the inexperience of the personnel, but more largely because of the latter. These requirements are being fulfilled to a much greater extent on the compilations recently received.

Experience up to the present time indicates that the methods employed are adequate to obtain the accuracy required for base maps. However, while the principles of radial line plotting are relatively simple to understand, the technique, particularly the painstaking care which is necessary for accurate work, can be acquired only by extensive experience. It is suggested that the best method in beginning a new project with inexperienced personnel is to have each new man re-compile a map which has already been satisfactorily completed. This would furnish a training period and would assist in eliminating those men not capable of executing the details and precise drafting required. Not much additional expense would be incurred as the revision of a poor first compilation is very often as expensive as an entirely new compilation. Furthermore, the revision is seldom as satisfactory as the new compilation.

The training methods and checks described will produce base maps but only if applied with strict attention to detail and accuracy in every step of the work.

THE ACCURACY OF SOUNDINGS AND POSITIONS OBTAINED BY METHODS USED IN THE UNITED STATES COAST AND GEODETIC SURVEY

by

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(Extract from an article in *Transactions of the American Geophysical Union*, Washington, August, 1935).

With the advent of acoustic methods in navigation and in Hydrographic Surveying, the field of accurate hydrographic surveying has been extended to several hundred miles off the coast, and many details of the ocean-bottom now can be obtained and charted with far greater fidelity than was possible in the past. The discovery of submarine valleys at the edges of the continental shelves, and the development of the details and configuration of the ocean-bottom in greater depths as aids to navigation, are opening up a wealth of information for the use of geologists and oceanographers. This paper has been prepared in answer to repeated inquiries as to the accuracy of soundings, that is, the probable errors of soundings both in depth and in position.

Long ago, charts were adequate if they showed only the shore-line, important shoals which were dangerous to navigation, and the main passable channels, with a few additional soundings to give the navigator a rough idea of the depths. With increased speed of ships, the need for more details of the ocean-bottom has grown until now, with modern high-speed vessels equipped with echo-sounding devices, it would appear that a good contour map is desirable to satisfy all the needs of modern navigation. A sudden change, however, from the present practice of charting to one that shows only the depth-curves with soundings given only for the least depths and the depths of the valleys or depressions, would not be accepted readily by the majority of seagoing people. It should be realized that, unless undisputed evidence that a certain depth-curve occupies a certain position is obtained, the cartographer hesitates to show the curve. Where soundings are not adequate to completely prove the form, the geologist usually interprets the shapes from his experience and knowledge of various geological forms, but the cartographer maintains that too much imagination is used in such delineation by geological interpretation. For these reasons it has been the policy of the Coast and Geodetic Survey to show on its charts only such depth-curves as can be determined with certainty. This applies to the detailed surveys made in shoal waters. The general form of the 100-fathom curve and in some cases that of the 1000-fathom curve have been shown on small-scale charts.

Inshore-soundings, that is, surveys within sight of land, usually are controlled by observations taken from the surveying vessel by means of sextants, sighting objects on shore which have been located by triangulation, or topography. This type of control is used on the Atlantic and Gulf coasts to about 15 miles offshore, approximately the limiting distance for visual fixes from triangulation-signals, water-towers, high buildings, or other structures that provide visible objects up to that distance. The sounding vessel proceeds along courses so determined as to give the most economical development of the area, but in general for the preliminary survey these courses are set so that the directions of the sounding-lines are approximately normal to the trend of the contours.

Beyond the limits of visual control, and in regions where foggy weather prevails, radio acoustic ranging has been used with remarkable success by the Coast and Geodetic Survey for the past ten years. This method, combined with echo-sounding, has greatly reduced the unit costs of all hydrography, and in addition has given more complete data.

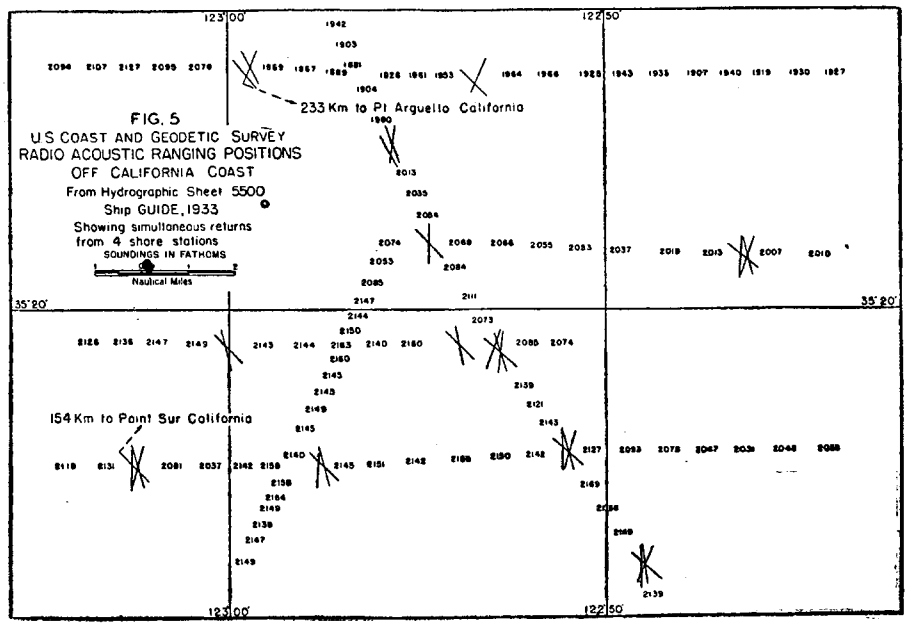
The method of recording fathometer-soundings, as has been used since the adoption of echo-sounding in the Survey, is to observe the indications of the fathometer, recording the depths at frequent intervals — one minute, 30 seconds, or less — depending upon depths. Although the fathometer gives twenty soundings per second in the case of the Dorsey Fathometer and four soundings per second in the case of the commercial fathometer in depths less than about 100 fathoms and about one sounding per second in depths over 100 fathoms, it is obviously impracticable to record so many soundings. The graphic recorder developed by a commercial firm is used on one surveying ship of the Bureau. Because it is an additional instrument which must be verified by visual observation, and for which corrections must be made, it has not been used as a permanent record. In addition to this, the records obtained by the graphic recorder require more work for reduction to the soundings that are selected for the chart than is at present necessary with visual recording. The soundings which are placed on the field-sheets, therefore, represent soundings that are observed, or are read from the fathometer-dial at various intervals, and might not in all cases show the small changes in depth between soundings. Ordinarily, the observer makes a particular effort to record any change in depth and the exact time at which the change occurs, in addition to the regular soundings that are taken at specified intervals.

From experience with comparisons over several years and from a consideration of the various instrumental difficulties, it is believed that the soundings, depending on the character of the bottom and the type of instrument used, are accurate to within one-half of one per cent up to 10 fathoms, within about one per cent between 10 and 200 fathoms, and within about three per cent over 200 fathoms. In some of the first echo-soundings, these limits were exceeded, but recent work is believed to be well within the stated percentages.

Errors in location of positions by visual fix as of any given survey are usually correct to within one part in 500 to 100, depending upon the relative positions of the control-stations and the distances offshore. For radio acoustic ranging-positions the accuracy is about one part in 200 to 500, again depending upon the locality surveyed and the positions of the shore-stations. As an instance of the agreement between several distances determined by radio acoustic ranging in practice, a copy of a section of the field-sheet of the ship *Guide*, Coast of California, is shown in Fig. In this case there were four shore-stations in operation which gave returns to the ship from four separate locations. The actual discrepancy in the distances as determined from the various hydrophone-locations is shown by the short sections of the intersecting arcs. From a study of the Figure, it will be obvious that there are no very large discrepancies; the experiments which have been made in recent years between known points indicate that the methods are quite dependable. It is most desirable as contrasted with the only other practical method of determining position, namely, astronomic fix. Ordinary astronomic positions taken from vessels underway are hardly dependable within one mile, although where it is possible to anchor for a series of astronomic sights it has been possible to determine the position within about one-quarter of a mile.

The depth-measurements which were made in deep water on the older surveys, while not so frequent, were comparable in accuracy to modern sounding; but the positions which were obtained by astronomic fix, or by dead-reckoning, were not. Relative errors between positions of soundings within small areas are usually less; for example, the development of some features at a considerable distance from shore where the same

hydrophones are used in the development of such feature. This means that the shape of the feature is more accurately determined than the true geographic position of any point on the feature with reference to the shore-control. It is difficult to state what the



relative accuracy in this case might be, but the consistency of such radio acoustic positions also is illustrated in the sketch showing a section of the field-sheet in the Figure.

INTERNATIONAL STANDARDIZATION OF BASE-LINE TAPES AND WIRES.

by

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(Reproduced from *Transactions of the American Geophysical Union*, Washington, August 1935).

The International Bureau of Weights and Measures has sent a group of invar base-line wires for standardization to several of the national laboratories. Twenty-four-meter invar wires are used rather generally in Europe for geodetic base-line work instead of the 50-meter base-line tapes used by the United States Coast and Geodetic Survey. These wires are described in "*La mesure rapide des bases géodésiques*" by J. R. BENOIT and C. E. GUILLAUME.

The standardization of these wires at the International Bureau is carried out in a basement-room in the main laboratory building. The new equipment installed a few years ago, is described by Dr. GUILLAUME in an article entitled: "*La nouvelle base édifiée au Bureau International*", published in the "Procès-Verbaux des Séances" of the International Committee for the session of 1925. The working standard for the measurements is an -H-shaped four-meter invar bar.

The equipment for standardizing tapes and wires is different in nearly every country. Some of these comparators were described in a paper "Precision machines and instruments for the measurement of length", presented by Dr. George K. BURGESS at the World Engineering Congress in Tokyo in 1929 and published as paper N° 335 in volume 5 of the Proceedings.