United States Patent [19]

Nelson

[11] **3,738,434**

[45] **June 12, 1973**

[54] **THE APPARATUS AND METHOD TO ESTABLISH AND SUSTAIN A SUBAQUEOUS STRATA DRILLING SYSTEM**

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[21] Appl. No.: **105,434**

[52] **U.S. Cl.** **175/6,** 166/.5

[51] **Int. Cl.** **E21b 7/12,** E21c 19/00

[58] **Field of Search** 175/6, 8, 9; 166/.5, 166/.6; 114/236; 61/69, 46

[56] **References Cited**

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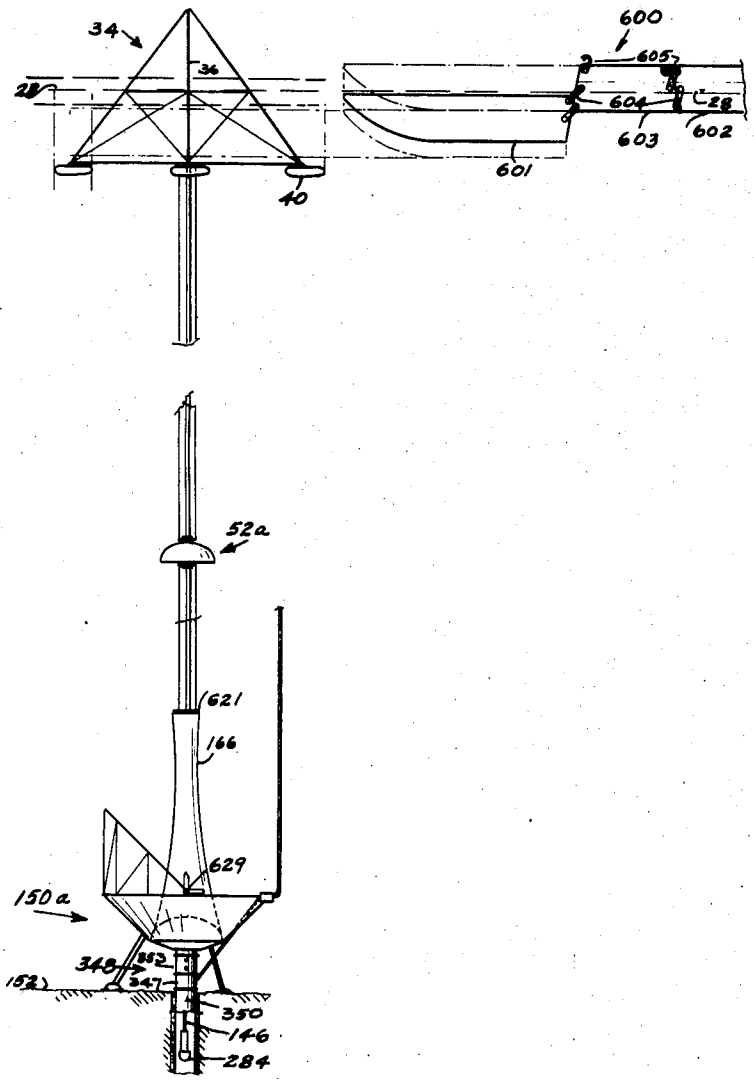
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Primary Examiner—Marvin A. Champion
Assistant Examiner—Richard E. Favreau

[57] **ABSTRACT**

The attended drilling system comprises a vertical array of objects without the conventional conductor pipe extending from floor to surface of a body of water to encase the drill string. The principal contributing objects of the array considered in the present application comprises: a drilling station that is to be established upon the floor, a control station stably maintained at the surface and a support station adapted to function between as an elevator. These stations are transported to a site upon a barge adapted to the method of drydock handling of buoyant vessels. Means to sectionalize the drilling station to permit variations to its assembly and the relocation of the portable sections minimizes lost time. Adjusting, monitoring and control means are provided and constructed to function in a prolonged underwater environment.

7 Claims, 24 Drawing Figures



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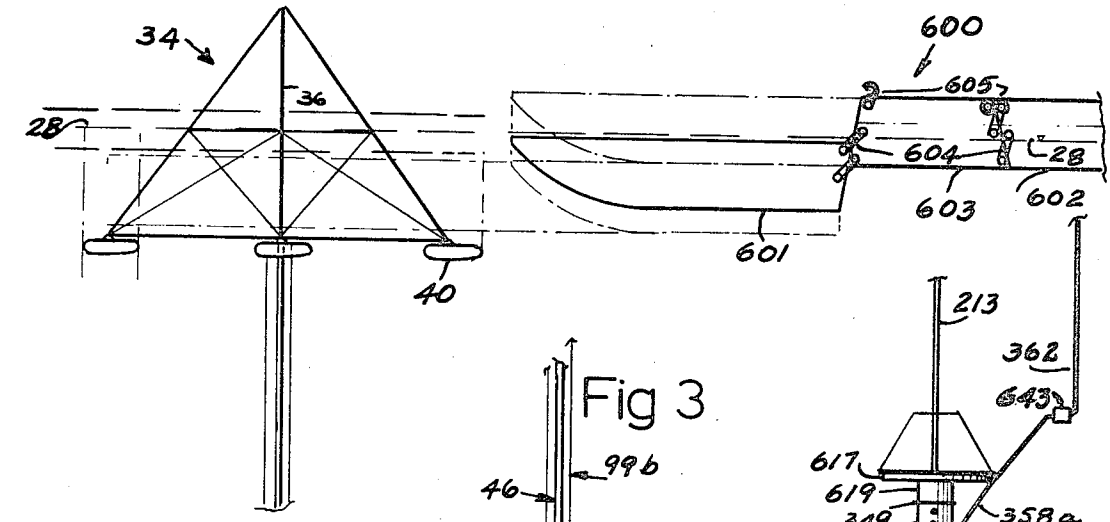


Fig1

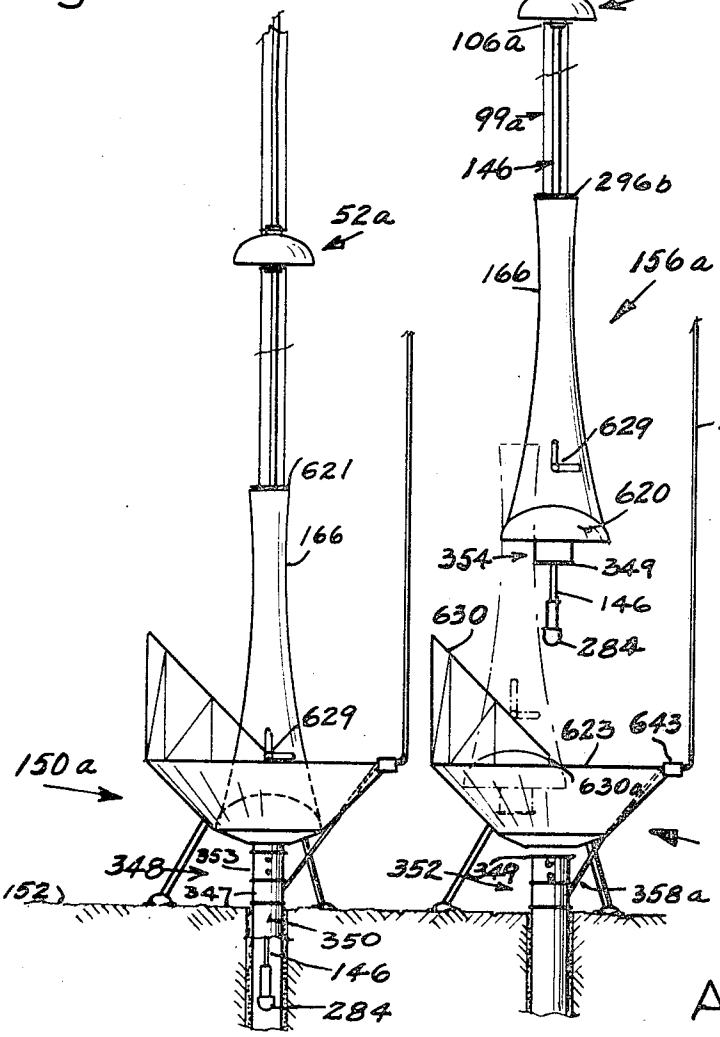
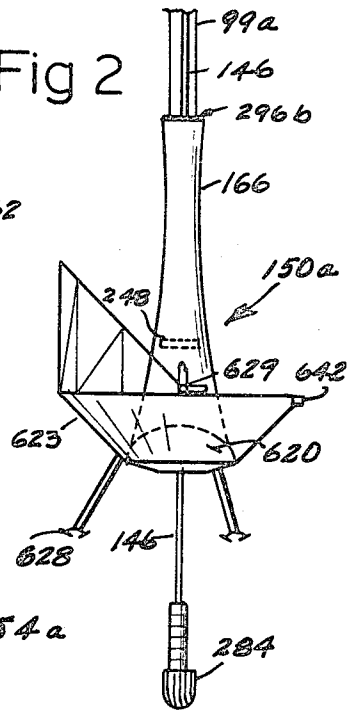


Fig 3

Fig 4

Fig 2



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Fig 6

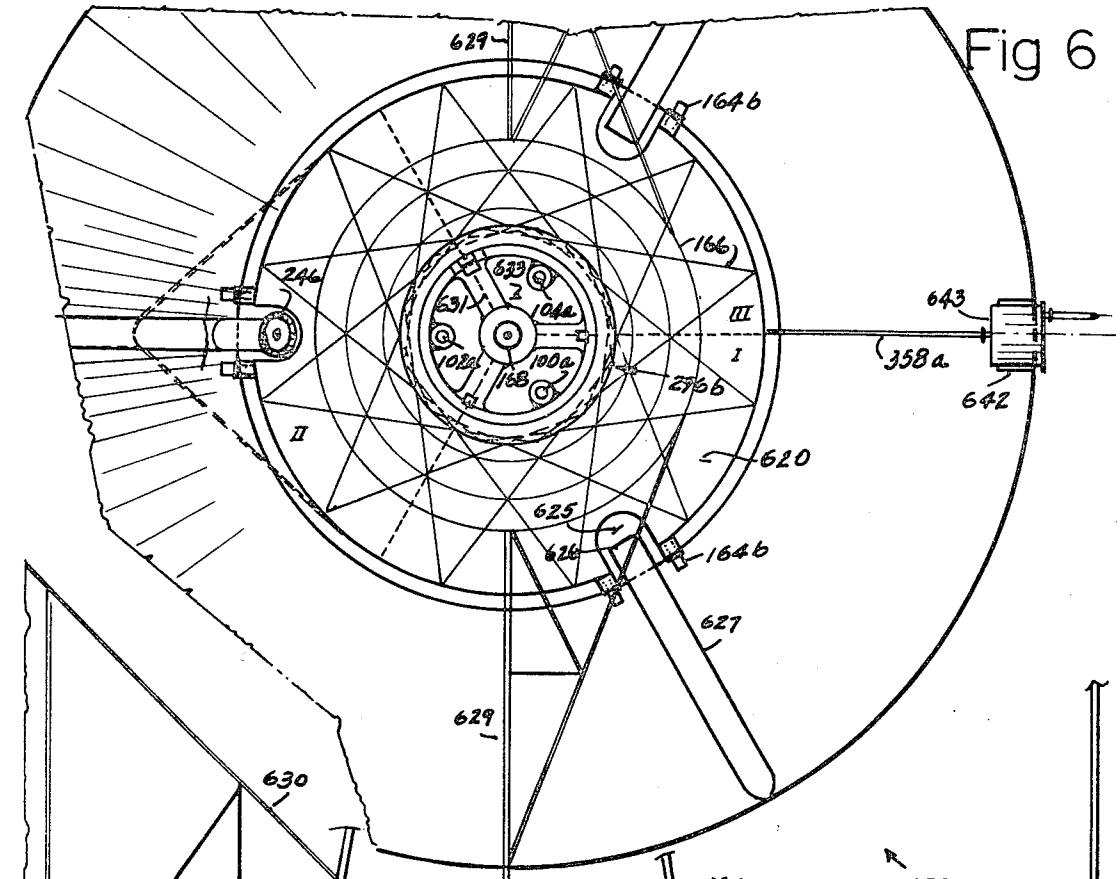
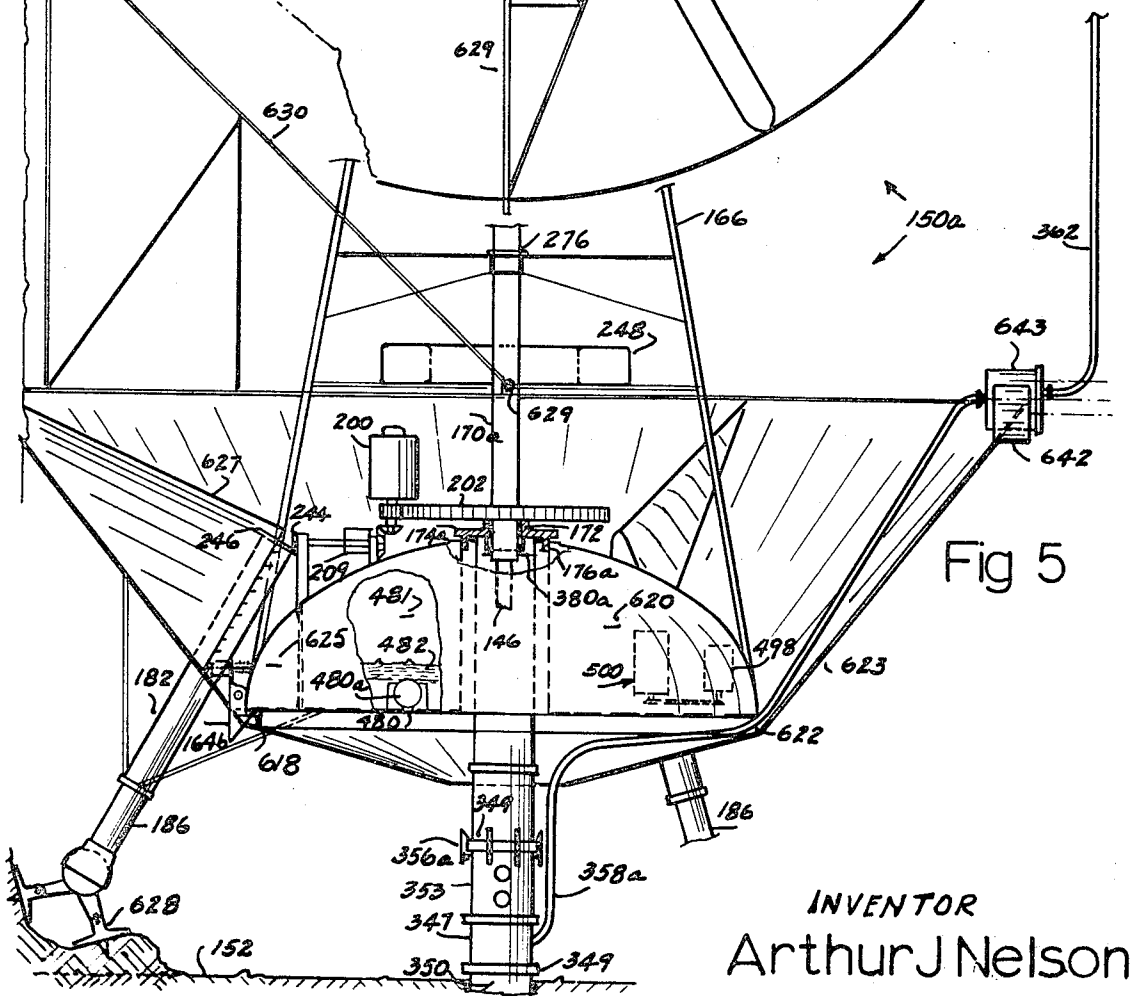


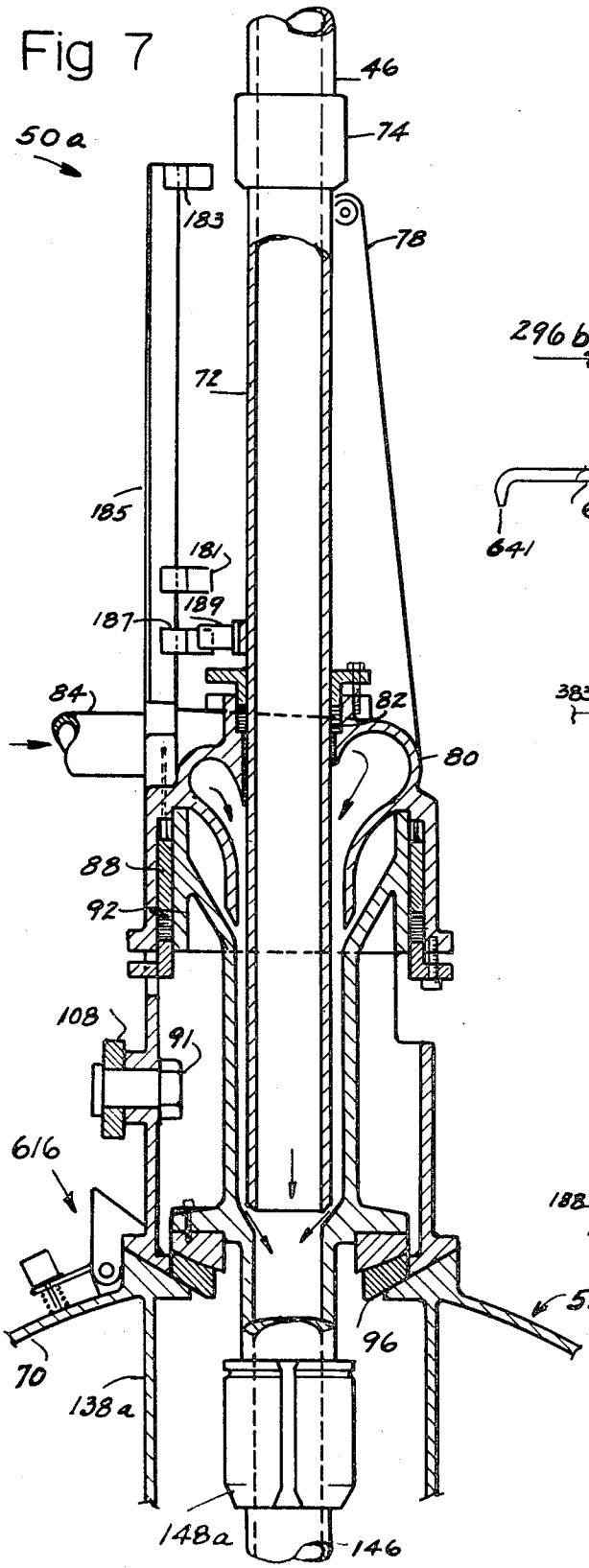
Fig 5



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Fig 7



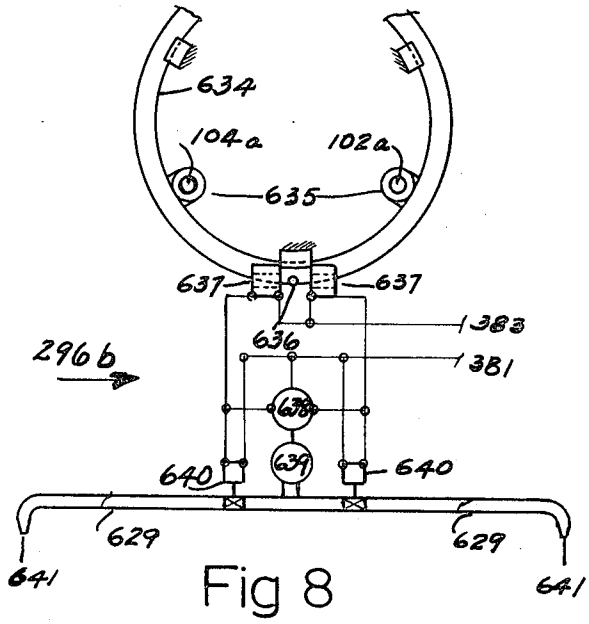


Fig 8

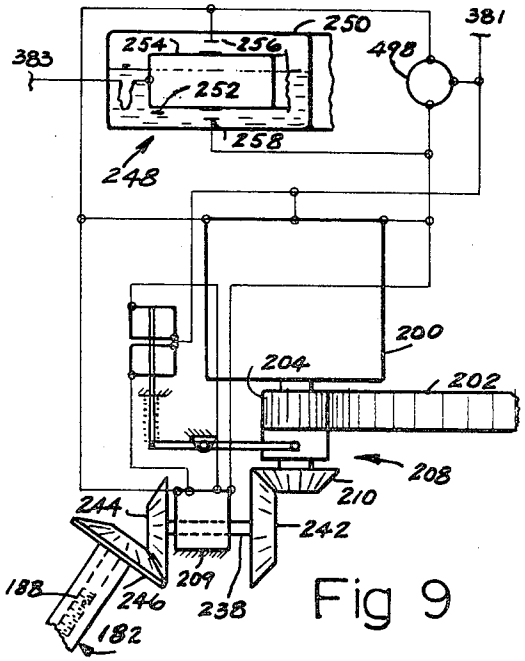


Fig 9

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Fig 10

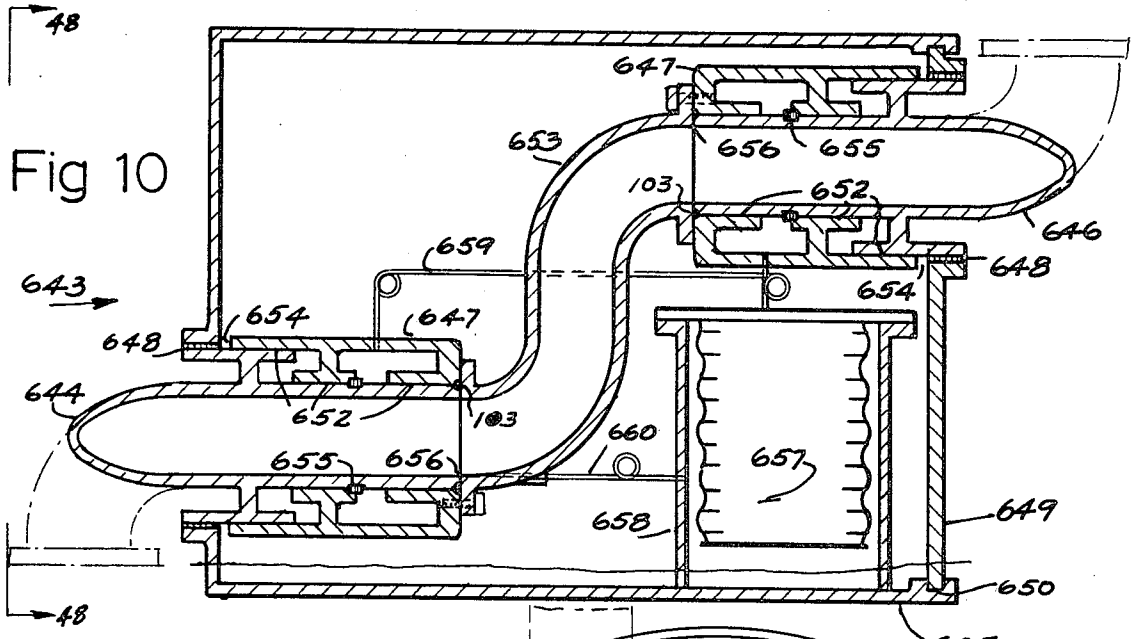
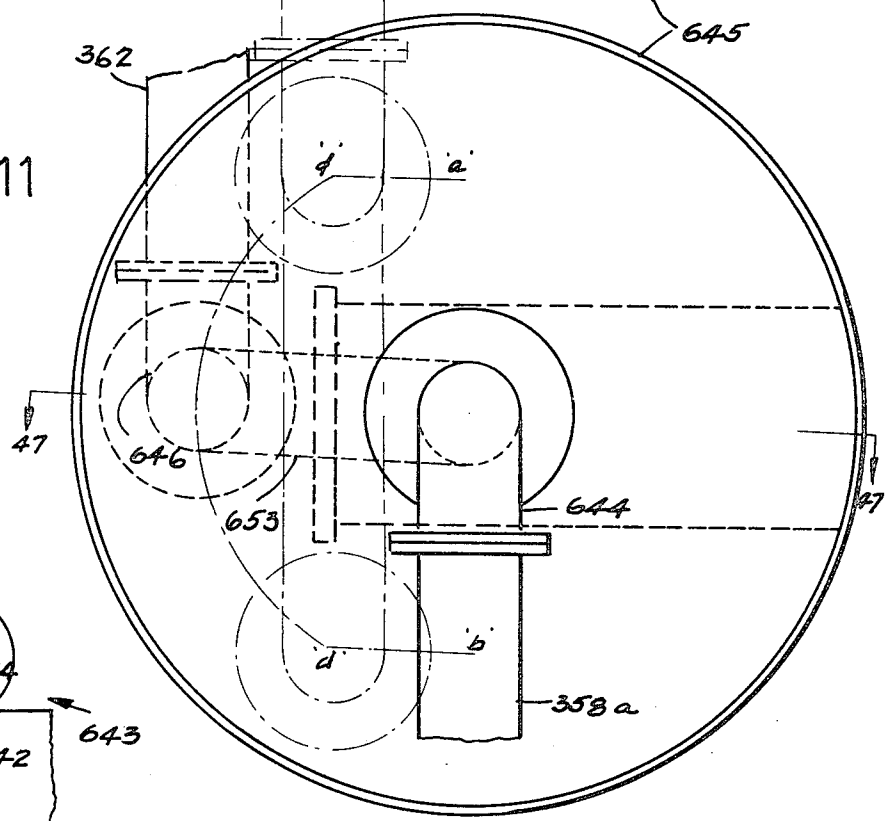


Fig 11



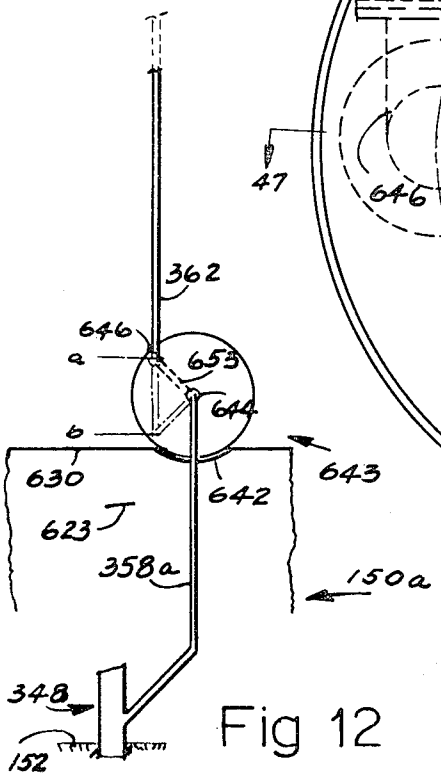


Fig 12

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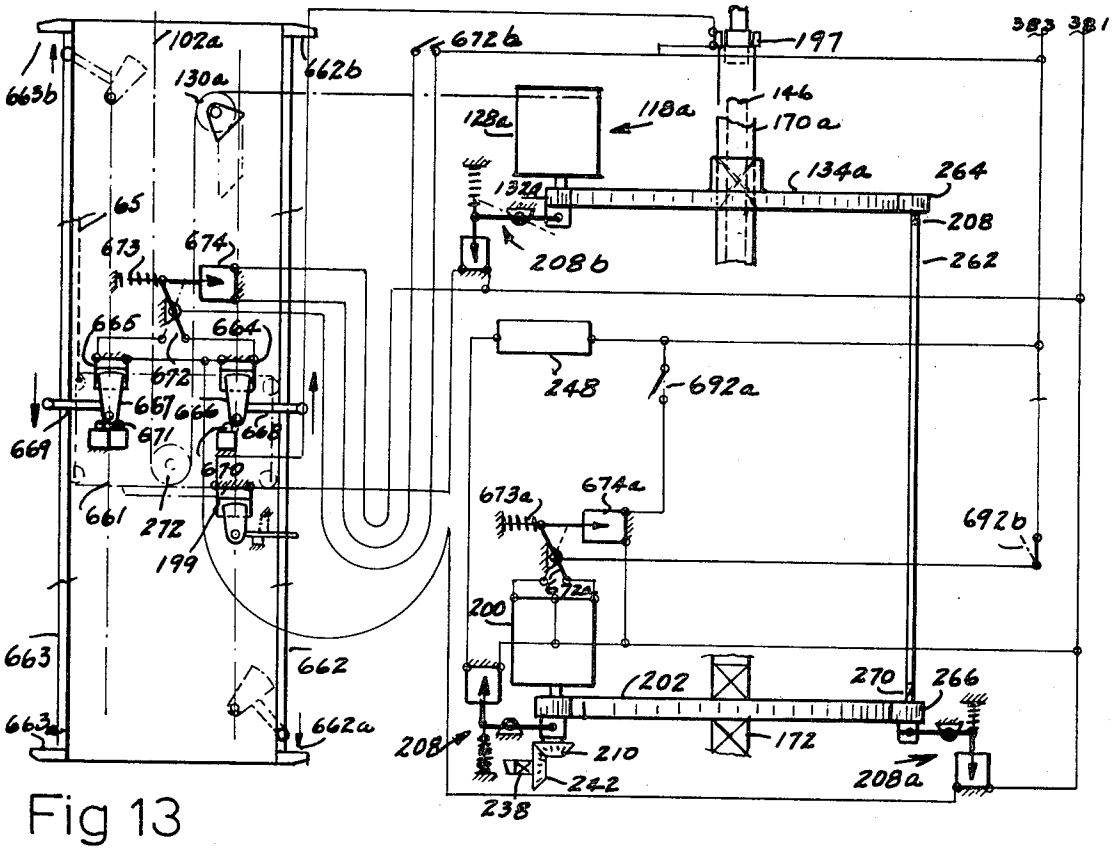


Fig 13

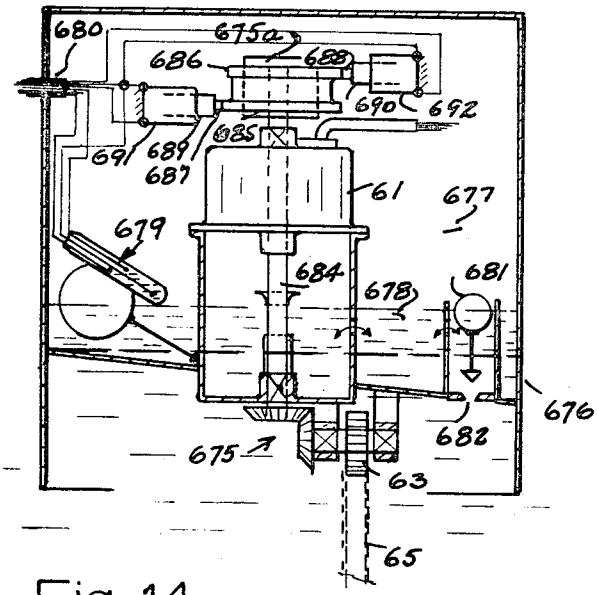


Fig 14

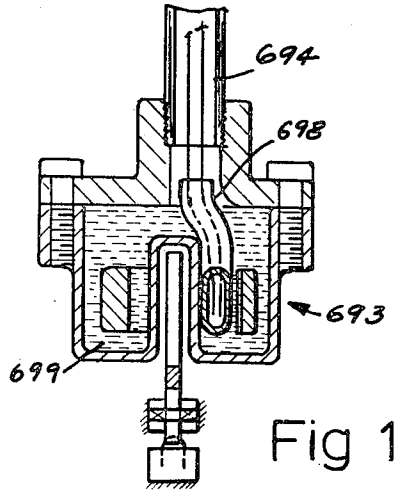


Fig 15

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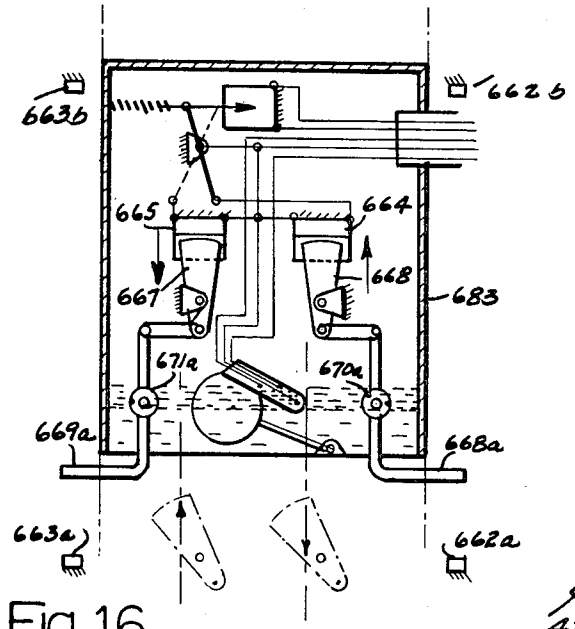


Fig 16

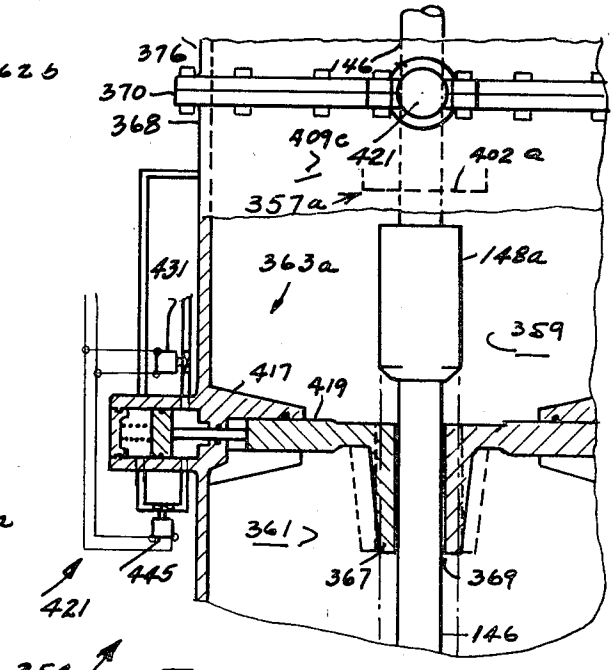


Fig 17

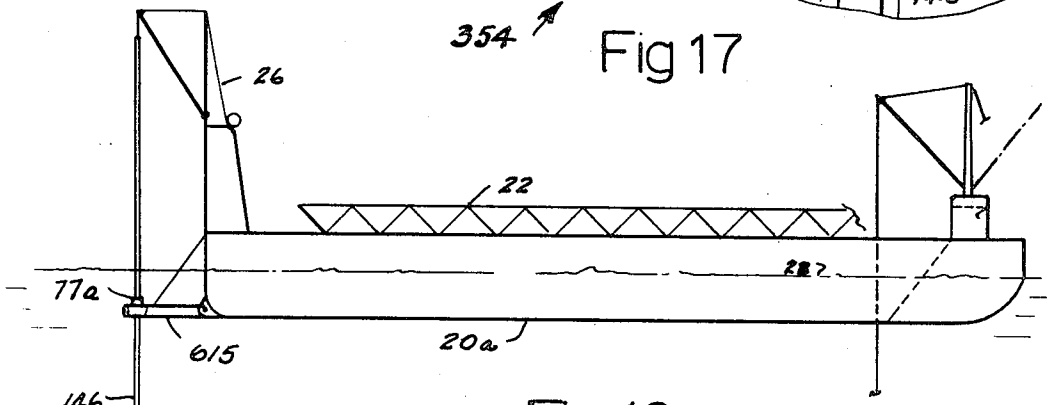


Fig 18

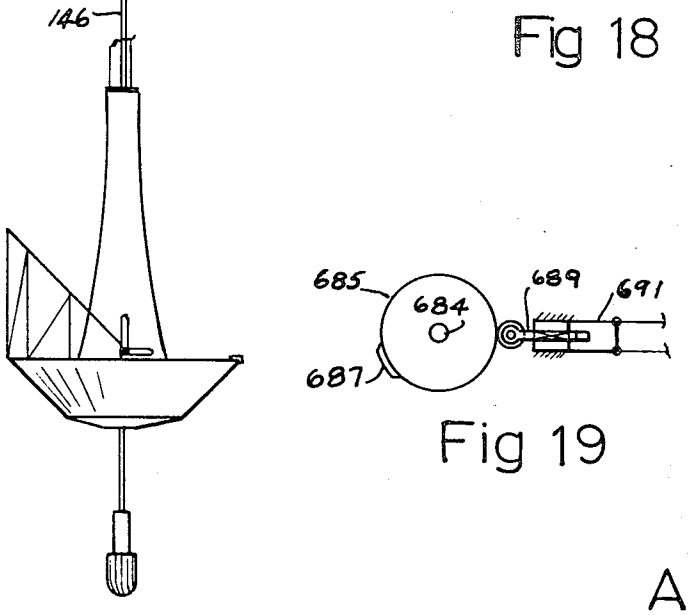


Fig 19

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Fig 20

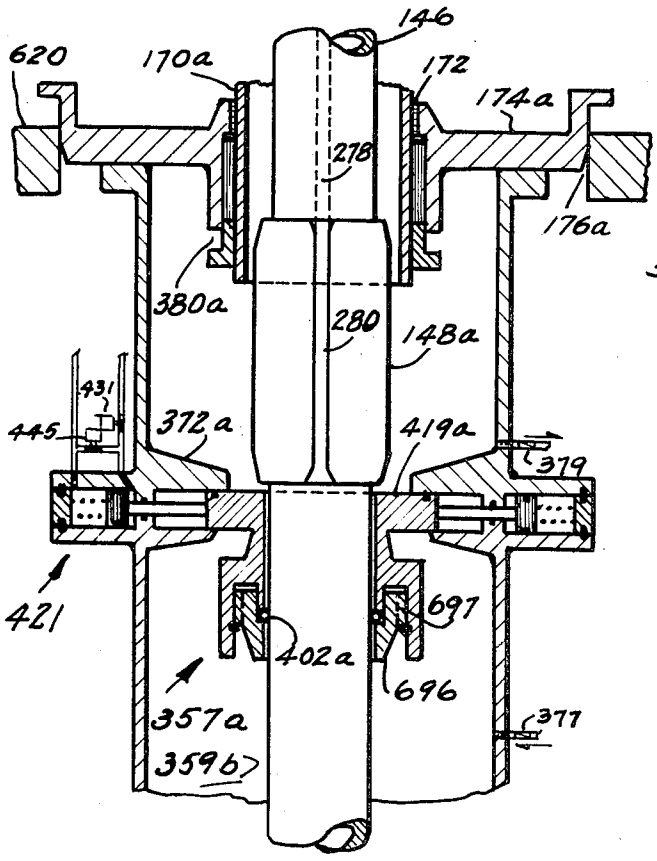
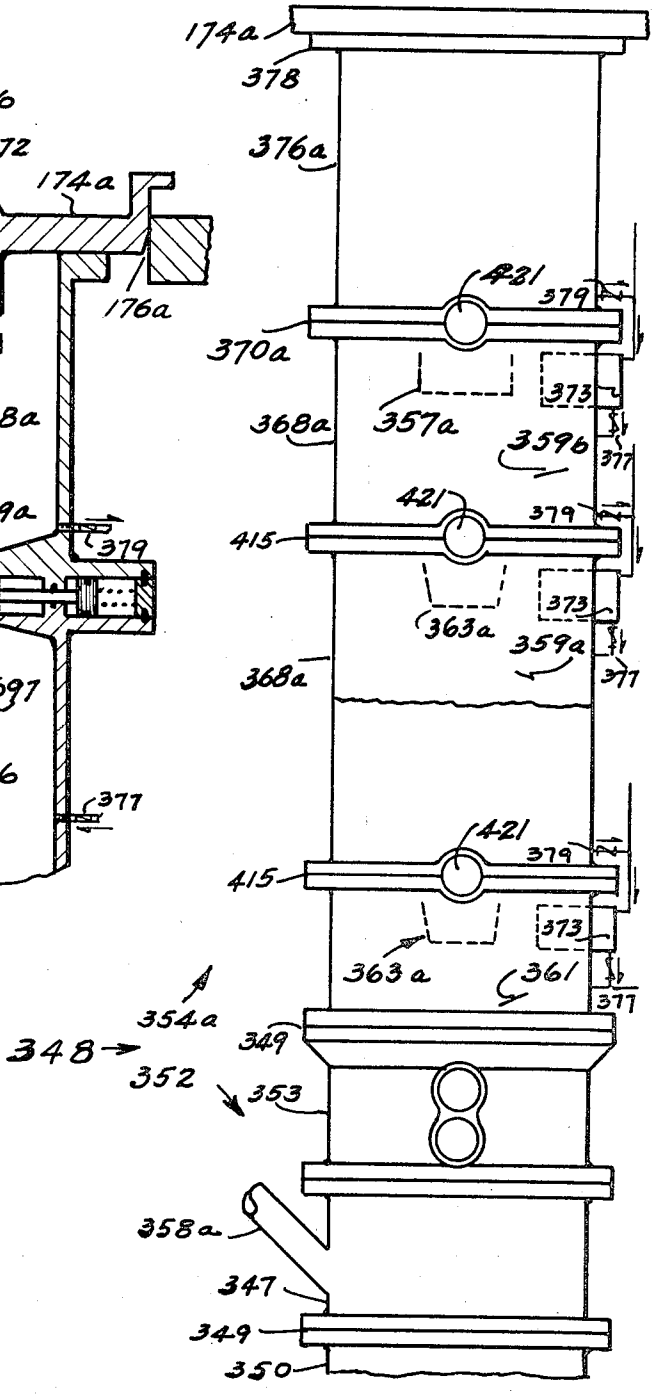


Fig 21



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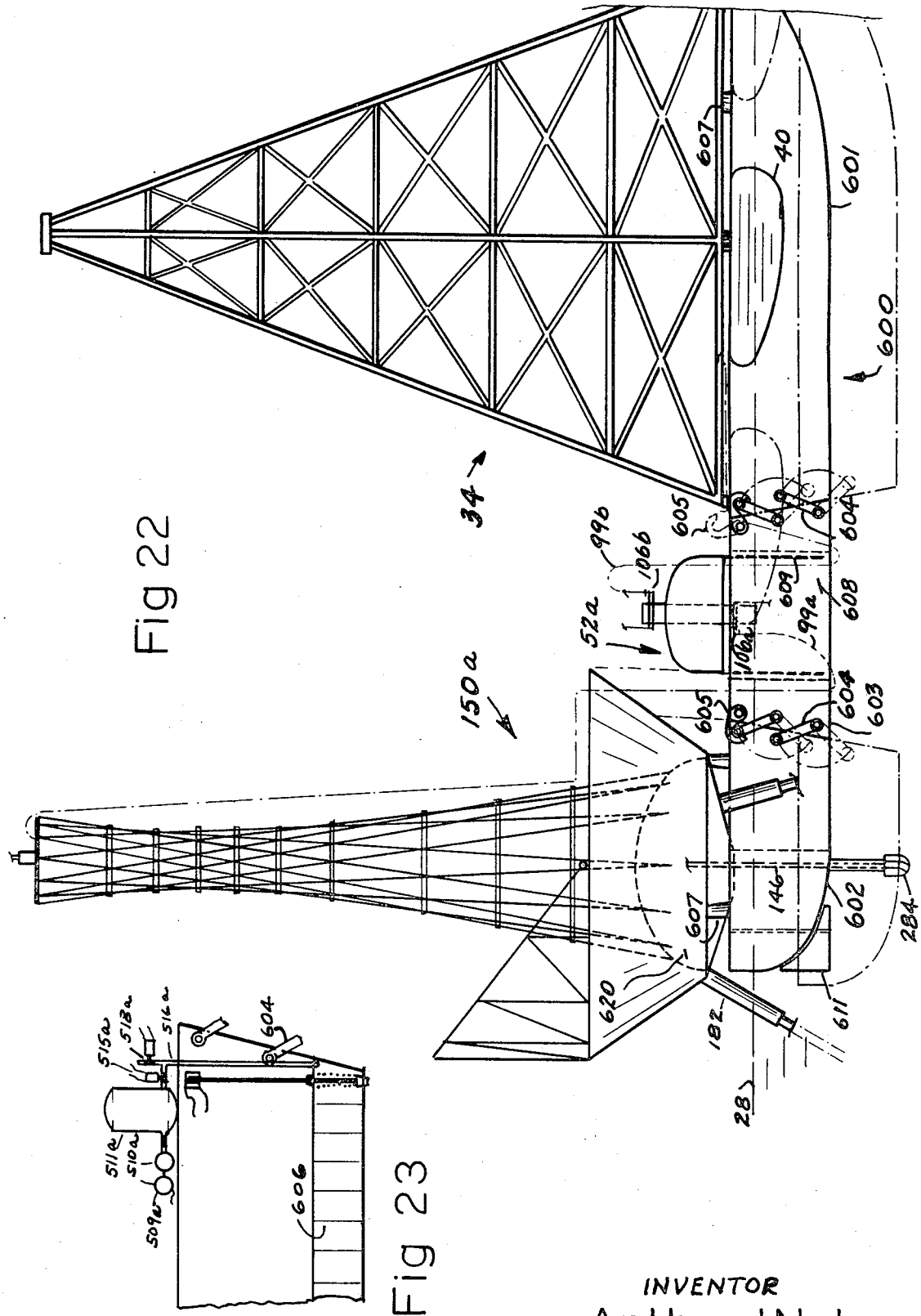


Fig 22

Fig 23

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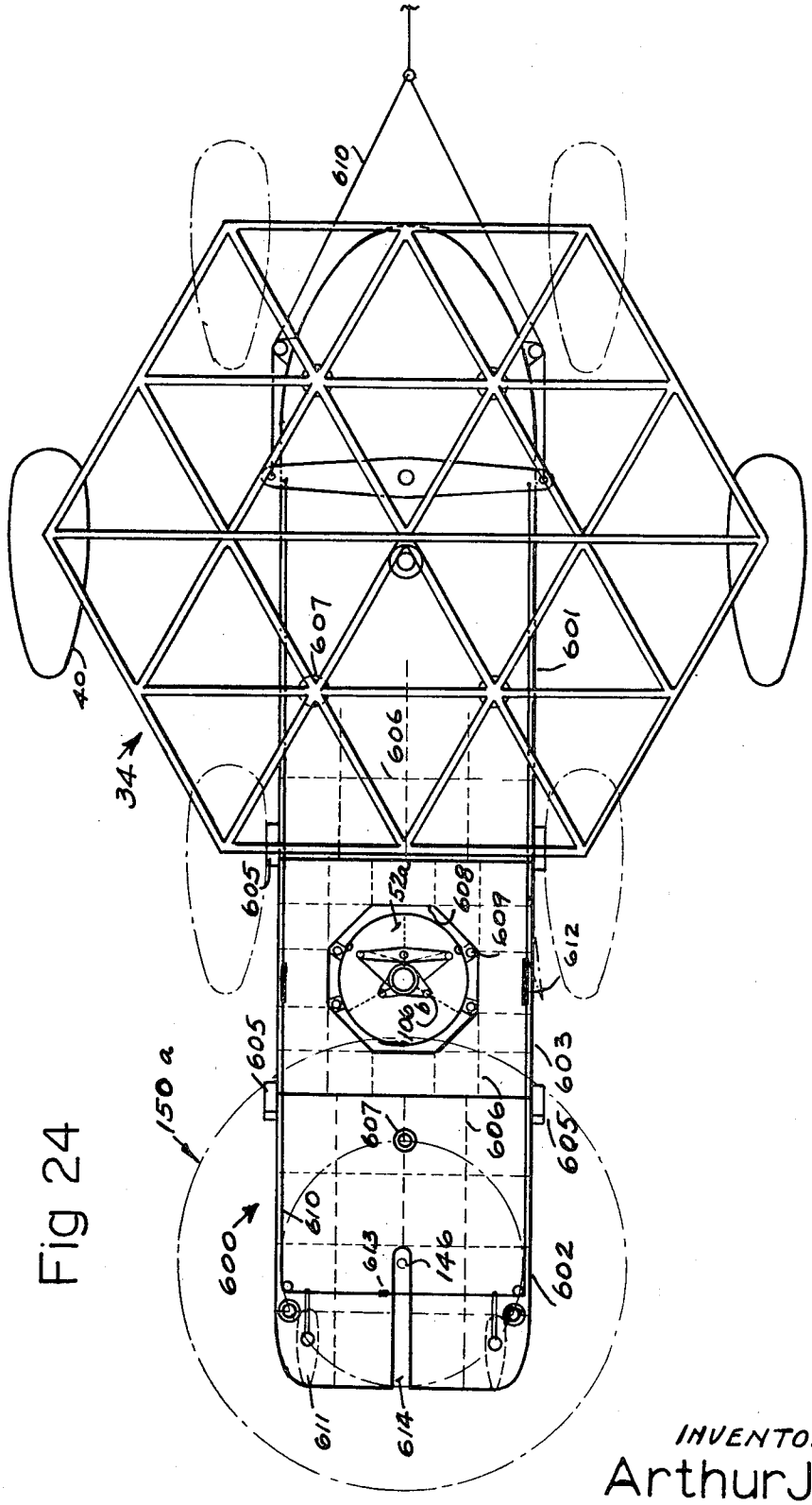


Fig 24

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THE APPARATUS AND METHOD TO ESTABLISH AND SUSTAIN A SUBAQUEOUS STRATA DRILLING SYSTEM

LEGEND

Symbol	Reference	Dated	Inventor
Ref. A	Pat. No. 3,593,808	8-20-71	A. J. Nelson
Ref. B	Ser. No. 63,507	8-13-70	"
Ref. C	Pat. No. 3,570,815	3-16-71	"
Ref. D	Pat. No. 3,359,741	12-26-67	"
Ref. E	Pat. No. 3,336,895	8-22-67	"
Ref. F	Pat. No. 3,526,097	9-1-70	"

CORRELATION OF APPLICATIONS

The present application is a further supplement to Ref. A in above legend. As provided in that disclosure the method depended upon three separate stations retained in vertical alignment as contributing factors to prolong uninterrupted drilling of a hole in the ocean floor. A subsequent application, Ref. B, covers in detail various means obviating the need of the conventional conductor pipe, discloses variations to achieve the basic principle and introduces necessary intermediate phases with drilling to sustain the improvement in drilling progress. The present application discloses: means for handling the apparatus with regards conveyance to and establishing the site, facilities to remotely accomplish adjustments, variations to the assembly and particulars concerning protective measures in contention with environmental conditions affecting members immersed for extended periods of time. Ref. A, B, C, mutually dependent upon the other, and individually contend with a particular aspect of the entire system.

BACKGROUND OF THE INVENTION

As disclosed in the aforementioned applications advantage is taken of the 'space' available with deep water to preassemble a drill string to an integral length which together with the torque and feed means provides an extended time of drilling not feasible with conventional apparatus. To further this effectiveness, the multiplicity of segments comprising the integral length is minimized; so that fewer time consuming connections are required in the assembly. Consequently, each replaceable segment itself is of considerable length requiring corresponding extended apparatus to accommodate them. Limited integrity of a bored hole dictates the need to line the hole with a casing, necessitating removal of obstructions to their placement.

The omission of the conductor pipe also normally used as a conveyance tube for transfer of materials through the body of water necessitates a substitute means such as the diverter to control the well.

The automatic and continuously effective torque means is dependent upon a control system monitored by means subject to long immersion and detrimental effects by not only the well fluid but also by environmental conditions.

The establishment of an erect station to the floor must be sustained in contention with erosion of the floor supporting the station.

Accordingly it is a principal object of the present application to provide those features insuring continuous drilling and to provide means by which the establishment and servicing of apparatus is effective.

A prime object contends with the handling of apparatus not feasibly manipulated by cranes and the like.

A further object is to minimize the makeup of connections so that shop assemblies eliminates many arduous tasks otherwise undertaken under more trying conditions.

A still further purpose is to provide means enabling removal and replacement of components of the assembly in contention with forces acting on the extended assembly in reach to the floor.

A further object is to insure the continuous performance of remotely operated control means subject to adverse environmental effects.

SUMMARY

This application is concerned first with the conveyance, handling and establishing of a specific form of a subaqueous strata drilling apparatus that has been extensively adapted to prolong penetration of that strata. The primary structures of the vertical array of that apparatus are transported aboard a common carrier and the sequence of their discharge permits interconnecting flexible members to remain intact. To effect the discharge the carrier sectionally assimilates a floating drydock in the handling of those structures as buoyant vessels relying on operational control means to assist manipulation of the various objects from an 'aboard' position to operating condition. The service station attending the vertical array is introduced to make up the drill string to the anticipated integrated length prior to placement of the drill station to the floor, thereafter assists in the establishment of the apparatus and finally becomes inclusive with it.

Secondly, this application proposes sectionalizing the drill station to provide a permanent portion that facilitates re-entry into the hole of assemblies with needed modification to stepwise accommodate various phases of the operation to the completion of the well.

Thirdly, insurance is provided for the continued performance of the apparatus by the mode of operation and protective features employed to contend with not only "well" conditions but environmental liabilities.

This application therefore discloses means for establishment of the apparatus and means improving performance and continuance in operation.

The term 'continuous drilling' is predicated upon the space between the surfaced control station and the remote drilling station below that permits lowering therebetween of the support station as a regulated elevator of the preassembled drill string retained as an integral length through that descent.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an elevational view diagrammatically illustrating the assembly having performed a drilling operation and in which a conveyance **600** is immediate to the control station **34.**

FIG. **2** is a partial elevational view diagrammatically illustrating the initial assembly of the drilling station **150***a* in the process of being lowered to the floor where it is to be established.

FIG. **3** is a partial elevational view illustrating the drilling station **150***a* with the base portion **154***a* fixed to the floor and portable superstructure portion **156***a* thereof separated as would be during a servicing operation.

FIG. **5** is an enlarged elevational view with parts broken away of the drilling station **150***a*.

FIG. 7 is a sectional elevational view with parts broken away showing construction of joint 50*a*.

FIG. 8 is a schematic diagram of the antirotational means taken from FIG. 6.

FIG. 20 is a sectional elevational view of an alternate sealing arrangement to that of the shuttle mechanism 357 of Ref. B.

FIG. 6 is a plan view with parts broken away of FIG. 5.

FIG. 21 is an elevational view of the diverter assembly 348.

FIG. 17 is a sectional elevational view with parts broken away showing construction of the throttle mechanism 363*a* incorporated in the diverter assembly 348.

FIG. 9 is a diagram expanding on the control to include establishing the drill station at the floor.

FIG. 4 is a partial elevational view illustrating the first supplementary operation to drilling having bored the upper hole portion.

FIG. 18 is an elevational view of the apparatus in the process of being modified while attending to supplementary phases to the drilling operation.

FIG. 16 is a sectional elevational view illustrating an assembly of apparatus housed for protection against the environment.

FIG. 14 is a sectional elevational view illustrating an assembly of apparatus housed for protection against the environment.

FIG. 19 is an end view typical of the cam operated switch as part of the selsyn assembly of FIG. 14.

FIG. 15 is a sectional view showing means to protect members immersed in a liquid.

FIG. 13 is a schematic diagram of controls associated with adjustably positioned members.

FIG. 22 is a partial elevational view of drilling apparatus aboard a conveyance.

FIG. 24 is a plan view of FIG. 22.

FIG. 10 is a sectional view of a compensating means 643 for coupling the oscillating conduit 362 to the fixed portion 154*a* of the drilling station taken from 47—47 of FIG. 11.

FIG. 11 is an end view of FIG. 10 taken from 48—48.

FIG. 12 is an elevational view schematically illustrating operation of the compensating means 643.

FIG. 23 is a diagramatic illustration of one type of ballast control for the barge 600.

DESCRIPTION

The procedure concerned with handling the apparatus from aboard a conveyance, through the various stages establishing the array and intermediate steps in servicing the system is presented first in a general discussion to be followed with detailed particulars of pertinent apparatus thus far deferred or modified from the references.

See FIGS. 1, 22, 24. A barge 600 preferably as for Ref. E is used between situations to convey the three stations employed in the vertical array, namely: drilling station 150*a* to be established at the floor 152 of a body of water, the support station 52*a* monitored to feed the drill string into the floor and the control station 34 partially submerged at the water surface 28. Unloading from the barge is to be in this stated sequence as required by flexible lines retained intact between them as represented by phantom lines 99*a*, 99*b*. This discharge is manipulated without use of a crane or the like, though the barge may be so fitted for other purposes.

The barge 600 is sectionalized (as arbitrarily shown) having a foresection 601, an aftsection 602 and a midsection 603; the three sections hinged together by sets of equal length parallel mounted linkage 604. Either fore or aft section is free upon release of locks 605 (as shown in phantom view for the foresection) to be displaced from an aligned position of the three sections. Such displacement is controlled by any suitable ballast system that regulates buoyant support of a selected section by introducing or removing water to its hold. The hold interior is partitioned as by ribs 606 that are penetrated by small holes to provide common fluid communication among all yet avoids horizOntal surging of the confined water. Suitable chockS 607 that are permanent to the deck are contrived to grip the supported structures 34, 150*a*, and are remotely controlled to be selectively operable. The midsection 603 has a well 608 formed through it accommodating passage of support station 52*a* from an above water storage position to an immersed condition as manipulated by jacks 609. It will be observed in FIG. 24 that structures overhang the barge and in the case of superstructure 34 by a considerable amount. In this case its buoys 40 actually contribute to the stability of the floating mass by the outrigger effect, noting structure 34 is last-off first-on the barge.

Upon arrival at a site service station 20*a* is brought alongside barge 600; so as to be made up to the feed end of terminal for the intact flexible members represented by lines 99*a*, 99*b*, to provide the means to manipulate various controls as assistance in discharging and establishing the array. Meanwhile selected locks 605 are freed to release the aft section 602 supporting the drill station 150*a*, then still held in position because of its buoyant capacity slightly in excess of its aggregate weight (as will occur for the forward section indicating the midsection contributes less support than its aggregate weight). By adding ballast to section 602 the mass is made to part from bearing to the midsection and by the parallel linkage descend with retention of the plane of the deck parallel to that of the rest of the barge. The aft deck becomes immersed with continued controlled feed of ballast to gradually bring the pontoon 620 of the drill station into play as the buoyant support means as in FIG. 3*b*. At some point a supply of baffle fluid 482 introduced to chamber 481 confined above port 480 will be displaced upwards by entry of water past foot valve 480*a* to a predetermined level fixed by structure 500 as disclosed in Ref. B.

Trim of the barge 600 is maintained while simultaneously diminishing its freeboard; so as to bring the deck of the aft section below the free floating position of station 150*a*. When that position has been reached the chocks are freed whereupon the buoyancy of pontoons 620 are increased while that of hold of section 602 is decreased. The pontoon 620 gradually takes over support of its structure to part from the deck, then to be cleared free of the barge.

Incidentally as seen in FIG. 24, the preferred barge of Ref. E utilizes a steering cable system 610 to actuate rudders 611 in steering the towed barge when deviating off course set by the towing tug. This steering cable is released from its operative condition by jack-knife operating comalongs 612 (schematically shown) to provide the necessary cable extension when the sections 601, 602 are displaced. This wire is also detachable at coupling 613 so that drill string 146 is unconfined in al-

leyway **614** through which it has been extended. It is to be noted that the weighted drill bit serves as a keel towards stabilizing the drill station when freed off the barge and not yet controlled by wires **99***a*.

See FIG. **18.** Service station **20***a* is then employed to make up the drill string length to the required extension of the lowest segment included in the station assembly and bearing the bit as exemplified in FIG. **2***b*. Derrick **26** is complimented with portable platform **615** that bears a clamp means **77***a* similar to that of clamp **77** of Ref. B to assist in the make up or dismantling of circuit **46** with surplus segments stored aboard the service station **20***a*. Prior to completion of the string assembly, the support station **52***a* is lowered below barge **600** and floated to position adjacent platform **615** for eventual positioning concentric to the completed string thereafter elevated above station **52***a* whereupon fitting **50***a* is connected by coupling **148***a* to the string. Finally the completed string is lowered for engagement by automatic clamping means **616** of FIG. **7** to station **52***a* now in support of the string. Hereafter platform **615** is removed to storage.

The removal of control station **34** off barge **600** will have been previously undertaken employing the practice for removal of the drilling station; noting the flexible members represented by line **99***b* likewise pass down through the well **608** as attached to station **52***a* to extend up the outside of barge **600** to the terminal at the structure **34.** Control station **34** is centered above the lowered array thus far assembled, whereupon the system is operated for controlled lowering to establish the drill string upon the floor. FIG. **2** depicts this assembly noting the absence of the diverter components **348** and conduit **46** since borings of the first short portion of the hole are washed to waste by a supply of water introduced by conduit **84** having plugged off coupling **74** seen in FIG. **7.**

In FIGS. **5, 9,** the erect posture and stable position of the drill station **150***a* is obtained by means of leveling device **248** in control of individually powered legs **182** as developed in Ref. A and B to include impressing the feet **628** into the floor under maximum dead weight by minimizing support by the pontoon chamber **620** and thereafter relieving the load on the legs to buoyantly support a share of the weight. The telescopic leg portion **186** terminates with the foot **628** universally mounted and preferrably has three toes to which pads are flexibly joined so that the gross bearing area of the foot is deployed into smaller units more widely dispersed to contend more effectively with uneven terrain. As previously covered in Ref. A and B leveling device **248** is used to stabilize the drilling station and with reengagement of gears **244, 246** with return of portable portion **156***a* in subsequent operations the legs are always controllable to correct any list from the desired station posture. FIG. **31***a* furthermore discloses the effectiveness of rotary limit switch **209** to automatically limit the extent of movement of leg assembly **182** with remote warning (not shown) to reveal such condition.

In FIG. **6** a reference centerline extending through the saddle **642** divides the plan view into symmetrical halves whereas the perpendicular centerline to it divides the plan into non-uniform halves with nonsymmetry arising from use of triple 'leg' components and a single remote conduit. A method is adopted to provide return of members as withdrawn, so that a non-rotating means **296***b* is employed to supplement stabilizing means included for support station **52***a* and service station **20***a* as disclosed in Ref. A and B. Such antirotational means permits descent of objects free of concern of twisting the flexible members. Projecting this reference centerline to the surface through the remote conduit **362** establishes proper orientation of subsequent transfer operations.

By referring to FIG. **3** it is seen that drilling station **150***a* is parted having removed the portable portion **156***a* from the stationary portion. This premature viewing serves to illustrate a previous first separation of the initial assembly represented by FIG. **2,** then leaving only a bare hole below the receptacle like station **154***a*. While the portable portion is remotely disposed for rearrangement as needed for the following drilling operation, the preassembly of FIG. **4** representing a portion of any other adaptable assembly of Ref. B. (Ref. B) being lowered for temporary engagement of mounting jig **617** to fit **618** of FIG. **5,** thereby fixing the position of surface casing **350** and bottom section **352** of diverter assembly **348.** Jig **617** with fixture **619** physically substitutes for the pontoon **620** and top section **354** of the diverter assembly **348** and sustains the grouting-in operation as covered in Ref. B. Thereafter the remotely operated clamps **356***a* are released so that the assembly above flange **349** is then removed. What remains is that lower fixed portion of FIG. **3** noting also that remote conduit system **362** was established with the setting of assembly represented as FIG. **4.**

The upper portion of FIG. **3** schematically shows the appearance of the portable portion **156***a* as reconditioned for re-entry to the well to perform major extended boring operations and now fitted with the top section **354** of the diverter assembly. As in FIG. **5** and **20** member **174***a* is adapted for sliding engagement **176***a* with the pontoon **620** so as to accommodate any minor axial dimensional difference that would prevent the engagement of a member common to two independent bases. As arranged clamps **164***b* and **356***a* will make up automatically. A gap **622** is provided to discontinue fit **618** as a full circle; so that formed conduit portion **358***a* is provided room to nest between pontoon **620** and the receptacle like member **623.** Conduit **358***a* extends from the diverter **347** to a coupling **643** connected to conduit **362** providing fluid communication therebetween. Coves **625** are formed in the periphery of pontoon **620** which completes free passage of the portable portion **156***a* from base portion **154***a* avoiding interference with gear protrusions **246** extending within the receptacle **623.** Shroud **627** guards these protrusions comprising the adjustable leg driven gear **246** that is re-engageable with gear **244,** depending upon the mesh of these gears as other separable means besides that at fit **618** and flange **349.** Though receptacle **623** will funnel the drill bit central to the site, a pair of extending arms **629** redirect mounting of the portable portion **156***a* in correct orientation by its sliding bearing to deflector **630.** These arms correct and stabilize the suspended portion to prevent damage and align gears to mesh to reinstate control of the fixed base portion that is subject to external effects.

Again referring to FIG. **3** it will be observed that conduit **46** is now included in the assembly having been made up per Ref. B as the assembly is lowered. With first contact of the mating assemblies phantom lines thereon depicts an off-center condition where eventually arms **629** will have sliding bearing with the sloping

contour of deflector **630**; finally squared by the short vertical configuration **630***a* of deflector **630** which provides alignment of fits and gears to engagement. When pontoon **620** seats in fit **618** the upper diverter assembly **354** suspending in sliding fit **176***a* will be displaced upwards by an established tolerance due to engagement of flanges **349** to produce an assembly as depicted in FIG. **1.** Meanwhile during the final makeup of the drill station the conduit pivotal portion **22** is connected to complete the fluid circuit that had been temporarily displaced as in FIG. **18.**

During the drilling operation station **52***a* will descend commensurate with penetration of the strata to a lowermost position in vicinity of the top **621** of tower **166**; whereupon station **52***a* is raised to retract the drill bit up clear of the preventer **353** which can then be closed to seal off the well from the seas. Retracting of the string is accomplished as discussed in Ref. B with regards dismantling conduit **46** and a subsequent discussion of the automatic operation of the diverter means **348** and the sealing assembly **357***a* therein.

DETAILS

Barge **600**

Sufficient discussion has covered this conveyance except for the remotely controlled chocks **607.** An adequate disclosure may be based upon adopting the method to secure fitting **50***a* of FIG. **7.** Thus each of the chocks strategically positioned to support a structure would provide a conical or taper mating of parts with spring loaded locking jaws solenoid released.

In FIG. **23** a representative diagram illustrates a pneumatic system for the control of ballast in the hold of the sections comprising barge **600.** This air supply may also be taken from the pneumatic system on vessel **20***a*.

Drilling Station **150***a*

FIG. **5** is distinguishable from FIG. **3***a* in the rearrangement of pontoon **620** now to be the base to which the tower structure **166** is constructed. Thus the pontoon is part of the portable portion **156***a* to enable various controls for it to be periodically inspected. Controls to the lower portion **352** of diverter assembly **348** are trained along the remote conduit **362** so remain with the permanent portion of the installation.

Anti-rotational means **296***b*

See FIGS. **8, 6.** The torque tube **170***a* is supported within structure **166** by a lower journal **172** an upper journal **168** and an intermediate thrust bearing **276.** BearinG **168** is centered by a supporting spider **631** at the top **621** of structure **166** that provides clearance space **633** through which flexible members pass as illustrated by wires **100***a*, **102***a*, **104***a*. A concentric ring **634** free to turn above the spider bears inwardly extending ferrules **635** for each of the said wires and a vane **636** located with a normal mean position midway between two magnetic switches **637** also supported by the spider. In much the same way as disclosed for the means **296** the taut wires are relied on when twisted to rotatably displace the vane **636** to an extreme position when either switch **637** is activated to actuate a motor **638** driving pump **639** and open the corresponding solenoid valve **640** to provide a fluid jet discharge from one of two nozzles **641** to establish a reaction to the force causing the displacement. The arms **629** serve the dual function of transmitting fluid to the nozzle located at their extremities, advantageously acquiring the needed torque with least energy. It is anticipated this device may also employ the leverage principle of Ref. B, so that with the slightest twist of the station **150***a* during descent to the floor it is instantly corrected.

Compensating Coupling **643** See FIGS. **10, 11, 12.**

The remote conduit **362** buoyantly supported is connected to formed conduit portion **358***a* that is fixed to solidly established drilling station **150***a*. The necessary compensation of relative motion between the two conduits is effected by this coupling **643** which is supported in saddle **642** provided at the periphery of receptacle **623.** The fixed conduit **358***a* is terminated with a first horizontal axis member **644** centrally located to the axis of an accommodating housing **645** that also shrouds a second horizontal axis member **646** disposed at a substantial space from the first member to form the lower terminal of conduit **362.** The members **644, 646** are identical and their axis established parallel having member **644** journalled at bearing **648** free to rotate about an axis common to the centerline of housing **645** whereas member **646** is journalled at bearing **648** in the end cover **649** enclosing the housing **645** to establish the said spacing of axis. End cover **649** is supported in groove means **650** formed in housing **645** for free rotating fit therein; so that member **646** is free to revolve about the axis of housing **645.**

Each of the members **644, 646** is encompassed by a cylindrical housing **647** that is free to rotate about the common axis as supported by distributed bearings **652.** The two cylindrical housings are flanged together by an interconnecting *s* type fitting **653** which established their longitudinal spacing in housing **645** to provide suitable end clearance **654.** Split retaining rings **655** prevent the endwise separatiOn of means **644, 646** whereas shoulders **656** butt to the flanges of *s* fitting **653** to resist their inward displacement.

A substantial volume of a lubricant is contained in a bellows type reservoir **657** that is mounted within a pressure tight tank **658** to provide lubricant for the bearings **652** via flexible tubing **659.** Tubing **660** establishes a balance of pressure for the injected lubricant to that of the conduit system pressures.

As seen in the schematic view FIG. **12** the conduit **362** has alternating vertical positions where its lower terminal **646** assumes some position *a* then a lower position *b*, possible because of the provided rotatable end cover **649.** Since the conduit **362** remains perpendicular though displaced horizontally, the journal **648** is required as the connection to the cover. It is observed that no such movement occurs between conduits **358***a* and housing **645** therefore member **644** could have been made fixed; but as arranged they are more economical, being exchangeable. As seen in the end view FIG. **11** the vertical displacement of conduit **362** from *a* to *b* is obtained by pivot of *s* fitting **653** through the arc *d—d*.

Control of reels **118***a*

In FIG. **13.** This schematic diagram illustrates monitoring means for the actuation of reels **118***a* periodically employed to handle flexible members as covered in Ref. B wherein one of several wires **102***a* is representative of the method to accumulate or store wire in a loop fashion by means of a weighted sheave **272.** Again briefly, a motor **200** is clutched **208** to selectively power a turn table **202** or leg **182.** By an automatic monitoring means a second clutch means **208***a* is employed to mechanically transmit this power to oper-

ate reels **118***a* as needed. To compensate for possible variations in existing members a third clutch means **208***b* connects each of the several reels to the common mechanical drive of the cluster of reels. In this diagram sheave **272** is mounted in a carriage **661** guided for vertical travel between rails **662, 663** that terminate with limiting lower stops **662***a*, **663***a* and limiting upper stops **662***b*, **663***b*. A pair of magnetic switches **664, 665** together with pivotal vanes **666, 667** are also mounted on carriage **661.** Arms **668, 669** extend as projected parts of the vane to be intercepted by the stops for their pivotal displacement to a held position by any suitable spring type clamps **670, 671.**

Switch **664** monitors reel **118***a* during the drilling operation; so that with descent of sheave **272** accounting for the accumulation of wire as station **52***a* lowers to feed the drill bit into the strata, the vane **666** is in displaced position (non-activating the switch) represented by phantom view there imminent to the position of its arms **668** being acted on by stop **662***a*. Such interference establishes the vane **666** to a position activating switch **664** shown with carriage **661** at some upward traveling position occasioned by the now hauling-in of accumulated wire by reel **118***a*. Note clamp **670** stabilizes the vane to such position opposing the gravitational effect of the extended arm **668** to displace the vane. With travel of the sheave **272** dimensionally half of the length of cable hauled in, the arm **668** is intercepted by the upper stop **662***b* so that switch **664** is then inactivated thus clutch means **208***a* discontinuing to power reel **118***a*. Sheave **272** then repeats the downward travel for accumulation of more cable until stop **662***a* again interferes.

As long as switch **672** is closed by spring **673** then magnetic switch **664** can be activated to control reel **118***a*, but by remote closing of master switches **672***b*, **692***a* solenoid **674, 674***a* are powered to oppose springs **673, 673***a* whereby switches **672, 672***a* are transferred to make magnetic switch **665** effective to control reel **118***a* and reverse the rotation of motor **200** when retracting the drill string. Thus to raise station **52***a* to retract the string an accumulation of wire is provided by payout of wire by reel **118***a* until sheave **272** is at a lowermost position whereupon stop **663***a* interferes with arm **669** to disengage clutch means **208***a*. Thereupon sheave **272** is raised with raising of station **52***a* to an uppermost position where stop **663***b* interferes with arm **669** to reactivate switch **665** to again power reel **118***a* for further payout of wire and return of sheave **272** to the lowermost position. It should be noted that the reels **118***a* are geared to rotate at high speed to minimize the time in transferring wire.

In FIG. **14.** As provided in Ref. B, the sheave **272** was relied on to activate a monitoring means to control crane motor **19** regulating the elevation of frame **41** supporting conduit **46** in space relation with fitting **50.** Again chain **65** in FIG. **13** is so connected to activate selsyn transmitter **61** for the remote operation of selsyn receiver **49** attendding the crane. However, in FIG. **14** the sprocket **63** drives gearing **675** contained below a housing **676** enclosing thee selsyn **61***a* and other apparatus associated with the operation of the throttle system **363***a*. Housing **676** establishes a gaseous chamber **677** separated from the water body by a liquid baffle **678.** A liquid level controller **679** relying on the mercoid type electric contacts similar to that of Ref. B monitors means associated with pontoon **620** to retain chamber **677** in balanced fluid communication via conduit **680** also enclosing electric leads for makeup in chamber **481** of pontoon **620.** A float type foot valve **681** is provided to retain the supply of baffle fluid from escaping via the passageway **682** in the floor of the housing providing transfer of water therethrough.

In FIG. **16.** A similar enclosure **683** provides protection of switches **664, 665** and appurtenances associated with their operation as discussed covering FIG. **13.** Enclosure **683** is shown with an alternate arrangement omitting a floor when unconcerned in the loss of the baffle fluid.

In FIG. **17 – 14**

The throttle assembly **363***a* distinguishes in the removal of monitoring and switch means from within the diverter cylindrical portion **368** used to provide for the passage of couplings **148***a* past throttle **367.** Since as covered above movement of sheave **272** is related to movement and length of string segments (spacing between couplings) the monitor means **274***b* is relied on to serve a dual purpose to include control of throttle **376.** Accordingly, the shaft **684** of selsyn **61***a* is double extended to drive also a member of disc cams with only two represented by **685, 686** that are caused to rotate one turn for the total turns of sprocket **63** (resulting from travel of sheave **272**) through the reduction designed into exemplary gearing **675, 675***a*. As in FIG. **19** cam **685** profile includes a protrusion **687** which displaces vane plunger **689** to activate magnetic switch **691** for the duration of time needed to pass coupling **148***a* by expanded throttle **367** held open by the switch **691** manipulating solenoid valves **431–455** pneumatically controlling power means **421.** Ref. D is relied on for the system to establish the gas pressure and volume requirements of the stations depending upon byouant support, chambers, apparatus utilizing gas as a protective environment, energy to operate associated power means and the ejection of leakage in a bypass system. Similarly cam disc **685** with protruding profile **688** displaces vane plunger **690** to inactivate switch **692** in control of motor **200** (otherwiSe shown as switch **692***b* in FIG. **13**); so that turn table **202** is idled. Thus without centrifugal force, seal **402** opens for the time interval to pass coupling **148***a* upwards without any interferences when retracting the string. Again note the remote closing of switch **672***b* as master control when withdrawing the string. The angular magnitude of the protrusions **687, 688** and orientation with regards the turn of shaft **684** conforms to provide a minimum allowance in excess of that needed to effect the passage of the coupling.

In FIG. **20.**

This sectional view of the upper portion of diverter assembly **348** shows the sliding fit **176***a* of bearing member **174***a* with pontoon **620** as previously covered and the substitution with sealing means **357***a* for the shuttle mechanism **357** of Ref. B. Sealing means **357***a* embodies all the features of throttle mechanism **363***a* of FIG. **17.** The two half portions **419***a* formed around the drill string **146** are separable by power means **421** to provide passage through of the couplings **148***a* and returned thereafter by spring means to reseal the string. With this arrangement the stuffing-box sealing means **480***a* is relocated at bearing member **174***a* with the lower end of the torque tube **170***a* now not including the coupling means **414–416** of Ref. B.

Halves 419*a* bearing against internal ring flange 372*a* opposes higher pressure of chamber 359*b* below and backs up the seal 402*a* in contact with string 146. To make this seal more effective gland halves 696 are free to be urged against seal 402*a* by the mentioned pressure and retained in assembly with the parted halves of members 419*a* by dovetails 697. All of the power means are represented as 421 like that described for throttle 363*a* and actuated by a cam disc and switch means of FIG. 19 stacked to shaft 684 within chamber 677 of FIG. 14.

The position of sheave 272 is indexed with the descending couplings 148*a* when in imminent position to the seal 357*a* so as to be approaching its lowermost position whereupon the cam 685 has been rotated to have its protrudence 687 effective to cause the expansion of seal 357*a* as explained. With continued descent of the coupling subsequent throttles will pass the coupling until it is disposed below all in the well, whereupon switch 664 is acted on to cause reel 118*a* to haul in the accumulated wire. As covered in Ref. A and B the torque tube 170*a* is arranged in length to enclose one coupling at all times and as seen in FIG. 20 a coupling is in imminent position with seal 357*a* when emerging from the tube 170*a*. Thus the coupling then just entering the tube will be indicative of the lower coupling position and acts with magnetic switch 197 to close the circuit that will cause clutch means 208*b* to release reel 118*a* from the drive of gear 134*a*, if sheave 272 is higher than should be. Switch 199 normally closed is included in the circuit with switch 197 normally open and is positioned to be deflected open when the sheave 272 is at the position when throttles shOuld be attended. Thus the reel 118*a* can be released if the sheave 272 is higher than should be to pay out cable too with that still being accumulated with descent of the coupling until the switch 199 is inactivated with the apparatus in position as intended.

In the operative position with the throttle assembly 363*a* restricting leakage between serially established chambers, the well pressure in the stagnant chamber formed by the throttle assembly immediately above the blow-out preventor dominating the bottom sPction of the diverter is reduced substantially to ambient pressure at the sealing assembly 357*a* by the pressure loss occurring as frictional resistance to flow through each throttle. Accumulation of leakage liquid within a chamber is avoided by a bypass system permitting flow only as drainage from an upper chamber to a sump 373 below, whereupon the accumulation within a sump to a certain volume is monitored by a conventional liquid level device to activate the pneumatic system extension of the gas volume control at the drilling station to eject the draimed liquid to a chamber below. When a throttle has been expanded to pass a coupling as described, an excessive discharge of liquid accompanies the coupling into an upper chamber which liquid is restrained therein to nominal leakage past the closed throttle assembly defining that chamber and to drainage to the sump as described. The final chamber above the sealing assembly 357*a* dominated by the elongated torque tube 170*a* is not subject to leakage fluid flow but the discharge of well fluid into it with passage of a coupling through the expanded seal assembly is again dispersed by the bypass system.

In FIG. 15.

Switch 693 is exemplary of electrical devices immersed to great depths and the means employed to adjust with pressure changes. A network of pressure tight conduits 694 conveying electric leads are in fluid intercommunication to a neighboring gaseous chamber exposed to approximately the same environmental conditions and already regulated to provide an environment free of deteriorating effects of the sea in accordance with Ref. F. In this particular switch of the magnetically actuated type, the reed-like contacts are first encased in a gas filled capsule 698 to maintain its operating clearances while being stabilized within a metallic enclosure by a resilient material 699 and thereafter the capsule is punctured; so as to subject said clearances with other voids to be in balance with the controlled gaseous chamber.

SHALLOW WATER

As anticipated in previous coverage this drilling apparatus is dependent upon the space provided by the depth of water to yield protracted use of an integrated assembly. The overall performance improves with increase in depth of water to the subaqueous strata. In what is herein termed shallow water amounting to present day maximum depth of 'worked' waters the present invention is therefor adapted to periodic lengthening of the string without resorting to the system of divesting the well of the portable drill station and well head. Such alternate method is considered to be within the realm of the disclosure of Ref. B substantiated by the following disclosure.

With reference to FIG. 7 it is considered obvious to modify the arrangement by extending tubular support 138*a* above chamber 70 to include the mounting of equalizer 106*b*, relocating the flange and thrust bearing immediately thereabove and beneath seal 92. Thus the remountable flange and thrust bearing secured by clamp 616 are removable when the string has been retracted by raising the support station 52*a* to its initial position below and in bearing with the control station 34.

The same method is employed, as disclosed in Ref. B to sectionally remove segments of conduit 46, to remove fitting 50*a* and segments of string 146. Thereafter with a new drill bit the string is reassembled with more segments to re-establish the drill bit to the depth of hole penetration; so that support station 52*a* bearing fitting 50*a* connected to the integral string is in uppermost position with the control station 34 in support of a minimum number of segments forming conduit 46 to be periodically lengthened with progress in drilling.

CONCLUSION

From the foregoing description it is believed apparent that the present invention enables the accomplishment of the objects initially set forth herein. It seems apparent that the extent of the present application justified treating it as a supplementary application, deferring claims with this full disclosure of previous concepts then necessarily included in briefest form to fulfill the purpose.

What is claimed is:

1. In a system to establish a vertical array of assembled objects in cooperating arrangement with a surface service station to automatically and uninterruptedly bore a hole in subaqueous strata with an integral drill string of a length commensurate with the array extend-

ing from the surface to the floor of a body of water said string having a drill bit at its lower end with the array comprising:

a. an elongated first member formed with a buoyant chamber to supplement support established on the floor for transmitting torque to rotate the string;

b. a second member for buoyant support of the drill string to selectively control bearing pressure of the drill bit upon said strata;

c. an elongated third member comprising the following components;

1. immersed buoys to provide compensating support for this third member respective said surface;

2. a conduit for fluid communicating relationship between said service station and said drill string; and,

d. flexible elements adjustably interconnecting the three members conveys means for coordinating control of the said bearing pressure and descent of the integral drill string and conduit corresponding to progress in boring said hole;

the improvement comprising:

1. a barge is adapted with chocks fitted to the deck to accommodate mounting said first, second and third members to safely convey the assembled array to and from situations;

2. said barge is sectionalized into independently buoyant portions selectively locked together as a unit, having an end section in support of said first member, a mid section with vertical well formed in it for passage therethrough of the said second member supported therewith and another end section in support of said third member;

3. said third member overhanging the deck is disposed to employ its buoys as outrigger buoyant support to the stability of the barge bearing the elongated first and third members comprising the barge deck load;

4. the end sections pivotally hinged to the mid section by equal length parallel mounted linkage permit selective vertical displacement of either end section while retaining parallelism of the planes of the three decks;

5. an arrangement to establish and maintain freeboard and trim of the barge comprises a ballast system regulating the exchange of water to and from the holds of said sections with the hold of each said section compartmentized by partitions penetrated by small holes to provide common fluid communication yet avoids horizontal surging of water introduced;

6. the deck of the end sections are immersible to enable said buoyant chambers and buoys associated with the first and third members respectively to assume support of a then released member; and,

7. said buoyant chambers are regulated through said interconnecting flexible elements extending to said service station to afford manipulation of said elongated members to or from the barge in compliance with the displacement of an end section.

2. A system to establish a vertical array of assembled objects supported in variable spaced relationship in a body of water having an uppermost control station retained at the water surface in buoyant support of a suspended rigid member and a load transmitted by selectively extendable and retractable primary flexible members tensioned by a support station likewise in buoyant support of a suspended rigid member and a load transmitted by selectively extendable and retractable secondary flexible members tensioned by a drilling station established to a stable and erect posture as monitored by a leveling device employed to monitor and control the support of the drilling station upon the ungraded floor below, the improvement comprising:

a. said drilling station has at least three supporting telescopic legs each individually powered to a required length to establish said erect posture as sensed by said leveling device monitoring and controlling the adjustment of each leg to an extension providing said posture;

b. said drilling station has a selectively variable volume gas filled chamber common with each leg to contribute its buoyant support to share the weight of the drill station as said volume responds to said leveling device in control of a liquid level controller adjustably contained in said chamber to regulate the liquid level thereby controlling the buoyant support;

c. articulatively fitted feet to the legs are to be impressed into the floor while said volume is temporarily minimized;

d. a stabilizing means for said stations comprises thrusters monitored and controlled to exert a reactive force sufficient to avoid oriented displacement and vertical misalignment between said objects when actuated by said flexible members displaced from a normal vertical disposition;

e. said drill station is touched down and erectly established to the floor by an arrangement comprising, controlled payout of said extendable members and rotary limit switches superiorly employed to automatically limit the extent of movement of the legs being adjusted in length; and,

f. an automatic monitoring means controls said selectively extendable and retractable secondary flexible members to provide adjustment to said flexible members commensurate with vertical and spaced disposition of said rigid members.

3. A subaqueous strata drilling station, responsive to remote control from a surfaced control station and a service station therewith, to be automatically parted into a portable portion and a stationary portion supported by legs bearing with the floor of a body of water to an immersed position accommodating a diverter assembly likewise adapted to be automatically parted into a top section in sliding engagement with said portable portion and a bottom section secured to a strata fixed surface well casing concentric with the drilling station providing uninterrupted torqued translation therethrough of an independently supported drill string terminating with a drill bit to bore a well in said strata, the improvement comprising:

a. a conduit system comprises, said diverter assembly accommodating the fluid sealed passage of the operating drill string therethrough and limiting fluid from the well to flow through a formed conduit portion connected to a coupling fixed to said stationary portion therewith to compensate for limited alternating vertical position of a remote conduit assembly buoyantly supported for fluid transmission to said surfaced service station;

b. said diverter assembly is journalled to the drilling station for tolerable axial space relationship therewith accommodating dimensional discrepancies between a member common to two independent bases temporarily engaged upon removal of said portable portion and top section from said stationary portion and bottom section respectively;

c. said drilling station is remotely and selectively separable into a stationary portion designated as the receptive permanent fixture to the floor and the upper superstructure formed portable portion optionally disposed to divest the well of the drill string with the top section of the diverter assembly;

d. said drill station is sustained to an erect posture and stable position by a support means comprising, a pontoon formed integral with the portable portion and individually powered and adjustable telescopic legs extending as foundations for said stationary portion to firm footing with the floor;

e. antirotational means applied during descent of the portable portion for correct oriented reengagement with the stationary portion comprises, said portable portion bears protrudences for slid-ing bearing with the sloping contour of said receptive permanent fixture to provide guided return of the portable portion to re-engage cooperating members between said portions comprising matching gears selectively employed to transmit said same power to said legs as dually adapted also to power said drill string; and,

f. the drilling station support means further comprises, said pontoon formed into compartments provide an adjustable gas volume for each of at least three said legs for mutual support of the drilling station with each automatically responsive to a leveling device sensing said erect posture for selective monitoring and controlling both said individually powered legs and a liquid level controller adjustably contained in said chamber adapted to regulate the gas volume therein.

4. A drilling station according to claim **3**, wherein said remote conduit extends from the surfaced service station as a vertical array supported by buoyant means permitting axial surging of the conduit and is connected through a compensating coupling by a formed conduit portion to said diverter assembly, the improvement comprising:

a. an accommodating housing provides for the central location thereto of the terminal of the formed conduit portion connected at the central horizontal axes and to one end of the accommodating housing;

b. an end cover rotatably fitted to and enclosing said accommodating housing provides for the connection of said remote conduit with inlet axis offset and parallel to said horizontal axis;

c. an offset fitting provides fluid communication between said formed and remote conduits with fluid tight journal-like fit therebetween and within said accommodating housing;

d. said offset fitting pivots about said horizontal axis through an arc defining a lower and upper remote conduit inlet position as sustained by the rotatability of said cover to accommodate said surges; and,

e. a supply of lubricant for said journal fits in pressure balance with that of the fluid transported through the coupling.

5. A drilling station according to claim **3**, wherein the bottom section of the diverter assembly is dominated by at least one blow-out preventor manipulated by a remote control system integral with the said remote conduit to selectively seal off the well at any time with or without removal of the drill string, said top section of the diverter further comprises:

a. joined cylindrical bodies provide a first stagnant chamber established between said blow-out preventor and a partition supporting a throttle assembly accommodating passage therethrough of the drill string with close annulus clearance and at least one transition chamber serially established thereabove by addition of like partitions and throttle assemblies for each, all in space relationship in excess of the coupling length joining tubing segments of the drill string;

b. a sealing means, operatively incorporated with a partition establishes the uppermost transition chamber to provide said fluid sealed passage of the drill string with close fit to said segments;

c. all said throttle assemblies and the sealing assembly are split axially into halves movable to and from the drill string segments to provide an open passageway for said couplings between chambers; and,

d. a power means connected to each of the halves are serially operated to pass a coupling and means urge the halves together before another throttle assembly is parted.

6. A drillinG station according to claim **5**, wherein the said close annulus clearance restricts leakage flow from the well to the said serially disposed chambers, the improvement comprising:

a. an external bypass effected around each throttle assembly transmits said leakage back to a transition chamber beneath from which it escaped; and,

b. said transmission of leakage further comprises, the drainage of leakage flow from a transition chamber to a sump for ejection therefrom by an extension of the gas volume control system for the drilling station.

7. A drilling station according to claim **5**, wherein said independently supported drill string suspends from a thrust bearing mounted on a buoyant support station stabilized for controlled vertical travel to feed the drill string bit into the strata below the drilling station as revealed by flexible members adjustable interconnected as taut wires between the two stations, the improvement comprising:

a. a wire length adjustment means periodically spools said wires, to retain a limited store of wire, corresponding to change in elevation of the support station above the drilling station;

b. a weighted sheave establishes said taut wires as supported in the loop developed in the return of a wire on itself to accommodate the change of accumulated wire responsive with movement of the support station with the store of wire trained below said adjustment means;

c. said periodic spooling transfers a wire length commensurate with the span of equally spaced said couplings and effects the vertical travel of the sheave in a distance measurably one half of said span;

d. said sheave is correlated with couplings of the string to reciprocatingly return once to a specific

position coincident with the imminent position of each coupling to said diverter assembly; and,

e. monitoring means intercepted with vertical travel of said sheave for control of said throttle assemblies comprises, said interception activates magnetic switches regulating each throttle assembly sequentially to provide said passage of a coupling with each incidence when confronting a throttle assembly or the sealing assembly.

* * * * *