United States Patent

[11] 3,590,878

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[73] Assignee **North American Rockwell Corporation**

[54] **SUPPORT FOR UNDERWATER PIPE LINES**
11 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **138/106,** 138/172, 52/693
[51] **Int. Cl.** **F16l 3/02**
[50] **Field of Search** 138/172, 106, 107; 52/693, 646

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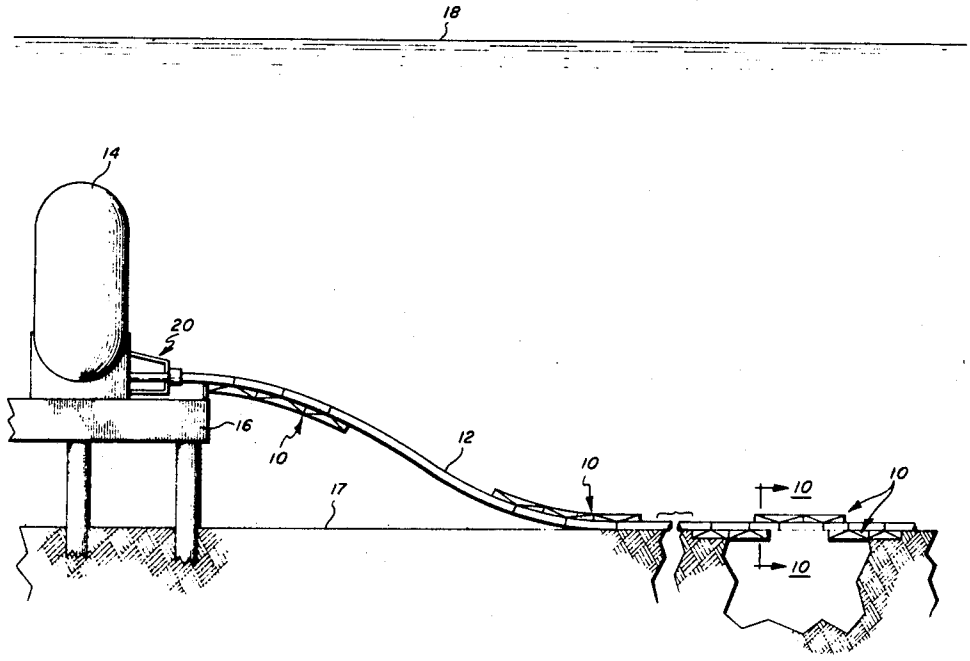
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ABSTRACT: This invention relates to a stiffener assembly for controlling the bend of a pipe or pipe bundle in areas where large bending moments are expected. A plurality of stiffeners are secured along the length of pipe in an end-to-end relationship and in such a manner as to allow the pipe to deflect to a point where the bending stress is still below its yield point.



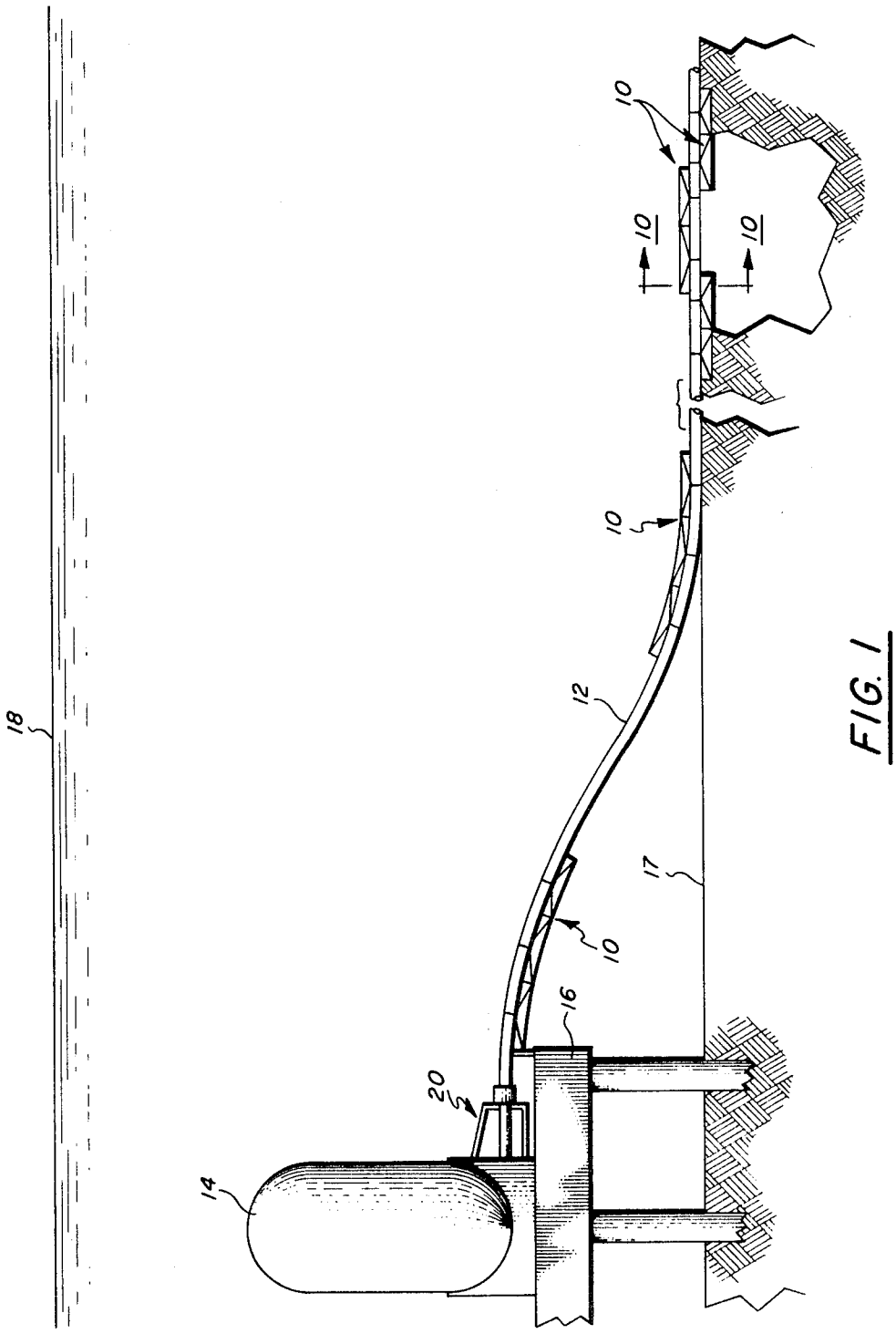


FIG. 1

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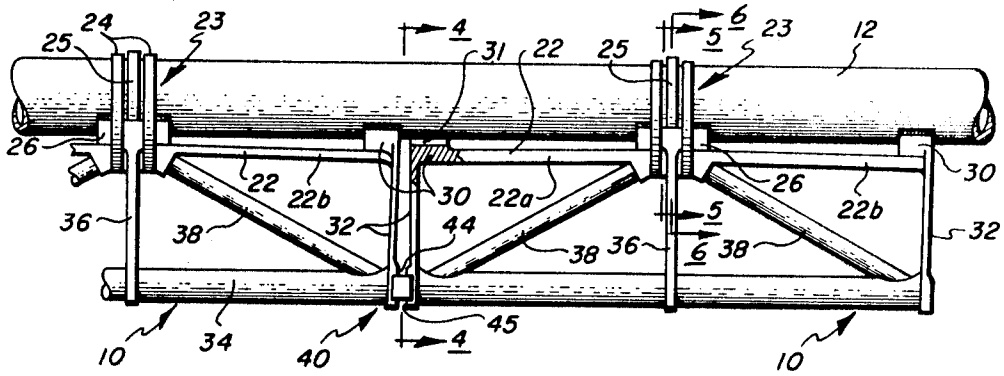


FIG. 2

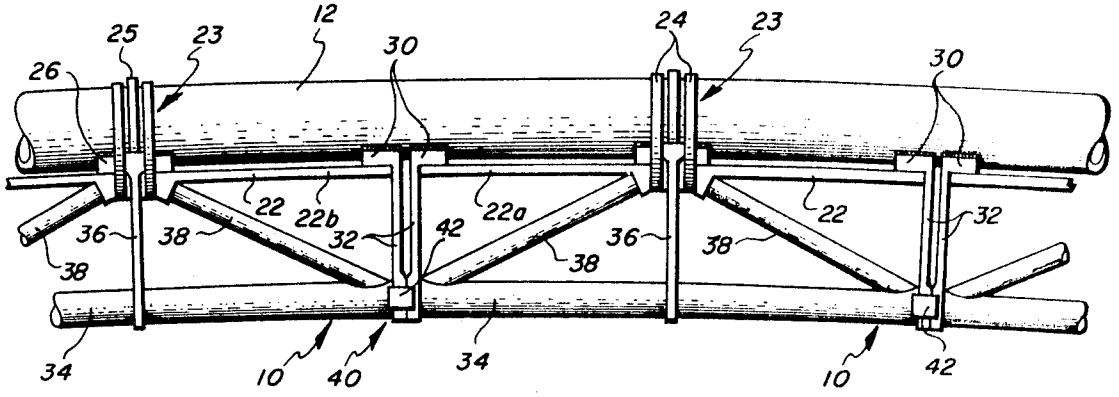


FIG. 3

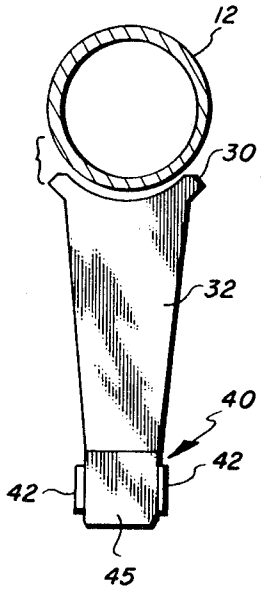


FIG. 4

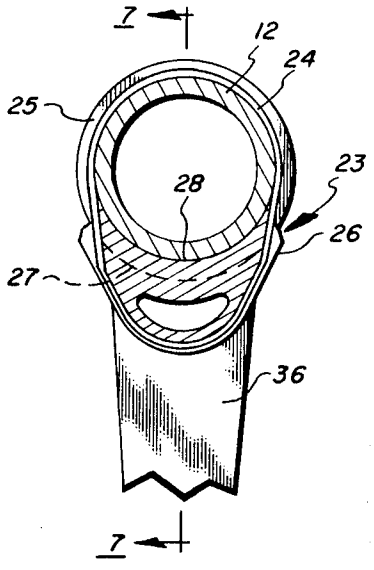


FIG. 5

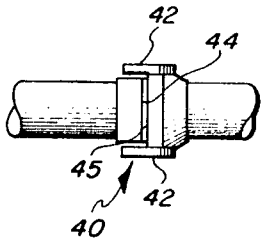


FIG. 8

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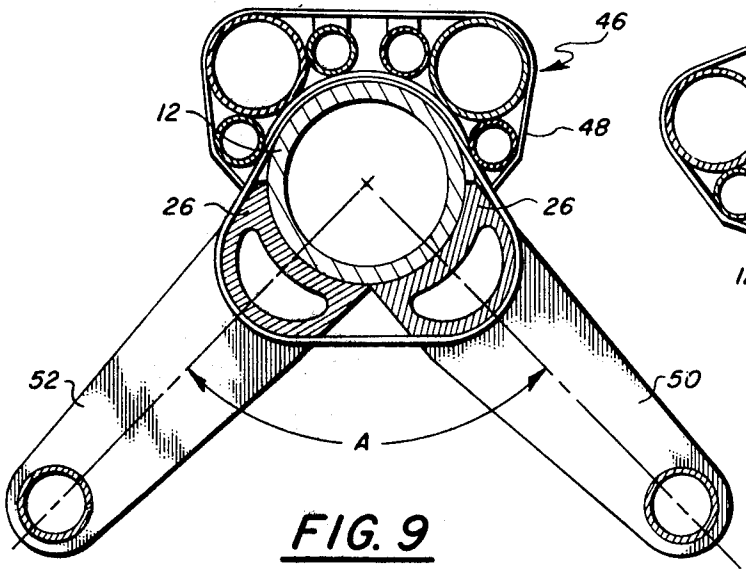


FIG. 9

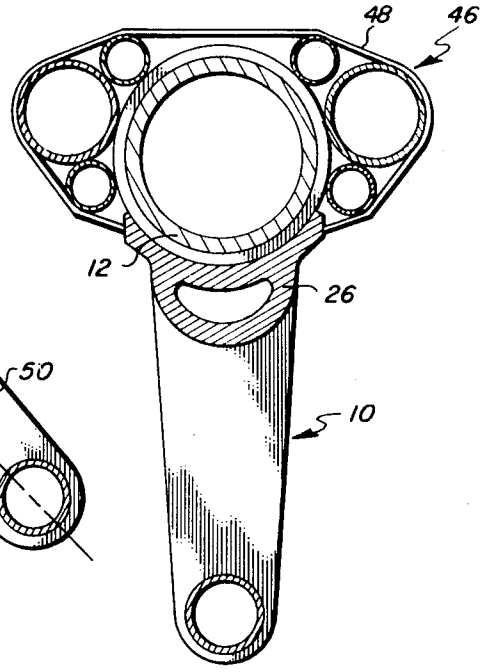


FIG. 6

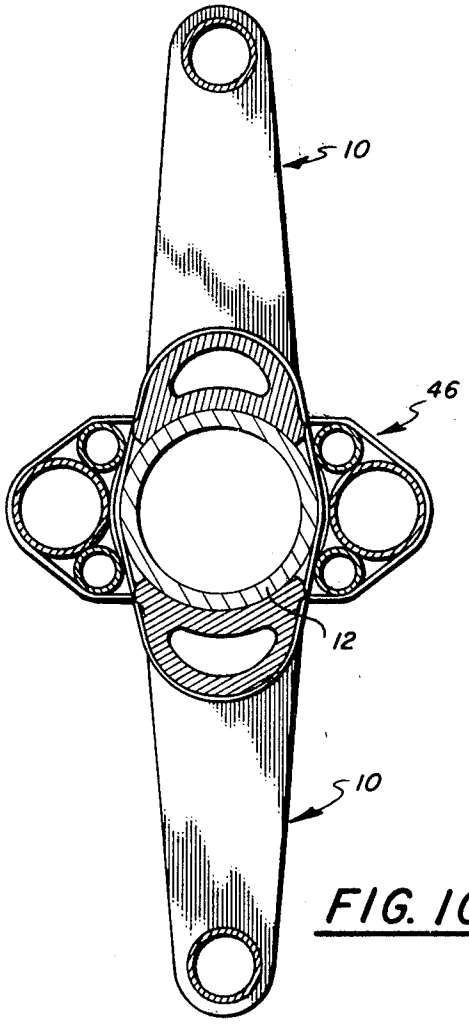


FIG. 10

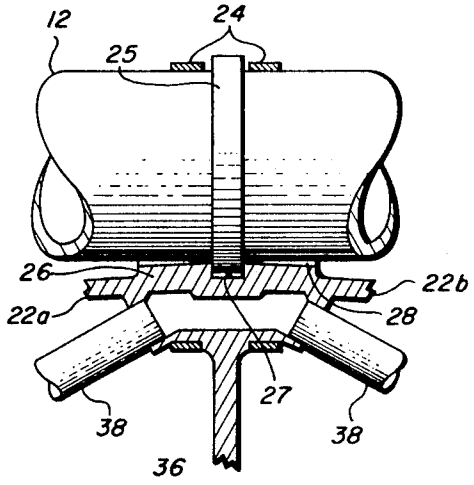


FIG. 7

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SUPPORT FOR UNDERWATER PIPE LINES

BACKGROUND OF THE INVENTION

With the increase in underwater activities in recent times, there have arisen many problems in areas which did not exist heretofore. One of the important areas, as an example, is underwater oil or gas wells. There are three phases involved in underwater oil well operations. That is, first, drilling the well; second, completion of the well; and third, production of the well.

The phase that this invention is more concerned with is the third phase, wherein the well is capable of producing a flow of gas and/or oil with maximum trouble free operation.

This invention relates to pipeline or pipe bundles that are needed as conduits between underwater vessels, pumping stations, wells or other type of flow stations including riser manifolds.

It should be noted that this invention is particularly concerned with oil well operations where the depth of the ocean or sea floor is such that divers are unable to work.

When laying pipe on land it is customary to dig a ditch, the bottom of which is smooth with only gradual changes of inclining or declining grades for large transitional radii. In the case of ditches or valleys that have to be crossed bridges or bridgelike devices are provided. Therefore, it can be understood that the pipe is supported over its full length and is not subjected to bending stresses.

However, when laying pipe in deep water, the above procedures are, for economical reasons, out of the question. The underwater geographical conditions and terrain are somewhat unpredictable. The pipe may be lying partly in soft sand, mud, and/or bedrock and will have additional problems to overcome, such as sudden steps in terrain, sharp rocky ridges or valleys which cannot easily be removed.

As an example, a pressure vessel is normally located on a base support structure above the ocean floor, but well below sea level. The base structure is generally located at least 25 feet above the ocean floor. Therefore, any pipe connections, such as a flowline connector from a pressure vessel or the like, will be at a substantial distance above the ocean floor. A pipe connected to a unit under the above conditions will have to bridge an unsupported distance without buckling or causing an unacceptable reduction of flow area. It is obvious that under these conditions, the pipe or pipe bundle near the pressure vessel will be subjected to a high degree of bending moment between the base structure and the ocean floor.

A similar support requirement is also to be found near the crossing of a ravine. Stiffener assemblies are, therefore, required in these areas to eliminate or control any positive or negative bending moments that would tend to occur due to the weight of the pipe being supported by uneven features of the terrain at various specific points.

SUMMARY OF THE INVENTION

This invention relates to stiffener assemblies which are required to be placed at points along pipe or pipe bundles, where insufficient support of the pipe can be expected rather than preparing the ocean or sea bottom for the support thereof. The control of the bending moment of the pipe is necessary and is accomplished by securing stiffener assemblies in end-to-end relationship to each other at specific points along the pipe.

Since the depth of the ocean in which the pipeline is to be laid is at such a depth that it is not possible for divers to work, a fathometer reading of the area is taken. The reading will then indicate the required position of the stiffeners on the pipeline.

Collars are then located at the required locations along the pipe. In the case of pipe bundles (a group of different sized pipes strung together along their length) collars will be secured to the largest pipe in the bundle, in this specific case having a size of approximately 8 inches.

After the collars are secured to the pipe, which is normally accomplished by welding, the pipe line is floated on the water and required size stiffeners are fastened around each equally spaced collar. When the stiffeners are secured in place, the pipe and stiffeners are lowered into position.

The stiffeners will start taking hold after the stiffest pipe in the bundle has started bending and before the bending stress reaches the yield point of the pipe.

The stiffeners themselves can be made of any suitable light material having an open lightweight truss design so that flotation devices are not required to support the pipe.

Each stiffener comprises a connecting saddle which is centrally positioned on the upper portion of the stiffener assembly. The saddle is located intermediate the ends of a nonlinear convexed support beam and is an integral part thereof. At each free end of the support beam there is fixed a shoe member and each member is formed to receive the pipe for engagement therein when the pipe has a bending moment in the direction of the shoes. Positioned in opposing relationship to the shoes are end braces which are fixed to the underside of the support beam and extend substantially perpendicularly thereto. A column is connected at its respective ends to the extended ends of each respective end brace and remote from the support beam. The alignment of each stiffener assembly in a side-to-side relationship is accomplished by guide means attached to one of said braces at the lower end thereof, for receiving the adjacent brace of an adjoining stiffener assembly. For greater support of the support beam, a center brace is vertically positioned between the lower column and the support beam. In addition, a pair of diagonally supporting trusses are included and are fixed at one end to the upper support beam, adjacent to the center bar, the opposite end of which is fixed to the lower column adjacent the lower end portions of the end braces.

Therefore, it is an object of the invention to control the bend of pipe by use of a group of stiffener assemblies where known bending moments are to occur when the pipe or pipe bundle is laid on the bottom of the ocean floor.

A further object of the invention is to stiffen the pipe bundle or pipe at places where insufficient support can be expected rather than prepare the supporting sea bottom.

It is still a further object of the invention to limit the bend of a string of pipe before the bending stress reaches the yield point.

Other characteristics, advantages and objects of my invention can be more readily appreciated from the following description and appended claims. When taken in conjunction with the accompanying drawings, this description forms a part of the specification wherein like references and characters designate corresponding parts in several views which are as follows:

FIG. 1 is a diagrammatic illustration showing typical applications of the invention;

FIG. 2 is an elevational view of the invention secured to a string of straight pipe;

FIG. 3 is an elevational view of the invention secured to a string of pipe being bent by a bending moment;

FIG. 4 is an enlarged cross section taken along line 4–4 of FIG. 2;

FIG. 5 is an enlarged cross section taken along line 5–5 of FIG. 2;

FIG. 6 is a cross section taken substantially along line 6–6 of FIG. 2 showing a pipe bundle supported thereon;

FIG. 7 is a cross section taken along line 7–7 of FIG. 5;

FIG. 8 is a bottom plan view of the guide means;

FIG. 9 is a sectional view illustrating another method of positioning a pipe line;

FIG. 10 is a sectional view taken along line 10–10 of FIG. 1 showing the invention positioned on a pipe line bundle which is capable of having a positive or negative bending moment.

Referring now to the drawings, there is shown in the diagrammatic view of FIG. 1 a schematic illustration of a group of stiffener structures, generally indicated by reference numeral

10, which are attached to the elongated element 12 along its length. The elongated element represents either a single or multitubular line of end-to-end welded pipes. The above view illustrates the many typical areas in which the application of stiffener structures can be used. As can be seen, there is a pressure vessel 14 which is located and supported by a base or platform structure 16 just above the sea floor 17 but well below the water surface 18. Whenever a pipeline such as 12 is to be connected to a pressure vessel of one kind or another, there will be a flow connection as illustrated generally at 20. One free end of the pipeline 12 is connected to the flow connector 20 and then lowered therefrom to the sea floor 17, wherein the distance between the connection and the sea floor is such that a bending will occur in the pipeline which would cause damage in the form of buckling or an unacceptable reduction in the area of the pipeline to cause a reduced flow of fluid therethrough. It is, therefore, necessary to support the pipe at this critical bending area by the stiffeners 10.

It should be noted at this time that the above referred to multitubular line comprises a group of two or more pipelines, each of which generally has a different size diameter. These pipes are supported and tied to the largest pipe of the group. This multitubular line will hereinafter be referred to as a pipe bundle.

The stiffener assembly 10 comprises a rigid skeleton-type framework having a nonlinear convex support beam 22 which is positioned longitudinally along the length of the pipe 12 at predetermined points along the length thereof and substantially parallel thereto, as can be readily seen in FIGS. 2 and 3 respectively. A securing means, generally indicated as 23, for securing the support beams to the pipe is located intermediate the ends of said support beams. The securing means 23 comprises a connecting means such as a pair of fastening straps 24, collar 25 and a saddle member 26 which cooperate together to establish the location of each stiffener assembly in an end-to-end relationship. Each collar 25 is selectively positioned along the pipe 12 and is attached thereto by welding or other suitable means. The collars are evenly spaced relative to each other and located in the area where the bending of the pipe will most likely occur. After the attachment of the collars 25, each assembly structure is fitted to each collar by means of the saddle member 26, as can be seen in FIGS. 5 and 7, respectively. This is accomplished by a channel 27 in the concaved face portion 28 of the saddle member which engages with the collar 25. The concave face portion 28 is curved to fit the outer curvature of the pipe 12. Each stiffener structure 10 is then secured to the stringer 12 by the tie-down bands or straps 24 located on each side of collar 25. The straps 24 encircle the pipe 12 along with the saddle 26 and are secured thereto by welding each strap into place. The saddle member 26 is centrally positioned on the support beam 22 as that of an apex having divergently angulated extending arm members. Said angulated members 22*a* and 22*b*, respectively, are an integral part of said saddle member and each member, together as a unit, comprises the support beam 22. At each free end of each arm member, there is fixed a concave shoe or bracket 30, which is adapted and formed to receive the outer curvature of pipe 12 for engagement therein when said pipe has a bending in the direction of the shoe.

It can be seen in FIG. 2 that the pipe 12 does not have a bending moment at this particular point and the support beam 22, being angulated downwardly and away from said pipe, creates a space between the convex surface 31 of the shoe 30 and the lower portion of the pipe wall. This space then becomes a working area wherein the pipe may move or bend under stress but yet can be controlled so that the pipe may be stressed only to a set point below the yield stress and thereby protect the pipe from damage.

Referring now to FIG. 3, there is illustrated a stringer which is shown bowed under stress by a bending moment occuring in pipe 12. The curvature of the pipe fits and is received into the convex surface 31 of the shoe at each end of the stiffener assembly.

Positioned below each shoe and integrally connected thereto are end braces 32 which extend downwardly from said support beams and substantially perpendicularly thereto. Connected to each of the respective lower end portions of the end braces 32 is a horizontal compression column member 34, which is substantially parallel to the axis of the pipe 12 and is remotely located from the support beam 22 for greater structural support. Intermediate the ends of the lower column member 34, and centrally mounted thereon, is a vertical center brace 36. The opposite end of said center brace is joined to the support beam at the apex thereof. That is, the upper end of the brace 36 becomes an integral part of the saddle and support beam 22 as means to aid in the structural support of the skeleton-type framework. In addition, a pair of diagonally supporting truss members 38 are arranged so that one end of each truss is fixed to the column member 34 adjacent to the lower end of each end brace, and the opposite ends are fixed to the saddle member at the intersection of the angulated extending arms 22*a* and 22*b*, respectively.

Alignment of each stiffener assembly 10 is in an ent-to-end relationship, which is accomplished by guide means 40 attached to one of the brace members at its lower end. This guide means receives the adjacent brace member of the adjoining stiffener assembly. The guide means comprises two flat oppositely disposed fingers 42 which are fixed to each side of the end brace members, forming a substantially U-shaped configuration that can be clearly seen in FIG. 8. Said flat members or fingers 42 are welded to the surfaces of the brace member and are so arranged as to be located at one end of the stiffener structure 10. This, then, leaves the opposite end of the structure free to engage in the guide members of an adjoining structure. Not only is guide means 40 used to control lateral movement of each adjoining stiffener structure, but it is used to keep the pressure pad faces 44 and 45 aligned for movable engagement with each other. It can be seen, as illustrated in FIG. 3, that any stress which is placed upon stringer 12 would cause a downward bending moment whereby faces 44 and 45 would be brought into contact with each other. This, then, would limit any further bending to occur in the string of pipe. Thus, the pipe is protected from undue damage by limiting the bending stress before it reaches the yield point.

Referring now to FIG. 6, there is shown a main stringer pipe 12 supporting a typical type bundle, indicated at 46. Generally, the stringer pipe is the largest and the most rigid pipe of the group, normally having a diameter of 8 inches or better. The attached bundle of pipes typically comprises a variety of pipe sizes having diameters of 2 to 4 inches and are secured to the structure stringer pipe 12 in a group by any suitable means but, for illustrative purposes, it has been shown tied down by a strap or a band 48. These pipes can be used in varying numbers and sizes depending upon the requirements of any one given situation.

At this time, the other configurations and uses of underwater stiffener structures should be also considered.

If stiffeners are required at a point far from the connectors at each end, the pipe could possibly be twisted so that the center plane of the stiffener would not coincide with the plane of the bending moment. There will occasionally occur a situation wherein the pipe and/or pipe bundle is of such length along the ocean floor that it is subjected to undue twisting about itself. Thus, a bend in the pipe would then become unstable. In this case, a configuration, as shown in FIG. 9, should be used. The pipe then would become stable for any bending plane as long as it stays between the center lines of the stiffener 50 and 52, respectively. The bundle of pipe, generally indicated at 46, as well as pipe stringer 12 are supported by the stiffeners 50 and 52, respectively. Each of the stiffeners are attached to the stringer pipe in the same manner as hereinbefore described. However, the positioning of the structures are such that they are not only in end-to-end relationship but are, in addition, placed side by side at right angles to each other. The right angle relationship is indicated at A which comprises an angle of approximately 90°. Thus, the arrange-

ment will resist bending moments in a plane that would be subjected to more than a rotation of plus or minus 45°, on each side of the center thereof.

Another configuration is illustrated in FIG. **10** wherein the pipe will be subjected to a condition having a positive or negative bending moment. This condition is apt to occur where the pipe would have a tendency to develop a double bend at crossings such as ravines or crevices. This situation is most likely to be brought about at a point along the pipe, as indicated at **10–10** in FIG. **1**. Here again, the attachment of the stiffener structures are accomplished as hereinbefore described, with the exception that each stiffener assembly **10** is positioned diametrically opposite the other, that is, each being separated from the other by half the circumference of the pipe **12**.

We claim:

1. A stiffening assembly for elongated pipe comprising:
- a rigid skeletal structure having a support beam angulated at its midportion;
- a brace connected to each end of the support beam and extending substantially perpendicular thereto;
- a column member connected at its respective ends to the ends of each respective braces remote from said support beam; and
- means for maintaining said support beam in fixed position along the length of said elongated pipe.

2. A stiffening assembly as recited in Claim **1** including:
- a guide means attached to one of said braces at the end thereof remote from said support beam for receiving a brace of a second similar adjoining stiffener assembly.

3. A structural stiffening assembly for an elongated element which is subjected to a limited amount of bending, said assembly comprising:
- a plurality of stiffener structures adapted to be secured to said elongated element in end-to-end relationship to each other, each of said structures comprising:
- a support beam having an apex, said beam being divergently angulated from said apex;
- a securing means for securing said support beam to said elongated element;
- a brace connected to each end of said support beam and extending substantially perpendicular thereto;
- a slidable guide means fixed to one brace of each structure and adapted to receive an adjoining brace of the adjacent structure; and
- a column connected at its respective ends to the free ends of said respective braces and remote from said support beam.

4. An assembly as recited in claim **3** wherein said securing means comprises:
- a saddle member positioned at the apex of said support beam for receiving said elongated element; and
- a connecting means for connecting said saddle to said elongated element whereby said stiffener structures may be secured in end-to-end relationship to each other in predetermined positions along the length of said elongated element.

5. An assembly as recited in claim **4** wherein said stiffener structure includes:
- a shoe mounted to each opposite end of said support beam, said shoe formed to receive said elongated element for engagement therewith, when said element has a bending moment in the direction of said shoe.

6. An assembly as recited in claim **5** wherein said stiffener structure includes:
- a guide means for positioning an adjacent stiffener in end-to-end alignment, said guide means fixed to one of said braces of the lower end thereof.

7. An assembly as recited in claim **6** wherein said stiffener structure further includes:
- a center brace support joined at one end to said support beam at the apex thereof, and the opposite end joined to said column intermediate the ends thereof; and
- a pair of diagonal supporting truss, each of said truss having one end fixed to said column and the opposite end thereof is fixed to said saddle member adjacent to said support beam.

8. A structural stiffening assembly for support of an elongated element which is subjected to a limited amount of bending comprising:
- a plurality of stiffener structures adapted to be secured to said elongated element in end-to-end relations, each said structure comprising:
- a nonlinear convexed support beam having free ends thereon;
- securing means for securing said stiffener structure to said elongated element, said means being positioned intermediate the free ends of said support beam;
- a pair of end braces each connected to each free end of said support beams and extending perpendicular thereto, and in spaced relationship with an adjoining end brace of the adjacent stiffener structure; and a truss arrangement interposed between said end braces and attached thereto.

9. A structural assembly as recited in claim **8** including:
- a guide means for end-to-end alignment with adjacent stiffener assembly, said guide means attached to one of said braces at the end thereof, remote from said support beam for receiving a brace of said adjoining stiffener assembly.

10. A structural stiffening assembly for support of elongated pipe element comprising: a first group of stiffeners attached to said elongated pipe element in end-to-end relationship to each other; and a second group of stiffeners attached to said elongated pipe element in end-to-end relationship with each other, and positioned adjacent and at right angles to said first group of stiffeners, whereby said elongated element becomes stable, wherein each of said stiffeners comprises
- a rigid skeletal structure having a support beam angulated at its midpoint;
- a brace connected to each end of the support beam and extending substantially perpendicular thereto;
- a column member connected at its respective end to the ends of each respective braces remote from said support beam;
- means for maintaining said support beam in fixed position along the length of said elongated pipe element; and
- a guide means attached to one of said braces at the end thereof, remote from said support beam for receiving a brace of a second similar adjoining stiffener assembly.

11. A structural stiffening assembly for support of an elongated pipe element having a positive and negative bending moment comprising: a first group of stiffeners attached to said elongated pipe element in end-to-end relationship to each other; and a second group of stiffeners attached to said elongated pipe element in end-to-end relationship with each other, and positioned diametrically opposite said first group, each group being separated from the other by half the circumference of said pipe element, wherein each of said stiffeners comprises:
- a rigid skeletal structure having a support beam angulated at its midpoint;
- a brace connected to each end of the support beam and extending substantially perpendicular thereto;
- a column member connected at is respective end to the ends of each respective braces remote from said support beam;
- means for maintaining said support beam in fixed position along the length of said elongated pipe element; and
- a guide means attached to one of said braces at the end thereof, remote from said support beam for receiving a brace of a second similar adjoining stiffener assembly.