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FLIP, FLoating Instrument Platform

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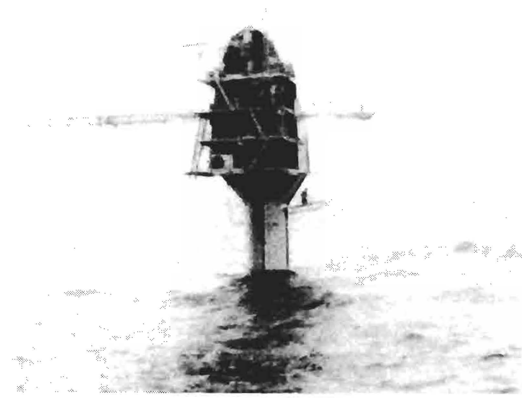

FLIP

FLoating Instrument Platform

Earl D. Bronson and Larry R. Glosten

(Revision of previous SIO Reference 73-30
by Charles B. Bishop and Dewitt O. Efird)

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CONTENTS

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"
aft	12' - 5"
Draft Horizontal Normal	
fwd	10' - 5"
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. 3B	30 Long Tons
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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ABSTRACT

A general summation of the construction, operation and potential of the R/P FLIP. FLIP, i.e., **FL**oating **I**nstrument **P**latform, is designed as a super-stable open-sea free-floating platform from which to conduct research in the field of physical oceanography.

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 12-1/2 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. Arriving 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

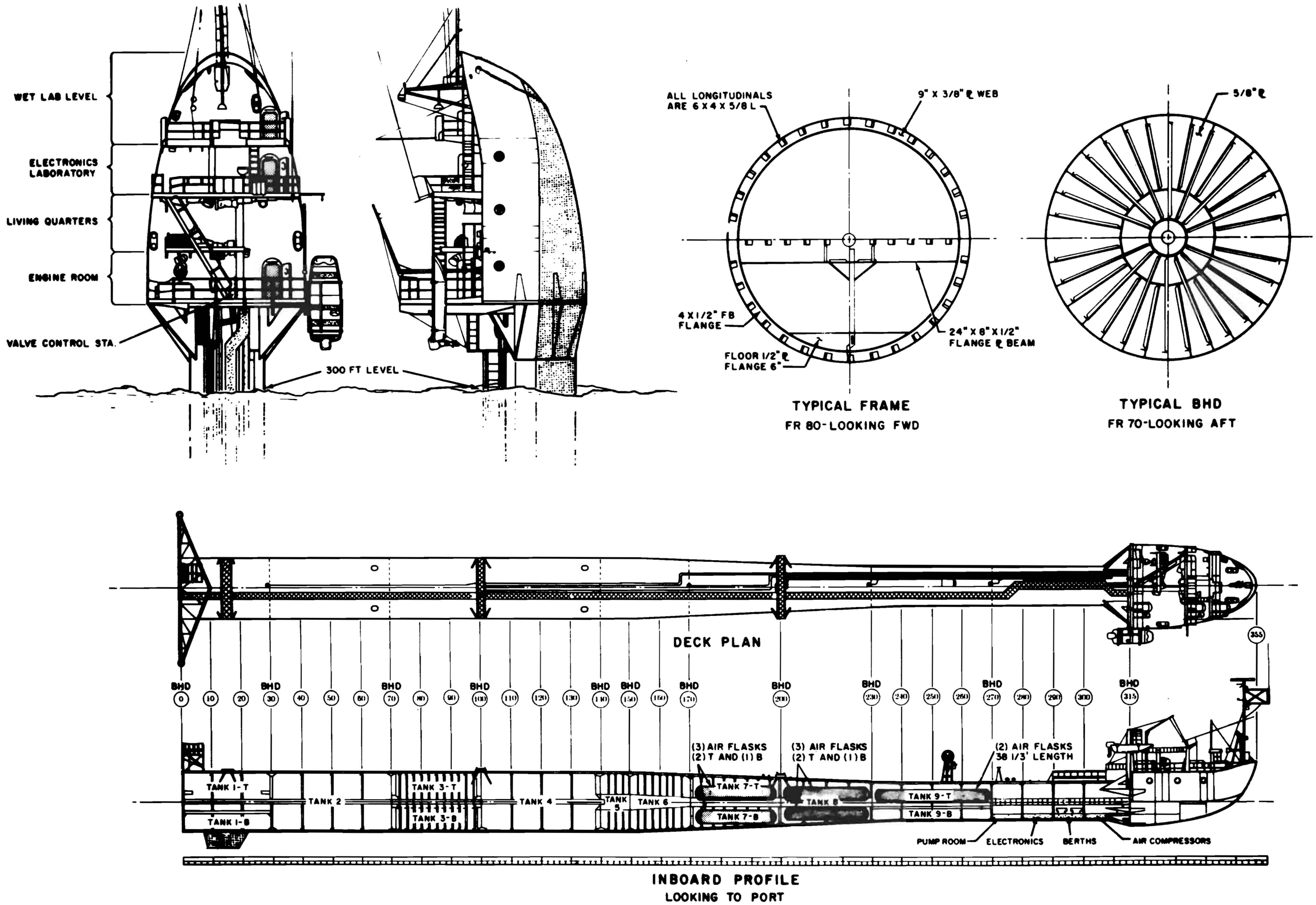
WET LAB LEVEL
ELECTRONICS LABORATORY
LIVING QUARTERS
ENGINE ROOM
VALVE CONTROL STA.
300 FT LEVEL
ALL LONGITUDINALS ARE 6 X 4 X 5/8 L
9" X 3/8" ℞ WEB
4 X 1/2" FB FLANGE
FLOOR 1/2" ℞ FLANGE 6"
24" X 8" X 1/2" FLANGE ℞ BEAM
TYPICAL FRAME
FR 80-LOOKING FWD
5/8" ℞
TYPICAL BHD
FR 70-LOOKING AFT
DECK PLAN
(3) AIR FLASKS (2) T AND (1) B
(3) AIR FLASKS (2) T AND (1) B
(2) AIR FLASKS 38 1/3' LENGTH
TANK 1-T
TANK 1-B
TANK 2
TANK 3-T
TANK 3-B
TANK 4
TANK 5
TANK 6
TANK 7-T
TANK 7-B
TANK 8
TANK 9-T
TANK 9-B
PUMP ROOM
ELECTRONICS
BERTHS
AIR COMPRESSORS
INBOARD PROFILE
LOOKING TO PORT

Figure 1

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 has been no apparent necessity for doing this, and all scientific work has been done from the operating platforms above the 300 foot water line. Observations deep below the surface are made by means of instruments fixed to the hull or lowered on cables.

However, Tank No. 5, frames 140 and 150, now a buoyancy tank, can be altered to a biological observatory in the future.

Running through the axis of FLIP is a 12-inch diameter tube providing a straight, clear line of sight from Tank No. 5 to the bottom or after end of FLIP, but not for direct visual observation into the water. FLIP can remain on station in a vertical position indefinitely, 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 space 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 submarine terminology, 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 water level within them coincides with the external surface of the water. In the horizontal position Tanks 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 judgement must be exercised to insure that excessive pressures are not allowed to build up in 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. Tank No. 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 No. 6 is the variable tank which is used to control the draft in the vertical position. Tank No. 9-B is fitted for flooding and is normally empty except during the evolution of flipping from the vertical to the horizontal positions, 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. Tank No. 8 is normally empty, but can be used as variable ballast.

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 air compressors are mounted in gimbals and made 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 beams have been installed so that multiple hydrophones may be mounted at the 100' and 200' draft levels.

II. TANK ARRANGEMENT

Ring frame and longitudinal 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:	Approx. 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

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	192.2	70.6	351	131.5	131.5	351	50	144.2	70.7	82.5	107.4	50.4	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	23000	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
Vent Line Pressure psi	120	0	0	120	120	0	0	75	65	65	40	30	0

*NOT USED FOR BALLAST

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, bunkroom, gyro room 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:	1500 gal.	3500 gal.

III. PIPING

A. Vent and Blow

The vent-blow control lines consist generally of 3" schedule 40 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 67, 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 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.

An automatic backup system for flood valve control is provided by a pneumatic pump which 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, which are disconnected when flipping.

A 40 kw, GM, 3-53 diesel generator set is mounted on gimbals, adjacent to the main switchboard. 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. It provides power while flipping since all its connections are flexible.

B. Pumps

Two FLOMAX Model-10 motor-driven saltwater 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 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. Watermaker

A reverse-osmosis fresh watermaker is installed on a gimballed platform in the Engine Room. It is capable of producing 400 gals/day, and requires, 220 v, 3KW.

E. 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 starboard. Shore power is on the starboard 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 volts, 3-phase, a.c.; from the board: 440 volts, and through transformers 110 volt for lighting, etc. and 220 volt for galley equipment.

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.

F. Radar/Communications

The radar installed is a Furuno model 1011 with 48 NM maximum range scale. Its display is located in the upper lab. Radio equipment located in the upper lab includes:

HF/SSB(USB)	Raytheon-1275A	XCVR(4-22MHz)
	Raytheon-1275B	XCVR(4-16MHz)
	SGC (AM compatible)	XCVR(2-10MHz)
	USN-R1051	RCVR
VHF	INTEC-V108	XCVR-(12 channels)

G. Orientation

An hydraulically operated orientation system has been installed in order to maintain azimuthal direction when in the vertical position. This system consists of two entirely divorced electro-hydraulic units, one of 60 HP and one of 25 HP, driving A-end pumps which in turn drive B-ends directly shafted to thrusters mounted on the hull at the 250-foot level.

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. An additional component for this system is the MK 27-4 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.

V. COMPRESSED AIR, STORAGE AND DISTRIBUTION

There are 8 air storage flasks, comprising 3 banks. They store a total of 3000 cu.ft. of air at a maximum pressure of 250 psi. No. 1 bank of three bottles, has two in No. 7-T and one in 7-B ballast tank; No. 2 bank of three bottles, is in No. 8; 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. The bottles are secured horizontally by clamps and vertically by retaining rods.

Reduction of air storage space has necessitated the installation of a low pressure blower which is used to void residual water after returning to 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 manifold. 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 24' x 12' 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 and 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 L-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 part corner and also furnishes additional lab space. A larger 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 deckhouse 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.

B. Laboratories

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

The main laboratory located alongside the upper lab when vertical, below when horizontal, provides space for 4 specially constructed instrument racks. These racks, about 6' x 6 'x 2" 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 through the large hatches provided in the horizontal overhead of the labs while the platform is horizontal.

VII. OPERATING PROCEDURES

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. Tanks 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 would 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.

A. 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 draft of not more than 14'6". Towing trim for heavy seas 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.

Note: Towing bridle length is 30 ft. Towing pendent length is 100 ft.

B. Preflipping Check-off

From towing attitude:

1. Secure towing bridle
2. Lock radar mast in horizontal
3. Secure loose gear in all compartments and on deck.
4. Check electrical load on 40 KW units.
5. Check following equipment for gimballing:
   - a) all bunks
   - b) galley
   - c) engines
   - d) gyro
   - e) air compressors
   - f) thruster motor
   - g) deck chill box

6. Check all air ports closed.
7. Close head discharge valves, close all interior doors and hatches.
8. Close all platform doors. Close intake to Tank 10 vent.
9. Pump hydraulic accumulator to maximum pressure (1300 lbs). (Leave pump running.)
10. Don life jackets
11. Unlock hydraulic valves.
12. Open air bank risers as required. Normally all bottles cut in.

From vertical to horizontal:

1. Transfer electrical load to 40 KW generator and secure main engines.
2. Secure air compressors. Check air compressors clear for gimballing.
3. Secure all interior doors.
4. Secure air portal
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.)

C. To Flip Horizontal to Vertical

1. Complete pre-flip checkoff (Horizontal to Vertical).
2. Check all blow and vent valves for proper operation.
3. Blow Tanks 9B, 8, 7T and 6 with low pressure blower. (Tanks must be empty.)
4. Flood Tank 7B until full, then secure vent and flood valve.
5. Flood Tank 1T for 15 minutes
6. Flood Tank 3T for 10 minutes (5,6 can be done simultaneously).
7. Disconnect tow and make below deck check off. Secure all hatches and gates and lower mast (Shut gate on expanded metal decks).
8. Open flood valve on Tank 6.
9. Open air bank risers
10. Open vents to Tanks 1T, 3T and 3B.
11. Let Tank 6 pressurize to 18 pounds, then close flood valve (adjust for scientific load).

12. After FLIP is vertical, make below deck inspection 13. Open flood valve 7E 14. Open vent 7B and 7T.
15. Secure air bank risers.
16. When 7T and 7B are equalized, secure vent 7B.
17. Open blow on 6 and 7B.
18. When Tank 7T stops venting, secure blow valves 6 and 7B.
19. Open air bank risers.
20. Blow 7B until 7T stops venting (or until heel is connected).
21. Secure all vents, blow and flood valves.
22. Record tank pressures.

D. Flip Vertical to Horizontal

1. Complete pre-flip checkoff (Vertical to Horizontal).
2. Bring all air flasks up to 250 psi and secure manifold.
3. Open flood valve 7E
4. Open blow valves 7B and 7T
5. When 7B and 7T equalize, secure blow valve 7B.
6. Open vent 7B.
7. When 7B stops venting, open blow valve 6.
8. When 7B again, stops venting, secure all valves.
9. Make inside inspection and secure all hatches.
10. Open flood valve 7E
11. Open vent 7B.
12. Open air bank manifold (all banks cut in).
13. Blow 3T at 120 psi and maintain.
14. When FLIP rises 5', open flood valve 9B (FLIP will go to original draft).
15. When FLIP again rises 5', open vent 9B until full (secure vent when tank is full).
16. Blow 7T until 10 psi on gauge.
17. When FLIP reaches 45°, reduce blow on 3T to 100 psi.
18. When FLIP reaches 30°, secure air banks.
19. Open cross-over valve 3T to 9B (maximum 10 psi on 9B).
20. Open blow valve on Tank 1T (maximum 10 psi).
21. When Tank 9B is empty, secure all valves 22. Blow Tanks 1, 3, 6, 7B, 7T, and 8 with low pressure blowers.

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

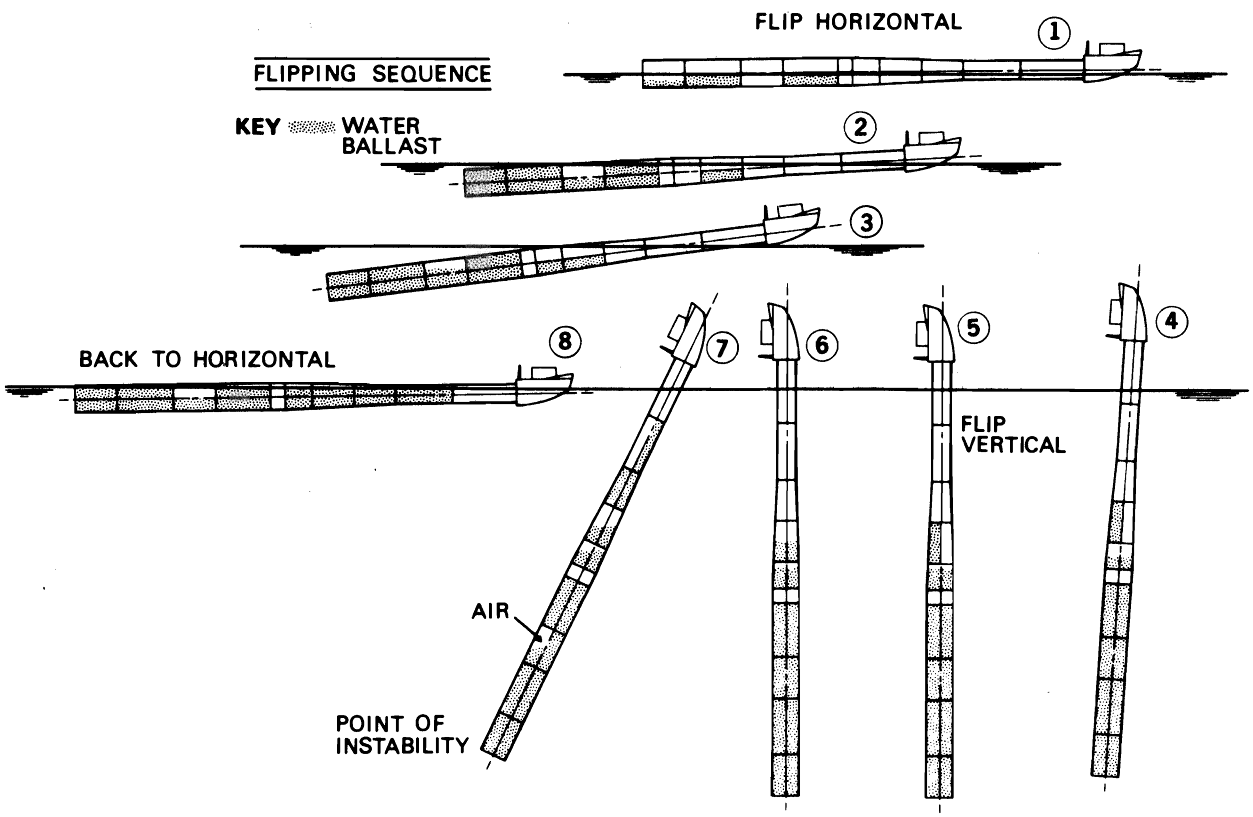
FLIPPING SEQUENCE
KEY WATER BALLAST
FLIP HORIZONTAL
1
2
3
4
5
6
7
8
BACK TO HORIZONTAL
FLIP VERTICAL
AIR
POINT OF INSTABILITY

Figure 2

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.

Unqualified personnel should not attempt operation of machinery or of FLIP itself.

VIII. NAVIGATION 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, block shapes in the form of Ball, Diamond, 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.

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 blanketed before entry. A summary of methods and materials 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 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 FLIP (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 capable of 200 ft depth is required.

D. Fire Fighting

CO_2 or Halon extinguishes are located in readily available storages throughout the platforms manned spaces. Breathing apparatus (5 sets) are stored in Tank 10 bunkeroom. Procedures to be followed in case of Fire aboard FLIP:

Situation I: Fire is discovered in spaces other than Engine Room.

Action:

(Discoverer)

1. Voice alarm "Fire-Fire-Fire-Location".
2. Evacuate personnel from affected spaces.
3. Fight fire with CO_2 Halon extinguisher until relieved.

(Flip Crew)

1. Proceed to scene of fire and relieve fire fighters.
2. Ensure personnel evacuated from affected spaces.
3. Secure electrical circuits to affected spaces.
4. Provide emergency lighting.
5. Provide backup extinguishers.
6. Notify escort ship and WWD of situation by radio, including FLIP's position.
7. SIC muster scientific party in clear area, with lifejackets.
8. Determine cause of fire and correct.

Situation II: Fire is discovered in Engine Room, or fire alarm sounds.

Action:

(Engine Room)

1. Stop engines.
2. Secure switchboard.
3. Evacuate personnel from Engine Room.
4. Secure hatch to Tank 10 and doors to galley and outside platform.
5. Activate Halon fire fighting system.
6. Establish sound-powered telephone contact with personnel in Tank 10 and maintain.
7. After 10 minutes, enter Engine Room wearing emergency breathing apparatus, verify fire out, determine cause of fire and correct, and if safe, ventilate.

(Tank 10)

1. Secure hatch to Engine Room.
2. Don emergency breathing apparatus, minimize activity.
3. Establish sound-powered telephone contact with personnel in Lab Space.
4. Follow instructions of Officer-in-Charge.

(Lab Space)

1. SIC muster scientific party with lifejackets.
2. Notify escort ship and WWD of situation by radio, including FLIP's position.

E. Life Rafts/Preservers

Two Zoman inflatable life rafts are stored topside, port and starboard, equipped with emergency rations and signalling equipment. They can be released manually or hydrostatically.

Individual life preservers (PFDs) are stored in locker in forecastle.

An EPIRB (Emergency Position Indicating Radio Beacon) is mounted topside.

D334 GENERATOR ENGINES

Starting Instructions

Warning: Never start engine without compartment properly ventilated.

1. Check lube oil level with dip stick located at base of engine. (Make-up oil in a tank located on the starboard side of the engine room). Check engine cooling water.
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. Start raw water pump on main switchboard as soon as power is available. Check for water pressure, 20 psi (gauge located port side).
5. Check breaker switch on generator panel (off).
6. Depress starter button on engine panel until engine fires.
7. Allow engine to idle and check for proper oil pressure and cooling water pressure.
8. Turn engine alarms on (normal).
9. Adjust throttle slowly to 1800 rpm (60 cycle).
10. Rotate regulator control switch to manual.
11. Adjust voltage to 450v with normal control rheostat.
12. Rotate regulator control switch to automatic.
13. Adjust voltage to 450v using auto voltage rheostat. Engine and generator are now ready to supply power by closing circuit breaker on control panel.

    Warning: On port engine do not close circuit breaker until it is verified that port buss of switchboard is not being supplied from 3-53.

Stopping Instructions for D334 Engine

1. Shift electrical load to another source of power.
2. Stbd. engine - turn circuit breaker on switchboard off (no breaker for port engine).
3. Turn circuit breaker (150A) on generator panel off.

4. Turn regulator control switch to manual.
5. Reduce voltage to minimum with manual control rheostat.
6. Reduce engine speed to 800 rpm.
7. Turn regulator control switch to off.
8. Turn engine alarms to off.
9. After about 5 minutes stop engine (during emergencies secure immediately).

Note 1: If engines are shifted do not close sea valves or overboard discharge.

Note 2: Engine low pressure and high temperature alarms should be set on *normal* when operating. If alarm sounds - shut off alarm, then check gauges for causes. 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

1. Check cooling water.
2. Check lube oil.
3. Start s/w raw water pump (same as for D334)
4. Check circuit breakers on switchboard and generator. Set to off.
5. Set throttle in idle position.
6. Pull shut down override out.
7. Press start button until engine fires then release.

Note: If engine fails to start in 30 seconds, release button and wait a few minutes before trying again.

8. Note oil pressure after engine has started, and when pressure reaches 40 psi, release override.
9. Allow engine to idle approximately 5 minutes.
10. Increase engine speed until 60 cycles is observed on generator panel.
11. Adjust voltage to 450 volts using voltage adjust rheostat.
12. Turn circuit breaker on generator to "ON".

The generator is now able to supply power to switchboard either port or stbd buss, by closing appropriate circuit breaker on switchboard.

Warning Be sure that the buss you plan to supply is not being supplied by another generator. When shifting secure power to buss then close circuit breaker for 3-53.

Stopping Instructions

1. Shift electrical load to another source.
2. Turn circuit breaker(s) on switchboard to off.
3. Turn circuit breaker on engine to off.
4. Reduce voltage to minimum using voltage adjust rheostat.
5. Reduce engine speed to idle, and wait 5 minutes.
6. Trip engine throttle.

Note: This engine has automatic overspeed, overheat and loss of lube oil shut down.

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 at control manifold.
3. 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. Push start button on compressor control panel.

Note 1: These compressors are designed to operate continuously to 200 psi and intermittently from 200 to 250 psi.

Note 2: Start ventilation to compressor room.

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, four-burner range, oven and sink. Working areas are adjacent to the 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 has been attached near the freezer, range and sink so that they 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, 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 are 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 attached to a swivel-jointed drainpipe, plus other minor items.

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 storage is located adjacent the Engine Room in Tank No. 10.

Berthing facilities for crew and junior scientific personnel are located in the crews quarters forward and in a portion of the Tank 10 conversion. Because of a need for still more research and berthing space, the deck house conversion included a ships officers' cabin containing two bunks, a shower and head. A total of 16 berths are available.

By removal of the two large air flasks and the flat on which they are 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.

A 7- 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.

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 measurements of internal waves. In addition, there have been other studies of a more classified nature.

FLIP has spent over 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 operation there have been four deployments to Hawaiian waters where FLIP operated out of Honolulu for a period of 7 months, 3 months, 2 months and 5 months respectively.

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.

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.

Both Navy (USN and USNS) and commercial tugs are used for towing although Scripps vessels may be used when the research at hand requires special services of the towing vessel.

Vertical tows at 3/4 - 1 Kt can be made for stationkeeping or very small changes in position.

Since certain types of research can be more efficiently conducted from a stationary rather than drifting platform, 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 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 many successful deep moorings to date.

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.