# EXPLORING INNER SPACE

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## Introduction

MANKIND'S programs for outer space exploration have been publicized by all international media of information. More orbits around the earth, space platforms, and visits to other worlds have been forecast. Landings and stations on the moon and planets of the solar system are under consideration for the future. But this exploration, fascinating though it may be, seems a paradox to oceanographers, who realize the depth of man's ignorance concerning the resources of inner space—the oceans that cover seven-tenths of our planet.

Scientists and technologists who move in the opposite direction from their colleagues in outer space work believe that humanity in general will benefit far more by utilizing the vast and untapped resources of inner space, than through exploration of outer space.

Why should the oceans be studied far more intensively than at present? What does it matter what is below the sea surface? There are many answers to these questions. First—and perhaps most compelling—inner space offers an economic richness of food, minerals, and other resources in a superabundance that has not even begun to be exploited, but which is available to any peoples who will direct scientific effort to obtaining it.

Environmental factors that control the life processes or abundance of sea organisms are as yet not well understood.[1] Cheap and abundant food for the protein-deficient peoples of the world should be a primary objective of any study of the sea.[2]

Another item of economic importance is the mineral wealth contained in the sea-water and on the sea-floor. Most people are aware of the salts of the sea, not only sodium chloride the table salt, but bromides and iodides which are nearly as important. Others of these minerals such as calcium will plate out on the sea-floor. Even more essential are the phosphates and manganese oxides. Their abundance is beyond belief, but technology for recovering them remains inadequate.

Aside from the economic aspects, a knowledge of the sea is necessary for efficient navigation both for commercial and naval ships. The sea can also offer protection from enemy attacks by serving as a shield against radiation blasts and by providing a means for eluding pursuers. When the situation is reversed and it is the enemy that must be sought out, difficult problems are manifest. The sea is nearly opaque to some types of light and sound, and it must be analyzed closely to establish the best ways of seeing, hearing or sensing through it. Ships must go on top of the water as well as through it. Designing them to travel fast and safely requires a knowledge of such aspects of the sea as viscosity, turbulence, corrosion, waves, tides, currents and other factors that must be determined if optimum efficiency is to be achieved.

A potent but often little-understood objective in a massive exploration of inner space is the acquisition of knowledge, the application of which is not as yet known, but which could be all-important in the future. The characteristics of the subsurface oceans must frequently be determined from the view-point of applied economics or military objectives. In this regard, there has been much discussion about the relative merits of applied *versus* fundamental studies. But until all the facts about the sea are established they cannot be applied for any reason, and no fact has been uncovered so far that is not applicable pragmatically. In the search for information, some objectives have been given priority over others, but the ultimate value of acquired data cannot be known *a priori*.

Without elaborating on all of these needs, we can now consider seven fields of sea exploration along with their methods of implementation. These may be identified as synoptic oceanography; 3-D oceanography; *in situ* underwater visibility; stability for motion studies; deep oceanography; sub-floor structure; and remote areas.

## Synoptic Oceanography

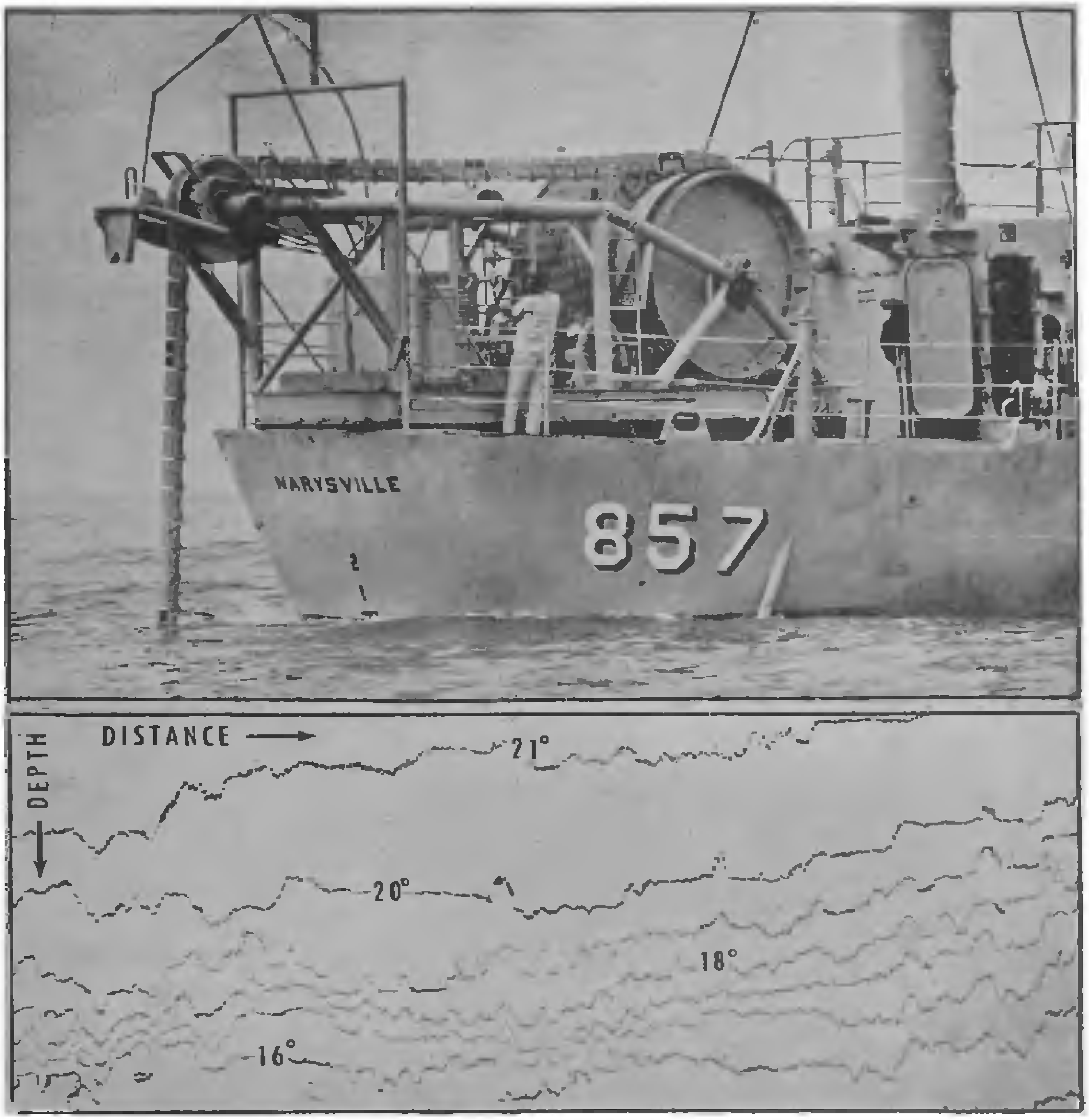
This process can be defined as the study of an ocean variable in many places at the time. The present system for areal coverage is to take a ship, stop at one position, sample the sea and move on to another position for the next sample. Thus a considerable lapse of time transpires between samples, the sea conditions change, and a simultaneous picture of the particular sea variable cannot be obtained.

One solution is to deploy a hundred or more ships, equally spaced in a grid pattern and sample an area quickly, but this type of operation has proved to be too expensive. A more economic solution is to have small, anchored buoys floating, but unmanned, which sense the variable desired and automatically radio this information to a central station. Experimental buoys are being tested. In the future the ocean may be peppered with such devices, all sending in information by radio to furnish a synoptic picture.

### 3-D Oceanography

This method of sea exploration is similar to the synoptic approach, but here the requirement is a three-dimensional picture of some variable, such as the temperature structure in both its horizontal and vertical aspects. The requirement is much more complex than the synoptic picture of the surface temperature since it introduces a third dimension, depth, and is a consideration of space rather than of time.

One procedure for solving the problem is through the use of the towed thermistor chain which gives a nearly two-dimensional picture as the ship tows the vertical string of sensors through the water (Fig. 1).[3] Some additional time is involved, but still the ship does not need to stop. The printed record is automatically contoured for isolines by interpolating between sensors. By towing in circles in a network pattern, we can approach a three-dimensional condition.




A

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**Fig 1.** Three-Dimensional Oceanography. A. U.S. Navy Electronics Laboratory's Towed Temperature Profiler. B. Temperature structure record made with the Profiler.

The most promising solution to the problem, however, may be achieved through use of a scanning technique. A ship can cruise along under favorable conditions, acoustically scan the sea-floor and derive data from which its topography can be obtained. Schools of fish and other biological populations can likewise be delineated by sonar scanners. It is possible many other factors still utilize visual observation as the most practical technique. A principal problem is how to get the eye close enough to the object under favorable lighting conditions. For shallow water studies, Self-Contained Underwater Breathing Apparatus (SCUBA) is being used extensively to acquire data on marine environment.

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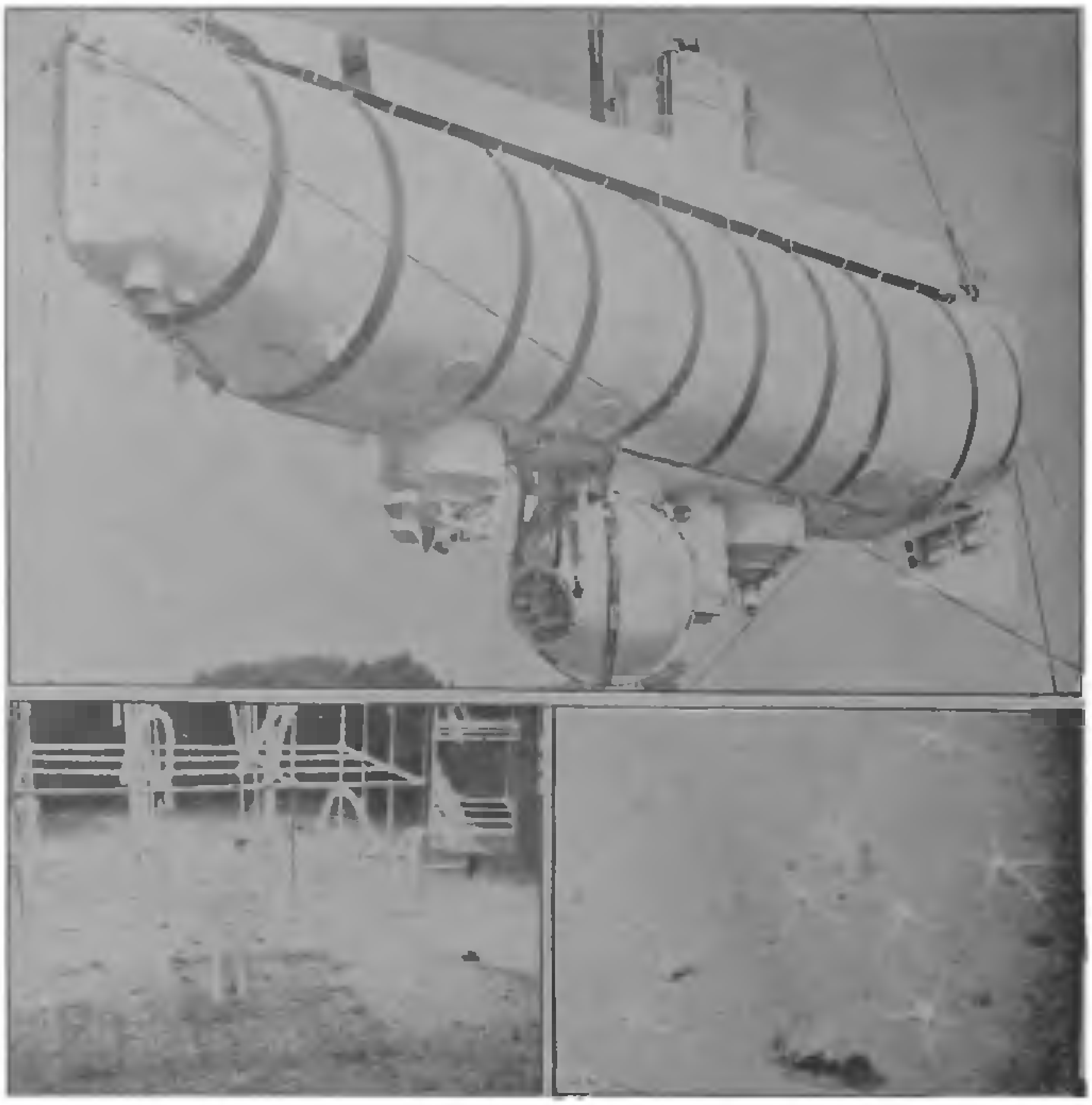

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FIG. 2. Deep-Water Oceanography. A. U.S. Navy Electronics Laboratory's Bathyscaph, TRIESTE. B. Deep current measurement equipment used with the TRIESTE. C. Sea-floor organisms photographed from the TRIESTE.

that scanners of the future will be triggered by a given temperature or light intensity and thus present a three-dimensional oceanographic picture.

### First-Hand, *in situ* Underwater Visibility

Studies of the characteristics of marine organisms and their behavior in the depths of the sea, light and color distributions, microrelief, sediment movements of the sea-floor, and

One remote system that will achieve this visual aim is the use of closed-circuit underwater television which has already been successfully employed both in shallow water and at great depths in the sea. A television system of this type has been mounted on a remotely controlled tractor that runs along the sea bottom.

Underwater photography, including stereopticon techniques, is used to record sea-floor features. In a water column the organisms are difficult to identify because of the relative motion and lack of suitable lighting. The solution is to use a submersible to take the observer within close proximity of the object. The bathyscaph[4] and other manned underwater vehicles with suitable lights and windows are making possible the study of many inhabitants and features of the ocean *in situ* (Fig. 2).

### Stability for Motion Studies

The study of motion in the sea from an unstable moving ship has been found to be impractical and television studies without stability are unsatisfactory. The only desirable arrangement is a stable platform.

One recent technique is to construct a long tube that can be tilted on its end so that it operates as a spar buoy. In this way the vertical surface motion can be damped to 10% or less. One such 350-foot spar, called Floating Instrument Platform (FLIP), has already been constructed and is now being used as a semi-stable platform by towing it to the desired site and tilting it to a vertical position.

For shipboard use, a large gyro was constructed to resist ship motion. This has been used to study cloud and other sky features at sea. But the most successful device yet used is the oceanographic tower, which is secured to the sea-floor and is presently being used for shallow-water analyses.[5] Such a stable platform is the oceanographic research tower of the U.S. Navy Electronics Laboratory. This tower was installed off Mission Beach, San Diego County, California (U.S.A.) and from it the surface wave motion, internal wave motion, and turbulence are being studied (Fig. 3). With this tower firmly rooted in the sea-floor, it forms

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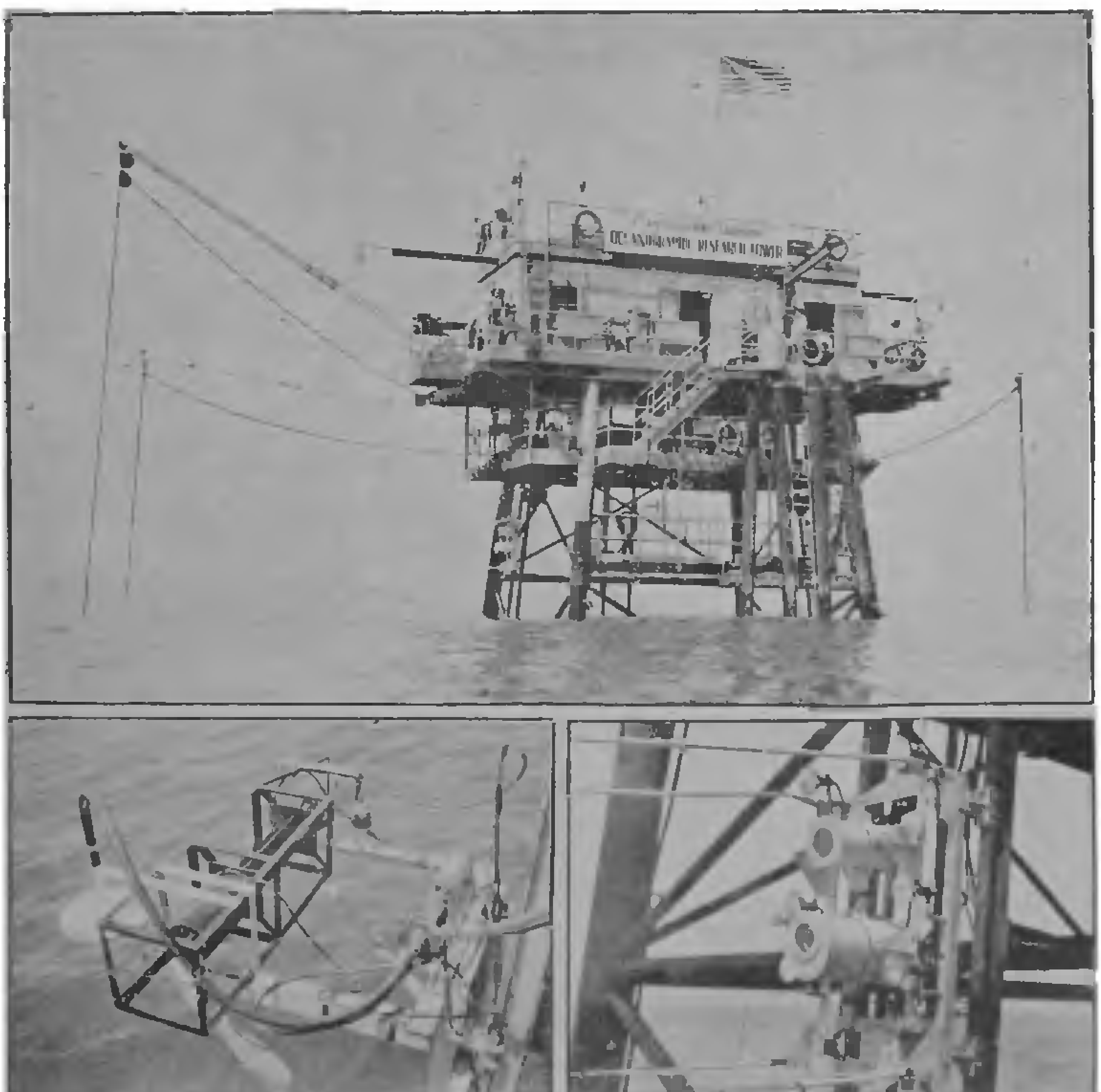

FIG. 3. Stability for Water Motion Studies, A. U.S. Navy Electronics Laboratoty's stable Oceanographic Research Tower. B. Water turbidity and sampling equipment on the tower. C. Underwater movie camera and TV on the tower.

a stable platform for underwater television and motion-picture studies. Planned for the future are other stable reference platforms, including gyrostabilized floats or even boats.

### Deep Oceanography

Deep-water studies are more difficult than other oceanographic investigation because the pressure and remoteness of operation are formidable obstacles not only to entry into these realms but even to the acquisition from the surface of deep-water conditions. The most common procedure is to lower instruments on long, strong, heavy wire rope. Knowledge of their proximity to the bottom and the actual depth of the sensor is, however, often uncertain. The more sophisticated equipments that require long electric cable also offer more drag in the water, are not strong and are subject to leaks. A manned submersible such as a bathyscaph can go to the maximum depth in the sea, but the number of dives per cruise of the present deep submersibles is limited by logistics and can only carry an operator and one or two observers. Other submersibles being planned will be more efficient.

Sensors and recorders can be anchored on the sea-floor; after a prearranged period, a mechanism releases the anchor and allows the recorded data to float to the surface. The preliminary experiments with this technique have not resulted in many readings and recovery of the record is difficult.

A projected means of studying the ocean deeps is by unmanned submersibles, much as outer space is now being probed by unmanned space instruments. New deep-diving vehicles are now being tested that can be programmed to go to any depth, make recordings, and return to the mother ship. These are likely to be popular vehicles in the new programs.

### Sub-Floor Structure

The nature of the sea-floor surface can be determined by echo sounding, photography, visual inspection, bathyscaph observation and bottom samples. These methods, however, do not get much below the water-sediment interface. The first attempt to study the subsurface sediment layers was by means of corers which can penetrate soft sediment up to about 100 feet.

More recently, high-powered acoustic spark signals or explosive signals have been used to penetrate the various layers of sediment and return an echo that identifies the general hardness or reflectivity of the layers and their depth. As a ship moves along, a profile on the sub-bottom layers is revealed, down to a depth of a mile in some places.[6]

A recent program, termed Project Mohole, attempted to drill a hole in the floor of the sea. An oil-well-drilling barge, positioned by several outboard motors over a given spot in deep-water, operated a long drill into the sea-floor. Project Mohole was only partly successful. Several hundred feet were cored but when hard, basalt material was encountered and no mud-lifting flow and casing could be devised; it was necessary to abandon the operation.[7] When a second and more elaborate program is conducted, it is expected that more information will be revealed about the earth's mantle or sub-floor below the sea. In this case, as in others, technological developments of new oceanographic instruments are badly needed.

### Remote Areas

In order to save money and in view of the facilities available, there exists a natural tendency for oceanographic investigations to be centered near a home laboratory. In America, for example, the east and west offshore coastal areas of the United States have received the most attention. For similar reasons the Atlantic Ocean has been studied largely by European oceanographers and a large part of the Pacific by Japanese oceanographers. The Arctic Ocean has been either neglected or has received little attention and only lately has the Indian Ocean begun to be systematically explored. Some expeditions to the Arctic Ocean have been conducted in recent years around the fringes of the ice pack by U.S. ice breakers, principally in summer, and a few airplanes have landed on the ice pack during good weather conditions. A technological breakthrough in Arctic Ocean investigations came with the development of the nuclear submarine and its enormous fuel supply and cruising range.[8]

With this formidable addition to the vehicles suitable for oceanographic application to remote areas, if only as a sideline, the entire Arctic Ocean basin can be traversed under the relatively shallow ice cover and underwater studies of it can be made. Such investigations will become more numerous with an increased number of available ships. What is needed most now is a development of additional specialized oceanographic instruments.

The Indian Ocean can be studied from conventional oceanographic vessels. Its former remoteness from oceanographic centers of study mainly accounts for the present relative lack of knowledge concerning it, but with the accelerated interest in oceanography in India and the other nations of South-East Asia, this situation will not long continue. During the next two years, a concerted effort to be known as the Indian Ocean Expedition will be made to conduct as much work as possible in this area. Twenty-five nations are planning to conduct studies and they are expected to furnish a total of at least forty ships. Much more will be known about this area in the near future.


### SUMMARY

The most pressing need in the exploration of inner space is a better picture of the sea variables through the medium of synoptic and 3-D structures. It is necessary to go below the surface for a really comprehensive study of ocean life and its environment. Stability in the sea as a reference point from which to carry on motion studies must be achieved. Investigations of the deeper portions of the sea, including the sub-bottom, should be conducted. Finally, a thorough exploration of the least known large bodies of water, the Arctic and Indian Ocean, must be completed.

Many of the solutions to the problems outlined can be found in the development of new techniques and specialized oceanographic equipment. One of the best possibilities is offered by scanning techniques, especially acoustic for both the water medium and the sub-floor.

The large ocean areas of the earth will receive high-priority study effort in the next few years. The study of inner space will become increasingly implemented as additional tools are developed to extract its secrets for the betterment of humanity. It will be borne out that these investigations of the world's oceans will have greater potentiality for the replenishment of human resources and an enrichment of human life than the widely publicized and spectacular moon program.



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## ELECTRON-PAIR INTERPRETATION OF THE PION INTERACTION AND THE STRUCTURE OF HEAVY MESONS

THE following is a summary of the paper on the above title presented by E. J. Sternglass of Westinghouse Research Laboratories, before the American Physical Society, New York City, on January 24, 1963.

1. The over-all objective of the present approach has been to explain all the various unstable nuclear particles in terms of as few truly fundamental particles as possible.

2. Among all the known particles, only the electron and its oppositely charged antiparticle of equal mass, the positron, have so far been found to be structureless and stable. Although electrons can be created from radiation or annihilated to form electromagnetic radiation pulses, this happens only in association with the positron, and never when either of the two particles are isolated.

3. Therefore, the basic assumption is to regard the electron-positron pair as the elementary building blocks of matter, including ultimately even the proton and neutron itself, both of which are now known to contain many unstable particles classified as mesons.

4. The first step in this program was to find the simplest particle that could be constructed from electrons and positrons alone, using only the known laws of electrodynamics and relativity theory (*Physical Review*, July 1961, pp. 391-398). This turned out to be the neutral pi-meson, or pion ($\pi^0$), which was found to be explained in terms of a single electron-positron pair moving in a small hydrogen-like orbit at very high rotational velocity. By allowing the speed to approach practically that of light, the mass of the two electrons increases many-fold over their mass at rest. When this system is given the same basic unit of angular momentum as the hydrogen atom of the Rutherford-Bohr theory, the mass is automatically fixed at some 137 times the mass of two electrons, or 274 $m_0$. This is very close to the mass of all the so-called pi-mesons, believed to be present in the nucleus and responsible for nuclear forces.