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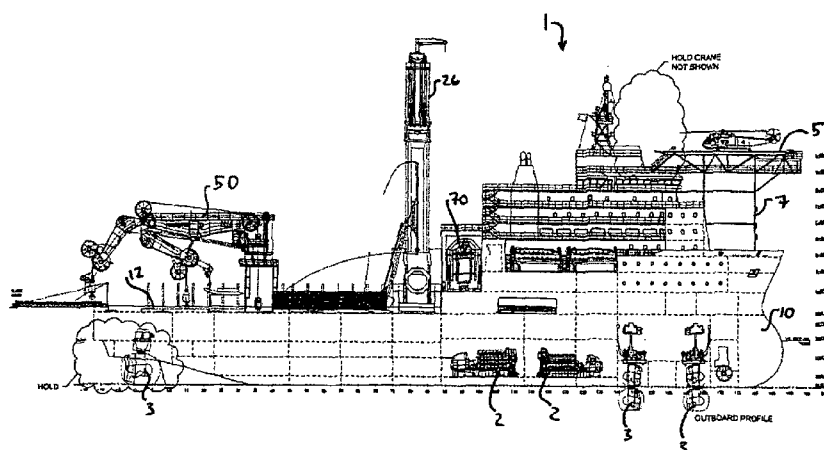


Fig. 1

(57) Abstract: A drill ship is provided for conducting subsea operations, including intervention, maintenance and workover operations. The ship includes a hull having a substantially wide beam-to-length ratio and a deckspace. An automated system for handling tubulars and risers is mounted to the deck space, along with a pipe racking system. The deckspace includes a heavy-lift heave crane for handling seafloor operations and a medium duty crane mounted over the deckspace. The ship is configured to provide heavy lift subsea construction operations including 16-inch riser well intervention and workover programs, connected riser completion operations, and riserless tophole drilling and casing operations. The ship is also able to perform connected riser remedial drilling and slim hole well construction. The ship maximizes environmental efficiency in both construction and use, and provides a stable and safe work and living environment for operations personnel.

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## DRILL SHIP FOR DEEP SEA INTERVENTION OPERATIONS

### SUMMARY OF THE INVENTION

In one embodiment, the drill ship is configured to operate in multi-tasking environments for subsea oil and gas field development and maintenance, including various subsea operations up to 7,500 feet of water depth. The drill ship includes capabilities for connected 16" riser well intervention and work over programs, heavy lift subsea construction programs, connected 16" riser small outer diameter tubing hanger completion programs, riserless tophole large outer-diameter drilling and casing batch programs, and connected riser remedial drilling and slim hole well construction.

The design of the drill ship incorporates elements to ensure safety of personnel and environmentally efficient and "green" operation and construction. In particular, the ship exceeds the Mobile Offshore Drilling Unit (MODU) Passenger Vessel Intact and Damage Stability regulations. The design also incorporates concepts for protected temporary safe refuge muster concepts. Provisions on the ship are also made to form exhaust NOX emission reactors.

The design of the ship's hull incorporates a small force "hull form" which provides low fuel consumption within an environmental class. Furthermore, the hull is double-hull compliant and includes nitrogen-blanketed hull methanol and helifuel storage capability.

The deck of the ship includes automated deck tubular handling systems along with pipe racking systems and a riser handling system. Furthermore, knuckle-boom cranes are implemented on the deck for above-deck and subsea operations. Finally, a regulation-sized helipad is provided on the bow section of the ship.

In the present embodiment, the light displacement hull includes a variety of operational areas and systems, including a blowout preventer (BOP) handling system, a 13-5/8" subsea BOP, a 16" pressurized riser system, a box tower hoisting and lowering system with a top drive and an active heave compensated drawworks, the heavy-lift heave crane, and the medium duty deck crane. The power systems on the ship include a plurality of 2,200 horsepower fluid pumps and 2,200 horsepower cement units.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a side view of a first embodiment of the drill ship of the present invention;

Fig. 2 is a rear perspective view of the drill ship of Fig. 1;

15 Fig. 3 is a right front side perspective view of the drill ship of Fig. 1;

Fig. 4 is a right front side perspective view of the drill ship of Fig. 1;

20 Fig. 5 is a perspective view overlooking the deck of the drill ship of Fig. 1;

Fig. 6 is a right side perspective view of the hull of the drill ship of Fig. 1;

Fig. 7 is a rear, right side perspective view of the drill ship of Fig. 1, showing portions of the deck operational areas;

25

Fig. 8 is a rear perspective view of the aft deck operational areas;

Fig. 8a is a top plan view of the aft deck area of the ship of Fig. 1;

30 Fig. 9 is a side perspective view of the drill ship of Fig. 1;

Fig. 10 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 11 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

5 Fig. 12 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 13 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 14 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

10

Fig. 15 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 16 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

15 Fig. 17 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 18 is a cross-sectional plan view of a portion of the drill ship of Fig. 1;

Fig. 19 is a perspective view of a portion of the deck of the drill ship of Fig. 1;

20

Fig. 20 is a top plan view of the drill floor for the ship of Fig. 1;

Fig. 21 is a side schematic view of a subsea BOP system with the embodiment of the drill ship of Fig. 1;

25

Fig. 22 is a perspective top view of the box tower hoisting and lowering system for use on the drill ship of Fig. 1;

Fig. 23 is a rear right-side perspective view of the heavy-lift active heave crane of the drill ship of Fig. 1;

30

Fig. 24 is an upper plan view of the rear portion of the deck of the drill ship of Fig. 1;

Fig. 25 is a perspective view of the medium duty deck crane for use on the  
5 drill ship of Fig. 1;

Fig. 26 is a cross-sectional view through the hull of the drill ship of Fig. 1; and

Figs. 27 and Fig. 28 are schematic slender well construction examples for  
10 well operations using the drill ship of Fig. 1.

## DETAILED DESCRIPTION OF THE INVENTION

### Hull And Main Ship Design

As shown in Figs. 1-6, the drill ship 1 includes a hull 10, crew quarters struc-  
15 ture at section 7, a helipad 5 and a main deck 12. Positioned on the aft re-  
gion of the deck 12 are the box tower hoisting and lowering system and top  
drive 26, a heavy-lift knuckle-boom seafloor active heave crane 50, a me-  
dium duty seafloor and deck crane 60, and an ROV installation with an inte-  
grated vessel control center 70.

20

As shown in Fig. 1, directional thrusters 3 are positioned at various points in  
the hull, and the engines and power systems are housed within the hull as  
shown at 2. 4 azimuthing & 1 tunnel variable frequency thrusters are used.  
(20.3 MW combined thrusters rating), and capability to allow for loss of 1  
25 Thruster in a Worst Case Compartment or Component Failure Mode which  
complies with requirements for redundant dynamic positioning capability.

The main hull 10 of the drill ship 1 is shown in the drawings at Figs. 1-6. The  
hull 10 is formed for light displacement moderate environment conditions. In  
30 the preferred embodiments, the hull is 120 meters in length, 32 meters in  
breadth with an 8 meter operating draft. The drill ship has 23,000 metric tons

of operating displacement, and utilizes 75% less shipyard steel fabrication weight than conventional newly-built drill ships. It is important to note that the hull includes a wide beam-to-length ratio to provide for improved deck operability. The hull form limits combined seas for operation  $H_s=4m$ ,  $H_{max}=8m$ , and the significant pitch is  $2^\circ$ . The connected standby meets the  $H_{max}$ -11.8m parameter.

The hull has a DP-3 stationkeeping with +15 knot transit rating. The parameters for the hull are as follows:

10

- DP-3 Rating for 57Knt wind, 2.5Knt Current in Combined Beam Condition
- 4 Independent Engine Rooms, 22.6 MW combined generating power
- Design Transit Speed + 15 Knts
- +30 Day F.O. Capacity in High Load Conditions

15

- Panamax Compliant

As shown in Figs. 1 and 2, the hull 10 of the drill ship 1 includes a wide deck area 12 for subsea operations. The deck 12 includes an integrated system storage area 20 close to the control center 22 of the ship 1 as shown in Fig. 7. Also shown in Fig. 7 is the helipad 5, crew quarters 7, a tubular storage area 24, the box tower 26, and a pipe racking and handling system 30. All of these integrated systems are rated for a water depth of up to 7,500 feet.

A perspective view of the deck 12 is shown in Fig. 8, which also shows the box tower hoisting and lowering system 26, the heavy-lift heave crane 50 and the light-duty deck crane 60. The large ultra high capacity load rated open aft deck 12 is suitable for a wide range of configurations. The loading on the ultra high capacity deck 12 is rated at 10-15 T/m<sup>2</sup> (2,000-3,000 pounds/foot<sup>2</sup>). (Typically, on other types of global offshore drilling units, the load rating is only 500 pounds/foot<sup>2</sup>). The high deck load rating allows a wide range of subsea well and subsea construction activities to be conducted including

30

storage of subsea trees, assembly of coiled tubing or wireline intervention equipment, staging of subsea construction elements, storage of drilling equipment and many others. The wide hull 10 allows for 1,050 m<sup>2</sup> of usable unobstructed deck area. The deck area in the aft region is also shown in the  
5 top plan view Fig. 8a.

As shown in Fig. 9, both the port and starboard sides of the hull 10 are integrated with the Remote Operated Vehicle (ROV) portion of the hull 10 is integrated with the ROV installation 70. The ROV installation 70 preferably includes an integrated vessel control center, with a system designed for dual  
10 work-class ROV systems. Various integrated control centers and systems are shown as indicated in Figs. 10 and 11.

The hull design in the wide-beam of the ship allows for relatively large and comfortable crew quarters 7, the configurations of which are shown for example in Figs. 12, 13 and 14. As shown, the ship quarters 7 provides for 140-  
15 person quarters and project office facilities. As shown, 100 single man cabins 81 are shown and 20 dual man cabins 82 are provided. A plurality of mess areas 83 are provided along with a plurality of galleys 84 and storage compartments 85 in the crew area.  
20

In general, the cross-sectional layouts of the crew areas in relation to the hull 10 of the ship 1 are shown in Figs. 17 and 18. Tubular storage area 24 is provided for vertical storage of the tubulars in the midsection behind the operational control center 22 for the ship, as shown in Fig. 16. A cross-sectional  
25 area, vertically through the hull 10 is shown at Fig. 15. Various below-water facilities and operational areas in the lower decks, including engines 2, engine control rooms 91, workshops 92 and various utility rooms 93 are shown in Figs. 15 and 16. In general, the ship of the present embodiment includes  
30 seven decks above the bottom floor base 95 of the hull 10 at its highest elevation as shown in Fig. 16.

### **BOP Handling System**

The drill ship 1 includes a specialized and efficient handling system for the BOP as shown in Figs. 19 and 20. The handling system 100 includes a hinged rig floor and unitized stack handling capabilities. Efficient workspace is provided by a driller control room 104 and vertical tensioning slip joint storage 106.

### **Slender Riser and Subsea BOP System**

10 The Subsea BOP system utilized in the present embodiment is a 13-5/8", 10 ksi, NACE-compliant BOP stack. The BOP stack will be a conventional well-head connector, double ram, annual ram, LMRP configuration. Optionally, a crane-retrievable BOP/LMRP system may be provided with an infield wet storage of the deployed riser. Furthermore, 3, 4 or 5 ram stack options are available, dependent on the subsea test tree requirements in the program  
15 implemented. The riser may be a 16" slender riser implementation.

An MUX control system is also provided with 3.38" ID kill-and-choke lines. A riser boost line is also provided and the system includes an EMI-pressurized  
20 500 psi gas buster riser rating (in lieu of a diverter). Finally, the system includes a tensioning slip joint, all of which are shown in Fig. 21.

### **Bog Tower Hoisting and Lowering System With Top Drive**

A box tower hoisting and lowering system with top drive and active heave compensation is provided at 26 as shown in Figs. 22 and the foregoing figures. In the exemplary embodiment, the box tower is a 400 metric ton multi-purpose tower implemented for vertical lifting above the deck 12. The system includes a 400 metric ton heave-compensated AC drawworks and a 350 metric ton top drive. Finally, the tower includes a segmented traveling block system as shown.  
30

**Heavy-Lift Crane**

Importantly, the deck 12 of a ship 1 is implemented with a heavy-lift knuckle-boom, seafloor active heave crane 50 as shown in Fig. 23 in the previous figures. The crane 50 in the exemplary embodiment of the drill ship 1 is rated at 250 metric tons. The crane 50 also includes a 250 metric ton rated single fall rated hook with capacity to 5,000 feet of water depth. Also, a 200 metric ton single fall rated hook is provided for a capacity to 7,500 feet of water depth. Higher load capacity can be accommodated into the crane design. Preferably, the crane includes a two-hour lowering speed to the rated depth at maximum loads.

**Crane, such as medium duty crane**

As shown in Figs. 24, 25 and in the previous figures, the medium duty seafloor and deck crane 60 is also provided on the deck 12 of the ship 1. The crane is a knuckle-boom deck utility crane nominally rated at 50 metric tons, and in the preferred embodiment includes a 15 kip seafloor rating to a water depth of 7,500 feet. The boom reach of the crane 60 covers the entire usable vessel deck area, including the aft deck 12. Furthermore, the crane 60 preferably includes a pipe gripper arm for manipulating the tubulars from a tubular storage area 24.

**Fluid Power Systems**

As shown in Fig. 26, the ship 1 includes a plurality of fluid pump systems and cement units. In particular, the present embodiment includes four 7,500 psi, 2,200 horsepower quintaplex fluid pumps with precision AC drives. The system includes an option for a higher working pressure as well. Below deck, charging pumps in the special piping system maximize the usable tank volume relative to a 2,200 horsepower cement unit. The main system includes a 3,000 bbl NAF mud system including a 1,200 gpm fluid processing system. The system also includes a 3,000 bbl completion brine system with 1,880

gpm, 2 micron filtration system. Additional base oil and brine capacity can be incorporated into the design.

### **Slender Well Construction Examples**

- 5 The exemplary drill ship 1 of the present embodiment is capable of maintaining both large and slender casing schemes, the parameters of which are shown by the schematics of Figs. 27 and 28. In particular, the large casing scheme is shown in Figure 27, including the hole construction for a 16" casing. Fig. 28 shows the casing scheme for a slender 13-3/8" casing.

10

### **Specification Summary**

The following ratings, parameters and specifications are provided for the present embodiments of the drill ship 1:

#### **15 Design Criteria**

- Water Depth                      7,500 ft.
- Dynamic Positioning      DP(AAA)

#### **Derrick**

- 20
- Multi Purpose Lift Tower
  - 400 mt capacity
  - Segmented Traveling Block
  - 350T Top Drive

#### **25 Fluid Pumps**

- 4 x 2200 HP Quintaplex Pumps
- High Volume and High Pressure Capability

#### **Cranes**

- 30
- 250 mt deck mounted, heave compensated, crane for subsea construction, rated to 7,500 ft. water depth

-50 mt deck mounted, knuckle boom crane with integral fast winch rated for 15 kips at 7,500 ft. water depth

### **Subsea BOP**

- 5 a. One Wellhead Connector, 13 5/8" x 18 3/4"
- b. Two 13 5/8" Double Ram BOP Units
- c. One 13 5/8" Annular Preventer
- d. One 13 5/8" Lower Marine Riser Package Connector

### 10 **BOP Stack**

- Crane Retrievable
- Multiple configurations optimized for program
- MUX control with acoustic & ROV backup control

### 15 **Operational Regions**

- Moderate Environment Deepwater, Worldwide

### **Drawworks**

- Active Heave Compensated

- 20 -400 mt capacity

### **Cement Unit**

- 2000 hp x 7500 psi WP quintaplex fluid pump
- 16" OD Riser x 14.85" ID

- 25 -75' Joints Lengths

- Two (2) 3.38" ID 10,000 psi Choke and Kill lines
- One (1) 1.40" ID 5,000 psi hydraulic supply lines
- One (1) 3.34" ID x 5,000 psi mud booster/circulating line
- Pup Joints, for any 5' increment

- 30 -Buoyancy

**Fluid Systems**

- Mud Pits 3,000 bbl, minimum
- Brine Pits 3,000 bbl, minimum
- 1,880 gpm 2 Micron Filtration System

5

**Bulk Capacity**

- Bulk Gel/Bar, 3,000 ft<sup>3</sup> combined
- Bulk Cement, 2,000 ft<sup>3</sup>

10 **Helideck**

- S61 or S92 Capable

**Quarters for 140 Personnel**

- 100 private staterooms with bath
- 15 -20 double staterooms with bath

It is intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the spirit and scope of this invention.

20

## CLAIM:

1. A drill ship for conducting subsea operations comprising:
  - a hull having a substantially wide beam-to-length ratio and a deckspace;
  - 5 an automated system for handling tubulars and risers, said system interfacing with a pipe racking arrangement mounted to said deckspace;
  - a heavy-lift heave crane mounted over said deckspace for handling seafloor operations; and
  - a medium duty crane mounted over said deckspace.

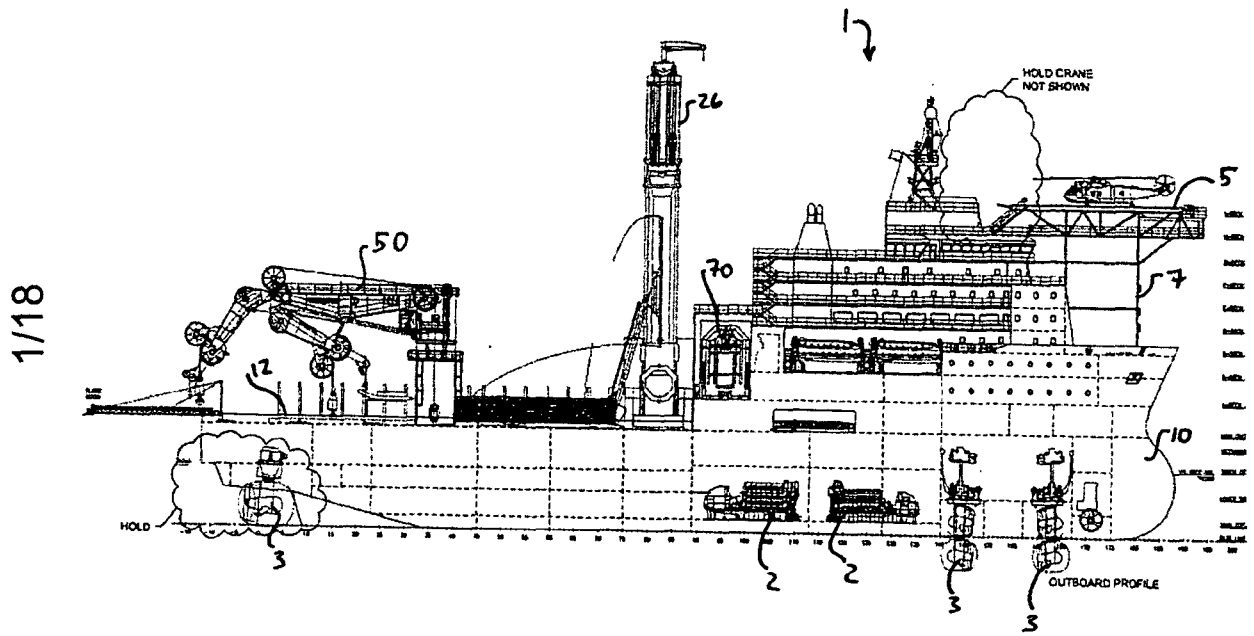
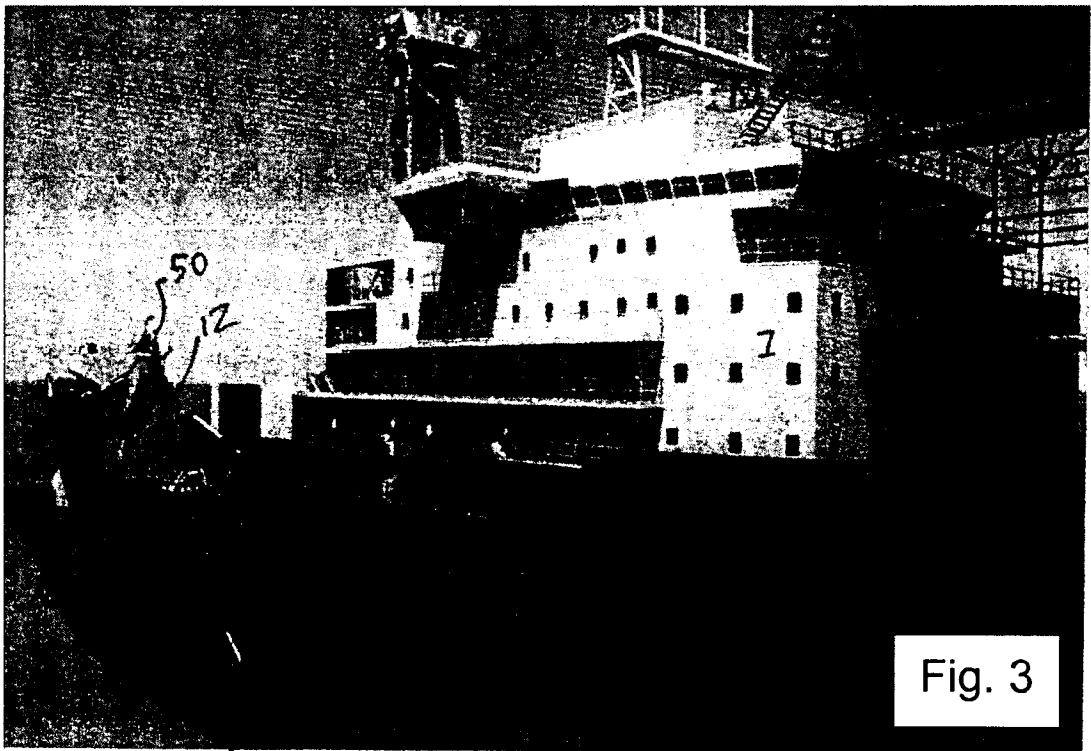
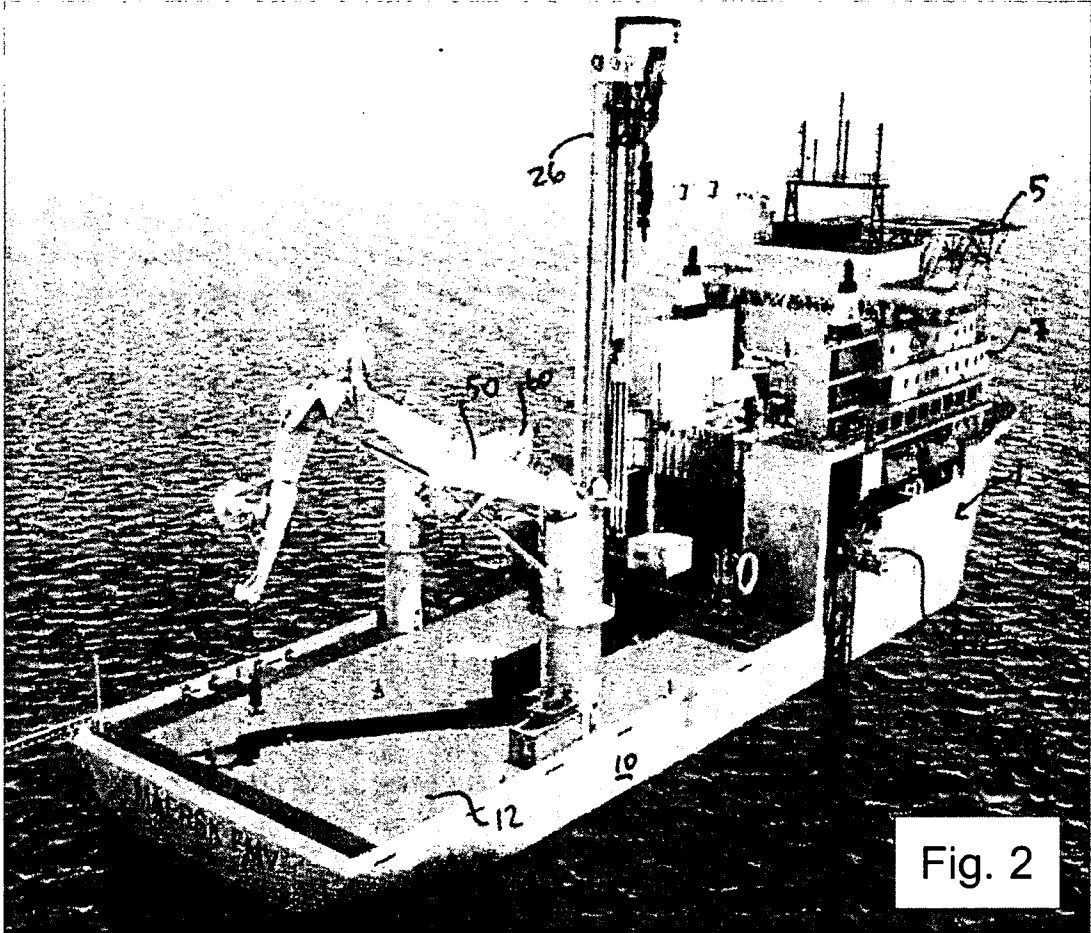


Fig. 1

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70 10

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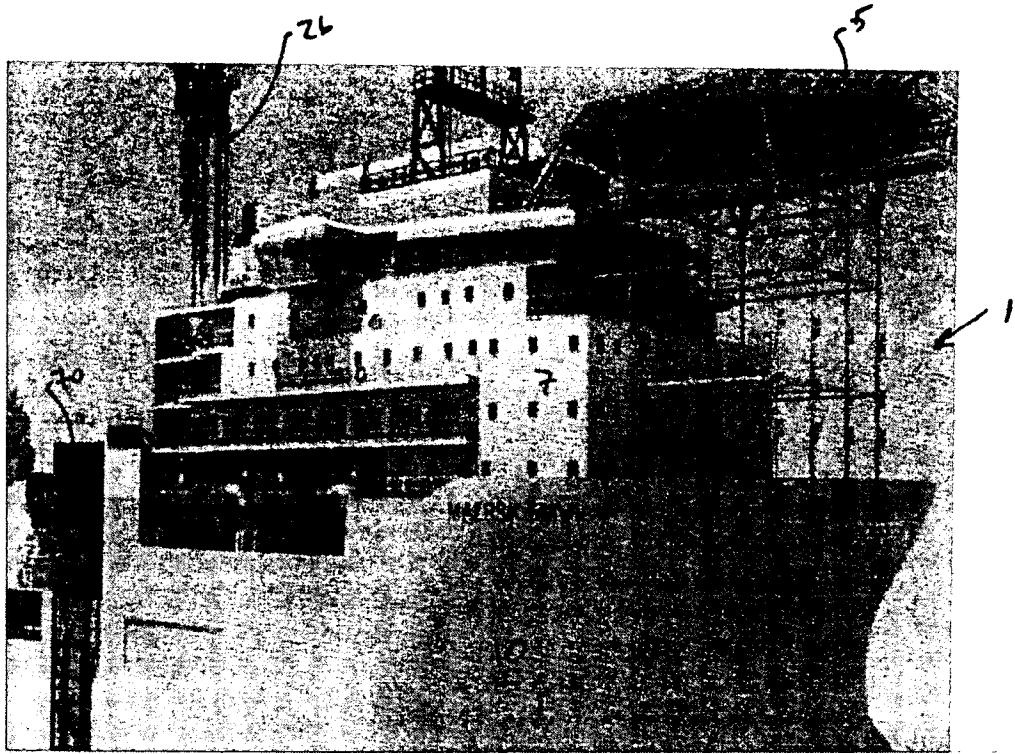


Fig. 4

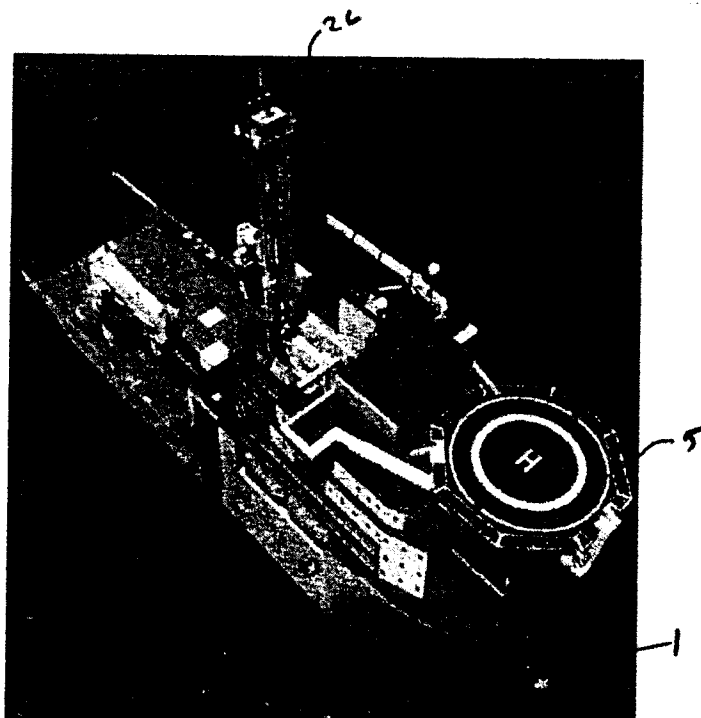


Fig. 5

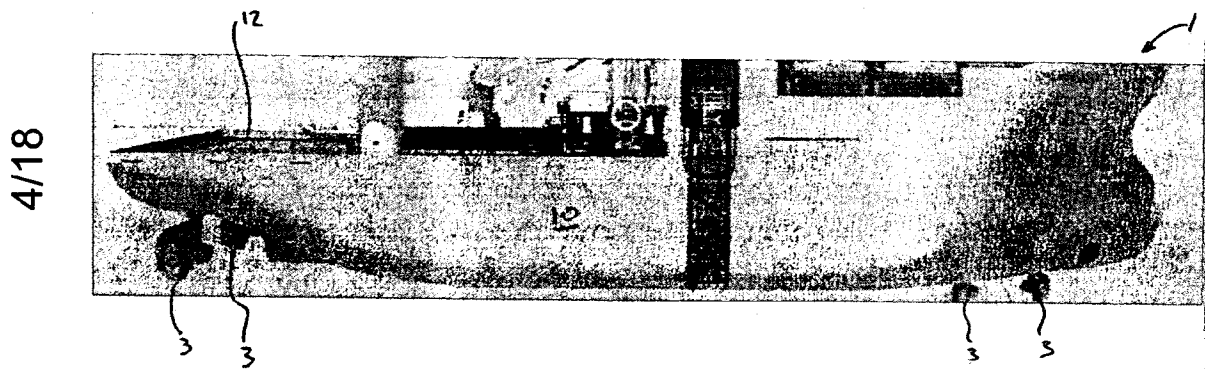


Fig. 6

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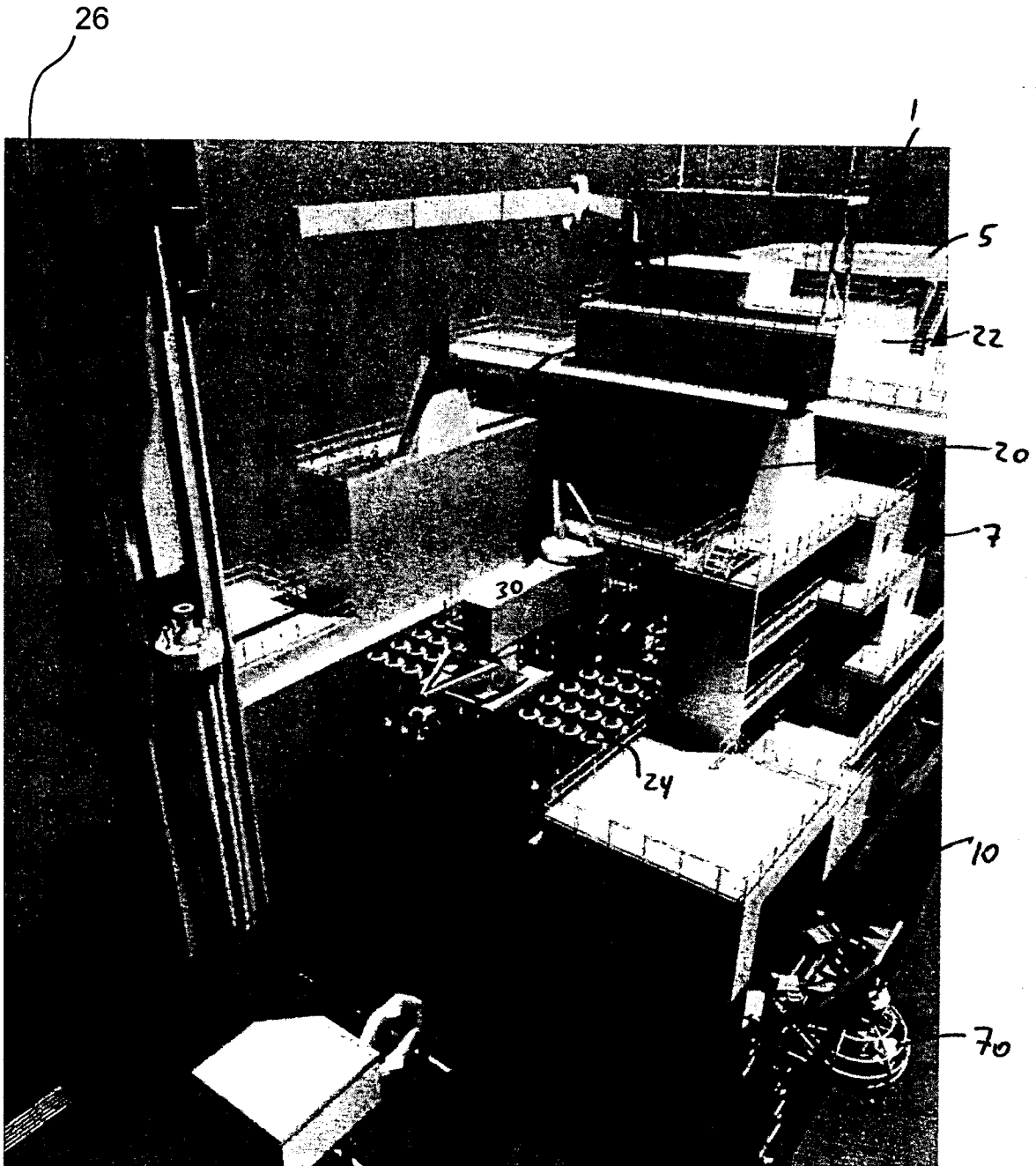


Fig. 7

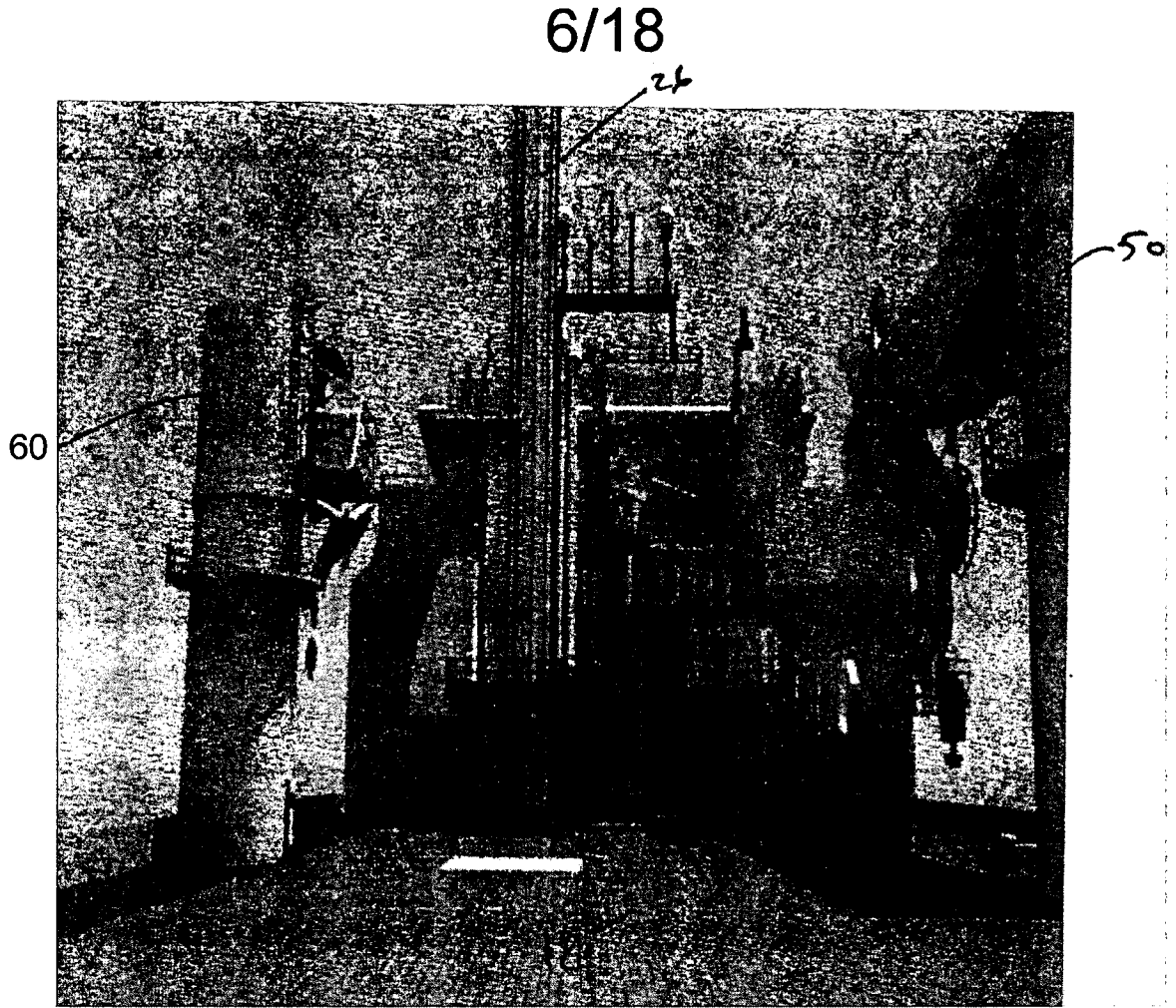


Fig. 8

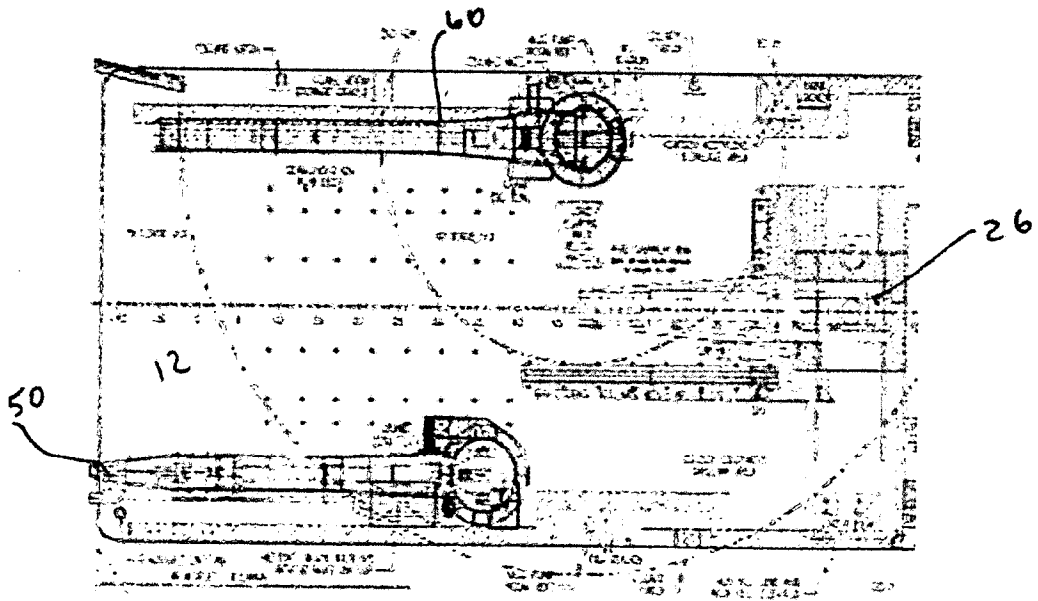


Fig. 8a





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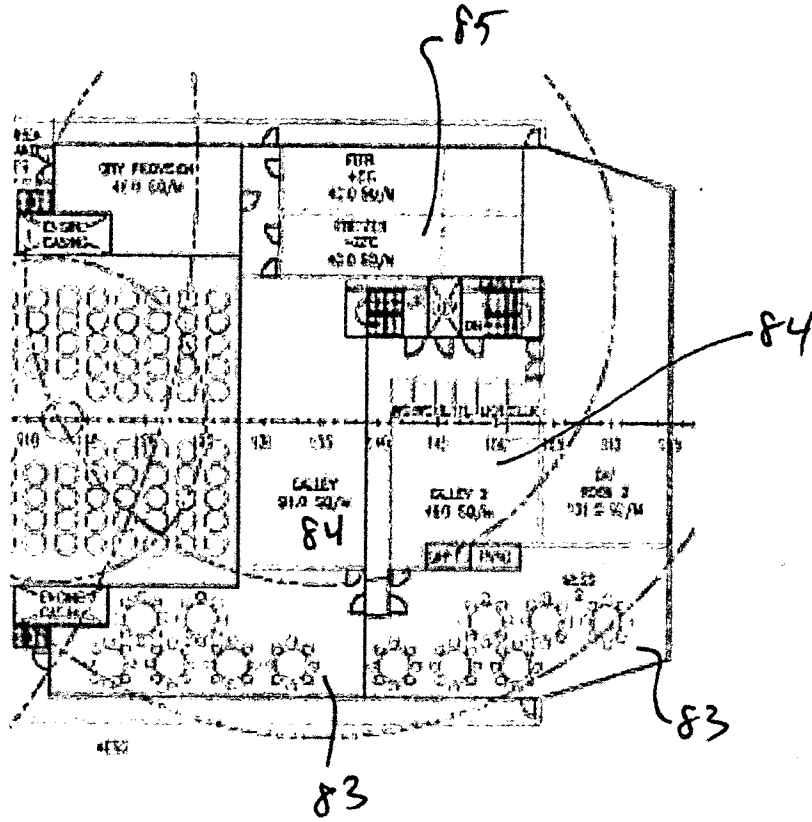


Fig. 13

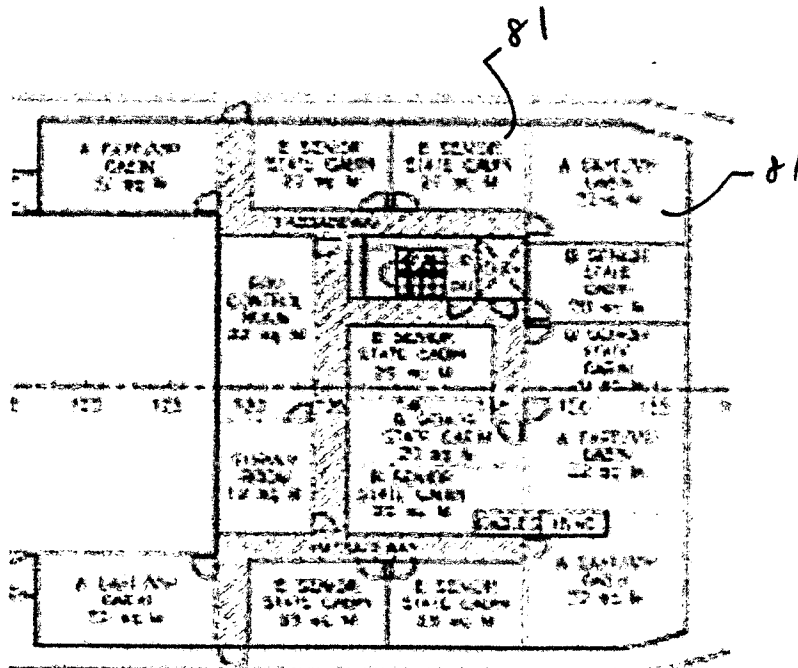


Fig. 14

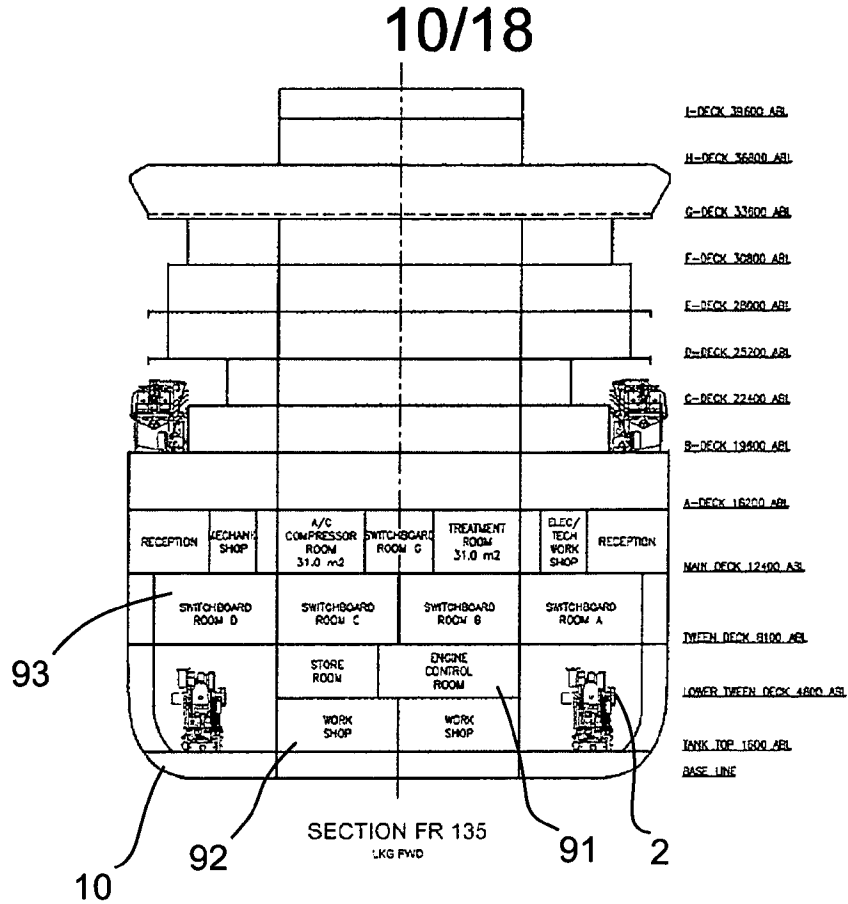


Fig. 15

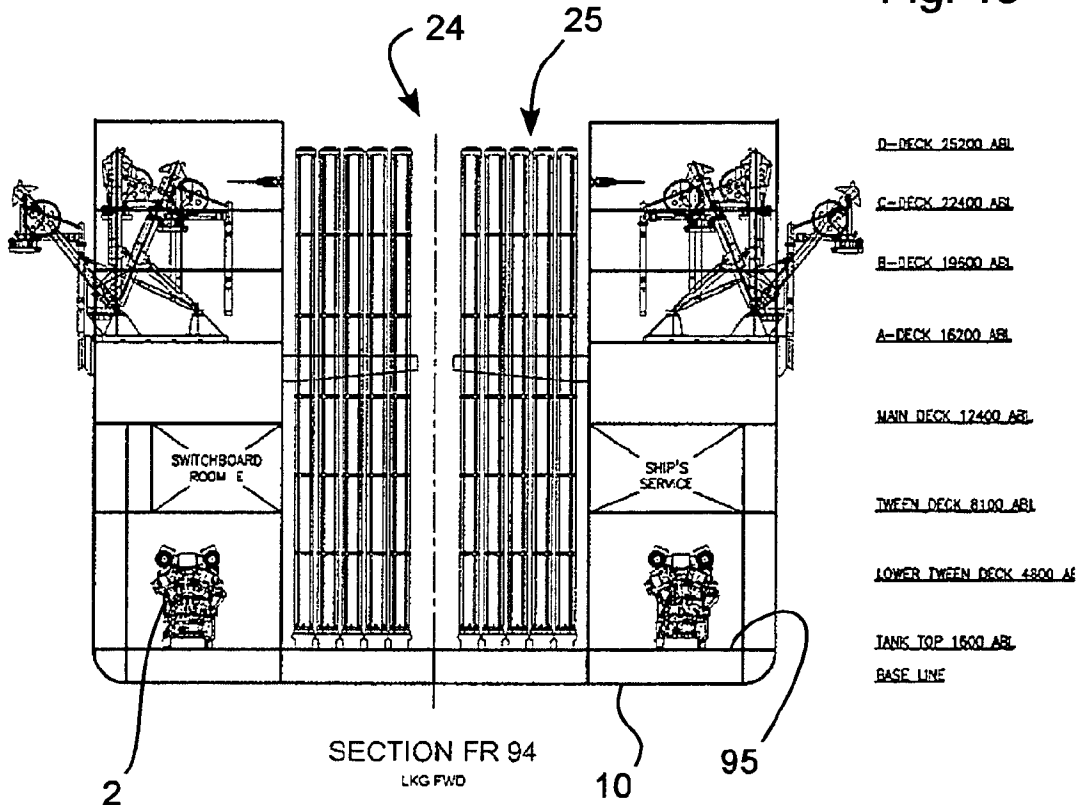


Fig. 16

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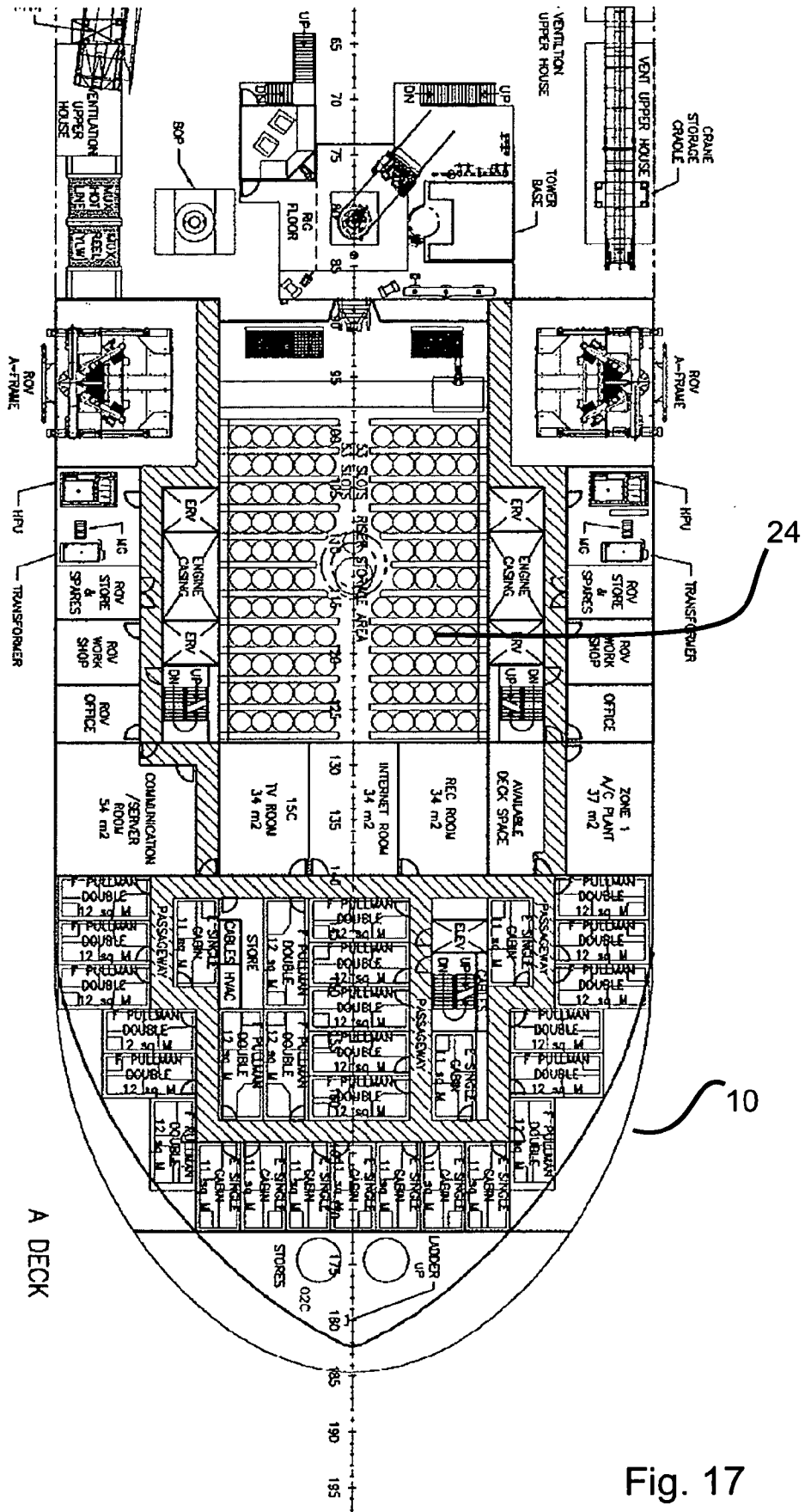


Fig. 17





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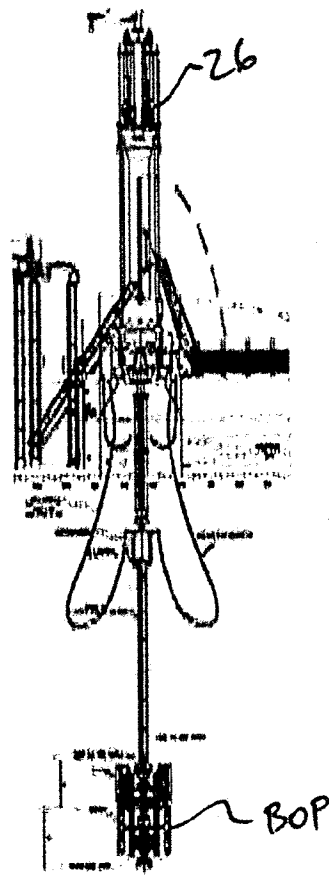


Fig. 21

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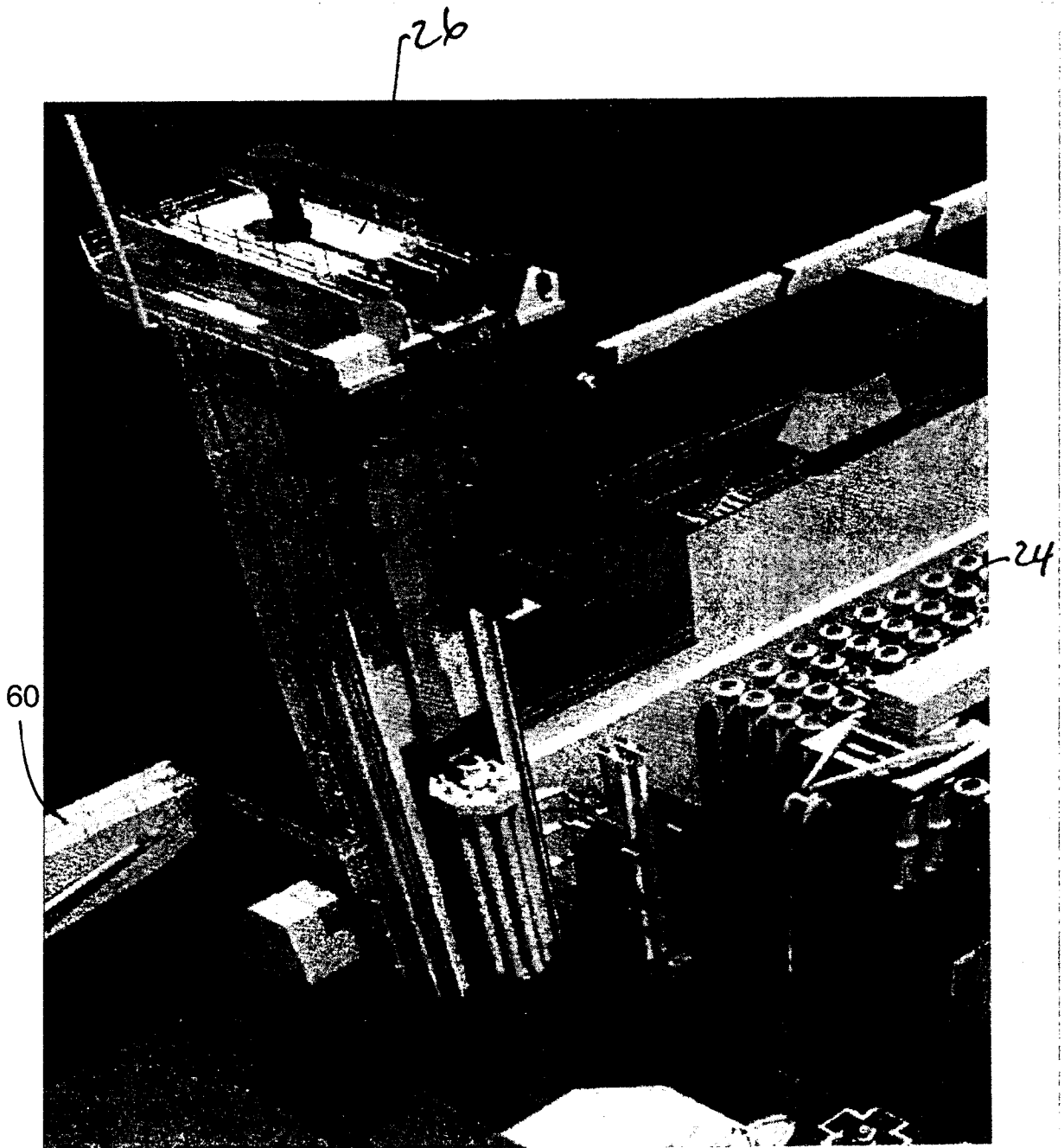


Fig. 22

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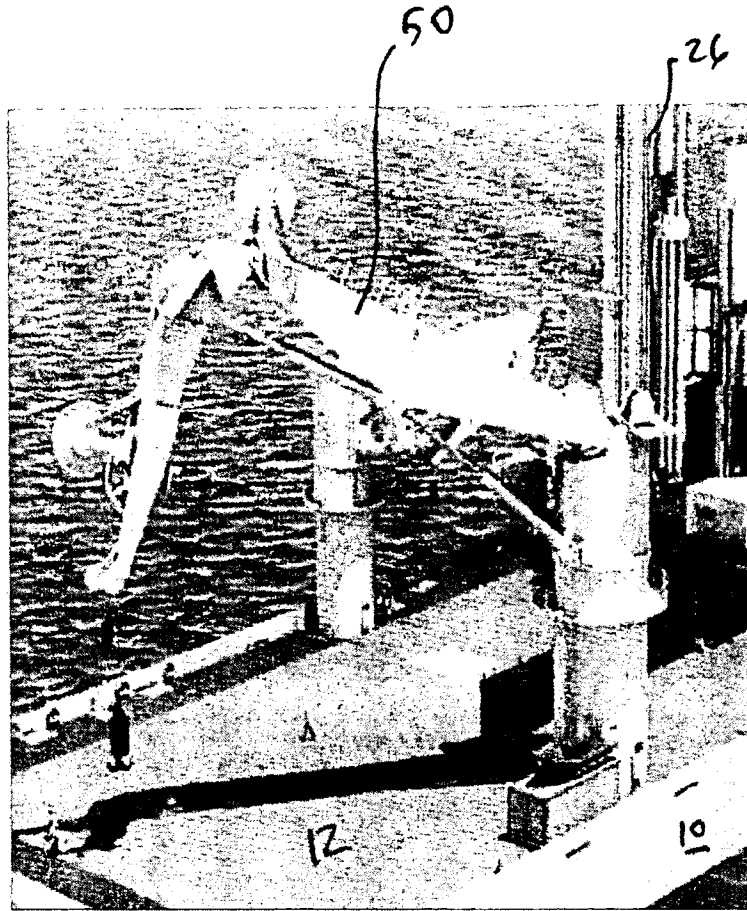


Fig. 23

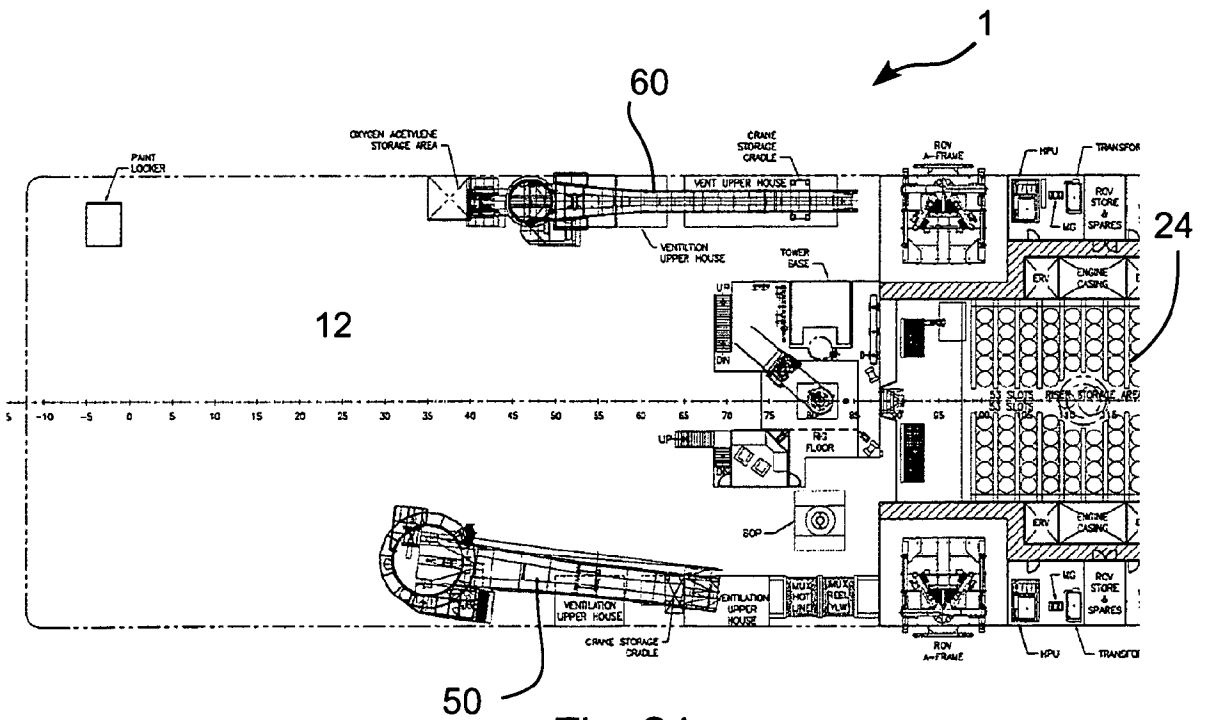


Fig. 24

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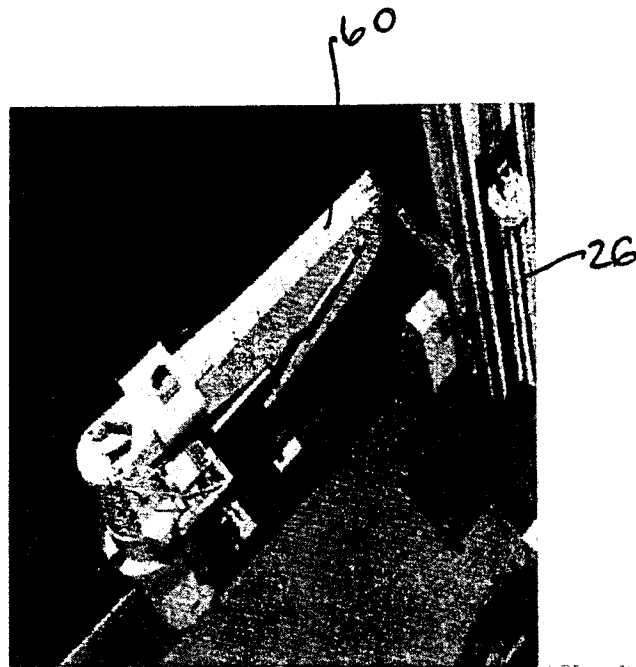


Fig. 25

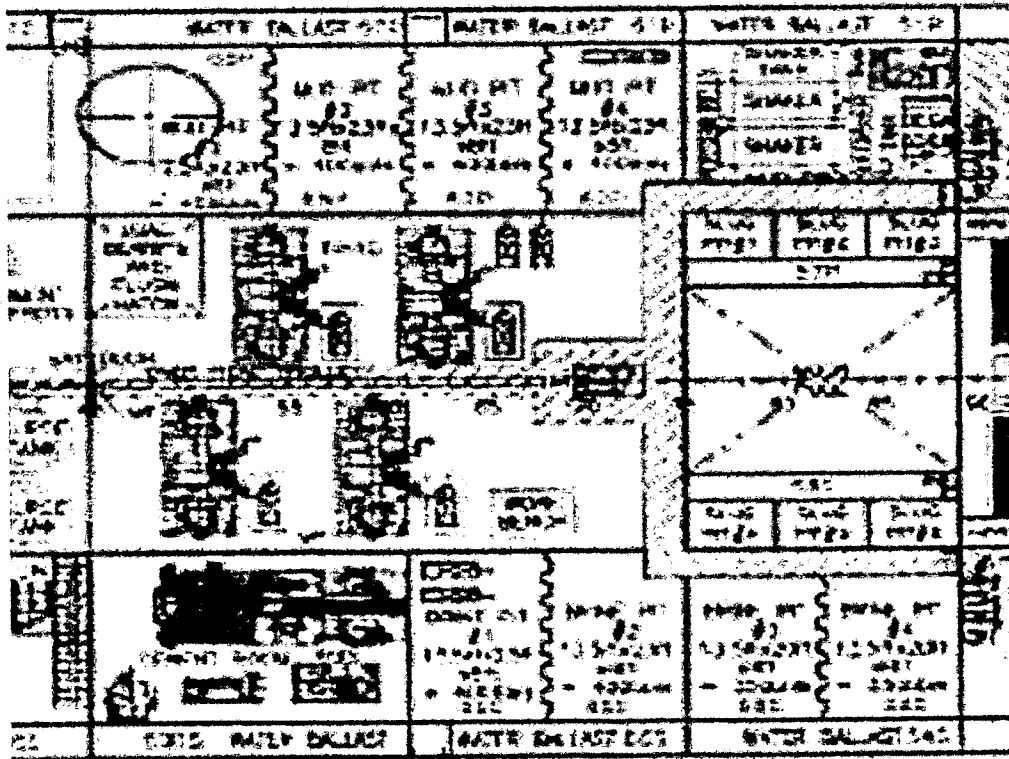
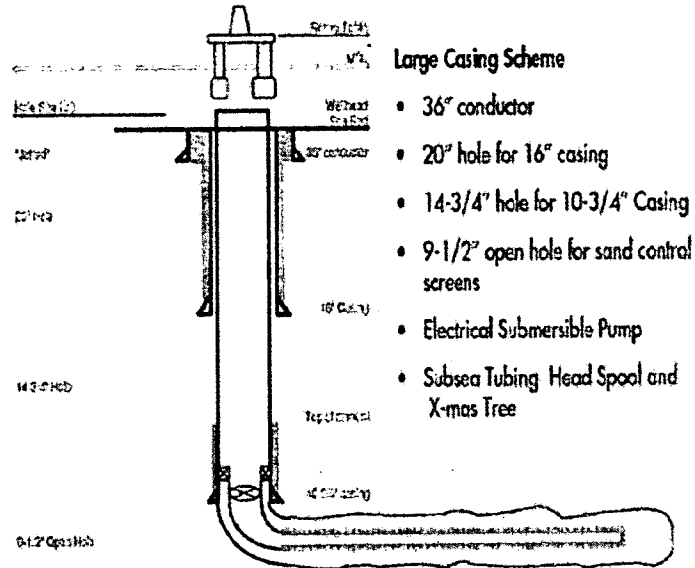


Fig. 26

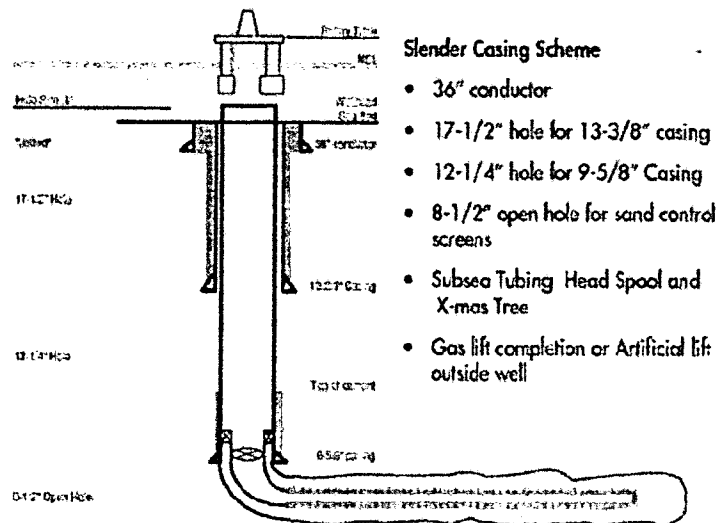
**Wells - Hole Sizes & Casing Scheme (1)**



- Large Casing Scheme**
- 36" conductor
  - 20" hole for 16" casing
  - 14-3/4" hole for 10-3/4" Casing
  - 9-1/2" open hole for sand control screens
  - Electrical Submersible Pump
  - Subsea Tubing Head Spool and X-mas Tree

Fig. 27

**Wells - Hole Sizes & Casing Scheme (2)**



- Slender Casing Scheme**
- 36" conductor
  - 17-1/2" hole for 13-3/8" casing
  - 12-1/4" hole for 9-5/8" Casing
  - 8-1/2" open hole for sand control screens
  - Subsea Tubing Head Spool and X-mas Tree
  - Gas lift completion or Artificial lift outside well

Fig. 28