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FLIP - FLOATING INSTRUMENT PLATFORM

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Scripps Institution of Oceanography

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A general non-technical summation of the construction, operation and potential of the *R/P FLIP*. *FLIP*, i.e., FLoating Instrument Platform, is designed as a super-stable open-sea free-floating platform from which to conduct research in the field of physical oceanography – primarily underwater acoustics to a scale heretofore impossible due to background noise and ship movement.

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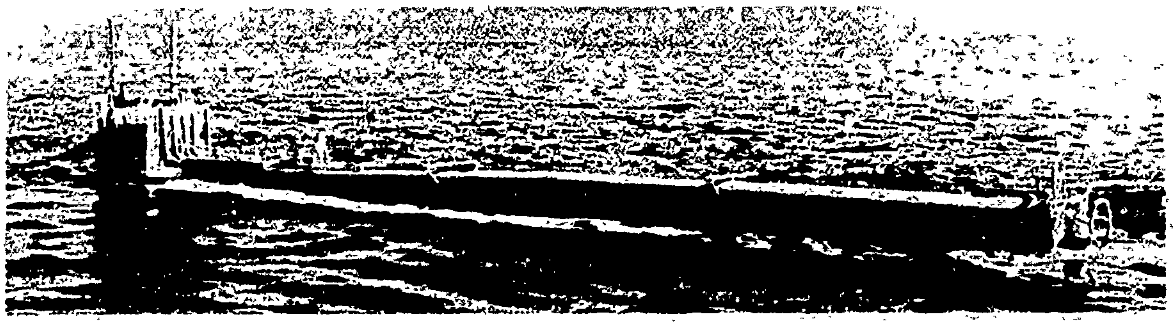
FLIP

FLoating Instrument Platform

EARL D. BRONSON AND LARRY R. GLOSTEN



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F. N. SPIESS, DIRECTOR
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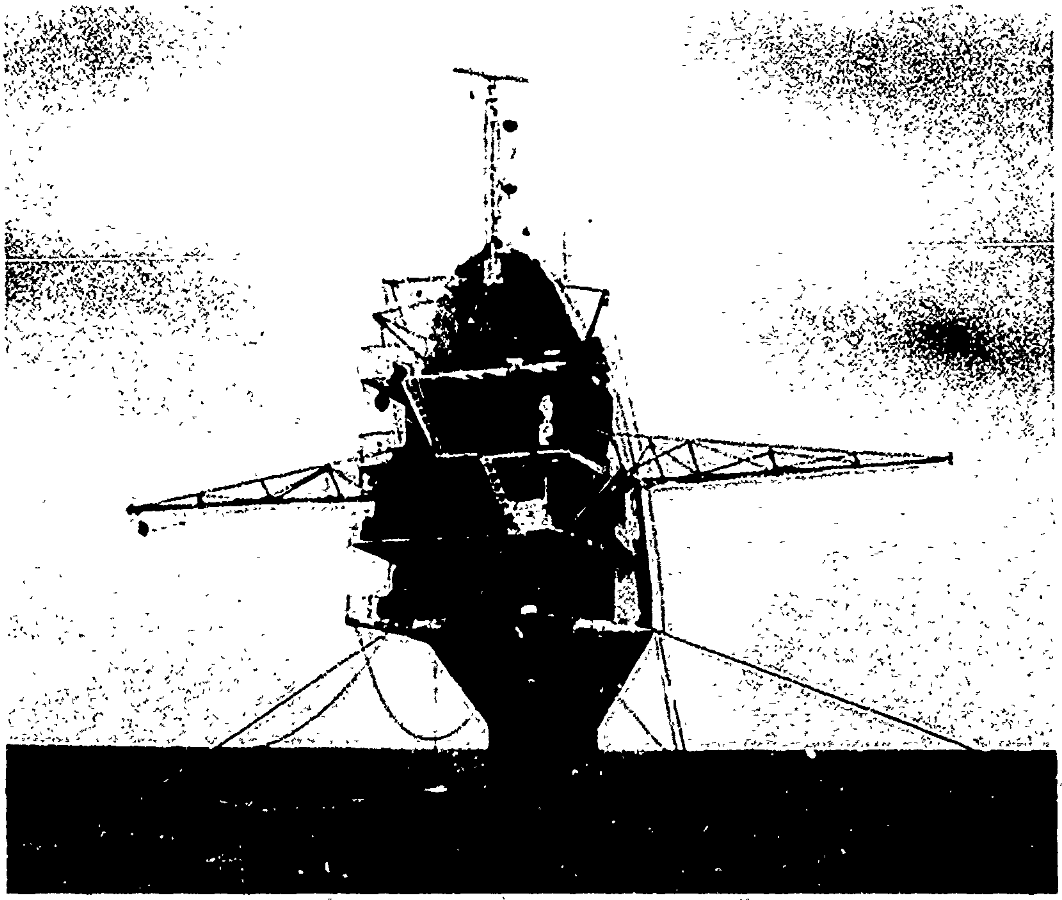

PRINCIPAL DIMENSIONS

Length Overall		355' - 0"
Hull Diameter, Maximum		20' - 0"
Hull Diameter, Minimum		12' - 6"
Breadth, over outriggers		50' - 0"
Skeg Draft below Bottom of Hull		2' - 0"
Draft Horizontal Normal	aft	13' - 8"
	fwd	8' - 10"
Draft Vertical Normal		300' - 0"

OPERATIONAL LIGHT SHIP CHARACTERISTICS

Ship in operating condition with average amounts of fuel and water on board.

Displacement	700.0	Long Tons
Transverse Center of Gravity	0.4'	Below Centerline Axis of Hull
Longitudinal Center of Gravity	182.0'	Forward of After End

These values do NOT include any free flooded water but DO include the effect of the solid concrete ballast which is located as follows:

Tank No. 4	87 Long Tons
Space No. 5	15 Long Tons
Tank No. 6	25 Long Tons
Space No. 10	23 Long Tons

TOWING DISPLACEMENT
Approximately 1500 Long Tons

VERTICAL DISPLACEMENT
Approximately 2000 Long Tons

FLIP

FLoating Instrument Platform

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Marine Physical Laboratory of the
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ABSTRACT

A general non-technical summation of the construction, operation and potential of the *R/P FLIP*. *FLIP*, i.e., FLoating Instrument Platform, is designed as a super-stable open-sea free-floating platform from which to conduct research in the field of physical oceanography – primarily underwater acoustics to a scale heretofore impossible due to background noise and ship movement.

I GENERAL DESCRIPTION

Figure 1 shows the general arrangement and inboard profile of *FLIP* in the horizontal towing position, and to a larger scale two views of the upper portion of the platform in the vertical or operating position, *FLIP* is essentially a long, slender tubular hull 20 feet in diameter for almost half its length from the stern, and tapering to a cylinder 12½ feet in diameter as the bow is approached. The bow, itself, of a full, deep spoon type, is unconventional principally in the fact that it terminates abruptly at the point where it joins the cylindrical hull some 40 feet from the forward end. Length overall is 355 feet. *FLIP* is designed to tow in a horizontal attitude ballasted with water so as to float at approximately half diameter with a draft of about 10 feet. Arrived at the scene of a research operation, controlled flooding of tanks will cause the platform to raise her bow and drop her stern until she floats in a vertical position drawing some 300 feet of water with the bow rising 55 feet into the air. As shown in Figure 1, in this position there are four operating levels in the bow section – a machinery space, living quarters, an electronics space and crews quarters in ascending order. There is a boarding platform at the lowest level and larger, external working and observation platforms at the two upper laboratory levels - the platform at the Engine Room level is also the location of the operating station from which the flipping maneuver is controlled. The spaces in the hull proper are essentially tanks flooded with water or held empty or partially full as necessary to give the desired draft and stability characteristics. These spaces and their use will be described in more detail later. It is of interest to note here that while it is possible for the crew to descend about 150 feet into the hull of *FLIP* when she is in the vertical position, there is at the present time no apparent necessity for doing this, and in all probability all scientific

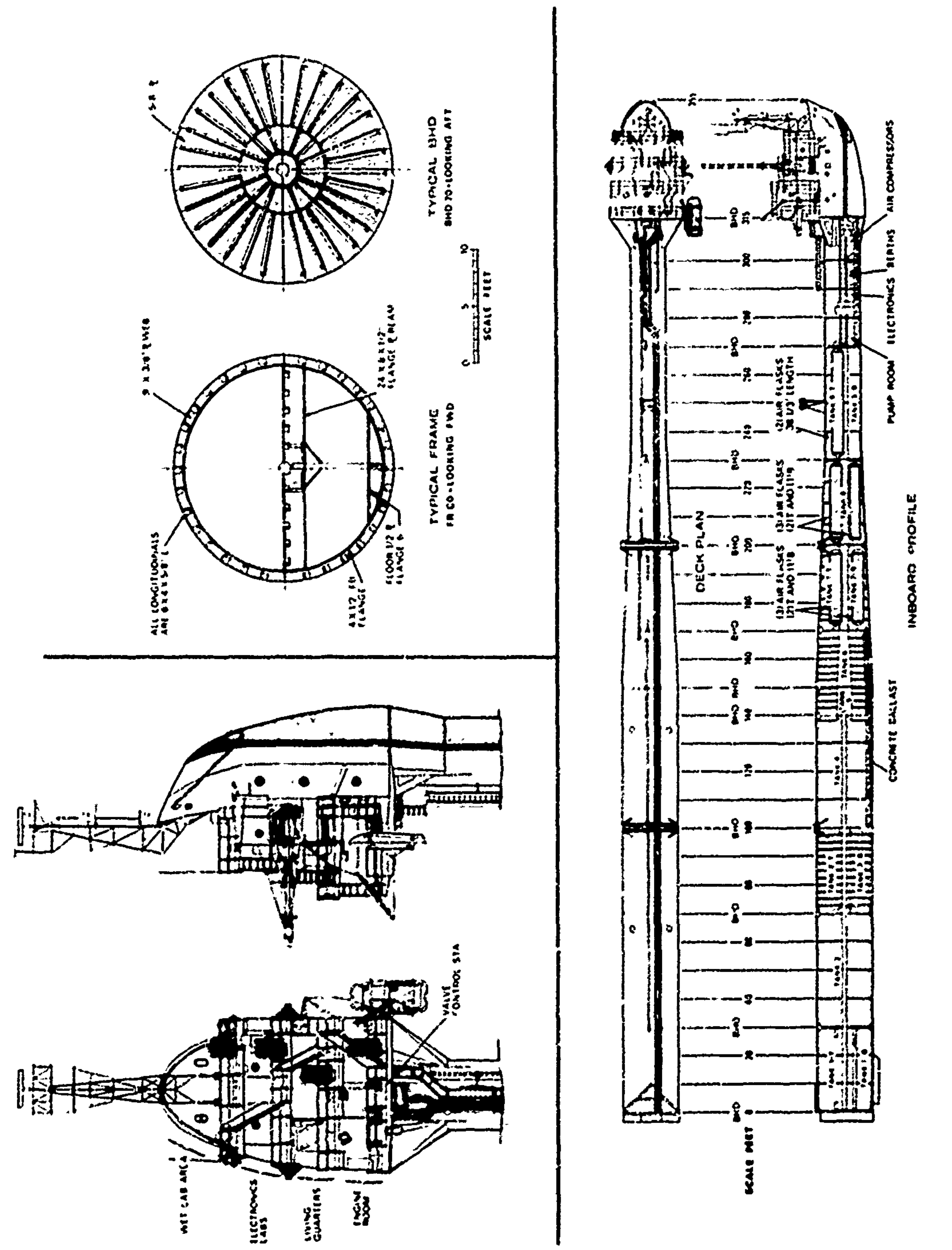

TYPICAL FRAME
TYPICAL BHD
DECK PLAN
INBOARD PROFILE
CONCRETE BALLAST
PUMP ROOM
AIR COMPRESSORS

FIGURE 1

work will be done from the operating platforms above the 300 foot water line. Observations deep below the surface will be made by means of instruments fixed to the hull or lowered on cables or by means of other devices still to be added.

However, tank No. 5, frames 140 to 150, now a buoyancy tank, will probably be altered to a biological observatory in the near future.

Running through the axis of *FLIP* is a 12-inch diameter tube providing a straight, clear line of sight to the bottom or after end. This is an important element in some of the projected scientific work, but this tube is not for direct visual observation into the water. Rather it will be used for making readings on instrumentation located inside the hull. *FLIP* can, of course, remain on station in a vertical position for days at a time, permitting extensive observations to be taken. When it is desired to return to the horizontal attitude the maneuver is accomplished by the controlled blowing of certain ballast tanks. Compressed air for this purpose is stored in large banks of receivers located in the upper part of the circular hull.

Referring again to Figure 1, it will be noted that the spaces in the tubular portion of the hull are numbered 1 to 10 in sequence starting from the stern. In addition some of the spaces are divided by flats in which case the upper portion of the tank is further designated "T" and the lower portion "B". Using the vernacular of the submariners, some of these tanks are "hard" in the sense that they are designed to withstand a full head of sea pressure. Others are "soft" and must be maintained essentially in equilibrium with no large differential between the external and internal pressures. Spaces 1-B, 2 and 4 are free-flooding, "soft" tanks. They are always open to the sea and the water level within them coincides with the external surface of the water. In the horizontal position then tank No.1-B would be completely full since its top is below the water line. Tanks 2 and 4 would be approximately half full. As the platform rotates to the vertical position, water flows freely into tanks Nos. 2 and 4 and quickly fills them. Inasmuch as there is no closure on these spaces the internal and external pressures always remain in equilibrium. Tank 1-T is also a "soft" tank, but while it is also always open to the sea at the bottom, its vent line runs to valving at the operating station. Consequently, the level of water in this tank can be controlled by venting or by blowing using the compressed air banks. Some judgment must be exercised to insure that excessive pressures are not allowed to build up on this tank. Tank No. 3, which is sub-divided into top and bottom sections by a flat at mid-depth, is a "hard" tank and as will be described later is the tank which is principally used to control the flipping operation, during the course of which both the cylindrical boundary of the tank, the end bulkheads and the flat within are subjected to high heads of sea pressure. All of the spaces above tank No. 4 are "hard" tanks designed to withstand the full head of sea water to which they are subjected in the vertical position. No. 5 is a buoyancy space which is never flooded. No. 8 is the variable tank which is used to control the draft in the vertical position. Tank 7, which is divided into top and bottom sections by a flat at mid-depth, is used to control angular heel in the upright position. Tank 6 is normally partially full in the horizontal position and variable in the vertical position. Tank 9-B is fitted for flooding and is normally empty except during the evolution of flipping from the vertical to the horizontal position, at which time it is used to give an initial heel in the right direction. Tanks 9-T and 10 are not fitted for flooding and are always dry.

A total of eight air receivers are distributed in tanks 7, 8 and 9-T. These receivers have a capacity of just over 3,000 cubic feet of air at 250 psi gauge. They are charged by means of electrically powered air compressors located between frames 300 and 315 in the forward compartment formed by the tank 10 conversion. Electric power for the air compressors and other ship's services is provided by two 150 kw diesel generator sets located in the machinery space. Both the generators and the air compressors are mounted in gimbals and made up with flexible connections so that they may be operated both in the horizontal and vertical positions. The portable outriggers shown at the stern of *FLIP* are used as mountings for scientific instrumentation and will be discussed hereafter in more detail. Additional bents have been installed so that multiple hydrophones may be mounted at the 100' and 200' draft levels.

II TANK ARRANGEMENT

Ring and longitudinal frame spacing is variable. Tanks are numbered from aft to forward. (Bulkhead boundaries are marked on hull adjacent the catwalk.)

Tank:	1-T and 1-B
Boundaries:	0 to 30′
Capacity:	1-T, 192.2 LT
	1-B, 70.6 LT
Test Pressure:	10 psi

This tank is split laterally, the flat below the lateral center line.

1-B, a free-flooding tank is always flooded when the platform is water borne. Flood openings are two 6″ holes at 29′ bottom. Vent holes are at the same frame just under the flat, one on each side, diameter 2″.

1-T is serviced by two 10″ pipes extending from the bottom of the hull at 1′ bottom and opening into the flat. A 4″ vent opening is installed at the top of the tank at frame 29.8. Access is through a standard manhole in the 0 bulkhead to 1-T and then to 1-B through the flat.

Tank:	2
Boundaries:	30′ to 70′
Capacity:	351 LT
Test Pressure:	0
	No differential

This is a free-flooding tank. It is always flooded to the water line of the platform. Two large flood openings are located at frame 31. Two vents of the same size are 30° from the top center line at frame 69. Four 1″ "pocket" vents are located at frame 69, two on each side of the top center line. Access is through either of the large vent openings.

Tank:	3-T and 3-B
Boundaries:	70′ to 100′
Capacity:	3-T, 131.5 LT
	3-B, 131.5 LT
Test Pressure:	90 psi

This tank, along with 1-T, is the main flooding and blowing control tank. It is split by a flat on the lateral center line. 3-B may be flooded or blown through two oval-shaped 8″ x 10″ openings at frame 70.3. 3-T is flooded or blown through six orifices in the flat at frame 70.3. There are six 6″ holes in the flat at this point. Each is fitted with a blank flange. Four flanges have 2″ orifices and two have 3″ orifices. It is apparent that this arrangement allows a latitude of 0 to six, 6″ orifices by merely changing the size or number of holes in the flanges. This capability is provided to maintain an even flipping rate and to minimize "surge" at the end of the flip. Access is through a standard manhole in the shell at frame 71 port side. To lower section, 3-B through the flat at frame 71.

Tank:	4
Boundaries:	100′ to 140′
Capacity:	351 LT
Test Pressure:	0
	No differential

This is a free-flooding tank similar to No. 2. It is always flooded to the water line and has large open vents at frame 139 and flood openings of the same size at frame 101. Four small pocket vents are open at frame 134, two on each side of the top center line. Access is through either of the large vent openings.

Tank:	5
Boundaries:	140′ to 150′
Capacity:	Approximately 50 LT
Test Pressure:	73 psi

This is a buoyancy tank and has no capability for flooding, venting or blowing. An access tube extending from the top of tank No. 8 through the longitudinal center terminates at bulkhead 140′, the lower or after boundary of tank No.5. Access to this tank is through a standard manhole through the shell at frame 144, port side.

Tank:	6
Boundaries:	150′ to 170′
Capacity:	144.2 LT
Test Pressure:	65 psi

This tank is fitted with a 10" hydraulically operated flood valve located in the bottom of the tank at frame 151. It has the standard 3" vent line opening from the top at frame 169.8. No. 6 is not a split tank but is pierced from end to end by the access trunk.

Tank:	7-T and 7-B
Boundaries:	170' to 200'
Capacity:	7-T, 70.7 LT
	7-B, 82.5 LT
Test Pressure:	65 psi

This is a split tank. The access trunk is welded into the flat at the center line. No. 7-B has a standard hydraulically operated 10" flood valve located at frame 201 bottom. Its standard 3" vent, located at the top of the 200' bulkhead, feeds into tank No. 8 and through the hull at frame 200.5, top center line.

The flat between 7-T and 7-B is also fitted with a 10" hydraulically operated valve so that water may be dumped or blown from top to bottom or vice versa (side to side when vertical) This is to provide a means of controlling "heel" or vertical list.

7-T also is fitted with a means of flooding independently, i.e., the standard 10" hydraulically operated valve installed in a pipe reaching through 7-B to the flat. Access is through a standard manhole in the shell at frame 172. 7-B is then accessible through a manhole in the flat at frame 172. Air bank No. 1, consisting of three 48" diameter flasks 28-1/3' in length is located in this tank. Two flasks above the flat - one below.

Tank:	8
Boundaries:	200' to 230'
Capacity:	107.4 LT
Test Pressure:	38 psi

Tank No. 8 is not a split tank but is pierced by the 3' access trunk running from end to end. The standard 10" hydraulically operated flood valve is located at frame 201 at the bottom. The 3" vent opening is located at frame 229.5 top.

No. 2 air bank, consisting of three 48" diameter flasks, is located two top and one bottom in this tank. Access is through a standard manhole in the shell at frame 202.

Tank:	9
Boundaries:	230' to 270'
Capacity:	9-B, 50.4 LT
Test Pressure:	9-B, 35 psi

This is a split tank. The top, 9-T, is a buoyancy tank and has no capability of flooding or blowing. Air bank No. 3, consisting of two 48" diameter, 38-1/3' long flasks, is located on the flat. 9-B is equipped with a standard hydraulically operated flood valve located at frame 231 bottom. The regular 3" vent takes off at frame 269.5 top. Access is through a circular scuttle from tank No. 10 to 9-T and thence through two standard manholes in the flat at frames 235 and 269.

Tank:	10
Boundaries:	270' to 315'
Capacity:	120 LT
Test Pressure:	10 psi

This tank was originally split laterally by a flat which supported two additional 48" by 38' air flasks.

As more space became necessary for laboratories and machinery, it was decided to remove the air flasks and the flat. The installation of a low pressure blower negated the need for the air volume supplied by these two flasks. This space was then converted to provide four (4) additional compartments separated by non-watertight but structural bulkheads. These spaces are utilized as a compressor room, bunk-room, classified lab and pump room as viewed from forward to aft or in the vertical attitude from top to bottom. The original concrete ballast was retained and used as a deck for these spaces.

Fuel and water tanks are located in the bow section double bottoms as indicated below.

Tank:	Fresh Water	Fuel Oil
Boundaries:	315' to 318'	331-2/3' to 340'
Capacity:	15[illegible] gal.	3500 gal.

TANK CHARACTERISTICS

TANK	1-T	1-B	2	3-T	3-B	4	5*	6	7-T	7-B	8	9-B	10*
Frames	0-30	0-30	30-70	70-100	70-100	100-140	140-150	150-170	170-200	170-200	200-230	230-270	270-315
Volume, cu.ft.	6730	2470	12300	4600	4600	12300	1680	5050	2480	2880	3760	1760	5312
Capacity, long tons, salt water	192	71	351	132	132	351	50	144	71	82	107	50	120
Long. Arm, ft. from after end	15	15	50	85	85	120	145	160	185	185	215	255	295
Long. Moment, ft. tons	2900	1100	17600	11200	11200	42100	7200	23006	13100	15200	23000	12800	16225
Transverse Arm, ft. from axis	+2.2	-6.0	0	+4.2	-4.2	0	0	+1.1	+3.6	-3.6	0	-3.3	0
Transverse Moment, ft. tons	+420	-420	0	+550	-550	0	0	0	+260	-300	0	-170	0
Test Pressure, psi	10	0	0	90	90	0	73	65	50	65	38	35	10

*NOT USED FOR BALLAST

III PIPING

A. Vent and Blow

The vent-blow control lines consist generally of 3" pipe running from the forward upper end of each tank externally along the hull to the operating platform on the grating at the Engine Room level. Here they terminate in the valves used to control venting. Just below these vent control valves is a valved connection from the compressed air manifold so that by closing the vent and opening the compressed air valve it is possible to blow back down the line to force the water from any given tank. Despite the fact that reducing and relief valves have been installed in the system to provide as many safeguards as is practical, operating skill and judgment are required to prevent over-pressuring tanks during the blowing operation. Vent stops (emergency vent valves) are located in each line at its hull penetration point. The sea valves, where fitted, are of the resilient seat, butterfly type of 10" size. These valves are operated hydraulically from the operating station.

B. Hydraulic System

This simple system is used exclusively for remotely controlling the flood valves in tanks 6, 7-T, 7-B, 8 and 9-B plus equalizing valve 7-E between 7-T and 7-B.

A pressure of 1500 psi is obtained by an electric pump taking suction from a 5 gallon replenishing tank and discharging to a nitrogen loaded, free piston, accumulator. A constant pressure is applied to the system from the accumulator and is controlled by two three-valve manifolds located between the high and low pressure manifolds. No. 1 manifold controls flood valves for tanks 6, 8 and 9-B. No. 2 manifold controls flood valves for 7-T and 7-B and an equalizing valve between the two, which is designated as 7-E.

There are two stainless steel lines (1/2" pipes) leading from the manifolds to the operating cylinders for each flood valve. Valves will operate on minimum pressure of 600 lbs.

Pressure is indicated on a gauge located between the two operating manifolds. The pneumatic pump is supplied with air from the LP air manifold. A gauge and shut-off valve is located in the line between the air pump and the manifold. 25 psi is required for operating this pump.

IV AUXILIARY MACHINERY

A. Diesel Generators

Power to all electrically operated machinery is obtained from two 150 kw, 440 volt, 3-phase, a.c. generators directly driven by caterpillar Model D334TC diesel engines. Engine speed is 1800 rpm, power is delivered to the switchboard through generator mounted automatic voltage frequency regulators. Engines are gimbaled for operation in either horizontal or vertical positions. Exhaust is through swiveled, flexible lines leading over-board.

A 40 kw, GM, 3-53 diesel generator set is mounted on gimbals, adjacent to the main switch board. This set is used mainly for housekeeping but is capable of maintaining the normal research load as well. When orientation or air compression is required, one of the larger engines must be utilized. Usually the small generator is left on the research circuits in order to maintain finer voltage and frequency control.

(Operating instructions are posted in the engine room.)

B. Pumps

Two FLOMAX Model-10 motor-driven salt-water pumps are located at the after end of tank No. 10, at bulkhead 270'. These pumps furnish cooling water to the diesel engines. They are controlled by switches located on the overhead, adjacent the pumps or directly from the switchboard. Normal pressure is about 20 psi on this system. Only one sea suction valve must be opened for either or both pumps. A remote sea valve operating wheel is at bulkhead 315 in the compressor room.

The SW pump suction may be diverted to the pump room bilge - discharge is bypassed overboard in the engine room.

C. Air Compressors

Two Ingersoll-Rand Model H25M Circular Space Air Compressors are located between frames 300 and 315. These are two-stage air-cooled compressors and are rated for continuous use until air pressure reaches 250 psi. Cycle is 30 minutes on, 30 off. Compressors will automatically shut off at 250 psi. A constant watch is maintained while charging.

These machines are gimbaled for operation in either horizontal or vertical attitudes.

(Operating instructions are posted near the compressors.) (About 5 hours are required to charge all banks from 100 to 250 psi, using both compressors.)

D. Electrical Distribution

The main switchboard is located in the forward port corner of the engineering space. In general, the board is split into two sections, port and and starboard. Shore power is on the port bus. Each diesel generator supplies its side of the board, and distribution switches are duplicated so that all lights and electrically operated machinery have a source on each side and from any engine. No provision is made for paralleling generators.

Interlocks are provided so that both sources cannot be applied to any circuit simultaneously. Breakers are individually marked. Power to the board is 440 volt, 3-phase, a.c. from the board 440 volts and through transformers 110 volts for lighting, etc. 220-volt transformers for galley equipment are located at the end of the transom in the Ward Room.

An additional 110 volt circuit has been added in order to supply the electronics laboratory with separate power whenever uninterrupted voltage and exact frequency regulation is required beyond the capacity of the small generator. This circuit is fed off the main board through a transformer bank mounted in old No. 10 tank under the Engine Room access landing.

E. Laboratories

The upper laboratory, created by the deck house addition, houses ships Radar, LORAN, tranceivers, orientation controls, anemometers, and space for one rack of research instruments. Entry for instrument cables is located in the horizontal overhead.

The main laboratory located adjacent the new space when vertical, below when horizontal, provides space for 4 instrument racks. These racks, about 6' x 6', are provided with hold down fittings and electrical outlets at each location.

Normally, racks are instrumented in the shoreside laboratories, shop tested, and loaded on board *FLIP* thru the large hatches provided in the horizontal overhead of the labs while the platform is horizontal. This system improves substantially the old situation of permanently installed racks which required each instrument to be brought on board and installed individually prior to testing.

F. Orientation

A hydraulically operated orientation system has been installed in order to maintain headings in the vertical position. This system consists of two entirely divorced hydraulic units each operated by 20 hp motors driving A-end pumps which in turn drive B-ends directly shafted to propellers which are mounted on the hull at the 100-foot elevation.

The motors and A-ends are mounted in the pump room and are controlled by switches and valves on a control stand located in the electronics laboratory adjacent the entrance.

An additional component for this system is the MK 18 gyro-compass mounted on gimbals in tank 10. This compass drives two repeaters, one located at the orientation control platform for use in either H or V position. A third repeater is located in the automatic control system.

An RTI (Robert Taggart, Inc) automatic control system has been installed which provides either manual or automatic orientation.

It is planned to replace the hydraulic orientation units with an electrical system in the near future, propellers for these units will be mounted at the 150' level, and will be driven by immersed armature motors controlled substantially the same as the present system.

This is in the interest of further noise reduction.

V COMPRESSED AIR, STORAGE AND DISTRIBUTION

There are 8 air storage flasks, comprising 3 banks. They, in aggregate, store a little more than 3000 cu.ft. of air at a maximum pressure of 250 psi. No. 1 bank, three bottles, is located in No. 7-T and 7-B ballast tank; No. 2 bank, three bottles, is in No. 8-BT; bank 3, consisting of two larger bottles, is in No. 9-T ballast tank. Air from the bottles in each tank is piped to a common riser which terminates at the control platform. Thus, there are three risers and three cut-in valves at the manifold. They are plainly marked and make it possible to utilize any combination of banks for air service. Each bank may be isolated from the rest by an individual stop valve at the operating manifold. Each bottle has a 3/4" drain plug at the aft end bottom.

Reduction of air storage space has necessitated the installation of a low pressure blower which is used to void residual water after re-attaining the horizontal attitude. This blower is located in tank No. 10 at frame 312 on the partial flat and is piped directly to the high and low pressure manifolds. Blower control is also at the control station.

VI CONTROL PLATFORM

The control platform, located outside the Engine Room space at frame 315, consists of an expanded metal platform (vertical position) with railing. The platform (vertical) and the main deck (horizontal) form the operating area where all flipping controls may be manipulated from either position. In general these consist of (1) high pressure blow manifold (valves 1-T, 3-T and 3-B), (2) low pressure blow manifold fed through a reducer from the HP manifold at 75 psi (valves 6, 7-T, 7-B, 8 and 9), (3) vent manifold for all eight tanks, (4) the air distribution manifold (section V), (5) the hydraulic flood valve operating manifold, (section III-B), and (6) the air reducer between the high and low pressure blow manifolds. Further, there are gauges showing tank pressures for each tank, a hydraulic pressure gauge and the hydraulic surge or replenishing tank. The hydraulic pump is located in the engine room.

This platform is now 12' wide and has openings for fairleading cable from the oceanographic winch through the platform when vertical. An electrically driven capstan head has been mounted on this platform to augment the capabilities of positioning, highlining, and to assist in the many line-pulling evolutions inherent to underwater research.

A gyro repeater is located on the middle platform in a position which allows both horizontal and vertical utilization.

A. Deckhouse and Additional Platforms

Additional berthing and lab space has been provided by the addition of a deckhouse on the main weather deck (H) extending from frame 323 to frame 340. The house is "⊏⊐" shaped, 8' high and is fitted with ports for use in either position. The smaller of the two compartments is fitted out as officers quarters complete with shower (H only) and bathroom facilities, (H or V). The larger compartment forward (H) or above (V) contains all of the ship's communications, navigation and orientation instruments in the port corner and also furnishes additional lab space. A large 48" x 96" hatch is fitted into the deck (H) with a corresponding hatch in the overhead of the deckhouse to allow direct access for large instrument packages into the lab spaces.

The forward end of the deck house serves as a deck when vertical and is further extended by a four foot expanded metal platform at that level. There are two other platforms between this and the basic engine room platform—one at the after end of the deckhouse and one at the midpoint. These platforms extend upward in the (H) position and are reached by accommodation ladders when *FLIP* is vertical and the platforms are horizontal.

VII OPERATING PROCEDURE

Naturally the aspect of *FLIP* which has attracted the most attention and been of most interest is her capability of changing from the horizontal to the vertical attitude and vice versa while at sea. In principle, of course, this is a simple enough maneuver. If, with the platform floating horizontally on the surface, enough tanks starting at the after end are flooded while tanks forward remain dry, eventually *FLIP* must assume a vertical position. If compressed air is now used to reverse the procedure, blowing the water from the tanks thus filled, it is reasonable to expect her to return to her original attitude. This is essentially the practice which is followed. However, there are certain necessary refinements in the operation which have required the working out of careful procedures in order to achieve all of the objectives. It is desirable, for example, to have the evolution take place in a reasonably short time but not with such excessive speed as to cause alarmingly violent motions which might injure personnel or equipment. Since many of the spaces in *FLIP* are not designed to withstand sea pressure, the operation must take place in a manner which will not expose these portions of the structure to loads for which they were not designed. The height of the operating platform should be kept within reasonable limits, in part for psychological reasons, but also to avoid unnecessary loading of structure. In flipping to the vertical position it is important to prevent the initiation of a plunging or heaving motion of such amplitude that a large portion of the bow could be immersed. On the other hand, in returning to the horizontal, the conservation of the somewhat limited supply of compressed air is important and it was necessary to work out a sequence of blowing which would achieve the desired results with the least expenditure of air.

Before discussing flooding and blowing sequences it is appropriate to review the spaces available for use in the operation and the manner of controlling them. As has been previously stated, tanks 1-B, 2 and 4 are free-flooding, open to the sea through relatively large holes so that it may be safely assumed that the water level within will at any time correspond to the external water line. Tank 1-T is a "soft" tank open to the sea at the bottom at all times but fitted with a controlled vent line through which it may also be blown. Tank 3-T and 3-B are also open to the sea but controlled with vent-blow lines and differ from 1-T in the sense that they are "hard" tanks designed to withstand the maximum head of sea pressure to which they could be exposed. The flat between 3-T and 3-B is perforated with holes of limited area which permit a restricted flow of water or air to pass between the tanks. Tanks 6, 7-T, 7-B, 8 and 9-B are also "hard" tanks, and in addition to being controlled by combined vent and blow lines they are fitted with remotely operated sea valves so that they may be held flooded at any level. There is also a remotely operated valve between 7-T and 7-B.

Following is the procedure which appears to meet the above requirements best. It is possible that further operation may require modification.

A. Preflipping Check-off

Prior to each flip, the following list should be checked against actual conditions.

To Rig for Flip

From towing attitude:

1. Lock radar mast in horizontal.
2. Secure towing bridle.
3. Open all emergency vent valves.
4. Open air bank risers as required. Normally all bottles cut in.
5. Secure loose gear in all compartments.
6. Check engines clear for gimbaling.
7. Check air compressors clear for gimbaling.
8. Check engine inboard exhaust valves closed.
9. Close salt water pump sea suction.
10. Check all air ports closed.

11. Close all interior doors.
12. Close all platform doors.
13. Pump hydraulic accumulator to maximum pressure (1500 lbs). (Leave pump running.)
14. Don life jackets.
15. Unlock hydraulic valves.

From vertical to horizontal:

1. Secure engines, close exhaust valves. Check engines clear for gimbaling.
2. Secure air compressors. Check air compressors clear for gimbaling.
3. Secure all interior doors.
4. Secure air ports.
5. Secure all loose gear in compartments.
6. Close all exterior doors.
7. Don life jackets.
8. Unlock hydraulic valves.

Note: Hydraulic accumulator should be pumped to maximum pressure prior to all flips. (Pump running.)

B. Pretowing Check-off

Prior to commencing any tow:

1. *FLIP* should be trimmed to correspond with Figure 2, (1). If more drag is desired, tank No. 3-B may be flooded to produce a trim aft of not more than 14′6″.
   Optimum towing trim is obtained by free-flooding tanks No. 7-B and 6, in addition to the inherently free-flooding 1-B, 2 and 4.
2. Mast must be secured in vertical position.

To Flip Horizontal to Vertical

1. Complete preflip checkoff (H to V).
2. Check all vent and blow valves for proper operation.
3. Check 7 Tango and No. 9 dry.
4. Free flood No. 6
5. Free flood No. 7 Bravo.
6. Open No. 3 Bravo vent.
7. Open No. 1 Tango vent.
8. Open No. 3 Tango vent.
9. Close No. 7 Bravo vent and flood valve when tank is flooded. (This tank MUST be completely flooded.)
10. Close No 6 vent when tank is flooded. (Keep flood open in case emergency blowing is required.)
11. Close No. 1 Tango when tank is flooded. (May also be used for emergency blowing. Maximum differential pressure 15 psi.)
12. Close No. 3 Bravo and 3 Tango when flooded. (Buoy will be vertical before No. 3 Tango is completely flooded.)
13. Cycle No. 1 Tango, No. 3 Tango, No. 3 Bravo, No. 6 and No. 7 Bravo vents. (Release trapped air.)
14. After No. 3 Tango ceases to vent, shift the the ballast in No. 7 Bravo to No. 7 Tango through the equalizing valve No. 7-E, to to remove heel.
15. Vertical draft may be adjusted by partially flooding No. 6 if more draft is desired, or blowing for less draft.

Note 1: Using the above procedure, vertical draft should be about 285 ft. before adjusting.

Note 2: When adjusting draft with No. 6 or 8 variable tanks – do not open vent unless pressure equalizes before desired draft is attained. Pressure trapped in this tank may be used to blow it again while surfacing.

Note 3: Keep hydraulic pressure maximum at all times.

Vertical to Horizontal

Start with 7 Bravo and No. 9 dry.

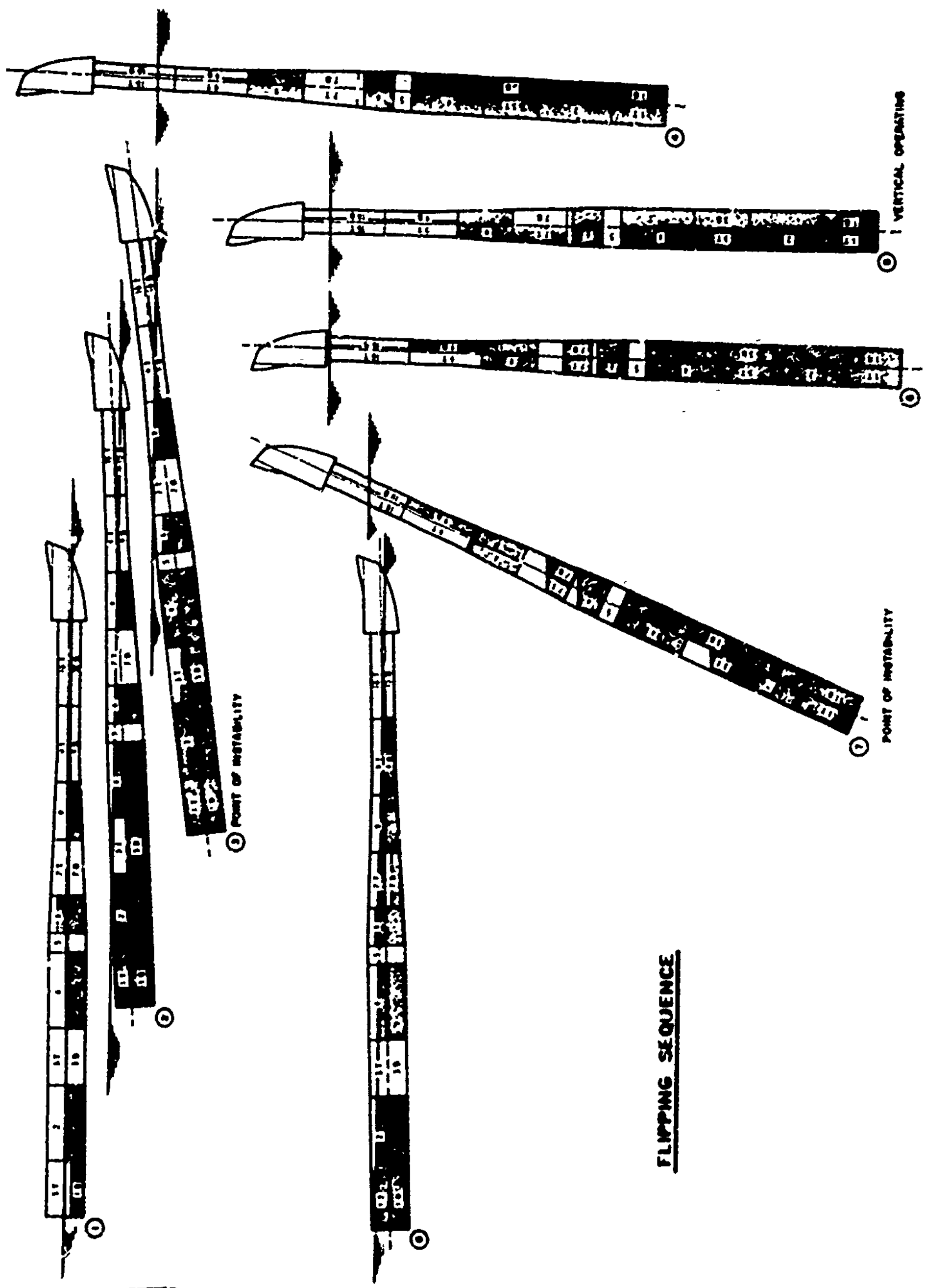
1. Complete preflip checkoff (V to H).
2. Transfer all ballast from No. 7 Tango to 7 Bravo (be sure 7 Bravo is full) through the equalizing valve.
3. Check all other vents closed.
4. Check air to high and low pressure manifolds (normally all banks on the line minimum pressure at least 240 lbs).

5. Blow No. 3 Tango at 120 psi until draft of 290 ft. is attained.
6. At draft 290 ft. flood No. 9 while continuing to blow No. 3 Tango.
7. When angle of 10° from vertical is reached, reduce pressure on No. 3 Tango to 100 psi.
8. When angle of 20° from vertical is attained, secure air to No. 3 Tango.
9. When *FLIP* broaches, open No. 1 Tango vent to allow tank to empty to sea.
10. Any residual pressure in No. 7 Tango should be used to blow No. 7 Bravo to sea using No. 7-E to cross connect.
11. If No. 6 has been used for adjusting vertical draft, blow with trapped air.
12. Blow No. 9 using air trapped in No. 3 Tango and manifold cross connect.

Sequence (1), Figure 2 illustrates the general distribution of liquid load which has been arrived at as a good compromise between stresses in both the hogging and sagging conditions, and a draft and trim which makes the platform comparatively easy to handle on the end of a tow line.

The foregoing checkoffs and instructions are to be used as guides and for training purposes.

It is not intended that unqualified personnel should attempt operation of machinery or of *FLIP* itself.



FLIPPING SEQUENCE

FIGURE 2

VIII NAVIGATIONAL LIGHTS AND SHAPES

When engaged in research in the vertical position at night, vertical lights - Red, White, Red must be lighted. Switches are in crews quarters.

When engaged in day operations, shapes in the form of Red Ball, White Diamond, Red Ball must be shown at the yardarm. These are stored in bosn's locker made up for use

When under tow at night the standard red and green running lights are to be turned on as well as the shielded stern light. During daytime the standard black diamond is shown at the yardarm.

When moored at a buoy, the obstruction lights aft must be lighted, as well as the all around white light forward.

A fog horn, which may be set for either inland or international signals, is activated by controls located in the Engine Room.

A portable bell for fog signals is located in the bosn's locker. A bracket for mounting the bell is located in the A frame adjacent the fog horn. In fog the bell is to be rung for 10 seconds each minute if *FLIP* is at anchor or moored.

IX SAFETY PRECAUTIONS

A. Drainage

All habitable spaces are fitted with a sump at the after corner of each compartment. Each sump is serviced by a 2" drain connection which terminates at a suction manifold in the engine room. The manifold may be manipulated so that individual or multiple compartments can be pumped overboard by a Marlowe Model H22 pump situated adjacent the manifold. Controls are at hand. A bilge alarm will ring in the engine room if water collects in lower tank 10.

Water collecting in the forward (upper) four compartments may also be removed by a portable electrically driven pump which is stowed in a bracket in the machinery space, starboard side. The machinery space may be pumped without removing the pump from the bracket. Suction and discharge hoses are attached. To pump any space beyond reach of the suction hose, the pump must be carried to that space and the motor plugged into the nearest 110 volt outlet.

Two portable electrically driven submersible pumps are available in the *FLIP* storeroom at all times for pumping tanks beyond the normal blowing-out limits. These pumps may be carried on board if desired.

B. Isolation of Tanks

From time to time it may become necessary to enter a tank for inspection or other purposes. Tanks No. 6, 7, 8 and 9 may be blown nearly dry by the normal process of opening the flood valve closing the vent and blowing. After blowing until an external bubble is apparent - close the blow valve, then the flood. Manhole cover can then be removed and tank entered *after* venting off excess pressure. Residual water, about 10 inches, must be pumped through the manhole with one of the pumps mentioned in section IX-A.

Tanks 1-T, 1-B, 2, 3-T, 3-B and No. 4, having no flood valves must be blanked before entry. A summary of methods and material needed follows:

Tank	Material	Method
1-T	Two 10" wooden plugs for floods	Diver required
1-B	Two 6" wooden plugs	Diver required
	Two 2" wooden plugs (vent holes)	Diver required
2	Two large blank covers stowed in wet lab bilge	Diver required
3-B	Two blank covers stowed in wet lab bilge	Diver required
3-T	Interconnected with 3-B No blank required when 3-B is blanked	
4	Same as No. 2	Diver required

Tanks No. 5 and No. 10 are buoyancy tanks and may be entered through the manhole at any time. Locations of manholes are tabulated in section II. In addition there is a small manhole to No. 5 through the access trunk.

C. Salvage

Inasmuch as the removal of water from tanks No. 1-T, 3-T and 3-B provides sufficient buoyancy to surface the buoy (i.e., change from vertical to horizontal), only 1-T and 3-T are fitted with salvage connections.

The salvage connections are standard 1-1/4" pipe connections with valves at the top center line (horizontal) located adjacent the emergency vent stops for these tanks. The male nipple on each is fitted with a cap having an 8" toggle welded to it. The toggles are pointed fore and aft and are supplied to facilitate location and removal by a diver.

If loss of air capacity or other casualty occurs while vertical, and surfacing becomes necessary, an air hose may be connected to these two salvage fittings and tanks blown from an outside source -- diver required.

D334 GENERATOR ENGINES

Starting Instructions

WARNING: Never start an engine with compartment door closed.
Never close doors and ports while an engine is running.

1. Check lube oil level with dip stick located at base of engine. (Make-up oil is in a tank located on the starboard side of the engine room.)
2. Check fuel level in day tanks directly under engine (direct reading dial on top of tank). Make-up fuel is carried in void tank under laboratory and is shifted to day tanks by means of a small electric pump located under the catwalk.
3. Open sea suction valve (remote operating wheel just inside No. 10 tank hatch).
4. Open overboard discharge valve (individual valves located just inside engine room aft).

4a Start SW-main switchboard as soon as power is available.

5. Open exhaust valves (top of engine room starboard side - special wrench adjacent).
6. Check breaker switch on generator panel - OFF.
7. Adjust throttle to 800 rpm.
8. Depress starter button on engine panel until engine fires.
9. Adjust engine speed to 1800 rpm.
10. Turn breaker switch generator panel to ON. (Adjust voltage to 440 volts by generator panel voltmeter.)
11. Check for water pressure - 20 psi (gauge just on top of optical tube aft).
12. Turn selector on generator panel to AUTOMATIC.
13. Turn distribution switches on switchboard to port or starboard, depending upon which engine is operating. (The down or right-hand side is port, opposite is starboard.)
14. Transformer switch on switchboard must be on for 110 volt distribution, lights, etc.
15. Make "Starting" entry in engine log.

Stopping Instructions for D334 Engine

1. Cut power (field) switch on board.
2. Trip throttle to stop engine.
3. Close exhaust valve.
4. Close sea valve and overboard discharge.
5. Make "Stop" entry in engine log.

Note 1: If engines are shifted, do not close sea valve and overboard discharge.

Note 2: Salt water pumps start manually. Be sure that proper side of switchboard is cut in; i.e., starboard pump switch for starboard engine, port to port. (Green light shows on board.)

Note 3: Engine low pressure and high temperature alarms should be set on NORMAL when operating. If alarm sounds -- shut off alarm (shut-off switches are located in each compartment). Then check gauges for cause: In case of actual high temperature or low pressure, secure engine and call engineer to investigate. Start standby engine.

3-53 GENERATOR ENGINE

Starting Instructions

Same as D334 **Generator Engines** Power to main switchboard is on starboard bus and is plainly marked.

Stopping Instructions for 3-53 Engine

1. Cut power on board.
2. Trip throttle.

Note 1: This engine has automatic overload and overheat cut-off.

AIR COMPRESSORS
Starting Instructions

WARNING: Air supply is from compartment. Door must be open before starting.

1. Check lube oil level in crankcase. (Use dip stick in unit base.) Additional oil is available in a 15 gal. drum nearby.
2. Open "Air to Manifold" valve on riser at starboard end of high pressure manifold under the shore connection terminal.
3. Open at least one air bank supply valve on three (3) valve manifold over high pressure manifold. (Gauge on high pressure manifold indicates bank pressure.)
4. Set selector on compressor starting panel to ON.
5. Be sure unit is cut in on main switchboard.
6. Set selector switch on compressor to AUTOMATIC.
7. Push start button on compressor control panel.

Note: These compressors are designed to operate continuously to 200 psi and intermittantly from 200 to 250 psi.

X HABITABILITY

The question of habitability became most important when it was found that open sea transfer of personnel was not always feasible. Accordingly, the space between frames 313-1/3 and 331-2/3 was divided into four compartments and fitted out as (1) galley and messing, (2) wardroom, (3) berthing and (4) head.

In the horizontal position the four compartments are two over two. In the vertical position the four become adjacent rooms on one level.

1. The galley includes a deep freeze, refrigerator, three-burner range, oven, and sink. Working areas are adjacent to the deep freeze and range. All the above is gimballed in one large frame so that all units are usable in either position.

A system of plywood shelves and cabinets have been attached near the freezer, range and sink so that they too are always upright and usable. A mess table and folding chairs are provided for seating five. These must be folded and stored during flipping operations.

2. The wardroom, directly under the galley in the horizontal position but becoming adjacent when vertical, consists of a two-position transom, a table capable of seating five, book and magazine racks, a broadcast receiver, and various other minor items. The table and chairs are folded and stored for flipping but the transom is rigged so that the seat becomes the back and vice versa for the two operating positions. Lockers for provision storage is located behind and under the transom cushions.

3. The berthing compartment is adjacent the wardroom and contains four gimballed bunks along with lockers for occupants, linen lockers and ventilation fans. Access from the bunk room to the head and wardroom is provided in the vertical position but only to the wardroom while horizontal.

4. The washroom and head is located over the starboard end of the berthing compartment in the horizontal position, adjacent when vertical. There are two wash basins—one for vertical, one for horizontal located at 90° angles, a shower usable only in the vertical position, the hot water heater which operates in either position, the medical locker, the water closet on telecoping standards and attached to a swivel-jointed drainpipe, plus other minor items.

5. Access to all these compartments is by "L" shaped doors or in the horizontal position by ladders. Food storage lockers are built along the outboard bulkheads and are fitted with small compartments to prevent spilling of contents.

In addition a large, gimballed refrigerator is installed topside on the weather deck. Additional bulk dry storage is located adjacent the engine room in tank No. 10.

6. Berthing facilities for crew and junior scientific personnel are located in the crews quarters forward and in a portion of the tank 10 conversion, a total of 16 berths are available.

7. Because of a need for still more research and berthing space, the new deck house conversion included a ships officers cabin containing two bunks, a shower and head.

By removal of the two large air flasks and the flat on which they were mounted, a circular space 45' in length and 12' in diameter was made available. This space has been divided into four compartments (H) or three decks (V). The air compressors have been moved to the first of these compartments and the others utilized as shown under "tank 10," Chapter II.

8. A 7-1/2 ton chilled water air conditioning unit has been installed in the pump room. This is a closed system which supplies chilled water to evaporators in all compartments except the engine and Air Compressor rooms. Each compartment has its own thermostat for individual temperature control.

The entire hull from frame 270 forward has been insulated to enhance performance of the air conditioning system.

XI OPERATIONAL RECORD

Because of vertical stability and the simplicity of design and operation, *FLIP* has exceeded by far its design criteria in operational capabilities.

As of this date there have been about 100 expeditions conducted by *FLIP* under leading MPL and SIO scientists. Practically all of these researchers have requested more *FLIP* time for future work in their specialties.

The field of applicability has continually widened as the advantages of a stable platform have been realized. So far, operations have encompassed studies in wave attenuation, sound propagation and bearing accuracy phase fluctuation, microthermal recording, ambient noise, seismic wave recording, meteorological research, wave pressure and acceleration measurements and measurement of internal waves by means of a thermistor chain. In addition, there have been other studies of a more classified nature.

Future planning includes a capability for biological oceanographic research as well as more on the physical projects already mentioned.

FLIP has spent some 1000 days at sea and has completed the transition from horizontal to vertical and return more than 200 times.

Although designed with an endurance capability of two weeks at sea, an operation of 45 days duration was scheduled and completed in late 1963. During this operation in the Gulf of Alaska 1800 miles from San Diego, *FLIP* was vertical for 27 consecutive days. Stores, fuel and water were transferred by highline once during this period. Ten men subsisted on board with relative comfort during the entire operation. Towing time to station was 10 days, the return trip 8 days.

While on station, gale force winds and seas were practically continuous and offered ample opportunity to evaluate *FLIP*'s capabilities. Maximum vertical oscillation was measured at *less than 1/10* wave height. Seas to 35′ were encountered during this period. Since this para-design operation there have been four deployments to Hawaiian waters where *FLIP* operated out of Honolulu for a period of 7 months, 3 months and 2 months respectively. Another Hawaiian expedition is scheduled for early 1970.

From late March to early August 1969 *FLIP* operated in the Caribbean as a valuable unit of the huge *BOMEX* operation off Barbados and then north of Puerto Rico collecting more data on bottom profiles.

As operating experience and confidence have been gained, it is no longer considered necessary to keep a vessel in attendance while on station. Tugs have been released for periods of over four weeks when it is desired to keep the local noise level to a minimum and/or reduce expenses.

Sea-keeping characteristics while under tow are quite satisfactory. *FLIP*, owing to a long "wheel base" and low freeboard, rolls much less than a conventional ship. The capability of flooding the lower half of the laterally split tanks may also be used to improve horizontal stability. Addition of the deckhouse has improved topside habitability while under tow and has provided much needed head facilities as well as a shower.

Towing speeds have ranged to 10 knots and are apparently limited only by the capabilities of the towing vessel and towing tackle.

Commercial tugs are normally used for towing although Scripps vessels may be used when the research at hand requires special services of the towing vessel.

Navy tugs have been supplied when operations such as *BOMEX* would require two ocean services of extended duration.

Vertical tows are also made for stationkeeping or very small changes in position.

It has, in the last few years become apparent that certain types of research can be more efficiently conducted from a stationary rather than drifting platform, accordingly a deep mooring system has been developed. The first mooring-made from a single point in 3000 fathoms, north of Hawaii in 1969 was successful and from this simple beginning a multiple point anchorage capability has emerged. It is now possible to moor *FLIP* from 3 points in any depth. One recent expedition maintained position in 2500 fathoms for a period of 35 days. The mooring line and components, except for bottom tackle are recovered and reused. There have been 10 successful deep moorings to date - more are scheduled.

Although *FLIP* has performed far beyond expectations, constant upgrading and changes are required to keep pace with the new uses found for this unique and valuable deep-sea research tool.