Aug. 22, 1967 G. W. COPPER 3,336,759

REMOVAL OF UNDERWATER SUPPORT STRUCTURES

Filed Jan. 4, 1965 3 Sheets-Sheet 1

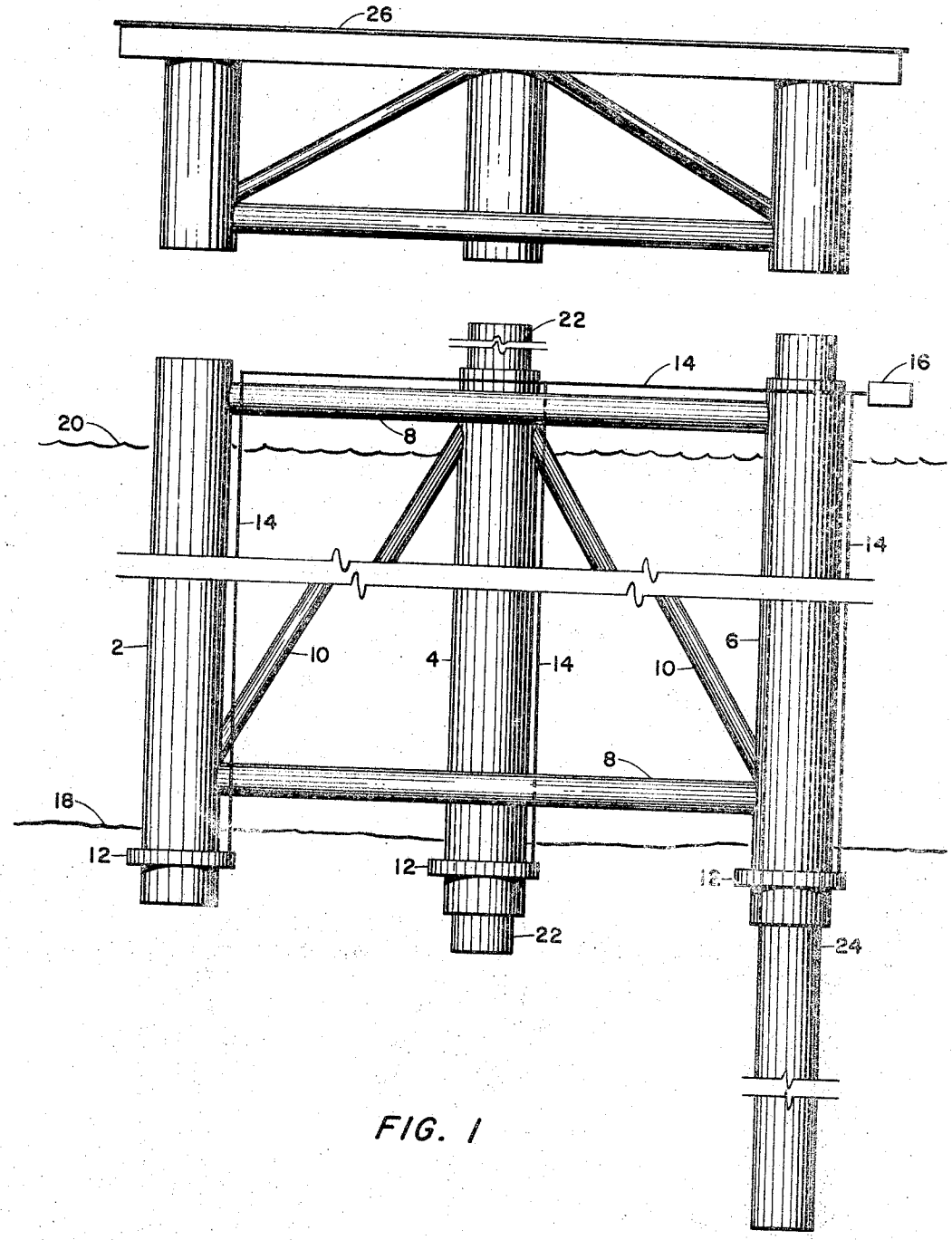


FIG. 1

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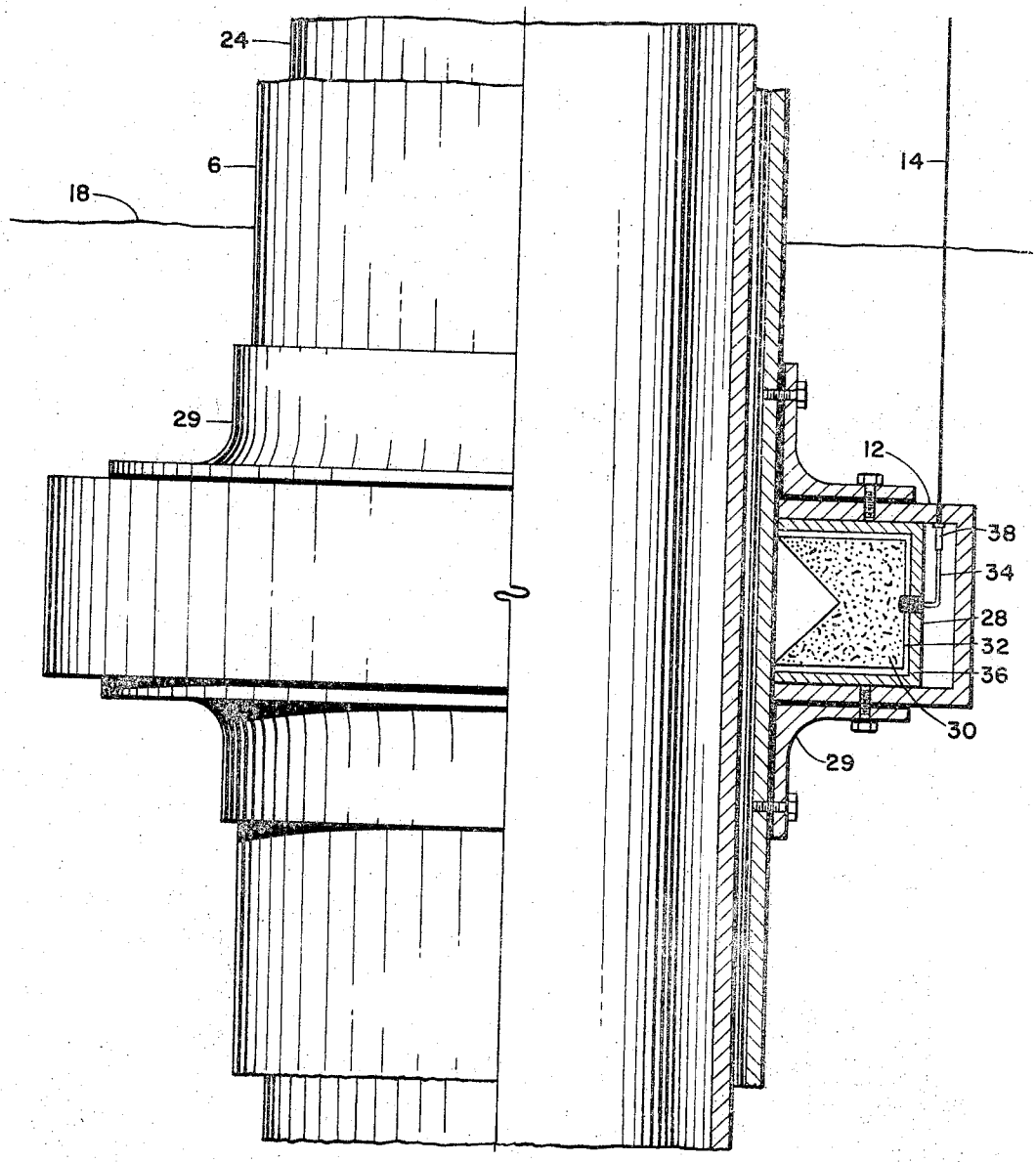


FIG. 2

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REMOVAL OF UNDERWATER SUPPORT STRUCTURES

Filed Jan. 4, 1965 3 Sheets-Sheet 3

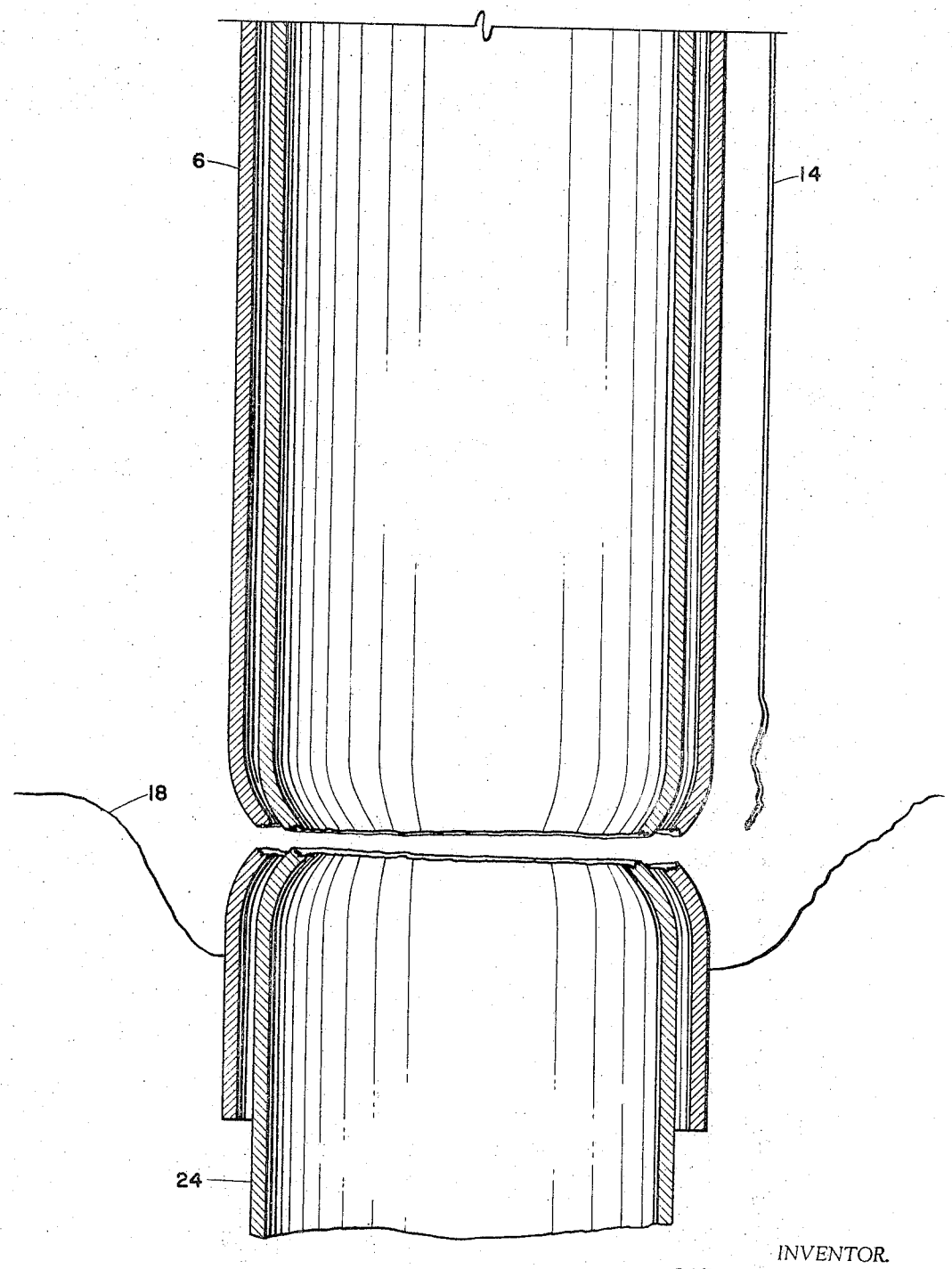


FIG. 3

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REMOVAL OF UNDERWATER SUPPORT STRUCTURES

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13 Claims. (Cl. 61—46.5)

ABSTRACT OF THE DISCLOSURE

A method of removing underwater support devices to be anchored in position by piling driven through the jacket legs of the support device comprising the steps of attaching a hollow annular ring to the periphery of the jacket legs, filling the annular ring with an explosive, detonating the explosive to sever the jacket leg and piling and removing the severed upper portions of the support device and piling.

This invention relates to a process for the salvage of structures used to support various types of equipment above or below the surface of a body of water. More particularly, this invention relates to the removal of anchoring devices used to position underwater support structures.

It is oftentimes desired to support above a body of water various types of equipment such as marine well drilling equipment, electronic equipment for offshore radar stations and the like. The first approach tried was to float a hull in position and then sink it so it rests on the bottom to provide a support base. However, undesirable movement of the support occurs due to shifting of the soil under the support because of the soil being subjected to repeated stresses caused by wave action on the support as well as the pounding action of the waves itself. A more successful approach has been to use as a support for the above-water structures a template type jacket or brace comprising two or more casings supported in fixed vertical or near vertical position by structural steel bracing. The jacket is placed in the desired underwater position and piling is driven through the casing into the subsoil, such as with the aid of pile drivers mounted on floating barges. The piling thus anchors the jacket in a fixed position. To support a large above-water structure which is to contain heavy equipment which may weigh hundreds of tons, several jackets may be used on one installation. The piles are then cut off a uniform distance above the surface of the water, suitably capped and steel trusses welded on them. A timber or steel deck is then generally constructed on the trusses and used as a support for various equipment.

When the usefulness of the structure has ended, it must be removed. Dismantling of the above-water portion of the structure presents no particular problem. However, removal of the jacket and piling has proven to be more onerous. Current methods of pile severance include placement of explosives on the interior of hollow piling just below the ground line and detonating with resulting outward flaring and shattering of the pile material. With this method, the flared piling cannot be withdrawn separately but must be recovered along with the entire underwater brace system or jacket. Increased lifting weights with increased water depth limits this method. The method is also limited to hollow piling. Another method of severence utilizes divers who go down either inside or outside the large diameter piling and effect severance by burning with an oxygen-electric hand cutting tool. Deep water poses a definite limitation on this method, as well as danger to the divers during the late stages of the operation. A third

method being developed utilizes a mechanical type rotary cutting tool which is lowered into the piling and held in position by hydraulic rams. Cutting action is accomplished by rotating a cutter head powered by air or a hydraulic motor in the unit or by a shaft from above. Remote positioning of this tool is difficult, and mechanical malfunctions as well as the great length of time required to make a cut have been additional problems. Underwater structures used to support various installations disposed partially or entirely underwater pose similar removal problems.

An object of this invention is to provide an improved method for removing underwater support structures. A further object is to sever underwater piling so that the same may be removed from location separately from the support jacket which surrounds it. A still further object is to remove all portions of an underground support extending above the bottom line so as to preclude leaving a portion of the structure protruding from the bottom as a potential hazard to navigation, or other underwater operations. Various other objects, advantages, and features of the invention will become apparent from the following detailed description when considered in connection with the accompanying drawings.

These objects are achieved by a process wherein an underwater brace assembly or jacket is positioned on bottom, piling is driven through the legs of the jacket to form an anchored underwater structure and either before or after positioning of the jacket an explosive charge is attached to the periphery of the jacket legs. When it is desired to remove the underwater structure, the explosive charge is detonated to sever the piling, and the piling and jacket are removed either separately or together.

FIGURE 1 is a fragmentary schematic side elevation of the structure used in the process of this invention depicting three stages of placement of piles.

FIGURE 2 is a sectional view showing details of the arrangement of the explosive charge around one leg.

FIGURE 3 is a sectional view following detonation of the explosive charge.

Referring to FIGURE 1, an underwater brace assembly comprising: triangularly disposed vertically parallel legs **2**, **4**, and **6**; horizontal braces **8**; diagonal braces **10**, both sets of said braces connecting each leg to each of the other two legs and holding said legs in spaced relationship to each other; sealed annular ring **12** containing an explosive charge (not shown) surrounding each leg near the bottom thereof; and electrical lines **14** connecting the explosive charge in annular ring **12** to junction box **16**; is positioned underwater with one end on the bottom **18** and the other end extending above water level **20**. Leg **2** is shown as placed on bottom before driving piles. Leg **4** is shown with hollow pile **22** partially driven therethrough to just below the lower extent thereof. Leg **6** is shown with hollow pile **24** fully driven therethrough to refusal and cut off at the top slightly above the upper end of leg **6**. When all three piles have been fully driven and cut off as illustrated by pile **24**, conventional deck section **26** is lowered onto the supporting piles and welded thereto. Any desired equipment such as well drilling apparatus, radar, and the like (not shown) can then be placed on deck section **26**.

FIGURE 2 shows explosive charges, i.e., shaped charges **28**, positioned in annular ring **12** around jacket leg **6**. Annular ring **12** is held in fixed position on jacket leg **6** by bolted flanges **29**. Each shaped charge **28**, the particular details of construction of which are not essential parts of this invention, is composed of a high explosive material **30**, usually a variety of trinitrotoluene, cast in the form of a forward directed hollow cone. High explosive material **30** is confined within an open-ended thin metal sheathing **32** of steel, copper or some similar

metal attached to a detonator of Primacord **34** all enclosed in a case **36** of plastic, ceramic or glass. An electrical blasting cap **38** is positioned in annular ring **12** and is detonated by an electrical impulse transmitted from the surface from junction box **16** (see FIGURE 1) through electrical line **14**, or as an alternative, electric line **14** may be replaced with Primacord **34** to the surface (not shown).

Blasting cap **38** in turn ignites a fuse of explosive Primacord **34**, a detonating fuse comprising a highly explosive core of pentaerythritetranitrate contained within a waterproof sheath overlaid by reinforcing coverings, which is connected to each shaped charge **28** and almost instantaneously detonates all of the same. The form of the inwardly facing conical shaped charges is such that the greatest part of the force developed by the rapidly expanding hot gases resulting from the explosion is directed inwardly and horizontally along the axis of the cone in a concentrated jet of great penetrating power. Thus, both jacket leg **6** and hollow piling **24** collapse inwardly.

FIGURE 3 illustrates the appearance of jacket leg **6** and pile **24** following detonation of the explosive charges. The upper section of both jacket leg **6** and pile **24** have been completely severed and can now be removed. The upper extent of the bottom section of each of these members which will remain in place is below bottom **18** and therefore does not present a protruding underwater hazard. It should also be noted that the inwardly directed explosive force has flared the severed edges of pile **24** inwardly so that it may be lifted out of and removed separately from jacket leg **6**.

The process of this invention is operable with any type of underwater support device, brace assembly, jacket or pile guide sleeve. One end of each such device rests on the bottom while the other end extends to any desired height above the bottom. The said upper end may terminate below the surface of the body of water, but generally extends far enough above the water line so that a platform placed thereon will be substantially above the height of waves even during a storm.

The piles used to anchor a jacket in position may be either solid, such as reinforced concrete, wood, or steel H beams, or more commonly of the hollow caisson-type. The piles may be up to 60 inches or more in diameter and may or may not be equipped with an inverted, cone-shaped concrete shoe on the bottom, which shoe aids in penetrating the formation underlying the bottom, mud line, or earth line. The piles may conveniently be driven into place with a reciprocating hammer, such as a steam hammer or other suitable driving means.

Any conventional explosive charge may be utilized to encircle the support legs. Included are both liquid and solid explosives. An example of a liquid explosive is a mixture of a major amount of a nitroparaffin such as mononitromethane or nitrobenzene and a minor amount (as 2 to 10 volume percent or more) of concentrated or fuming nitric acid or an amine such as aniline, morpholine and diethylamine or other aliphatic amine. The nitric acid or amine sensitizes the nitroparaffin, i.e., increases the shock sensitivity of the materials so that it can be detonated readily by means of common, high velocity detonators such as Primacord. The liquid explosive may be placed in the annular ring surrounding each jacket leg before the jacket is positioned under water. Alternatively, the fluid tight annular ring may remain empty throughout positioning of the jacket and subsequent use of the underwater assembly until it is desired to remove the same. At this time, the liquid explosive may be added to the annular ring, as by pouring the explosive material through a tubing string which is in communication with the annular ring and extends to a point above the surface of the water. The explosive is then detonated as by a string of Primacord run down the tubing string after pouring the liquid explosive therethrough, or by following said explosive with another liquid, such as furfuryl or furfuryl alcohol, that is hypergolic with the liquid explosive. A preferable explosive is a shaped charge. Such explosive pellets generally have a frusto-conical or elongated annular groove-shaped cavity which aids in concentrating the explosive force in one principal direction. It is preferred to evacuate the air from the fluid-tight annular ring containing the shaped charges and replace the air with an inert gas such as nitrogen, as the assembly may be in place months or years before it is desired to detonate the charge to remove the structure. The annular ring containing the shaped charges may be attached to the jacket leg at any time before the jacket is positioned on the bottom. The attachment can conveniently be made during the latter stages of fabrication of the jacket before shipment offshore. The shaped charge-containing ring may be attached to the jacket leg by means of a bolted flange assembly or by welding. As an alternative embodiment using either liquid or solid explosives, the annular ring and detonating means may be attached to the jacket leg after the jacket has been positioned on bottom, as by using divers to make the attachment.

The number of shaped charges required depends on the configuration of the charge, the strength of the explosive and the dimensions and character of the jacket legs and piles. Generally, at least four shaped charges spaced 90° apart in a plane should be used. Preferably, the annular ring should be filled with as many spaced charges as can be packed into a single layer. As the assembly often receives rather rough treatment during placement, it is preferred to use a non-sensitive type explosive, such as RDX (cyclotrimethylenetrinitramine), amatal (a mixture of ammonium nitrate and trinitrotoluene in a ratio of 80 to 20 or 50 to 50 parts by weight), explosive D (ammonium picrate) and picratol (a mixture of 50 percent explosive D and 50 percent trinitrotoluene). More sensitive explosives may be used with increased care in handling. Alternatively to the use of a blasting cap and electrical line, detonation of the explosive charge may be carried out by use of a fuse or primer such as Primacord connected to the explosive charge and extending to above the surface of the water.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, details of the illustrated construction and method of use may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A method of removing underwater support devices comprising:

(a) attaching a hollow annular ring to the periphery of the legs of an underwater piling-encompassing jacket assembly,

(b) filling said hollow annular ring with an explosive charge,

(c) detonating said explosive charge, and

(d) removing the severed upper portions of said piling and jacket assembly.

2. A method of salvaging piling comprising:

(a) attaching a hollow annular ring to the outside of the legs of a jacket assembly,

(b) positioning said jacket in an underwater location,

(c) driving piling through said jacket legs,

(d) placing an explosive charge in the annular ring,

(e) detonating said explosive charge, and

(f) removing the severed upper portion of said piling.

3. The method of claim **2** wherein the explosive charge is placed in the annular ring before positioning the jacket in an underwater location.

4. A method of salvaging piling comprising:

(a) placing a cluster of inwardly facing shaped charges around the legs of a jacket assembly prior to installation thereof,

(b) positioning said jacket in an underwater location,
(c) driving piling through said jacket legs,
(d) detonating said shaped charges, and
(e) removing the severed upper portion of said piling.

5. The method of claim **4** wherein at least four spaced charges are employed.

6. The method of claim **4** wherein the shaped charges are positioning around the legs of the jacket assembly at a point which is below the bottom line when the jacket assembly is placed in an underwater location.

7. A method of removing underwater support devices comprising:
(a) attaching a cluster of shaped charges to the legs of an underwater support structure near the lower end thereof,
(b) placing said structure in a body of water with the lower end thereof resting on the bottom and the upper end thereof protruding above water level,
(c) driving piles through said legs of said structure,
(d) firing said shaped charges to simultaneously sever the concentric jacket leg and piling, and
(e) removing the severed upper portions of said underwater support device and said piles.

8. The method of claim **7** wherein the severed upper portions of the underwater support device and the legs are removed separately.

9. The method of claim **8** wherein the severed upper portion of the legs is removed prior to the severed upper portion of the support device.

10. A method of salvaging fixed support structures for offshore drilling rigs comprising:
(a) encircling the legs of said support structure with a cluster of shaped charges,

(b) sinking said support structure in water until the lower end thereof rests on bottom,
(c) driving piles through said legs of said support structure,
(d) completing, utilizing and dismantling the above-water portion of the drilling rig assembly,
(e) detonating said shaped charges to sever the support structure legs and the piles into an upper and a lower section,
(f) removing the severed upper portion of said support structure legs and piles.

11. The method of claim **10** wherein the legs of said structure are encircled with at least 4 shaped charges.

12. The method of claim **10** wherein said shaped charges are detonated by remotely controlled electric firing means.

13. The method of claim **10** wherein the severed upper portion of the piles are removed first by withdrawing the same through the top of the severed upper portion of the support structure legs.

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