RECENT ADVANCES IN OCEANOGRAPHIC OPERATIONS ABOARD U.S.N. OCEANOGRAPHIC SURVEY VESSELS

(Lecture delivered on 16th March 1951 at the Oceanographic Museum, Monaco, by Mr. Robert B. ABEL, Chief Scientist, U. S. S. *Rehoboth* and *San Pablo*).

About five years ago when it was felt that more complete centralization of the oceanographic programs underway in the U.S. Military Establishment was needed, the Division of Oceanography was organized in the Hydrographic Office.

It was, however, not until two years later that the two vessels U.S.S. *Rehoboth* and U.S.S. *San Pablo* were assigned to the technical control of the Hydrographer for operations in oceanographic research and survey.

Larger than the average ship of the type used in this work, they are 328 feet long with a displacement of about 2700 tons. Their cruising speed is 12-15 knots, and range is over 6000 miles. The ships normally carry about 140 enlisted men, 12 officers, and between 5 and 9 scientists.

As the vessels were originally small seaplane tenders, modifications such as conversion of space to laboratories and drafting rooms and addition of winches and other specialized equipment had to be carried out before the oceanographic program could be successfully prosecuted.

As you will see, our oceanographic operations are carried out primarily in three spaces reserved for the purpose :

Our bathythermograph and Nansen bottle observations are based in the deck laboratory ; the chemical analyses are carried out in lower laboratory space, and certain specialized electronic equipment to be described shortly is housed in the chart room.

In addition, one large compartment has been converted for drafting, office, and library space, and a large photographic laboratory is situated on the after deck.

For Nansen bottle and other similar kinds of lowering operations, a new type of winch has been designed and has been used aboard, most successfully, for nearly two years. The hydraulic speed control is continuously variable from zero to the maximum speed which would raise the bottles if so desired at the rate of about 600 metres/minute. An air pressure type of accumulator succeeds in nullifying the effect of the varying tension on the wire due to ship's roll. Stainless steel wire is used and although expensive, has a lifetime many times that of the galvanized. For other activities, available winches range in size from the 15 horsepower BT winch to the deep-sea anchoring winch, also used for dredging and coring.

The large size of the ships and the availability of manpower and modern machinery have increased the scope of activity appreciably. Mr. Thomas Austin in his report in American Naval Institute Proceedings has covered that portion of the work done aboard these ships which is of a routine nature ; however, it's quite evident that the rapid expansion of oceanography has resulted in a shifting of emphasis from the Nansen bottle to the development of electronic devices the better to explore the oceans.

With your permission I should like to describe some more recent advances in oceanographic equipment as applied to our problems and operations.

Since it has been but recently that the Hydrographic Office has engaged in oceanography on its present large scale, it is very probable that many of this distinguished gathering have dealt with or are developing instrumentation along the same lines, very likely of a more perfect nature than much of that which is about to be described. I shall, accordingly, welcome your criticisms and suggestions.

Designed to combine the features of the Nansen bottle and bathythermograph, the Spilhaus-Miller multiple sea-sampler developed at the Woods Hole Oceanographic Institution has proved moderately successful when used in deep ocean work. Although the construction in general is similar to that of the standard bathythermograph, the body is ringed with twelve small sample containers, the closing mechanism of which is operated successively by a central pressure-activated bellows. Samples may be obtained at speeds up to 15 knots, and at depths as low as 200 metres. The time-saving features of this apparatus are at once apparent. Its advantages result from sampling-depth limitations imposd by the sped of the ship and the necessarily small size of the samples obtained, about 123 mil. or one-tenth of the standard Nansen bottle capacity. This instrument has been used most successfully in coastal waters where rapid sampling is desired and shallow water encountered.

A new echo sounder, constructed by the *Edo* Corp. has been found to exceed in performance any other apparatus of this type, its outstanding characteristics being its range, dependability, and clarity of trace.

In line with deep scattering layer investigations, we have equipped one of our ships with nets and a depressor unit of the type developed at the Scripps Institution of Oceanography. It is planned to tow these nets at 6 knots at depths up to 1000 fathoms. Since the composition of the scattering layer remains a mystery, much attention is being focused on these experiments although it is as yet too early for any statement as to the progress of this project.

Conventional equipment in long time use has sufficed for current measurements on anchor station ; the geomagnetic electrokinetograph has been operated for over two years to measure current velocity and direction while underway. The name itself provides adequate description of the theory : that the magnetic flux of the earth when traversed by electrolytes induces an EMF in those electrolytes, in this case, ocean currents. The apparatus as developed by Von Arx at Woods Hole consists essentially of a potentiometer on board which records continually the potential difference between a pair of electrodes streamed behind the ship and thus indicates the component of surface current normal to the ship's course. Current measurements are conducted by the use of a variety of sailing "patterns" all of which involve the determination of two components of the current by measurements made on two courses, usually at right angles to each other, and the calculation, from these vectors, of the resultant direction and velocity of the surface current. The equipment works quite satisfactorily, and formed the spearhead, so to speak, of the attack upon the Gulf Stream during operation CABOT during June of 1950.

As has been seen from the foregoing, the accent in modern oceanography is not only upon automatic measurement, but upon underway operation. Just as the sea sampler gathers samples and measures temperature under way and the geomagnetic electrokinetograph likewise determines current, the underway bottoms ampler, also called the "scoopfish", developed at Columbia University has been used for underway bottom sampling with varying success by American and Canadian oceanographers. The effect is similar to that of a bathythermograph with an open cylinder with cutting edges in its nose. The assembly is lowered in the same manner as the bathythermograph. However, as the instrument strikes bottom, a contact trigger mechanism snaps a lid shut on the cylinder, effectively capturing the sample. The limited success of this assembly is due to the importance of weight distribution and fin orientation,

poor adjustment of which has often caused this instrument to be inoperative in any but the shallowest water and at slowest speeds.

For deep-bottom sampling a piston corer as modified by Ewing at Woods Hole has been used with success on all of the recent cruise. Engineering improvements have made cores possible in almost any depth of water. The cores themselves average approximately 30-40 feet in length.

A program of seismology has been very recently initiated aboard the survey vessels. The two seismic techniques of refraction and reflection have been adopted from methods widely used in oil-prospecting on land.

The temperature-salinity-depth recorder (STD) has been used both under way and on station by our ships but proves more effective in coastal waters where larger gradients are encountered. Temperature is measured by a resistance thermometer which motivates a slide wire and recorder arrangement. Depth is determined by a bellows assembly and is recorded in a similar manner to that of temperatures. Conductivity is determined by an ordinary bridge circuit, and salinity is automatically computed and recorded as a function of conductivity and temperature. A continuous reading of temperature and salinity may be obtained by eliminating the depth recording assembly and using the instrument as a permanently installed overside unit, or the receptor unit may be lowered on a cable and a continuous vertical section of salinity and temperature may be obtained. The latter method has been used advantageously aboard small boats operating in inshore areas.

Chemical oceanography, except for salinity and dissolved oxygen determinations has not, up to the present time, been prosecuted to any great extent aboard our vessels. Recently, however, it has been decided to add a limited program of nutriention analyses. Toward that end, a seagoing photometer has been obtained from Woods Hole to be used in colorimetric analyses. It is a simple instrument consisting of a lamp sending two beams of light through adjustable apertures, prisms, and sample cells to a pair of photoelectric cells. The degree of manipulation necessary to balance the resultant intensities of the light beams as indicated by a galvanometer or electric eye is a function of the concentration of the color in the sample. Over a period of four years this instrument has proved itself, at sea, to be reliable and easily operated.

The time-honoured Knudsen method for salinity analysis has proved resistant to most attempts at major modification. However, this is an electronic age and it was inevitable that due to the time-consuming and exacting nature of the analysis, sooner or later a method would be developed to render the job nearly automatic in operation, retaining, at the same time, the sensitivity and precision of the Knudsen titration. The U.S. Hydrographic Office and the Woods Hole Oceanographic Institution are at the present time conducting simultaneous evaluations of two instruments developed by American research laboratories. Both these instruments are allegedly as accurate as the Knudsen titration, and both are fully automatic in operation. The method is based on a potentiometric titration using a silver-silver chloride electrode system, with the amplified potential driving the burette, in this case a large syringe. The difference between the two instruments so far seems to be that the one records the end point upon a flowing tape, while in the second case the volume of the delivered titrant must be read directly from the burette. The rate of flow of the titrant can be adjusted so as to preclude occlusion of titrant by the precipitate. It is felt that use of such equipment will aid in reducing the time and manpower required for salinity analysis.

Wave study has long been a part of the Oceanographic Survey program, but it was not until just before the present cruise that development of an automatically recording wave-meter was completed. The equipment consists of a staff, protruding from which at regular intervals is a set of spark-plug contacts.

As the staff oscillates in the waves, a succession of electrical circuits are made and broken, ultimately activating a brush recorder. The resultant trace gives a very clear delineation of the wave height and lengh. Since this instrument is but new in operation, a proper evaluation of its worth cannot as yet be given, but we have expectations of being able to make better wind-wave correlation studies in the future.

A hypersensitive temperature-depth recorder is being constructed by the Hydrographic Office for use on future cruises. Operations on the last cruise recorded fluctuations of the order of 1°4 C. The measuring unit consists in brief of a thermopile with a well-insulated reference junction. Clearer definition of internal waves is expected from this assembly, since the sensitivity of this receptor is about 10 times that of the bathythermograph.

An intensive light-measurement program has been initiated during the past few months. One of the ships has recently been equipped with an *Epply* pyrheliometer assembly consisting essentially of one receptor to receive from the sea surface, and a potentiometer recorder.

Simultaneously, measurements of the light penetrating the subsurface layers are taken, using a submarine photometer of the type used by Clarke at Woods Hole. Still more complete knowledge of the water transparency is gained through use of a standard hydrophotometer and a very recent modification of the Secchi disc. The latter apparatus appears as a large white disc and a smaller grey one, both of which are mounted upon a 10-ft. axle. When the entire assembly is submerged, the grey disc is drawn upward until the two discs appear equal in shade, at which point the water transparency is a function of the distance between them.

This, gentlemen, is a brief description of newer instrumentation acquired by our survey group to increase the scope of our survey operations. Much of it may appear primitive to some of you. I hope that parts thereof might have given some one some ideas. Oceanography, as an international science, will ever derive its greatest benefit from international exchange of thought.