Fig. 1. Echo Sounding Equipment NMC-2 Type.

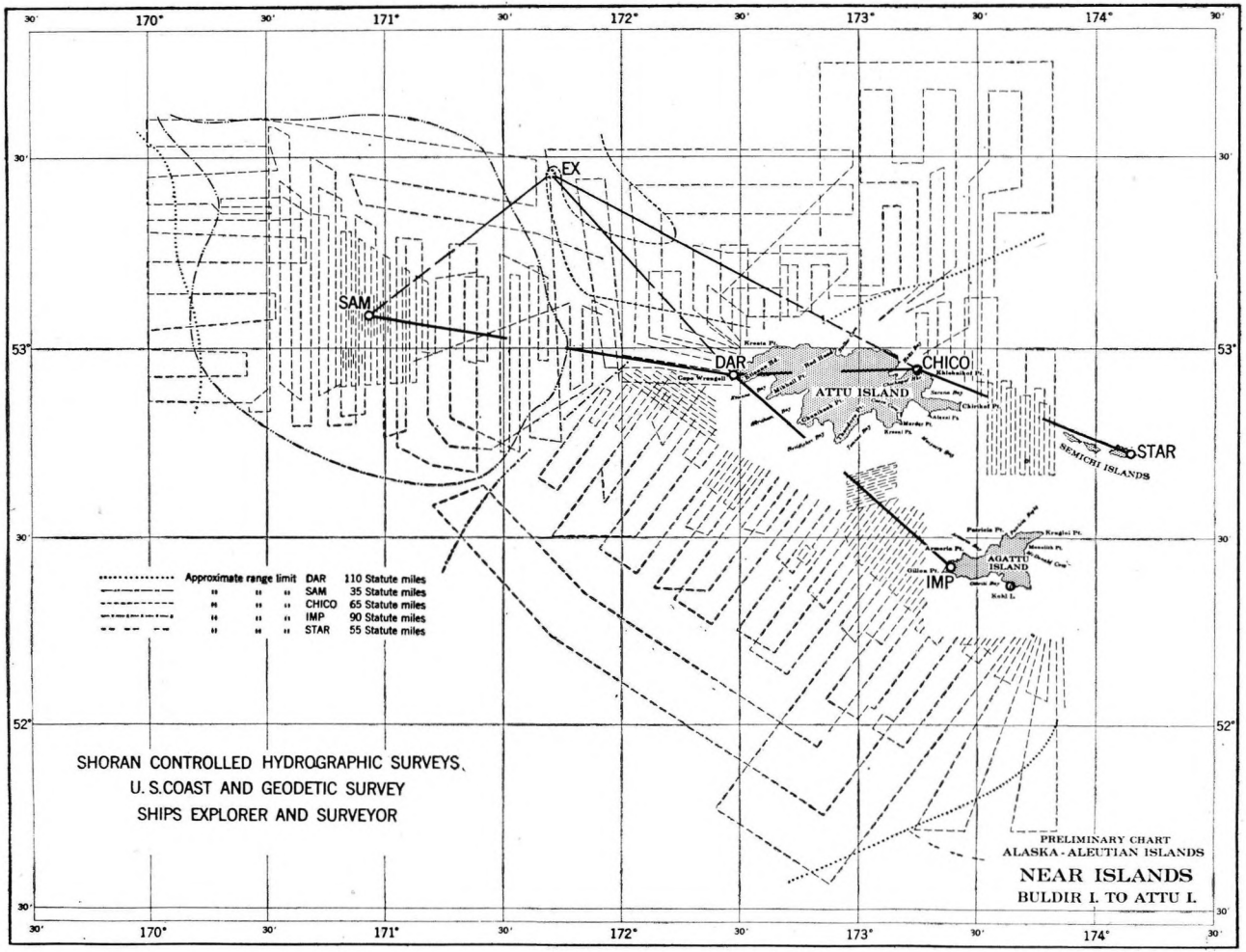
170°
171°
172°
173°
174°
53°
52°
EX
SAM
DAR
CHICO
STAR
IMP
ATTU ISLAND
AGATTU ISLAND
SEMICHI ISLANDS
Approximate range limit DAR 110 Statute miles
" " " SAM 35 Statute miles
" " " CHICO 65 Statute miles
" " " IMP 90 Statute miles
" " " STAR 55 Statute miles
SHORAN CONTROLLED HYDROGRAPHIC SURVEYS,
U. S. COAST AND GEODETIC SURVEY
SHIPS EXPLORER AND SURVEYOR
PRELIMINARY CHART
ALASKA-ALEUTIAN ISLANDS
NEAR ISLANDS
BULDIR I. TO ATTU I.

Fig. 2.

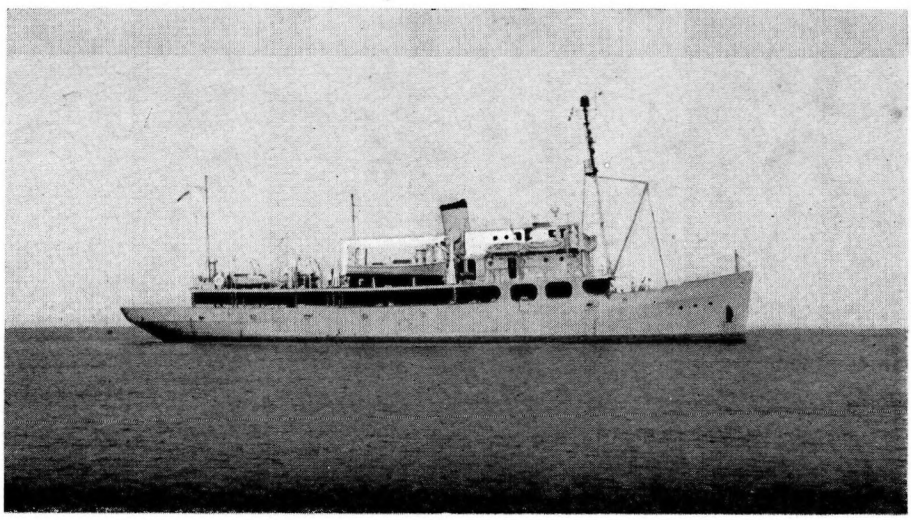

Fig. 3. Ship « Hydrographer » conducting surveys with EPI in the gulf of Mexico during 1950.

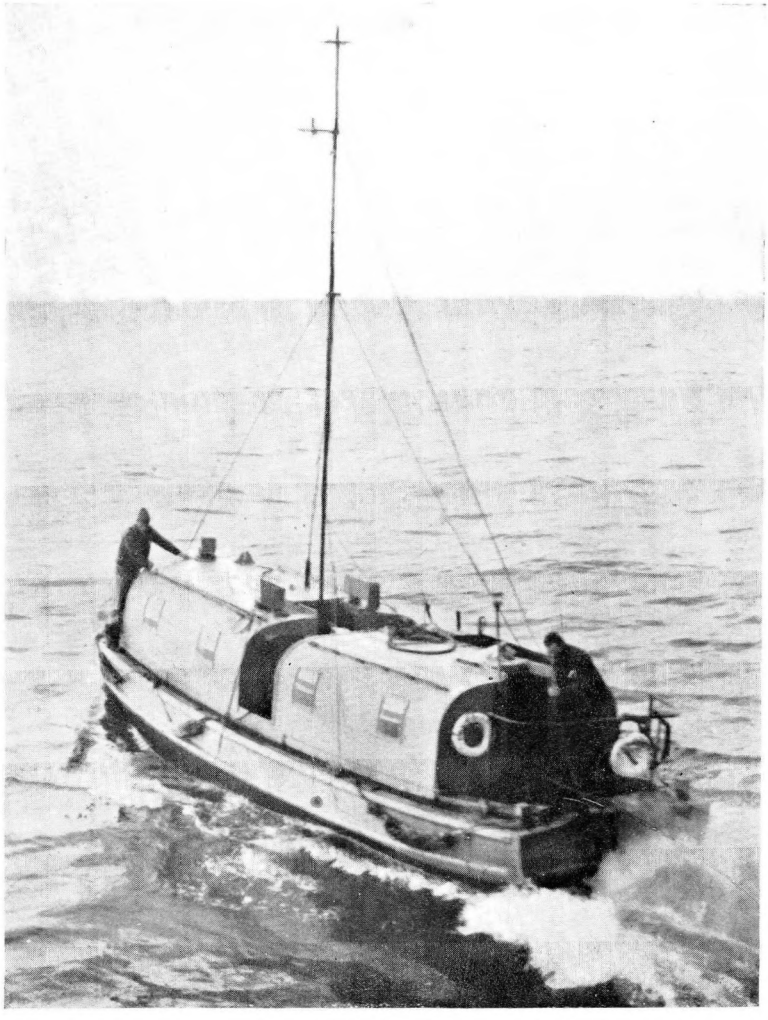

Fig. 4. Thirty-six foot hydrographic launch from ship « Pioneer » equipped with special shoran mast.

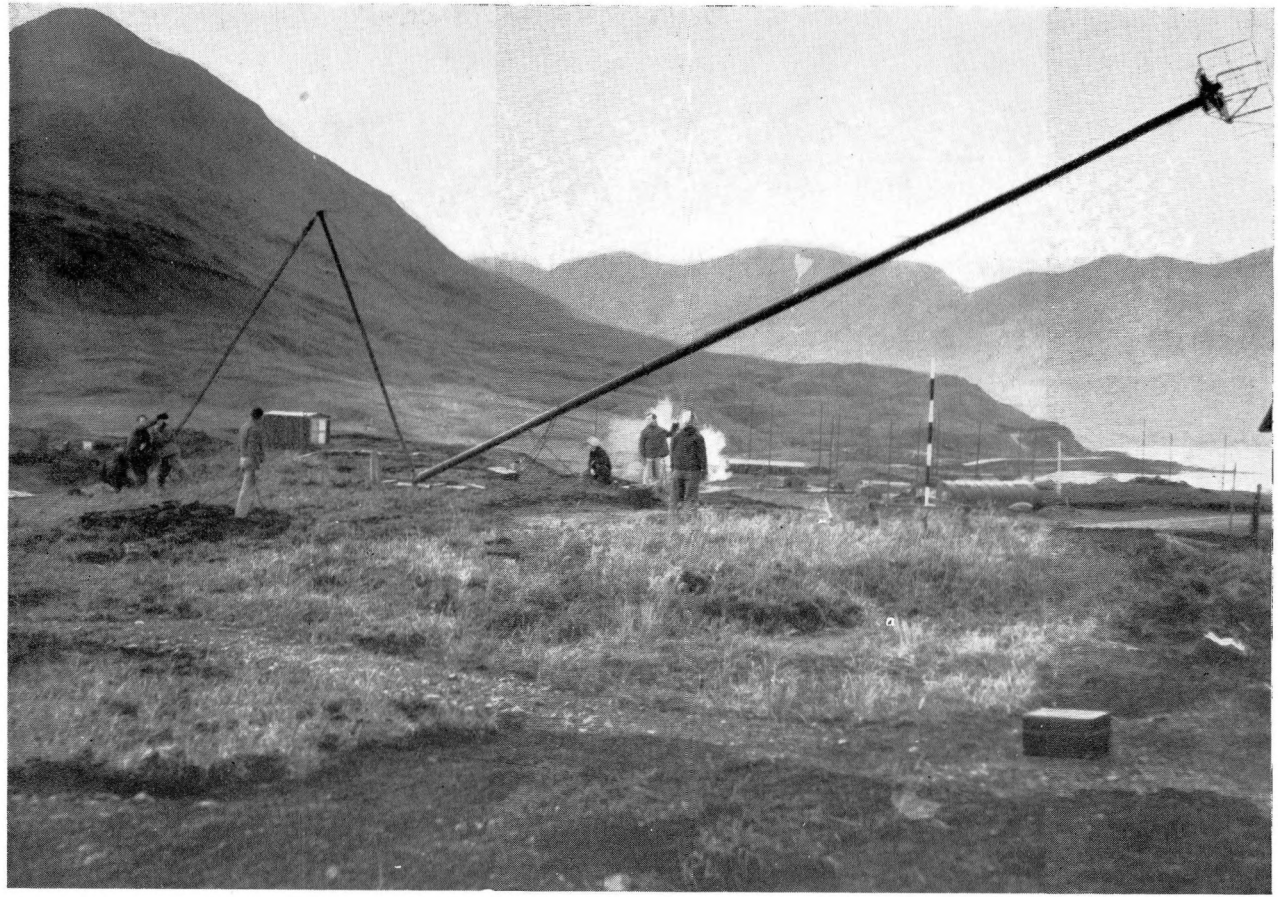

Fig. 5. Erection of shoran mast for ground station in Massacre Bay, Attu Island, Alaska.

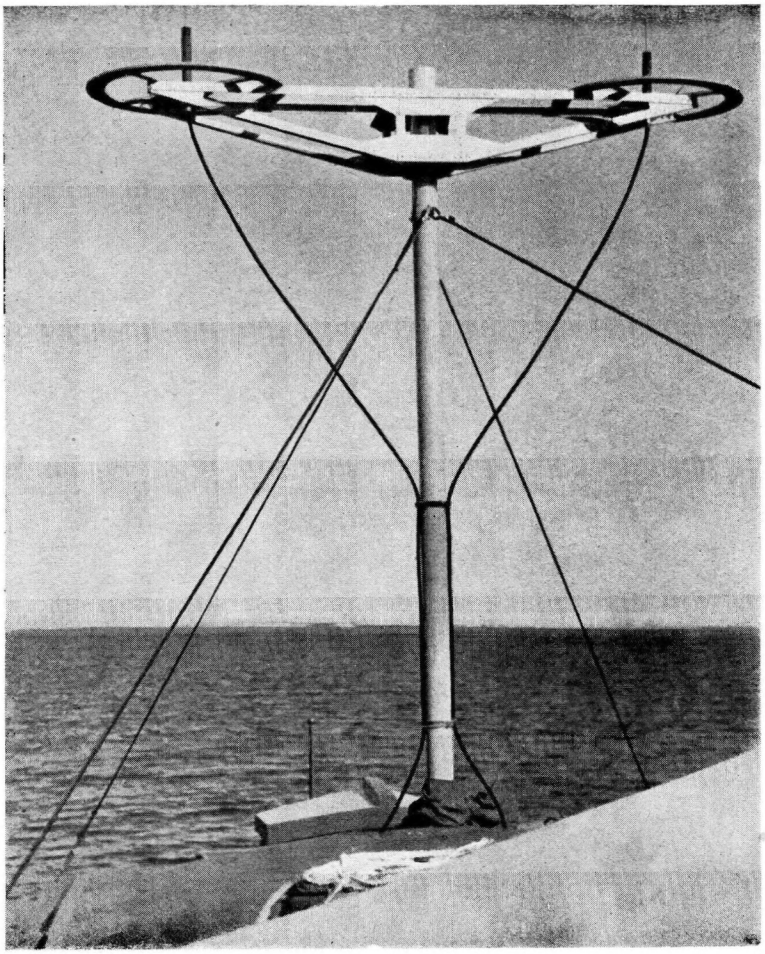

Fig. 6. Shoran mast on launch of the survey ship « Explorer ».

RECENT DEVELOPMENTS IN HYDROGRAPHIC SURVEYING AND CHARTING

by Rear-Admiral Robert F. A. STUDDS,
Director, U.S. Coast and Geodetic Survey.

Considerable advances have been made during the past two decades in the field of hydrographic surveying which have resulted in the development of a new and improved type of nautical chart. Echo-sounding followed by improved methods of position determination has provided an economical means of obtaining a wealth of submarine information useful to the navigator equipped with an echo-sounding device. Accurate profiles are now obtained of the ocean floor which provide the cartographer with a wealth of information for detailed charting of submarine relief often characterized by intricate and distinctive patterns.

Echo-sounding, one of the oldest electronic surveying equipments, is now used almost exclusively in the hydrographic work of the Coast and Geodetic Survey. The original equipments depending on audio and visual methods have been entirely superseded by instruments of the recording type. The Coast and Geodetic Survey uses two classes of echo-sounding equipments — those for relatively shallow water, such as obtained within a few miles of a shore, and those which record depths in very deep water. Most of our smaller or shoal-water equipments are portable and may be used in launches as small as 25 feet in length. Portable echo-sounders are used in the surveying of harbors, bays, rivers, and inshore areas along our coasts. Deep-water echo-sounders are used only in our larger ships, both for hydrographic surveying and for ship navigation.

Many submerged features of interest have been found by using echo-sounding methods. Coast and Geodetic Survey vessels have discovered mountain peaks rising to heights of 10,000 feet or more in ocean depths of 2,000 or 3,000 fathoms. Great trenches have been found along the continental shelf which drop to depths of more than 4,000 fathoms from a surrounding general level bottom not much deeper than 2,000 fathoms. By means of echo-sounding equipments, intensive surveys have been made by our ships of vast areas along the coasts of the United States and Alaska. Hydrography accomplished annually by the Survey averages more than 75,000 miles of sounding lines over areas totalling 25,000 to 30,000 square miles. In addition about 200 miles of water areas are wire-dragged each year.

CONTROL OF HYDROGRAPHIC SURVEYS

The method usually used to control hydrographic surveys depends on the distance from land and the depth of water. Where the survey vessel is close to shore its position or the position of the soundings is obtained from control stations on shore. The usual method of fixing hydrographic surveys within sight of land is by sextant three-point fix, which is almost universally followed for position-fixing.

Beyond the limits of shore objects and where the use of buoys or three-point fix control is impracticable or unwarranted, a number of methods of control have been used in the past. Radio Acoustic Ranging, or RAR, including the radio-sono buoy, was a method developed by the Survey after World War I for offshore hydrographic surveying. By this method the position of the survey ship was determined from two or more previously located control stations by exploding a small bomb in the water near the ship and measuring the interval of time required for the sound to travel to each station. The explosion of the bomb and the radio signals that were transmitted automatically from the control stations were recorded on a chronograph carried aboard ship. The distances from the survey ship to the control stations were determined by measuring the time for the transmission of the underwater sound impulse and the ship's position was thus determined.

The application of these scientific principles resulted in the extension of hydrographic surveying to considerable distances offshore with increased accuracy. This method was hailed as a great achievement and an enormous area was surveyed using the system. There were, however, several disadvantages inherent in RAR, none of which was completely overcome. World War II brought forth several new navigational methods which have made possible great improvements in our system of controlling surveys. As a result of these developments Radio Acoustic Ranging has been replaced in the hydrographic operations of the Survey.

The Coast and Geodetic Survey was the first agency in the United States to use Shoran for control of hydrographic surveys. The very great accuracy of the Shoran fix has made it an essential control method for hydrographic surveys. The system was first tested in 1945 aboard the Coast and Geodetic Survey Ship *Explorer* in the Aleutian Islands, Alaska, to determine its application in precisely locating a survey ship while traversing back and forth on depth finding operations. The test proved successful and Shoran is now used on all the Alaskan survey vessels as the standard method for ship control. Vessels controlled by Shoran are able to take soundings day and night, in fog and clear weather, continuously knowing the location of the vessel within an area of uncertainty of about 20 feet.

Shoran equipment is a special type of Radar system designed and built by the Radio Corporation of America for the particular purpose of controlling the position of an aircraft during a bombing mission. The fact that the equipment was designed to be used in and transported by aircraft is reflected in the general design of all components, including the power sources. The variation of our equipment from the original design is in the modification of the standard airborne equipment to serve as the beacon at the fixed control stations ashore.

Shoran being a line-of-sight method is limited to distances of 50 to 75 miles. While very accurate in its determination of a position, the system provides a relatively small service area, especially when equipments are installed at low elevations. An improved method of control was offered by the Loran system which utilizes low frequency radio impulses for transmission. Therefore an adaptation of Loran is not limited by the line-of-sight range as is the case with the high frequency pulses of Shoran. By combining the frequency and modulation of Loran with the distance measuring features of Shoran, the Survey built the *Electronic Position Indicator*. The principle of position-fixing with the E·P.I. is essentially the same as Shoran with a greatly increased service area.

Field tests made during the summer of 1945 were sufficiently gratifying to warrant further research and development in the system. The following months were spent in further design and engineering and the equipment now known as the Mark III, Model 2, has been developed. Field tests on this equipment have produced results fulfilling all expectations. Accurate control is now being obtained at distances ranging up to 400 miles. Recent tests have indicated a maximum usable range of about 540 statute miles without appreciable reduction in signal strength. Three of the major ships operating in Alaskan waters have been equipped with this system of control for use during the 1951 season.

MODERN NAUTICAL CHARTING

The application of the great volume of data obtained from modern intensive surveys to the nautical charts published by the Coast and Geodetic Survey has resulted in greatly improved accuracy and usefulness of our charts. During the past 15 years the nautical chart has undergone more radical changes in appearance and usefulness than in any similar period in its history. In addition to the rapid strides being made in surveying techniques, several basic factors are responsible for the significant changes in the modern nautical chart — charts are being modernized by improved cartographic techniques, simplified symbolization, and better reproduction methods with increased use of colors.

One of the most striking changes in the appearance of the nautical chart today is the substitution of depth curves and blue tints for sanding. The shading of water areas brings out the gradation of depths to emphasize dangers to navigation and to make channels and other safe waters apparent at a glance. In the days of sailing ships, the 18-foot curve was the danger curve on the Atlantic coast. Today, the 10-fathom curve is accepted as the danger curve and the blue tint is now carried from the shore to this depth. On the Pacific coast where the shores are bold and steep-to, the 20- or 30-fathom curves are the danger curves.

Detailed hydrographic surveys made with echo-sounding equipment have made possible more accurate depth curves on Coast and Geodetic Survey charts to bring out bottom characteristics and a truer portrayal of the actual shape of the ocean floor. This treatment permits the use of a minimum of soundings and has resulted in a chart which is not only extremely legible but invaluable for navigation with echo-sounding equipment. We are

adding depth curves to our nautical charts wherever complete modern hydrographic surveys have been made.

On the modern nautical chart of the Coast and Geodetic Survey all basic information is printed in black including topographic contours and soundings; various other colors are used to emphasize certain features. All land areas are overprinted in buff; blue is used to emphasize water areas between the low water line and designated depth curves; green, produced by overprinting in both blue and buff, is used to define marshlands and tidal flats; and red is used to indicate cable areas, anchorages, and red buoys. Advances in lithography have made possible increased use of colors without an undue increase in cost.

Frequent revisions are necessary to give an accurate picture of existing conditions. Constant changes are taking place along our coasts due to the forces of nature and the works of man. Ocean waves and currents are moving sand and mud from one place to another and are shifting channels and sand bars. We are dredging channels in one area, filling in another, building up tide flats, and establishing new port facilities. Safety of navigation depends upon an accurate representation of all of these changes on the published chart. Therefore, new editions are published frequently to furnish the mariner with charts which show existing conditions at the time when he is navigating the area of the chart.

To serve mariners using the Loran system for offshore navigation, a new type of nautical chart has been developed and published by the Coast and Geodetic Survey. On this chart Loran curves and all other basic information, including all required depth curves, are shown, but with soundings outside of the 10-fathom curve deleted. Charts of this series are printed on the reverse side of the standard editions. During 1951 we expect to complete a project now in work of applying Loran lines of position to nautical charts of the *General* and *Coast* charts series for both the Atlantic and Pacific coasts of the United States. The Loran lines of position are overprinted on the face of the series of *Coast* charts of the Atlantic coast instead of being printed on the reverse side by the method used on other series. The Loran lines printed on the face of the chart are broken for soundings and other important details; also, the lines are drafted fine enough so as not to interfere with the hydrographic information.

The policy of the Coast and Geodetic Survey is to design the nautical chart so as to develop the greatest usefulness of our coastal waters and to promote safety in marine navigation through constant revisions from surveys by the Bureau and other reliable sources.

RESEARCH AND DEVELOPMENT

Because of its highly specialized activities, the Coast and Geodetic Survey has from its inception recognized the importance of developing new and improved instruments, equipment, and methods in order that better results might be obtained in various surveying operations and charting techniques at reduced cost. Progressive research with the application of new scientific findings to our operations has been of paramount importance in developing our present-day methods and equipment. In recent years our research

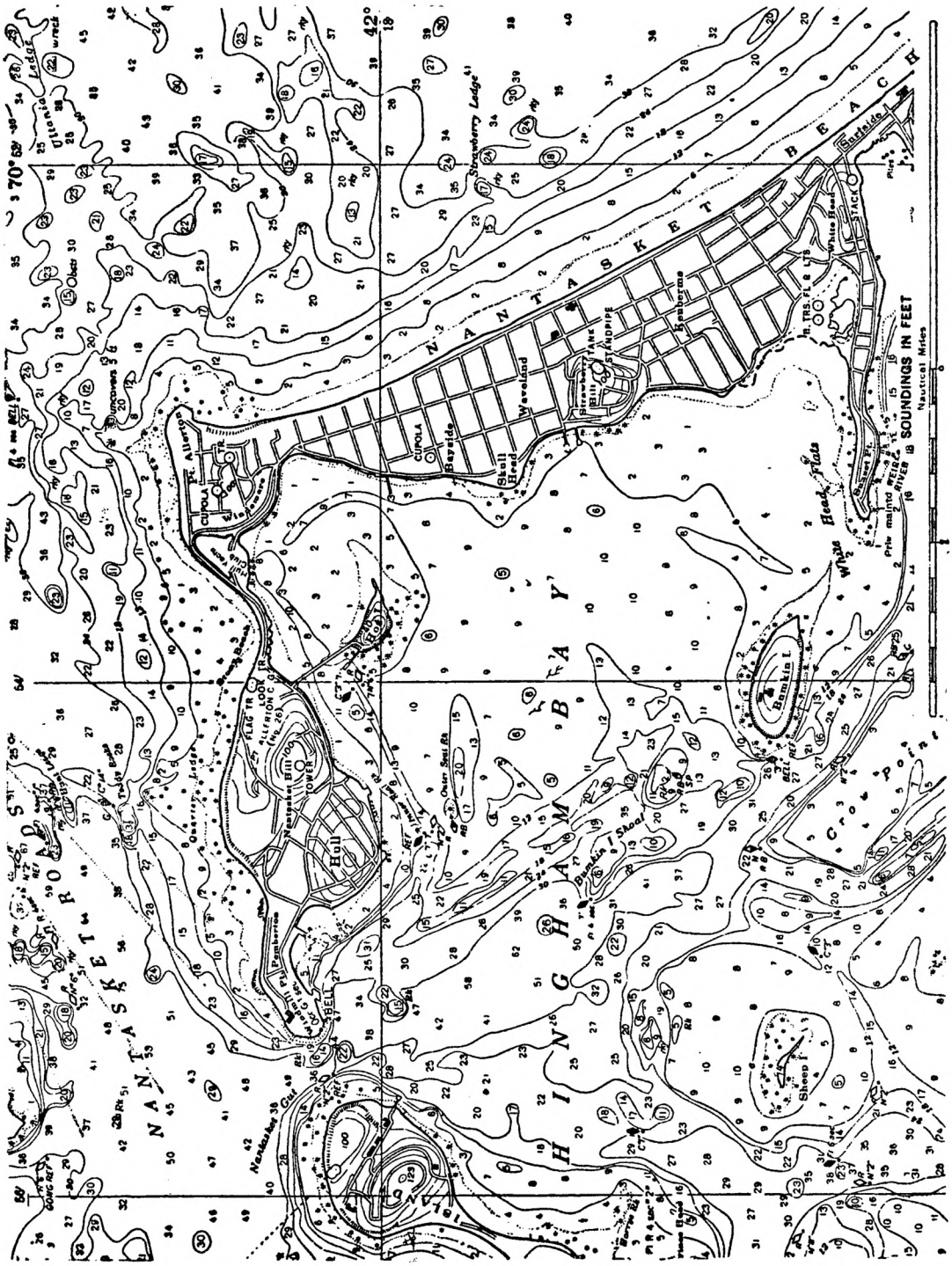

Fig. 7 : Section of chart 246, Boston Harbor, illustrating the use of depth curves to bring out submarine topography.

work has been intensified through maintenance of a Radio-Sonic Laboratory where improvements and adjustments are made of equipment used in the application of electronics to our surveying operations. Aerial photographic mapping is being continually improved through intensive research carried on in our Photogrammetric Laboratory by a technical group of experts assigned to this type of work. Improvements are being made in the quality, accuracy and speed of stereoscopic contouring with the Reading plotter. We also maintain a modern repair shop for servicing all instruments and equipment used in our field and office work.

Work now in progress includes the design and development of a new hydrographic launch and a landing craft to handle cargoes of up to three tons. To meet our special needs, an aluminum shoal-water hydrographic launch has been designed and is now undergoing field tests. Improvements have been made in our tide and current instruments, including modification of the NK-7 portable depth recorder for use as a tide gauge. New and advanced echo-sounding instruments, deep-water anchoring equipment for current meters and tide gauges, suitable equipment for positive calibration of sonic depth records, improved depth records, and improved logs for measuring the speed of vessels through water are among the objectives of our present research and development program.