolt holes formed therethrough, the bolt holes spaced circumferentially about the flange and positioned to align with the bolt holes formed in the slip ring, in one position of the slip ring, for bolting interconnection between the constructed riser and the underwater pipeline.

27. The apparatus of claim 26 defined further to include; flange alignment means supported generally between the underwater connecting end of the one riser-section and the underwater connecting end connected to the underwater pipeline to align the bolt holes of the flange of the underwater connecting end connected to the underwater pipeline with the bolt holes through the slip ring supported on the one riser-section.

28. The apparatus of claim 27 wherein the flange alignment means is defined further to include:

a pin having an upper and lower end, the pin disposed through one of the bolt holes in the slip ring and one of the bolt holes of the flange of the underwater connecting end connected to the underwater pipeline, in one position;

a clamp means connected to the pin generally adjacent the upper end thereof, the clamp means engaging a portion of the slip ring in one position of the clamp means to secure the pin in an assembled position, a portion of the pin extending through one of the bolt holes in the slip ring and a portion of the pin generally adjacent the lower end thereof extending a distance downwardly from the slip ring in an assembled position of the pin; and

a pair of guide members, each guide member removably supported on a portion of the flange formed on the underwater connecting end connected to the underwater pipeline and extending a distance generally upwardly therefrom, each guide member having a guide side, the guide sides of the two guide members defining a guide path in an assembled position of the guide members, each guide side alternately and guidingly engaging a portion of the pin generally adjacent the lower end of the pin in one position of the pin, to guide a portion of the pin through one of the bolt holes of the flange formed on the underwater connecting end connected to the underwater pipeline.

29. The apparatus of claim 5 wherein the guide coupling means is defined further to include:

a support base having an upper and lower end, a portion of the base removably disposed in a portion of the underwater pipeline generally near the underwater connecting end connected thereto, in an assembled position of the guide coupling means;

means supported on a portion of the support base to securedly position the guide coupling means in an assembled position in a portion of the underwater pipeline; and

a cone-shaped guide having an upper end and a circular-shaped lower end, the lower end of the cone-shaped guide connected to the upper end of the support base, the cone-shaped guide extending axially above the uppermost end of the underwater connecting end connected to the underwater pipeline, in an assembled position of the guide coupling means, the outer surface of the cone-shaped guide providing a guiding surface guidingly engaging a portion of the underwater connecting end of the one riser-section to guide the underwater connecting end of the one riser-section into an interconnecting engagement with the underwater connecting end connected to the underwater pipeline.

30. The apparatus of claim 29 wherein the means to securedly position the guide coupling means in the underwater pipeline is defined further to include:

a jaw member pivotally secured to a portion of the support base, a portion of the jaw member extending radially from the support base and engaging a portion of the underwater connecting end connected to underwater pipeline to securedly position the guide coupling means in one direction in the underwater pipeline, in one position of the jaw member;

a bias spring, having opposite ends, one end of the bias spring connected to a portion of the jaw member and the end of the bias spring opposite the end thereof connected to the jaw member connected to a portion of the support base, the bias spring biasing the jaw member in a biasing direction; and

a plate means secured to a portion of the support base, a portion of the jaw member engaging the plate means to limit the pivotal movement of the jaw member in a biasing direction to a position wherein a portion of the jaw member engages a portion of the underwater connecting end connected to the underwater pipeline to position the guide coupling means in an assembled position in the underwater pipeline.

31. The apparatus of claim 29 further defined to include:

an annular seal member, having an annular seal end and an annular tapered surface formed thereon, a portion of the seal member opposite the seal end thereof sealingly connected to a portion of the support base, the annular seal end of the seal member slidingly engaging an adjacent portion of the inner periphery of the underwater pipeline, the annular tapered surface of the seal end engaged by fluid entering the underwater pipeline via the underwater connecting end thereof, the fluid biasing the seal end of the seal member into sealing engagement with the adjacent portion of the inner periphery of the underwater pipeline thereby forming a fluid seal between the guide coupling means and the underwater pipeline, in one position of the seal member.

32. The apparatus of claim 31 defined further to include: a seal bias means supported in a portion of the support base, the seal bias means having a portion thereof biasingly engaging a portion of the annular tapered surface of the seal member thereby biasing the seal end of the seal member into sealing engagement with an adjacent portion of the inner periphery of the underwater pipeline, in one position of the seal bias means.

33. The apparatus of claim 32 wherein the seal bias means is defined further to include:

an elongated rod, having opposite ends, reciprocatingly supported in a portion of the support base;

a predetermined number of flanges, each flange being connected on one end thereof to a portion of the rod generally near one end of the rod, each flange extending a distance radially from the rod terminating with an outer end portion;

an annular bias ring having a portion thereof connected to the outer end portion of each flange, the bias ring biasingly engaging the annular tapered surface of the seal member, thereby biasing the seal end of the seal member into sealing engagement with the adjacent portion of the inner periphery of the underwater pipeline, in one position of the bias ring; and

a bias spring disposed about a portion of the rod, one end of the bias spring engaging a portion of the support base, the end of the bias spring opposite the end thereof in engagement with the support base engaging a portion of the flanges thereby biasing the rod in a bias direction wherein the seal ring biasingly engages the annular tapered surface of the seal member, the bias spring thereby augmenting the sealing integrity of the seal member with respect to the inner periphery of the underwater pipeline.

34. The apparatus of claim **33** defined further to include:

means to move the rod in a direction generally opposite the biasing direction and to support the rod in a position wherein the bias ring is disengaged from the seal member; and

means to move the rod in a biasing direction to augment the biasing force of the bias spring, thereby augmenting the sealing integrity between the seal member and the adjacent portion of the inner periphery of the underwater pipeline in one position.

35. The apparatus of claim **31** defined further to include:

a submergable pump means supported in a portion of the guide coupling means to remove fluid accumulated in a portion of the underwater pipeline generally near the underwater connecting end connected thereto and to remove fluid accumulated in the riser subsequent to the constructed riser being interconnected to the underwater pipeline.

36. The apparatus of claim **5** defined further to include: a slip coupling means interposed in a portion of the underwater pipeline generally near the end of the underwater pipeline having the underwater connecting end connected thereto, a portion of the underwater pipeline between the end thereof having the underwater connecting end connected thereto and the slip coupling rotatable generally about the slip coupling to facilitate the positioning of the underwater pipeline to be interconnected to the constructed riser.

37. A method for connecting an underwater connecting end of a riser to an underwater connecting end of an underwater pipeline, the connection between the riser and the underwater pipeline being generally below the surface of and near the floor of the body of the water, the method comprising:

supporting the riser from the marine support member;

supporting a portion of the underwater pipeline and the underwater connecting end thereof from the marine support member generally above the floor of the body of water; and

lowering the riser to a position wherein the underwater connecting end thereof interconnectingly engages a portion of the underwater connecting end of the underwater pipeline.

38. A method for constructing a riser of a plurality of riser-sections to be connected to an underwater pipeline, the method comprising:

supporting one end of one of the riser-sections on the support member;

positioning the end of another riser-section in connecting engagement with one end of the riser-section supported on the support member;

securing the riser-section supported on the support member to the riser-section in connecting engagement therewith;

lowering the interconnected riser-sections a predetermined distance;

supporting the last connected riser-section from the support member;

positioning another riser-section in a connecting engagement with respect to the last connected riser-section supported from the support member;

securing the riser-section supported from the support member to the riser-section positioned in a connecting engagement therewith; and

repeating the last two mentioned steps a predetermined number of times to interconnect a predetermined number of riser-sections to form the riser; and

lowering the interconnected riser-sections to a position wherein the lower end of the first connected riser-section connectingly engages the underwater pipeline.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,717,002 Dated Feb. 20, 1973

Inventor(s) Billy L. O'Brien and Heber P. O'Brien

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 26, line 64, change the word "if" to the word --of--.

Col. 27, line 41, change the numeral "30" to the numeral --300--.

Col. 29, line 21, change the numeral "350" to the numeral --360--.

Col. 29, line 32, change the numeral "364" to the numeral --354--.

Col. 30, line 19, change the numeral "354" to the numeral --384--; line 21, change the numeral "354" to the numeral --384--.

Col. 30, lines 24 and 26, delete the numeral "385".

Col. 30, line 58, delete the word "through".

Col. 32, line 4, change the numeral "438" to the numeral --436--.

Col. 35, line 1, change the numeral "464" to the numeral --404--.

Col. 35, line 67, change the word "off" to the word --of--.

Col. 36, line 5, change the numeral "466" to the numeral --462--.

Col. 36, line 7, change the numeral "482" to the numeral --466--.

Col. 37, line 62, after the words "bias assembly" change the numeral "440" to the numeral --410--.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,717,002 Dated Feb. 20, 1973

Inventor(s) Billy L. O'Brien and Heber P. O'Brien

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 40, line 48, change the numeral "504" to the numeral --506--.

Col. 48, line 25, claim 10, change the word "arm" to the word --end--.

Col. 50, line 15, claim 17, "as" should read -- an -- .

Signed and sealed this 20th day of November 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents