BASIC SURVEYS FOR BEACH AND HARBOR STUDIES

by Rear Admiral H. Arnold KARO, Director, Coast and Geodetic Survey

This paper was presented by Rear Admiral H. Arnold Karo before the May 1958 meeting of the American Shore and Beach Preservation Association. While the paper is somewhat different from the type of papers usually published in the Review, the Directing Committee believes it will be of interest to the States Members because of its discussion of tidal current surveys and the influence of these currents on bathing beaches and harbor pollution and flushing.

I am happy that the National Academy of Sciences was selected for the 1958 annual meeting of the American Shore and Beach Preservation Association. This stately and dignified building was generously conceived and skillfully executed. It is a lasting shrine to the ideal of science effectively dedicated to the welfare of humanity. This ideal is perpetuated through the National Research Council of the Academy. It recognizes that the progress of mankind depends directly upon increasingly harmonious application of scientific and engineering knowledge to our natural environment. The discovery of at least one million new scientific facts each year forcefully emphasizes man's never-ending efforts to attain this ideal. The impressive accumulation of basic data thus established provides vast potential support for progressively higher accomplishments in the future.

The National Research Council was created early in World War I for the purpose of mobilizing the scientific and technical brainpower of the Nation to provide a reservoir from which might be drawn, on short notice, that scientific knowledge and skill best equipped to cope with any one of many new and unprecedented problems demanding immediate solution.

In this building, almost thirty-two years ago, the American Shore and Beach Preservation Association was launched upon its mission of service. Notable achievements over the years amply justify the part played by the Council in its formation. I should like at this time to extend my personal congratulations to the National Academy of Sciences for their foresight and the marked success achieved in furthering and coordinating a multitude of scientific endeavors in the United States. As Chairman of the Academy's Committee on Cartography, I have had an excellent opportunity of observing at first-hand the highly efficient interpretation and direction contributed by this unexcelled scientific institution.

I am participating in this symposium today as Director of the Coast and Geodetic Survey of the United States Department of Commerce. The Bureau has been a consistent subscriber to the objectives of the American Shore and Beach Preservation Association in its essential program of

coastal planning. In fact, the record indicates that Admiral Patton, as Director of the Survey, was one of the small group concerned with organizing the Association. Your President this year, Admiral Colbert, who succeeded Admiral Patton, was especially active in supporting the Association during his twelve years as Director of the Coast and Geodetic Survey. My immediate predecessor, Admiral Studds, was also one of your active supporters. Each of these gentlemen has discussed at past annual meetings various aspects of Bureau activities which contribute directly to the objectives of shore and beach preservation.

On this occasion, which is my first opportunity to meet with you, I should like to report on several new Bureau projects now in progress which I consider particularly significant in beach and harbor development as it affects industrial expansion, improved navigation, and added utility of coastal property. Pertinent phases of Bureau activities must be reoriented and expanded in keeping with the great strides being made in modern technology. In developing our new work programs we are glad to collaborate with our contemporary agencies represented here today, in order that the maximum of service to all may result from our efforts. We join with you in devising new and better approaches to constantly-changing problems resulting from present day technological and scientific progress.

An important aspect of our common objective is to provide our rapidly increasing population with the advantages of adequate recreational areas. I have in mind specifically our beaches which can be protected, preserved and enlarged only through vigorous construction and protection programs based on intelligent planning.

The little Dutch boy with his finger in the earthen dike of long ago may be compared with the modern workman pouring concrete into a gaping hole in a damaged seawall. Both had a common objective — to balk ocean waves striving to nibble away at a structure, whether earth or concrete, constructed for protection of a coastal area. The various groups supporting the American Shore and Beach Preservation Association are vitally concerned with the many implications of this critical problem.

To illustrate the ever-broadening interest in developing recreational facilities, I should like to mention the recent introduction in California of a public outdoor recreation plan. This plan is being developed by a technical consultant group which has sought assistance of major agencies at all levels of Government in supporting and coordinating various matters involved in solving the recreational problem in California. The Coast and Geodetic Survey subscribes to this program and I have indicated our support through the facilities of our California District Offices. I have been informed that the first conference of the group held last December had representation from 56 agencies of federal, state, regional, county, and city governments. This broad representation is an effective demonstration of the widespread interest and concern with outdoor recreational facilities requiring cooperative measures by a multitude of organizations. The stated objective of this undertaking is to explore new possibilities for making California a better place in which to live.

Prominent in this ambitious planning are the beaches of California. Since 1955 the State Legislature of California has authorized a five-year program to cost 83 million dollars for the acquisition, development, and operation of State beaches and parks. This is an excellent example of a

master plan involving the broadest possible agency representation for meeting the exploding needs of outdoor recreation — a problem not confined to any one state. I note that Mr. Wirth is represented in this group through the Regional Division of Recreational Resources of the National Park Service in California. The Corps of Engineers is also represented, and I am sure that the Beach Erosion Board has taken specific cognizance of this new state activity.

We are now engaged in studying a unique situation involving water temperatures off the coast of California. The west coast temperature data obtained during November and December of 1957 and the first two months of 1958 reveal significant increases over the observations obtained prior to last summer. The cause of this situation has been the subject of much speculation as indicated by frequent inquiries received in the Bureau.

About ten days ago, I reported to Secretary of Commerce Sinclair Weeks concerning this phenomenon in which it appeared that the reduced strength of north winds that usually exert considerable influence on the height of tides along the California coast has apparently decreased the upwelling of cold water from the ocean bottom. We were especially impressed by the parallel increase in temperature of sea water and mean sea level. This parallel was revealed by plotting the monthly mean water temperatures for 1957 over corresponding figures for the previous ten years, and also the increase in the sea level for the area over the monthly mean for 19 years.

The two curves thus plotted were surprisingly similar. This coincidence of higher water temperature and higher sea level alerted the oceanographers of the Bureau to the possibility of reaching a logical conclusion concerning this strange parallel. They conceived the idea of reviewing the wind pattern for a possible explanation. Preliminary findings indicate that we have found the answer. From the limited research accomplished to date, it appears that the northerly component of winds computed from the barometric pressure charts diminished in strength during the past year. Winds from the north tend to move the surface water offshore along the Pacific coast with a resultant inshore upwelling of colder water. With this wind pressure reduced, the tide level rose with a corresponding reduction in the upwellings normal to the area when lower tide levels prevail.

This meant that the warmer offshore water was allowed to reach the coast with the upward adjustment of sea level. The supply of cold water normally rising from the bottom was reduced, with the water temperatures near the surface becoming considerably higher. In January and February, for example, monthly mean water temperatures were the highest ever recorded for those months at Newport Beach, Santa Monica, and Avila, California. The greatest increase was at Santa Monica, where the mean water temperature was 5.3° Fahrenheit above the February mean for the 12 years that the station has been in operation. At the same time an « override » of observed tides above predicted tides occurred in almost exact proportion to the temperature rise.

These investigations will be continued with detailed comparison of temperatures, sea levels, and wind conditions all along the Pacific coast from southern California to Alaska. We have arrived at the tentative conclusion, however, that the past decade of cooler water and lower sea level along our west coast is in fact abnormal, and that the present situation is

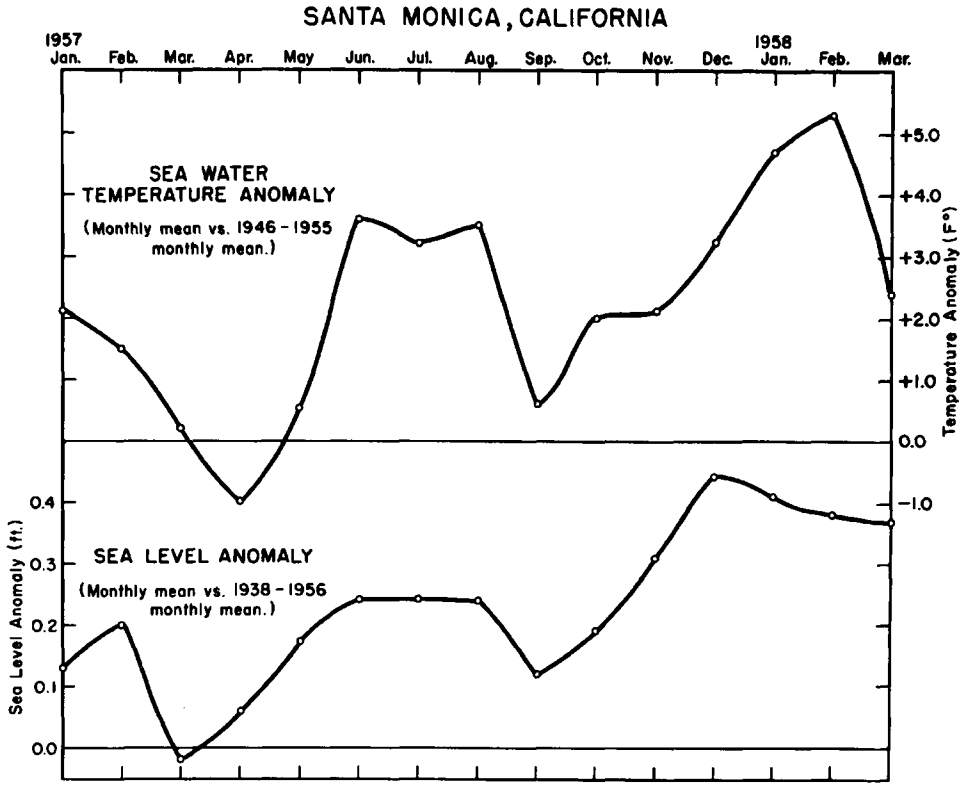

Fig. 1. — Graph showing the relationship between sea water temperature and sea level.

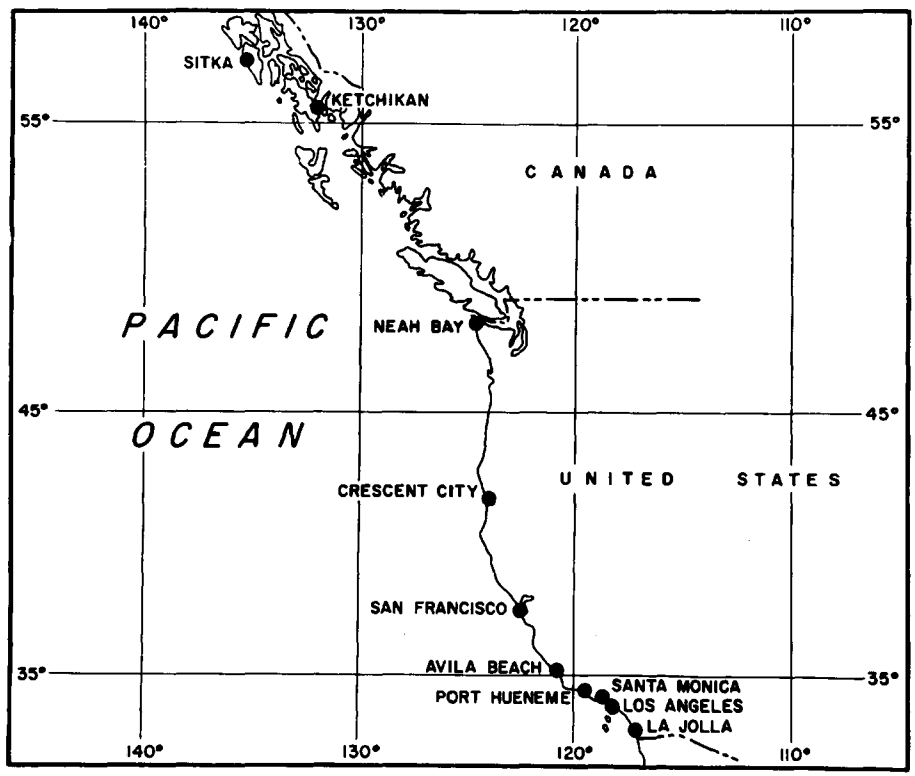

Fig. 2. — Map showing the locations for which sea water temperature and sea level anomaly graphs have been prepared.

actually a return to normal. It is too early for a truly scientific conclusion which must wait for further study based on additional data. I merely indicate the trend of our investigations and thinking to date.

In past annual Shore and Beach sessions, our representatives have emphasized the fact-finding operations of the Coast and Geodetic Survey, especially those involving hydrographic and topographic surveying and related activities. All of you know of the importance of our vast wealth of accumulated data in planning beach stabilization programs and in studying coastal engineering problems for any given locality. I should like to reiterate our frequently stated policy of encouraging the widest possible use of our survey data in support of coastal planning. This comprehensive record extending over a period of almost 150 years is essential in planning for beach conservation and development.

The atomic age has created many new problems, among which is the possibility of a special kind of pollution in harbor areas. Through its Committee on Effects of Atomic Radiation on Oceanography and Fisheries, the National Academy of Sciences recently sounded a warning; that entire harbors and adjacent areas could be made dangerously radio-active by collisions involving nuclear-powered merchant ships of the future.

Specifically, this committee report emphasized the serious hazards that may arise in confined waters from collisions in which the atomic reactor is damaged and the fuel elements with their contained fission products are released into the water.

The Academy's report is a forceful reminder of the need of research programs of sea water circulation, including mixing between surface and deeper layers. The report noted that the vastness, complexity, and imme-

Fig. 3. — The *Marmer* which is the first survey vessel to be assigned fulltime to current surveys. Currently working in New York Harbor.

diacy of the underlying scientific problems emphasized the importance of intensified pertinent oceanographic research on a world-wide basis.

Aside from atomic disaster possibilities, however remote, we have the present-day problem of harbor and beach pollution in many coastal cities. This rapidly increasing problem is nowhere more serious than in the waters around New York City. We recently initiated a survey project for the Maritime Administration and Atomic Energy Commission in New York harbor which coincides with a multi-million dollar pollution abatement program undertaken by the city government. Our investigations in New York harbor are being carried out with our survey ship *Marmer,* the first survey vessel to be assigned full-time to current surveys.

This project will provide information on the variations in the direction and velocity of surface and sub-surface currents and also temperatures and salinity of the tidal water in the harbor area. Data obtained during this survey are being used by the Atomic Energy Commission and the Maritime Administration in joint activities pursuant to the development of nuclear power for merchant ships.

We know, of course, that the only nuclear-powered American vessels now in operation are submarines. However, more submarines and several nuclear-powered aircraft carriers are planned. The keel for the first nuclear-powered merchant ship is scheduled to be laid this month with launching planned one year hence.

Our survey project will help to answer the question frequently asked in connection with the operation of nuclear-powered ships — What would happen if such a vessel blew up or sank in a harbor ? The answer to this question will depend on how fast currents take the harbor water away. The Chesapeake Bay Institute of Johns Hopkins University is cooperating

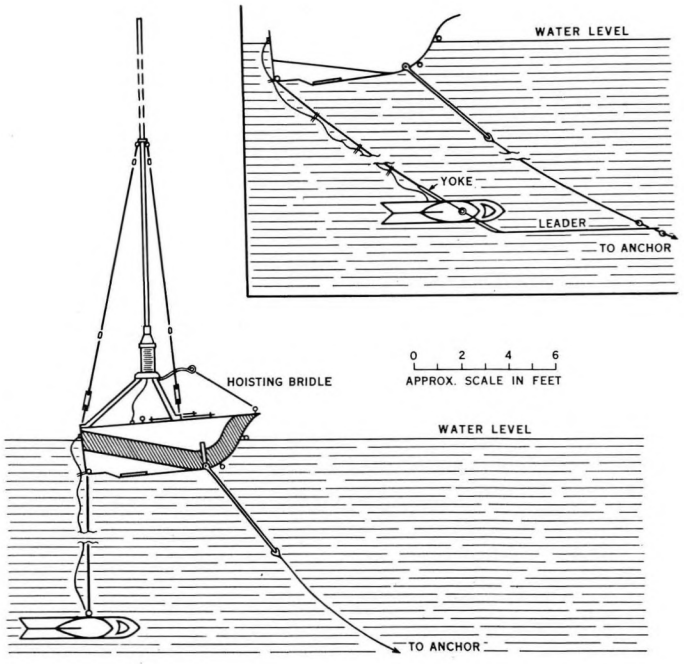

Fig. 4. — Schematic drawing which shows the current meter suspended beneath the current buoy.

in this project by assisting in the interpretation and evaluation of survey data obtained by the *Marmer*.

In addition to pollution abatement, the need has been accentuated in recent years for tide and current surveys for navigation, fishing, construction, and industrial uses. Naturally, the vast beach resorts adjacent to the New York harbor area are vitally concerned. Although the primary mission of our new undertaking is to furnish information for long-range planning, data thus obtained will also be of value to the Public Health Service and other agencies interested in the speed at which sewage and industrial wastes are washed out to sea.

In conducting this type of intensive harbor investigation, the technique we use is to anchor buoys at relatively close intervals throughout the working area. The present project in New York harbor includes 48 separate locations which also provide for observations in the Hudson and East

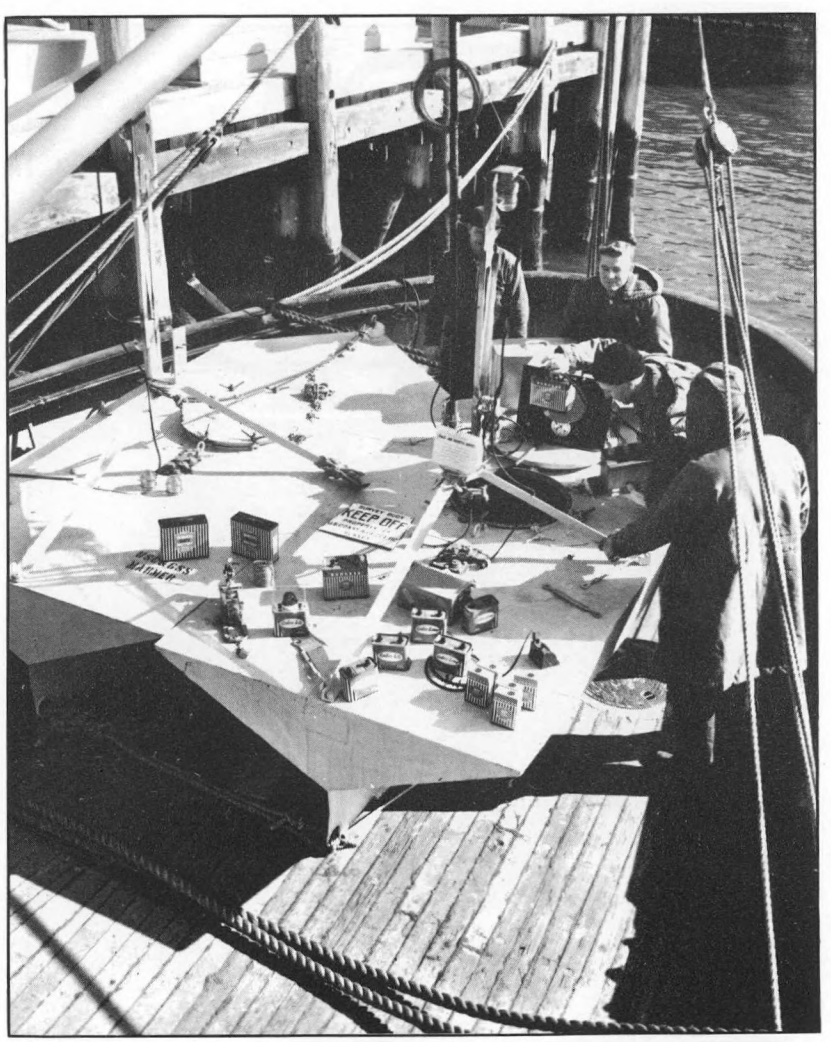

Fig. 5. — Survey personnel are installing batteries in the buoys which automatically transmit the coded data from the meters suspended below

rivers. Three current meters are suspended beneath each of these buoys at predetermined depths. With them measurements are obtained of the direction and velocity of currents. Coded radio signals transmit the data from each of the buoys to the ship where they are recorded on tape. Each instrument of the three-buoy groupings operates on a different frequency in transmitting the coded messages.

Current meters previously used for this type of work were capable of measuring velocities as low as .3 of a knot. Now an accurate circulatory survey such as the one in progress in New York harbor requires the measurement of velocities with considerably greater accuracy. To meet this need previously used equipment was redesigned and modified by Coast and Geodetic Survey engineers to measure currents with velocities as low as .09 of a knot.

The electronically recorded readings are made at 30-minute intervals covering continuous 100-hour periods, or more than eight full tidal cycles,

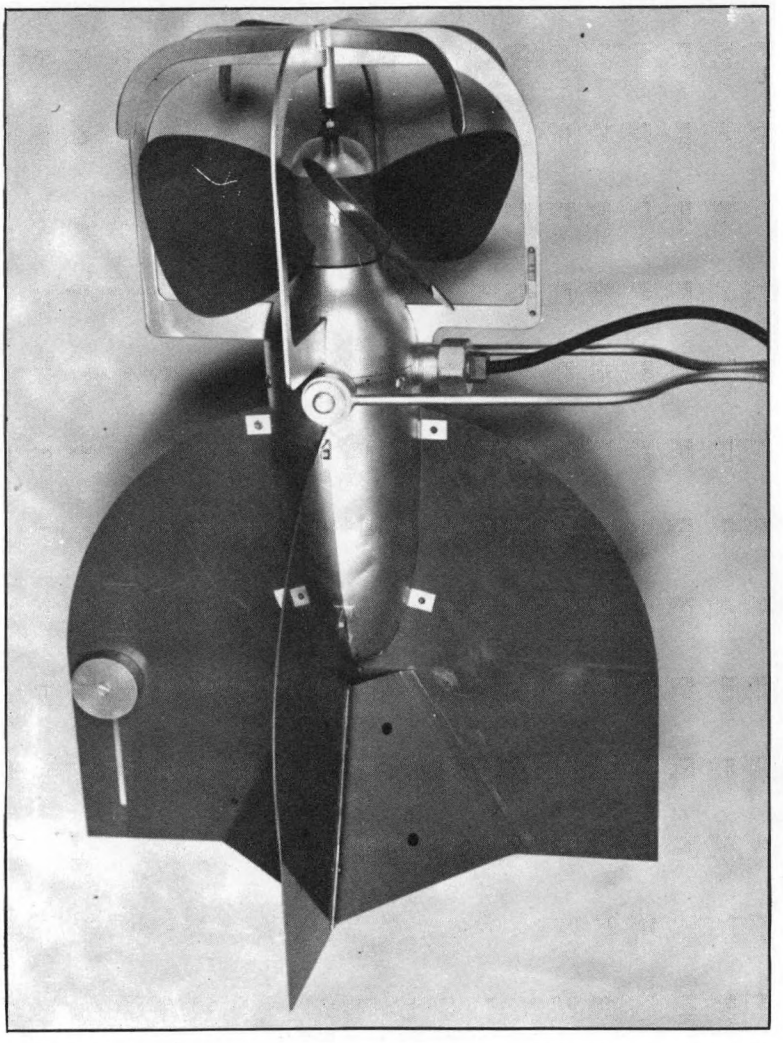

Fig. 6. — The Roberts Radio current meter which was redesigned and modified by Coast and Geodetic Survey engineers to measure currents with velocities as low as .09 of a knot.

at each station. An average of the readings together with a correction for astronomical relations give well - determined mean values. Temperature and salinity of the water are also measured as a part of these investigations. These two factors are indications of the speed with which fresh water from a river mixes with the salt water in an estuary. We call this the « flush » rate. Later we hope to make similar investigations in Delaware and Chesapeake bays.

We recently completed another special survey in Georgetown Harbor and Winyah Bay, South Carolina, as a cooperative project with the Corps of Engineers. The results of this survey are required by the Army Engineers in an extensive investigation to determine the feasibility of deepening the channel in Winyah Bay. In this undertaking, the Corps of Engineers took supplemental current measurements to correlate with the C & GS findings. In addition, General Itschner's engineers are also studying the spoil areas around Winyah Bay to test water flowing from waste areas. As a part of this phase of the investigation, the Engineers are collecting samples of water for testing salt content and to study sedimentation.

Shoaling has been a problem here for many years. The ordinary depth is about 19 feet, with a depth of 27 feet maintained by dredging. If the presently anticipated deepening of about 15 feet, increasing the channel depth to a maximum of 42 feet, is feasible then the way is opened for the development of a variety of industrial enterprises. The question of depth in this area is considered of multi-million dollar significance. Facts revealed during this survey will represent the first stage in solving engineering problems basic to industrial expansion along the shores of an important South Atlantic coastal area. A repeat survey may be required next fall due to seasonal effects which appear to be important.

Our survey data are necessary to determine the cause of shoaling and will provide the basis for Corps of Engineers planning to cut down the annual cost of maintenance. In addition to aiding in the solution of dredging problems the data will provide for improved predictions in the Coast and Geodetic Survey annual tidal current tables.

This project was conducted in two phases. During the first phase observations of current velocities and directions were carried on progressively at nine stations throughout several tidal cycles. These stations were distributed along Winyah Bay Channel and in the turning basin at the head of the project in Sampit River. Three torpedo-shaped current meters suspended beneath the water from 120-inch radio current buoys were anchored over the selected stations. Following generally the plan used in New York harbor, these meters are placed at 1/6, 1/2 and at least 5/6 of the total depth at the station. Two portable tide gages were installed to record the tidal movements in the area.

To meet the unique requirements of this operation we used a new technique in measuring current velocities. Due to the manner in which they are usually suspended, conventional current meters are subject to fluctuations caused by tidal movements. To overcome variations in tidal stages, our oceanographers placed an experimental current-measuring rig on the floor of Winyah Bay. Our objective was to measure water movement along the harbor floor from a stable position which could be maintained without interference from change in tide.

The experimental equipment was tested by Dr. H. B. Stewart, Jr., an

Fig. 7. — The inductive conductivity temperature indicator being lowered over the stern of the *Marmer*. This device measures the temperature and salinity instantaneously for any required depth.

outstanding oceanographer who recently joined our staff from Scripps Institution of Oceanography. In addition to being a nationally recognized scientist, Dr. Stewart is also a professional diver. The placement of the experimental rig comprising a meter supported by a submerged platform was directed by this scientist equipped with Navy frogman gear.

The underwater meter suspension was designed to insure stabilization of the instrument in a horizontal plane three feet above the bay floor. Placement at the submersion point in a depth of 24 feet presented a problem due to the lack of visibility which hampered the leveling of the equipment in a horizontal position. This problem was solved by improvising an overhead support for the instrument, utilizing the frame originally intended for lowering and raising the platform. The meter was removed from its tripod, which initially supported it above the platform, and was then suspended by a hanger from the overhead cross-section of the lowering attachment. Stability was maintained by suspending a weight centered from

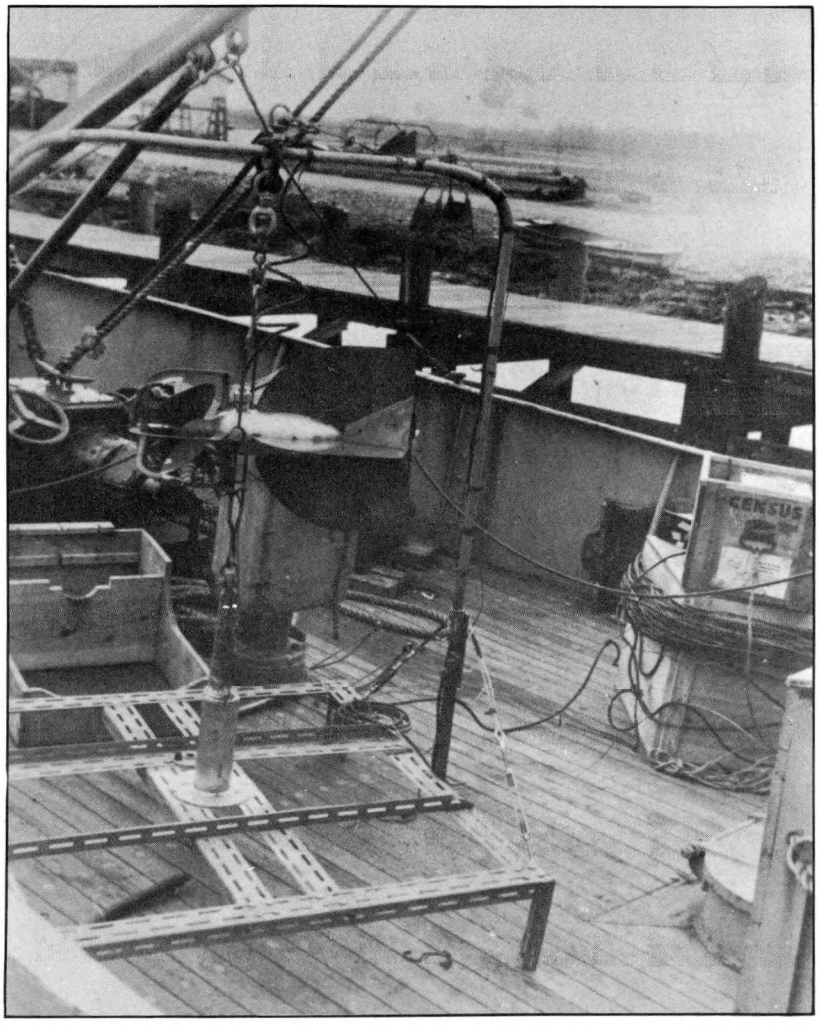

Fig. 8. — The experimental current-measuring rig which was placed on the floor of Winyah Bay at Georgetown, South Carolina.

the underside of the meter which held the free-swinging instrument in a horizontal position.

An automatic recorder used in this operation was field-checked for the first time as a part of the experimental project. This instrument records on tape the velocity of the current and the direction of flow for a period up to about 10 days before it is necessary to install new tape.

The experimental equipment for observing bottom currents will be given a further field-check this summer near the edge of the continental shelf southeast of Georges Bank. The selected location will be about 15 or 20 miles from the Texas Tower. Dr. Stewart, with another skin-diver as an assistant, will place the equipment at a maximum depth of 60 feet, with estimated bottom current up to three knots. The operation will include the gathering of bottom samples and taking of underwater photographs.

This work will be accomplished from the survey ship *Hydrographer*. Intensive soundings obtained by hydrographic surveys repeated at intervals

over three decades have revealed extensive changes in submarine topography on Georges Bank, especially the ridges on Georges Shoal. We now have the equipment to ascertain the relationship of bottom currents to the westward migration of the unstable sand ridges characteristic of the region.

Many changes have taken place in hydrographic surveying techniques during the Bureau's 150 years of public service. Each new milepost in this steady march of scientific and engineering progress has added more accurate and more detailed information to our accumulated knowledge.

We foresee unusual opportunities of extending oceanographic studies through use of improved techniques in tide and current investigations. We hope to make an effective contribution in solving problems pertinent to oceanographic research as recommended by the Academy's Committee on Effects of Atomic Radiation on Oceanography and Fisheries.

As a member Bureau of the United States Department of Commerce we are always alert to the needs of commerce and industry of the United States. Our beaches contribute in no small part to our national economy and require intensive consideration in devising better means for their protection and development. More accurate knowledge of tides and currents should provide a better understanding of the natural forces that influence shoreline configuration in many of our coastal areas. We expect to learn more of the part played by ocean currents in the movement of beach-building materials from our continental margins. No opportunity must be overlooked for positive action against erosion with its annual toll in damage to valuable sea beach property. Loss from erosion is held to a minimum only through concerted national effort, effectively co-ordinated by the American Shore and Beach Preservation Association.