ASSOCIATION OF FIELD ENGINEERS

U.S. COAST & GEODETIC SURVEY

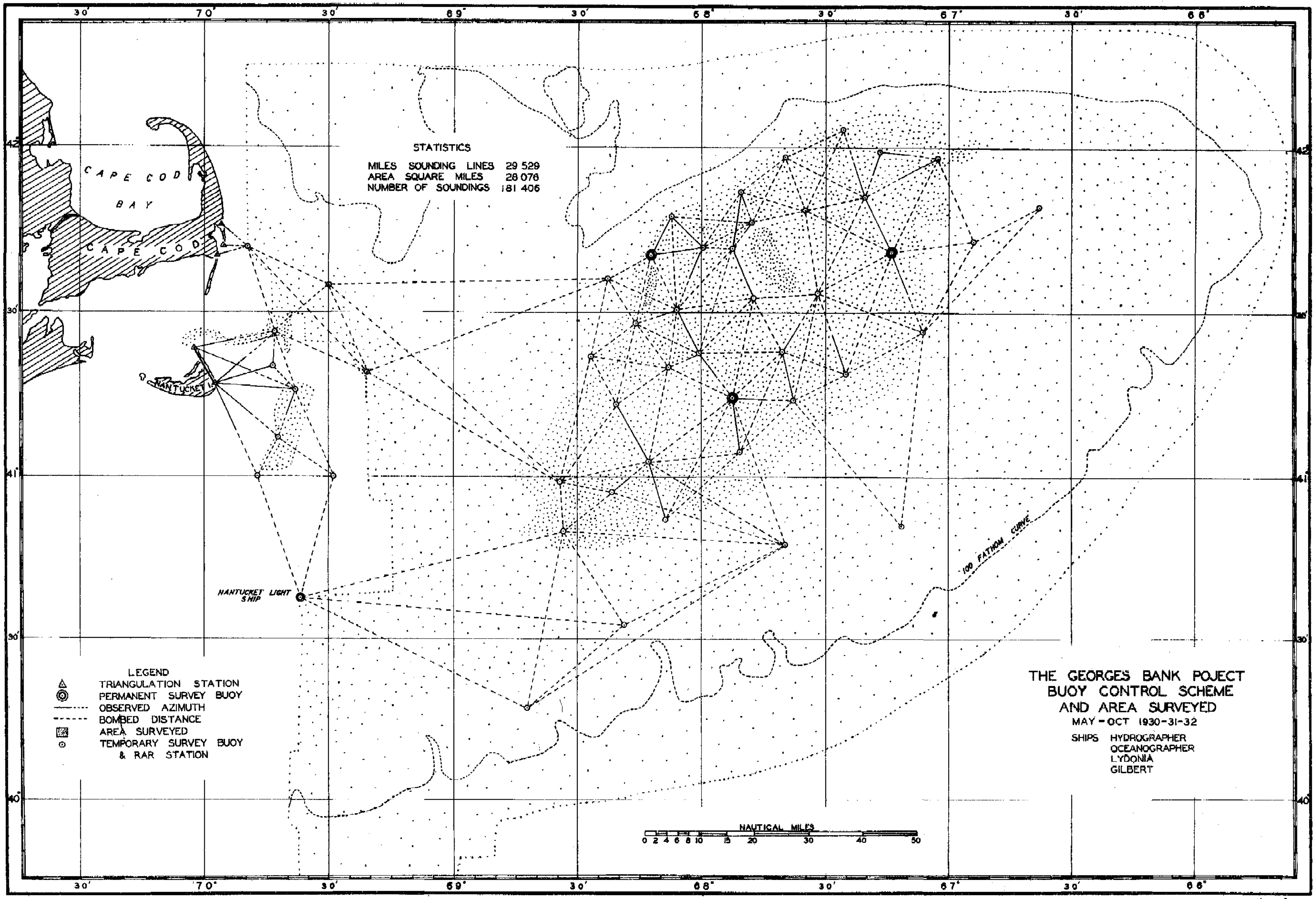
BULLETIN

DECEMBER 1932

No. 6

C&GS 457

THIS BULLETIN CONTAINS


THE GEORGES BANK POJECT
BUOY CONTROL SCHEME
AND AREA SURVEYED
MAY - OCT 1930-31-32
SHIPS HYDROGRAPHER
OCEANOGRAPHER
LYDONIA
GILBERT
STATISTICS
MILES SOUNDING LINES 29 529
AREA SQUARE MILES 28 076
NUMBER OF SOUNDINGS 181 406
LEGEND
TRIANGULATION STATION
PERMANENT SURVEY BUOY
OBSERVED AZIMUTH
BOMBED DISTANCE
AREA SURVEYED
TEMPORARY SURVEY BUOY
& RAR STATION
CAPE COD BAY
CAPE COD
NANTUCKET I.
NANTUCKET LIGHT SHIP
100 FATHOM CURVE
NAUTICAL MILES
0 2 4 6 8 10 15 20 30 40 50
30'
70°
30'
69°
30'
68°
30'
67°
30'
66°
42°
30'
41°
30'
40°
C.&G.S. 457

COMPLETION OF THE GEORGES BANK SURVEY

The past season marked the completion of the survey of Georges Bank, a project which has aroused an unusual amount of interest. Its progress has been closely watched by both shipping and fishing interests because of the vital importance to those industries of accurate charts of this region. Not only will the new charts afford additional security to lives and property represented by the thousands of vessels which annually cross the Bank, but evidence is already at hand indicating that the entire cost of the survey will be saved in a comparatively few years through economies resulting from shortened steamer tracks. A representative of the New England fisheries has stated that the two special fishing charts resulting from the new surveys will save one day out of each ten-day round trip of the trawlers to the Banks and may well make all the difference between a slight profit and the present losses which the fleet is suffering.

The project has also attracted special attention from geologists and oceanographers because of the discovery of several remarkable submarine valleys along the edge of the continental shelf. The fact that the Bureau, with its advanced methods of hydrographic surveying, can now develop such offshore features with an accuracy heretofore considered impossible has given to those interested primarily in submarine configuration a vast amount of reliable information on which to base their studies, while at the same time, it has obliged them to discard certain theories which have been advanced without a proper evaluation of the basic data supporting them.

To the Bureau, aside from the satisfaction that always comes from the knowledge that an important and difficult task has been successfully completed, it has meant another step in the development of efficient hydrographic surveying. The quality of the work was improved each season, the quantity increased and the unit cost reduced. It will be recalled that the survey was started, during the 1930 season, at the offshore end of the Bank in order to chart, as early as possible, areas where westbound transatlantic shipping lanes cross the edge of the continental shelf. The basic position therefore was an astronomical one and from it R.A.R. triangulation was carried inshore for a distance of 150 miles until a connection was made during the last season with the coastal triangulation. That the discrepancy found when the connection was finally made was only 400 meters is another tribute to radio acoustic sound ranging and to the skill and experience of the personnel of the field parties. Furthermore, it is proof that the path assumed for the sound wave as well as the theoretical velocities computed for that path were remarkably accurate.

The frontispiece shows the limits of the entire project and the R.A.R. buoy control scheme. A large percentage of the 29,529 miles of sounding lines required to develop this area of 28,076 square miles had to be run during foggy weather directly across the principal transatlantic steamer tracks. On many occasions it was necessary for the hydrophone station ships to remain at anchor in thick fog for days at a time, directly in those tracks. On one such occasion voices from the deck of a passing liner were plainly heard on one of the station ships. All soundings, with the exception of the relatively few required to develop the dangerous shoals, were obtained, with the fathometer. By-products of the survey included current observations at 107 stations, 609 water temperature and 392 salinity observations.

During the latter part of the last season, work was extended over a portion of Nantucket Shoals in order to develop a shoal on which a vessel had grounded while attempting a passage through Davis Channel. Advantage was taken of the control established for this work to resurvey both Davis and Great Round Shoal Channels and to relocate all the offshore aids to navigation in this locality.

Various articles and reports descriptive of the methods used on this project have appeared in previous issues of the Bulletin. In this issue are included a report of Lieutenant W. D. Patterson on the method of plotting the 1932 season's buoy control scheme, the methods used and the results of an experimental determination of the velocity of sound in sea water and copies of several forms devised by the field parties as useful in standardising and simplifying the records of the several survey units. Professor F. P. Shepard of the University of Illinois, who is much interested in submarine configuration and who spent some time on the working ground, has given us an article illustrated with the detailed contouring of three of the valleys developed during the 1932 season, In a future edition, it is hoped that an analysis of the costs of the project can be given.

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From the Master of S.S. PORT HUNTER

**** "A few days ago on a voyage from Halifax to New York this vessel had occasion to round Georges Bank on soundings, Admiralty Charts Nos. 2670 and 2492 being used. Considerable difference between soundings obtained on a course line and the estimated position on the chart existed. Now, after comparing the new survey soundings and those on the charts mentioned, there appear considerable differences. The new sheet (advance information chart of a section of Georges Bank) comes in very well with the soundings we obtained. On future occasions I shall have more confidence in thick weather and be able to save quite a few miles on any future voyage." ****

From the Master of S.S. AUSONIA

**** "I beg to thank you for the print of the new soundings along the edge of the continental shelf on either side of westbound track "C". This excellent work is most necessary and, in view of the general use in the near future of sonic soundings, an accurate chart showing the configuration of the bottom will be an absolute necessity to the navigator of the future who wishes to have his position accurately registered while proceeding at full speed. I wish to compliment your department on its excellent and untiring efforts to assist the navigator." ****

COORDINATION OF COASTAL TRIANGULATION AND EMERGENCY RELIEF

The allotment to the Bureau of a small portion of the funds appropriated in the Emergency Construction Act has made it possible to undertake, in addition to other much needed surveys, the coordination of the triangulation schemes that have been established from time to time along our. coasts since the original scheme was executed.

The original scheme was established from 75 to 100 years ago. A large percentage of the stations in it have been lost. New triangulation has been executed in many localities for the control of revision surveys, but this necessarily was local in character and in many cases, because basic stations could not be recovered, started from lines weak in both azimuth and distance.

Coordinating schemes are being established along the coasts of North Carolina, South Carolina, Georgia, Louisiana, Texas, and California and are of second-order accuracy. Wherever recoverable, stations of the original scheme are incorporated into them and line connections are made with each of the later schemes. The lines in the new schemes are, in general, from two to three miles in length and are so situated as to control all navigable inland waterways. Provision is made for frequent connections with the first-order arc, which lies from 10 to 30 miles back from the coast, thus permitting a rigid adjustment of all existing triangulation on the North American, 1927, datum.

As an important part of the work, connections are made with all schemes of the U. S. Engineers and the U. S. Geological Survey, from whom excellent cooperation is being obtained. Special attention is being paid to the selection of sites and to marking and referencing the stations in an effort to make them of maximum value and as permanent and accessible as possible. Descriptions are made in sufficient detail to permit spotting the stations on the air photographs which will probably be made of the coast in the near future. The 90-mile stretch from Beaufort, N. C., to the Cape Fear River has recently been photographed and the pictures are now in the hands of the parties operating there.

From 70 to 80 per cent of the cost of projects of this nature goes directly to the employment of labor. Employment is confined to those in actual need of it and, in so far as practicable, to the localities in which the work is done. Cooperation is maintained with relief agencies in selecting employees. In order that the maximum amount of the funds available may be used for direct employment, much of the additional equipment required has been obtained by transfer and loan. Trucks have been obtained from the Post Office Department and instruments from various colleges.

It is conservatively estimated that the funds provided for the Bureau in the Emergency Construction Act will result in the direct employment of 1,000 men for from six to eight months. To the Coast and Geodetic Survey this allotment means the economical and efficient accomplishment of a large amount of important work of value to all surveying and mapping agencies of the country. It constitutes a national investment, the maintenance cost of which will be almost negligible.

APPROPRIATION REDUCTIONS FOR FISCAL YEAR 1934

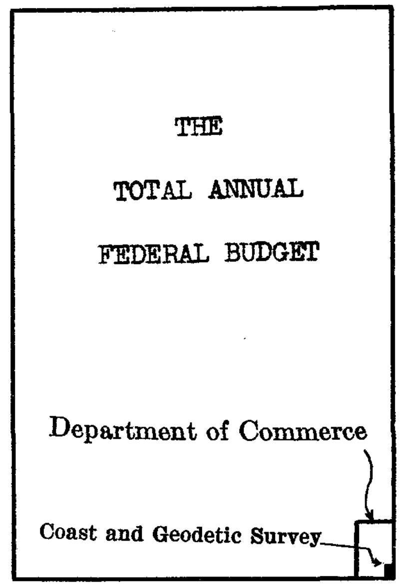
There are shown below two extracts from the report of the Appropriations Committee of the House of Representatives on the Departments of State, Justice, Commerce, and Labor Appropriations Bill, fiscal year, 1934. There is also shown graphically the proportion of the total annual Federal budget appropriated to the Bureau. This is approximately 0.0006 of the total budget.

COST AND GEODETIC SURVEY

For the fiscal year 1934 the committee has allowed $2,205,090, a reduction of $90,828 from the estimates as submitted in the Budget. This amount compares with an appropriation of $3,649,813 for the present fiscal year inclusive of $1,250,000 contained in the emergency relief and construction act of 1932 for engineering work.

The committee is impressed with the progress made in reducing the cost of triangulation work and the unit cost of hydrography. No effort should be spared to continue to effect economies in every field of endeavor with which the bureau is occupied.

The importance of this bureau in protecting lives of our citizens is not minimized and the committee does not desire materially to retard the work of this unit in charting information secured in the field. Some sacrifices, however, must be made by each and every agency of our Government. It remains for those charged with the administration of these funds to apply the reductions made to those activities having the least to do with the safeguarding of human life and property. The committee knows that this is the measuring rod that has been employed by the administrative authorities of this bureau, and commends its continuance. The committee is impressed with the efficient administration of this bureau.



Object	Appropriations, 1933	Budget estimates, 1934	Amount recommended in bill tor 1934	Increase (+) or decrease (—) bill compared with 1933 appropriations
Coast and Geodetic Survey:				
Party expenses, emergency construction	[13] 1, 250, 000. 00			—1,250,000.00
Field expenses—				
Atlantic coast surveys.	150, 000. 00	102, 000. 00	102, 000. 00	—48,000.00
Pacific coast surveys.	200, 000. 00	141, 220. 00	141, 220. 00	—58,780.00
Tides, currents, etc.	20, 000. 00	16, 820. 00	16, 820. 00	—3,180.00
Coast Pilot, compilation of	5, 500. 00	6, 205. 00	5, 200. 00	—300.00
Magnetic work	40, 000. 00	42, 160. 00	37, 160. 00	—2,840.00
Federal, boundary, and State surveys.. } Triangulation and leveling earthquake areas }	150, 000. 00	178, 702. 00	150, 000. 00	
Special surveys } Miscellaneous expenses }	7, 000. 00	6, 735. 00	6, 735. 00	—265. 00
Vessels, repairs of	60, 000. 00	66, 000. 00	63, 000. 00	+3, 000. 00
Pay, etc., men on vessels	555, 000. 00	543, 893. 00	533, 000. 00	—22,000.00
Pay and allowances, commissioned officers	662, 313. 00	633, 955. 00	633, 955. 00	—28, 358.00
Office force, salaries.	500, 000. 00	501, 048. 00	461, 000. 00	—39, 000.00
General expenses, office	50, 000. 00	57, 180. 00	55, 000. 00	+5, 000.00
Total, Coast and Geodetic Survey	3, 649, 813. 00	2, 295, 918. 00	2, 205, 090. 00	—1,444,723.00

(R-311)

INTERESTED SUBMARINE CONFIGURATION OFF THE CALIFORNIA COAST

F. L. Peacock, H. & G. Engineer, U.S.C. & G. Survey

Although sketchy information concerning the exceedingly irregular configuration of the ocean bottom off the California Coast has been available since early days and scrutiny of the land contours immediately adjacent to the coast shows that much irregularity is to be expected, it is only during the past few years and in the process of executing modern hydrographic surveys that the full extent of this irregularity has been appreciated.

The execution of an accurate and complete survey in such an area tests to the very limit the adequacy of our most modern equipment and the cooperative skill of the personnel engaged.

The 1932 season's work of the Ship GUIDE covers the area between latitude 36° 10' N. and latitude 37° 10' N., with the outer limit sixty nautical miles outside a line from Point Reyes to Point Sur. In other words, it constitutes a complete modern survey from Pigeon Point to Partington Point, twelve miles south and east of Point Sur.

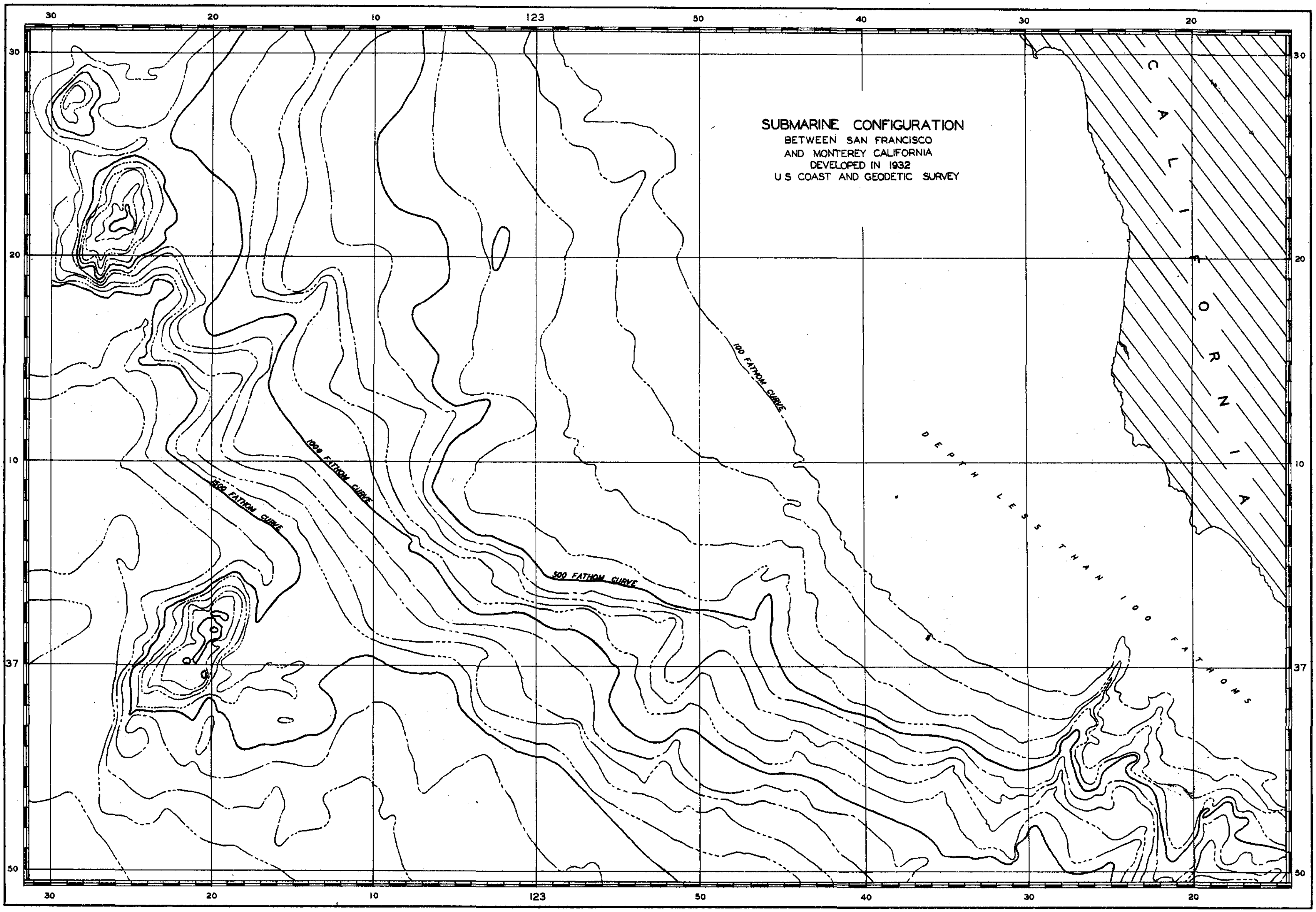
This area contains many examples of the unusual configurations to be encountered along the California Coast, including deep submarine valleys with their tributary gorges and canyons, submarine ridges and a large submarine mountain.

Previous surveys in this area consisted of close inshore hydrography, mostly executed many years ago, and a considerable area in and adjacent to Monterey Bay, executed in 1925 with vertical wire casts and some tube sounding. All these areas are being resurveyed. The 1925 survey, with wire, of the well-known valleys of Monterey Bay had been splendidly executed, with close spacing and good visual control, but even so, the irregularity of the bottom was such that depth curves could not be drawn with certainty. A resurvey of this area was instructed to secure the much greater information to be obtained from Fathometer sounding profiles than from even closely spaced vertical casts.

It is interesting to note that depths in excess of 700 fathoms are to be encountered inside Monterey Bay, and that the 1000-fathom curve approaches to within seven and one-half miles of Cypress Point, the point rounded just before entering the bay from the southward.

Three new submarine features of major interest to either the oceanographer, the navigator, or the geologist were developed during the season. Two of these are shown on the accompanying plate.

The first to be mentioned is a north and south ridge situated twenty miles west by north of Point Sur. The crest of this ridge is about six and one-half miles long, is very narrow and is covered throughout its length by depths of 450 to 475 fathoms. It slopes rapidly to 600 fathoms and deeper on all sides except the very southeastern extremity. This


SUBMARINE CONFIGURATION
BETWEEN SAN FRANCISCO
AND MONTEREY CALIFORNIA
DEVELOPED IN 1932
U S COAST AND GEODETIC SURVEY
CALIFORNIA
DEPTH LESS THAN 100 FATHOMS
100 FATHOM CURVE
500 FATHOM CURVE
1000 FATHOM CURVE
1500 FATHOM CURVE
123
37
C.& G.S.-457

feature was encountered in what was previously a blank area on the chart.

A second new feature is a narrow gorge extending into the continental shelf in a north-north-easterly direction for a distance of over three miles. The prevailing depths on the shelf adjacent to the gorge are from 65 to 80 fathoms. The gorge itself has maximum depths of over 200 fathoms throughout two-thirds of its length, and depths in excess of 300 fathoms for one-half its length. The head of the gorge is only six miles southwest of Ano Muevo Lighthouse. All the coastwise steamer tracks through this vicinity pass over or close to this gorge. When charted it will constitute an excellent submarine landmark in thick weather for all passing vessels equipped with echo sounding apparatus. One sounding obtained near the mouth of this gorge in 1925 was the only previous indication of its existence.

The third new feature is a large mountain, situated in latitude 37° 02' N. and 123° 20' W. The nearest land is Southeast Farallon Island, distant 44 nautical miles, and Pigeon Point, distant 46 nautical miles; and it is 20 nautical miles south by east of the mountain discovered by the party on the Ship PIONEER in 1929. The summit of this mountain is covered to a depth of a little more than 900 fathoms. It is entirely surrounded by depths greater than 1400 fathoms and slopes steeply to 1800 fathoms on the seaward side. The soundings obtained indicate the presence of a crater on the summit.

If it were possible to view this mountain from the eastward, at the bottom of the ocean, it would be seen as a mountain some 500 feet higher than Mount Tamalpais of California; and, if viewed from the seaward side under similar conditions, it would appear as a mountain twice as high as Mount Tamalpais.

H.O. Bathymetric Chart Ho. 5194 showed some indications of an elevation of the ocean bottom in this vicinity; also an isolated 1200-fathom sounding on Coast and Geodetic Survey Chart No. 5402 is in the same general vicinity. However, both these indications are considerably in error in position, probably being plotted from dead reckoning control.

The spacing instructed for the offshore portions of the season's work was as follows:

1/2	mile,	in	depths	between	30	and	100	fathoms
1	"	"	"	"	100	"	300	"
2	miles	"	"	"	300	"	500	"
4	"	"	"	"	500	"	1000	"
5	"	"	"	of over			1000	"

Cross lines were also instructed, spaced four miles apart inside the 100-fathom curve, and eight to ten miles apart outside the 100-fathom curve.

At first thought this spacing seemed entirely adequate, but due to the irregular configuration in the area surveyed, it was found that a vast amount of additional development was necessary in practically all depths to satisfy the requirement that sufficient information be obtained to draw definitely all depth curves.

From the standpoint of the navigator some exception might be taken to the economic desirability of specifying so rigid a requirement in the greater depths. The more experienced the writer has become in the various classes of hydrography, the more strongly he has believed that a hydrographer can not be positive that all possible dangers to surface and submarine craft have been found until he can draw any desired curve with a fair degree of confidence. Again the navigator's point of view is not the only one to be considered. Our Coast Survey hydrographic data are already of very great interest to other oceanographers and to geologists. In addition, it would be entirely futile to make a present prediction as to what further interests the increased detail of our modern surveys may ultimately serve.

This is the first instance within the writer's knowledge where so rigid a system of cross lines has been specified. The writer believes that such a system of cross lines is vital to an accurate modern survey. A part of them can be run at an exceedingly low cost while en route to and from anchorages. There are bound to be some, however, that constitute an aggravating and costly hindrance to the completion of a project. The value of cross lines is in the running check obtained on the adequacy of our surveying equipment, under all the conditions encountered, and on the skill and reliability of the different persons performing the several operations. We desire nothing less than accurate surveys, and if cross lines show up discrepancies, the remedy is not to omit the cross lines, but to improve our equipment, methods, and skill. Cross lines are especially indicated in radio acoustic ranging work in order to test the accuracy of everything pertaining to its operation before we rely upon it with undue confidence.

Among the many questions which demanded consideration during the field season, the following may be of interest:

1. In how rough a sea can accurate fathometer soundings be obtained?

Obviously the sea may become so rough that the noises incident to the waves striking the ship and the plunging of the ship in the seaway will prevent even the most experienced and skillful officer from obtaining accurate soundings. The experience for the season indicates that, for the Ship GUIDE, the sea produced by a steady wind of long duration, in excess of 35 statute miles per hour, makes hydrography in areas where the echo is faint, of doubtful accuracy. Stronger winds, of short duration, gave no trouble.

2. What sounding should be recorded when the bottom is of such a nature that simultaneous echoes are being received covering a range of 50 to 100 fathoms?

Obviously these several echoes are being reflected back from different places of the ocean bottom and this condition can only occur on steep, broken slopes. The most desirable echo to be recorded is of course the one nearest vertically below the ship. The practice has been to record the shoalest echo that was definitely a bottom echo and not a stray.

3. What effect does such irregular configuration as that encountered during the season's work have on the accuracy of determining distances by radio acoustic ranging?

During the present season the Ship GUIDE had excellent success in obtaining returns from sound ranging over extremely irregular bottom. The season's field records contain a great deal of information on this subject, both as a result of velocity tests, where visual fixes were obtainable, and of the fact that three shore stations were in operation most of the R.A.R. season. Up to the present time, however, there has been little opportunity to study and digest the information obtained.

The present season's work of the Ship GUIDE will complete the survey of the entire area of Chart 5402, with the exception of a narrow strip of inshore revision (launch work) in Monterey Bay and from Monterey Bay southward.

SOME SLIGHTLY ANNOYING R.A.R. SITUATIONS DURING THE PAST SEASON

SITUATION No. 1:
A new shore station had just been installed. After only one day's operation, persons unknown sighted the cable anchor buoy, and supposing that it marked a liquor smuggler's cache, hove up the cable end and magnetophone, then, disgusted, threw it overboard at a location some fifty meters distant from the original position.

SITUATION No. 2:
Another new shore station installed with the magnetophone planted not far from a seal rock. The seals evidently believed that a new plaything had thoughtfully been provided for their amusement. They played with the magnetophone for hours daily until its interest for them gradually palled.

SITUATION No. 3:
With the ship on R.A.R. sounding line fifty miles offshore and only two shore stations in operation, one shore station operator sends S O S a couple of times followed by "building on fire am abandoning station."

SITUATION No. 4:
No matter how well one shore station operator had been primed for an all night session, he could not get by 3:00 A.M. without falling asleep. No amount of calling on the instrument at his side could arouse him. On three occasions he was finally awakened by having one of the other shore station operators phone to a nearby neighbors of the sleepy operator to go over and wake him up. Probably that neighbor cussed plenty, but we got results.

SITUATION No. 5:
A substantial increase in the price of a certain variety of fish sent the fishing boats out in unprecedented numbers. Thereafter it was a daily occurrence to have bomb reception interfered with by boats fishing close

to magnetophones, and on one occasion all three shore stations were simultaneously not able to operate for a period of over an hour because of fishing boats operating in the immediate vicinity of each magnetophone.

SITUATION No. 6:

I have been so busy with R.A.R. that there has been no opportunity to get out on the golf course and usefully employ the new words and combinations acquired incident to Situations Nos. 1 to 5.

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Captain G. T. Rude presented a paper on December 28,, 1932, before the Geological Society of America at the annual meeting at Harvard University, Cambridge, Massachusetts.

Briefly, It was the purpose of the paper to illustrate the order of accuracy of various methods of hydrographic surveying and to suggest a guiding procedure for the evaluation of data used in chart construction, since limitations of basic data are not always recognized by the scientist in his interpretation of charts.

Because of the lack of detailed hydrographic surveys, early nautical charts were constructed from incomplete data, often of a reconnaissance nature. Detailed surveys for revised charts of the area may indicate extensive changes unless the charts are critically evaluated from an intimate knowledge of the factors involved in their production.

Again, with the aid of a few hundred soundings, not particularly well coordinated, but with an artist's imagination, bathymetric charts entirely misleading for geologic interpretations have been constructed; yet the general appearance of the charts has indicated that they filled fully the needs of the geologist. Later charting of the same areas from adequate surveys has forcibly illustrated the necessity of a knowledge of the basic data.

Immediately following the presentation of the paper, a conference was held with leading geologists with a view to their obtaining the cooperation of the Coast and Geodetic Survey with oil geologists in the determination of the depth of the sedimentary deposits over the continental shelves, and also in furnishing to the geological fraternity the data from this Bureau's modern offshore hydrographic surveys in the form of accurate bathymetric charts.

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From. Monthly Report, OCEANOGRAPHER (Sept.)

During the last trip to the working grounds, a sounding line was carried on continuously for 51 hours. During the period a total of 706 miles were run, the spacing of lines being one mile. In one period of 24 hours, there were run 360 miles of this line. (The entire line was well controlled by R.A.R.)

HINTS FOR SECURING ACCURATE TIDAL DATUMS

Paul C. Whitney
Chief, Division of Tides and Currents, U.S.C. & G. Survey

The accurate determination of tidal datum planes is assuming more than ever before a major role in the work of the Division of Tides and Currents.

In the early history of charting the coasts of this country, many of the tidal datums were derived from relatively short series of tide observations. This was necessary because the rapidly increasing commerce along our shores demanded the speedy publication of the data resulting from the surveys.

In the accurate determination of tidal datum planes much longer series are needed than were observed in those days. Our present knowledge of tides tells us that planes derived from a series of less than one month may be in error as much as one foot, and to reduce this to less than two tenths of a foot, the series must be reduced to mean values by comparison with a nearby primary station where a long series of observations has been made. An example will make this clear.

We have a series of tide observations at Prospect Harbor, Maine, covering a period of 17 months. Mean low water as derived separately and independently from each month of observation varied from a low reading of 1.33 feet on tide staff for February, 1930, to a high reading of 2.11 feet on tide staff for October of the same year, a total variation of 0.78 foot. When these mean low water readings are reduced by comparison with simultaneous tide observations at our primary tide station at Portland, Maine, the resulting monthly values are found to vary from a minimum of 1.39 feet for October, 1929, to a maximum of 1.68 feet, a difference of 0.29 foot. The reduced mean low water for the entire series is 1.56 feet. Thus in the monthly low waters independently determined, the maximum departure from the accepted value is 0.55 foot, while in monthly values reduced by comparison with the Portland tides, the maximum departure is only 0.17 foot.

The above results emphasize the need not only of extending observations over as long a period as practicable, but also of comparing the data with simultaneous observations at a suitable primary tide station.

One might now ask what matters three-fourths of a foot error in a tidal reducer for soundings in five fathoms or more of water when perhaps the depth is not known within a foot. That is the attitude we want to correct. The engineer in the field naturally thinks of his tidal work primarily in terms of its contribution to the specific job on which he is engaged at the moment, i.e., in the case of a hydrographic survey, to the reduction of soundings. Actually, the field is broader than that; it includes the whole field of tidal research, which is one of the specified functions of this Bureau. One of these is the determination of tidal datums and there is a very important and growing need for accurate datum planes, due to the increasing value of properties adjoining tidal waters.

It has been the custom to refer water boundaries to tidal datums, usually a high water datum, and the lack of accurate knowledge of such datums sometimes leads owners into costly legal entanglements. To guard against lack of information that will accurately determine datums, field officers should not overlook the wider applications of their tidal observations and that these must be of an accuracy above what is required for hydrographic reductions. And in this they should realize that the length of series is not the only criterion to accurate datums. As a chain is only as strong as its weakest link, so is the accuracy of determined datums only as high as each of its elements.

An observed datum of a tidal series depends upon several factors besides the length of the series. Fixity of the bench marks, accuracy of the levels between the mark and the zero of the tide staff, accuracy of the comparative readings, a stable location for the staff, and sufficiency of water depth at float well are some of them. Officers in charge of hydrographic parties should therefore be careful of these points when maintaining a tide station.

The bench marks must be established only where they will be reasonably free from destruction and movement. Marks should never be placed on concrete pavements, curbstones, runways, or any other structure which has a shallow foundation. If no solid rock is present near the gauge, concrete monuments deep enough to go below the frost line should be planted in preference to marks in buildings, the life of which is uncertain. Concrete monuments placed with permission of the proper authorities in public parks are very desirable. The bronze disk should always be used as the actual mark. Crosses or other such identifying marks are usually unsatisfactory in years to come.

Another step in the accurate determination of tidal planes is the line of levels connecting the zero of the tide staff with the bench marks. Without these levels, no matter how accurately the plane is determined on the staff, it is of no value for future use without being transferred to the permanent bench mark. And in this transfer officers should not lose sight of the fact that the levels must be run with extreme care. It detracts from the full value of the results to carry lines of first-order levels throughout the country from tidal bench marks poorly connected to the mean sea level determination on the tide staff.

Another important step in our problem is the accuracy and number of comparative readings between the staff and the tide curve. The staff should be read once a day if practicable. This observation should be made with care and not hurriedly, as a correct estimation of the true water level is not always easy when some sea is running. Numerous unbiased staff readings throughout a series of observations will generally give a mean difference very close to the truth. In reading the tide staff the observer should be cautioned against parallax, especially when a glass tube is used on the tide staff and the water surface is at a considerable distance below the place at which the observer is standing. Otherwise the readings may have a tendency to be too low. Another very important reason for visiting the gauge frequently is that any break in the record will then be of short duration, and thereby any considerable inferred tide curve will be eliminated.

As all the tide readings are predicated on a tide staff, the zero of which is maintained at a fixed level, care must be taken that the copper covered backing piece be securely fastened to a stable construction. Nailing the tide staff direct to a pile should be avoided if possible. The brass plate on the backing piece forms an auxiliary bench mark and convenient step on which to rest the level rod. The stop on the staff should be inspected at intervals to see that no displacement has occurred due to cracking of the wooden base. This has been experienced at the Washington Primary Station when vandals hit the staff with some heavy object which split the wood, allowing the staff to drop about three-tenths of a foot.

In the location of the float well care must be taken to choose a place where there is sufficient depth of water at all times. It is especially important for datum plane studies and determination of ranges that the extreme low tides be observed. Attention is called to the fact that a greater depth of water is required to float a portable gauge float than the standard gauge float, and due allowance must be made for this. The intake to the float well must be of large enough diameter to insure free access of the tidal wave. Broadening of the curve due to local waves is not undesirable, but rather shows that the tidal wave is being recorded accurately.

When a season's hydrography covers an area that necessitates the establishment of additional stations besides the primary station, the same care must be taken in the installation and maintenance of these auxiliary stations as with the standard station.

In addition to the requirements given for the location of his tidal stations, the officer must in so far as practicable select points where the tidal regimes are permanent unless otherwise instructed by the office.

Finally, if an outside person is appointed tide observer, he should be carefully instructed in the care of the gauge and reading of the tide staff. Records have been received where the observer has interpreted the scale graduations as feet and inches instead of feet and tenths, and trivial defects in the gauge have been allowed to interfere with a complete record.

Officers impressed with the care necessary to secure accurate datums will, I am sure, cooperate with the end in view of eliminating all uncertainties at their tide stations so that the final datum determined will be of a high order of accuracy.

In this connection it may not be amiss to emphasize the fact that the office instructions for secondary tide stations necessarily give minimum requirements with regard to length of series. Frequently the chief of party may find it possible to extend the lengths of such secondary series without material increase in the party's cost. Where this can be done it is obviously advantageous.

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HYDROGRAPHY, ETC., IN THE FIFTH CENTURY B. C.

Extract from AN ACCOUNT OF EGYPT (by Herodotus)
(Harvard Classics)

First when you are still approaching it (Egypt) in a ship and are distant a day's run from the land, if you let down a sounding line you will bring up mud and you will find yourself in eleven fathoms. This then so far shows that there is a silting forward of the land. Then, secondly, as to Egypt itself, the extent of it along the sea is sixty "schoines," according to our definition of Egypt as extending from the Gulf of Plinthine to the Serbonian Lake, along which stretches Mount Casion; from this lake then the sixty "schoines' are reckoned; for these of men who are poor in land have their country measured by fathoms, those who are less poor by furlongs, those who have much land by parasangs, and those who have land in very great abundance by schoines; now the parasong is equal to thirty furlongs, and each schoine, which is an Egyptian measure, is equal to sixty furlongs. So there would be an extent of three thousand six hundred furlongs for the coast land of Egypt.

* * * * * * * * * *

Let these matters then be as they are and as they were at the first: but as to the sources of the Nile, not one either of the Egyptians or of the Libyans or of the Hellenes, who came to speech with us, professed to know anything, except the scribe of the sacred treasury of Athene at the city of Sais in Egypt. To me however this man seemed not to be speaking seriously when he said that he had certain knowledge of it; and he said as follows, namely, that there were two mountains of which the tops ran up to Sharp point, situated between the city of Syene, which is in the district of Thebes, and Elephantine, and the names of the mountains were, of the one Grophi and of the other Mophi. From the middle between these mountains flowed (he said) the sources of the Nile, which were fathomless in depth, and half of the water flowed to Egypt and towards the North Wind, the other half to Ethiopia and the South Wind. As for the fathomless depth of the source, he said that Psammetichos, king of Egypt, came to a trial of this matter; for he had a rope twisted of many thousand fathoms and let it down in this place, and it found no bottom. By this the scribe(if this which he told was really as he said) gave me to understand that there were certain strong eddies there and a backward flow, and that since the water dashed against the mountains, therefore the sounding-line could not come to any bottom when it was let down.

THE STATUS OF FEDERAL CONTROL SURVEYS

William Bowie, Chief, Division of Geodesy, U.S.C. & G. Survey.

The horizontal and vertical national control surveys, consisting of triangulation and leveling, which were started in this country about a century ago, are assuming large proportions and are nearing completion. There are now 36,000 miles of arcs of triangulation and 75,000 miles of leveling in the fundamental control survey nets with many thousands of monumented stations whose latitudes, longitudes, and elevations are known.

The triangulation of the first-order was begun shortly after the creation of the U. S. Coast and Geodetic Survey, in the early part of the last century, as a means of strengthening the surveys made for use in constructing navigational charts. The resulting data were later used by the U. S. Geological Survey as the basis for its topographic mapping. They have been used in other engineering operations and now there is scarcely any engineering work needing accurate positions, distances and azimuths that is not based on triangulation.

The level net of the United States had its start along the rivers being improved or controlled by the Corps of Engineers, U. S. Army, and in the lines of levels run by the Coast and Geodetic Survey for the purpose of furnishing elevations at the places where base lines for triangulation were measured.

For many years the leveling and triangulation of the United States were executed at a very slow rate. This was due to a lack of use for the data, except for a few special purposes. However, with the expansion of the triangulation and level nets, demands for the results of the control surveys have been increasing rapidly and now the sentiment is wide-spread, that the federal nets, calling for a 50-mile spacing of arcs of first and second-order triangulation and lines of first and second-order levels, should be brought to a completion in the very near future.

A few years ago a substantial increase was made in the funds to be devoted to the triangulation and leveling nets and if an amount of money equal to that available for the fiscal years 1931 and 1932 were made available for succeeding years, the 50-mile spacing should be completed in about eight years. When this has been done, no place in the country will be more than about 35 miles from a triangulation station or a leveling bench mark. There is a demand for an even closer spacing of the arcs of triangulation and lines of leveling. This sentiment was voiced in a resolution adopted by the Board of Direction of the American Society of Civil Engineers at its meeting in Yellowstone Park, July 4, 1932. That resolution called for a spacing of 25 miles instead of 50. It was sent to the President of the United States who referred it to the Secretary of Commerce. The latter endorsed in principle the recommendation of the Society.

During the fiscal year 1932, 3,400 miles of triangulation were completed and 7,500 miles of first and second-order leveling. These were the largest additions to the control survey nets ever made in this country in one year and it is certain that such an amount of work has never been done in one year in any other country. A part of the triangulation and leveling of the past year was cooperative work with the Corps of Engineers, U. S. Army. This consisted of an arc of triangulation along the Mississippi River between Cairo, Illinois, and St. Paul, Minnesota, and an arc along the eastern shore of Lake Michigan and of leveling in Pennsylvania, Delaware, and Maryland.

The triangulation and leveling nets of the country necessarily had to be done piecemeal. Arcs and lines were extended along certain routes to meet special and local needs. The plan of adjustment followed by all countries, including ours, has consisted of first adjusting existing arcs and lines and then from time to time fitting in new work to the old. This plan worked satisfactorily until the nets became very much involved with many closed loops. Each piece of new work, that closed a loop of triangulation or leveling, had to take all of the closing error of the loop. This resulted in an excessive amount of correction being applied to the new arcs and lines. While this plan worked satisfactorily for sparsely spaced arcs of triangulation and lines of levels, it did not work well for nets that had many closed loops. In 1924 the triangulation nets seemed to have reached a critical condition. New arcs fitted into the old adjusted work were forced to take heavy corrections. This unsatisfactory condition led the writer to devise a method for adjusting large networks of triangulation. This method was adopted by the officials of the Coast and Geodetic Survey and has proved to be a satisfactory means for adjusting the triangulation nets of the United States and Canada.

Beginning in 1924 an adjustment of the western half of the triangulation net of the country, involving 12,000 miles of arcs and 16 loops, was started. The most probable values for the geographic positions of stations at the junction of the arcs were obtained in 1927. The remainder of the adjustment, consisting of fitting in the sections of the net between the junction points, was completed, for the western half of the net, in 1929.

Immediately thereafter work was started on the adjustment of the eastern half of the net. By the middle of July, 1932, the work was finished. The eastern adjustment involved 13,000 miles of arcs of triangulation in 26 loops. After it had progressed to the point where the most probable values for the positions of the junction points had been found, the Director of the Geodetic Survey of Canada recommended to the Director of the Coast and Geodetic Survey that an adjustment be made of the combined triangulation nets of New York, New England, and the provinces of Quebec and Ontario in eastern Canada. This request was complied with, for it was believed that it would be to the interest of both countries to have the combined nets adjusted as a single unit. The geographic positions for the Buffalo-Trenton arc, resulting from the eastern adjustment, were held fixed and the New York-New England-Canada net based on them. It is interesting to know that the positions of the stations at the junction points of this northeastern net are practically the same as those resulting from the eastern adjustment.

The readjustment of the triangulation net of the country has upset all geographic positions. This inevitably leads to some inconvenience to those who have used the old data, but everyone will profit in the future by having geographic positions of stations and lengths and azimuths of lines which will be held fixed for all time as far as surveying, mapping and other engineering work are concerned. Far greater confusion would have resulted from delaying the adjustment until some future date.

The triangulation along the coasts is being tied into the national triangulation system by means of arcs of first-order work extending immediately along the coasts. The old third-order work, used for the control of hydrographic and topographic coastal surveys, is connected at frequent intervals with the new arcs of first-order triangulation.

As rapidly as possible the recomputation and adjustment of the coastal triangulation will be made in order to make available standard or final data for the coast work. The triangulation data, in the form of descriptions and geographic positions of stations and lengths and azimuths of lines, will be published in pamphlet form as soon as practicable in order that the results of the work may be of the greatest use to the engineering profession.

Laplace stations have been established along all of the arcs of triangulation in order to control the directions of the lines. Those experienced in triangulation have found that an arc will swerve to the right or left for, apparently, no reason. This swerving may be due to atmospheric conditions, probably temperature effect, but it is difficult to evaluate. The only practical method of overcoming the swerving is to have what are called Laplace or true azimuths at frequent intervals along the arc. A true azimuth is obtained by observing the astronomical azimuth of one of the lines of triangulation and the astronomical longitude of the station were the azimuth observations are made. With these data it is possible to compute the deflection of the vertical at the station in question. A correction is then applied to the observed azimuth for this deflection and a true azimuth, referred to the spheroid rather than to the geoid, is obtained. In the adjustment of the triangulation net these Laplace azimuths were held fixed.

Base lines were measured at frequent intervals along the arcs of the net in order to control the lengths of the triangle sides.

The accuracy of the triangulation net is indicated by the small closing errors of the loops involved. In the western half of the net there are 13 loops and the average correction to close the loops was 1/450,000. There are only 2 loops in that portion of the net for which the closing error was greater than l/200,000. For the eastern half of the net there were 26 loops and the average closure was 1/193,000. One closure only was greater than 1/100,000. It is probable that the larger closing errors of the eastern net were due to the smaller loops. Necessarily, the larger the loop the more nearly do the accidental errors involved in the triangulation balance out. In any event, the net is so strong that future triangulation can be undoubtedly fitted into it as now adjusted without disturbing the old work.

Several adjustments have been made of the level net of the country, the first one in 1899, but the large additions to the net in recent years made it desirable to have a new adjustment in order to get the most probable values of the elevations of the bench marks. A plan similar to that used for the triangulation had for many years been employed for the level lines; that is, the old work was held fixed and the new lines were adjusted into it. This eventually led to the necessity of applying unduly large corrections to the new work for the new line closing a loop took all of the correction for the whole loop. This method was the only one practicable until the net had assumed such great proportions that an adjustment could be made which would give standard or final values to the elevations of the bench marks. In 1939 it was believed that this condition existed. It was then decided to make a readjustment of the net. For the first adjustment mean sea level at a single tidal station, Galveston, Texas, was held as zero and only the leveling of the United States was involved. The results indicated that there was a variation of mean sea level at the many tidal stations along the Atlantic, Gulf and Pacific Coasts from a level or equipotential surface. The leveling was strong enough to show clearly that these deviations actually existed.

Later an adjustment was made of the combined level nets of the United States and Canada, involving 45,000 miles of lines of levels in the United States and 20,000 miles of lines of levels in Canada. In this adjustment a single tidal plane was again held as zero elevation. The results of this adjustment were combined with the results obtained from the first adjustment and it was found that mean sea level at tidal stations to the north was higher than at the southern stations, and it was also found that the average mean sea level for the Pacific stations was about two feet higher than the average mean sea level for the stations along the Gulf and Atlantic coasts. The deviation of mean sea level from a level surface presented a very interesting and important problem to the engineers of the Coast and Geodetic Survey. If only one tidal plane should be held at zero elevation, the elevations of the net along other portions of the coast would deviate from mean sea level as determined by tidal observations. On the other hand, if mean sea level at each of the tidal stations was held as zero there would be a distortion of the whole level net. After long and careful consideration, it was decided that the only practicable method to follow was to hold all tidal planes at zero elevations and this was done for the combined nets of the United States and Canada. Although this resulted in some distortion, the error per mile introduced into the lines was so small as to be negligible in effect on any surveys, maps or other engineering activities.

What might be called the adjustment of the North American level net has furnished elevations which, it is believed, can be held for all time except in a few instances where the addition of new lines to the net may result in closures of such magnitude as to make it advisable to apply some of the loop closure to a line already in the net. Such changes will, no doubt, be rare and in no case will they be made after data for a state or region has been published. Of course, it is possible that triangulation station monuments and level bench marks may be disturbed by earthquakes, but such cases will undoubtedly be rare. Where an earthquake does occur and disturb the control data, new surveys will be made to furnish new positions and elevations.

The rapid extension of the triangulation and leveling work in recent years has been due to a number of factors. Among them may be mentioned larger appropriations. In 1900 the appropriation for the control surveys of the interior of the country was $25,000 annually. This amount was increased to $31,000 in 1913, to $55,000 in 1916, to $120,000 in 1919, and to $326,000 in 1930. During the present year an even larger amount is available because of the appropriation of money to relieve unemployment. Another factor was the extension of the highways of the country which make travel much easier.

Instruments used both in leveling and in triangulation have been greatly improved. About 1900, officials of the Coast and Geodetic Survey made a careful study of existing instruments and methods employed on first order leveling and reached the conclusion that a new instrument should be designed which would be less affected by variations in temperature than those in use at that time. Such an instrument was designed, and, with a few modifications, it has been the standard for the fundamental leveling of the Coast and Geodetic Survey during the past 32 years. Modifications since 1900 have been, first, to pivot the telescope tube directly over the vertical axis of the instrument and, second, to make the metal parts of the telescope of invar.

A great improvement in the level rods has also been made. Wooden rods, impregnated with paraffine to lessen the effect of moisture, were used for many years but were found to be somewhat unstable. They were replaced by a rod having a strip of invar on which the centimeter graduations were placed. The foot of the new rod was so designed that it could be supported on the heads of the spikes which fasten a railroad rail to the ties. Nearly all of our leveling is done over railroads, because of the lower grades and because greater progress can be made than over highways, thus reducing the unit costs.

In base measurements an advance was made in 1907 by the substitution of invar tapes for steel. As invar has a temperature coefficient not greater than 1/10th that of steel, measurements of satisfactory accuracy can be made with invar tapes during daylight hours. Steel tapes give sufficient accuracy only at night or on cloudy days.

There has been a gradual development, during the past 30 years, in the signal lamps used on triangulation. In 1902, acetylene bicycle lamps, with condenser lenses, were first employed. They proved far more satisfactory than kerosene lamps with reflectors, which had previously been used to moderate extent. Later came the automobile acetylene headlights and still later the automobile electric headlights. For the electric headlight a special contracted-filament bulb was designed which gives a very concentrated and a very powerful light. Ordinary dry cells are used to furnish the electric current. Experiments are now being made with different kinds of plating for the reflectors. Silver and nickel are excellent when new but soon tarnish and it is believed that chromium, or some other non-corrosive metal, will be more satisfactory.

From about 1895 until 1912, the standard theodolite of the Coast and Geodetic Survey had a 13-inch horizontal circle read by three micrometers. These instruments, which were made in the shops of the Survey, were excellent, as far as accuracy of results was concerned, but they were bulky and heavy and rather slow in operation. In 1912 the Coast and Geodetic Survey began using instruments of a different type which were made in Europe. They proved to be satisfactory as far as accuracy and ease of operation were concerned, but it was thought that several improvements could be made in the design. This led to investigations by officials of the Coast and Geodetic Survey, especially the late C. V. Hodgson, Assistant Chief of the Division of Geodesy, and D. L. Farkhurst, Chief of the Instrument Division, which resulted in the Parkhurst theodolite, an instrument with qualities superior to those of any other instrument in existence with which this Bureau is familiar. This instrument was described by the writer in the June, 1932, number of Civil Engineering, under the title "Standard Theodolite of the United States Coast and Geodetic Survey." With this theodolite the main scheme observations at a station can be completed within an hour, if the lights at the other stations are sufficiently bright and visible continuously. It is seldom that more than two hours are necessary to make these observations.

Triangulation is now carried on by large parties. Each of two parties now in the field is using four instruments simultaneously. At times observations are completed at four stations on a single day. A progress as high as 300 miles per month has been made by a triangulation party. A notable example of rapid work was the triangulation done by a party using only three theodolites along the Mississippi River from Cairo, Illinois, northward to St. Paul, Minnesota, between May 8 and August 18, 1932. The time elapsed between the first and last observations was 102 days. The length of the arc along the central axis was 640 miles. There were 147 stations in the main scheme, 52 supplemental stations for connections to state boundaries and to existing triangulation of a lower order, established by the Mississippi River Commission, and 139 intersection stations.

A party started observations near Providence, R. I., on May 19, 1932, and by the 10th of August had completed its arc of triangulation westward to New York City and southward along the Atlantic Coast to Cape May, New Jersey.

The horizontal and vertical control surveys of the country have become a public work, recognized by the engineering profession as of prime importance. The results are not only needed for engineering operations but they are being used more and more as the basis for cadastral surveys. The use of triangulation for the latter purpose will eliminate such confusion and litigation in the boundary surveys of public and private property. It can be seen, therefore, that what was popularly considered as only of scientific importance a few decades ago will soon be of proved practical service to most of the citizens of the country.

COORDINATING THE TRIANGULATION IN THE VICINITY OF NORFOLK, VIRGINIA

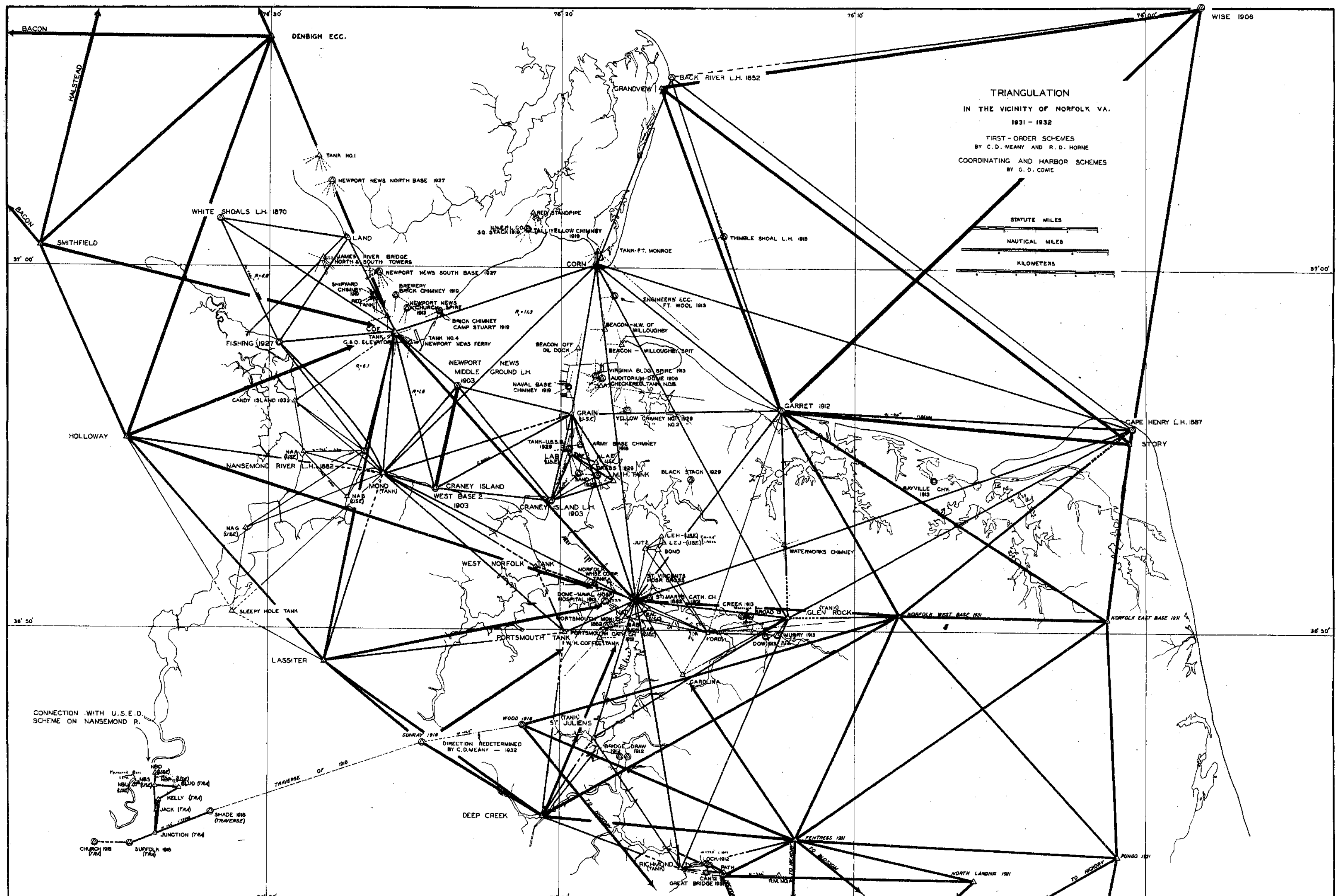
G. D. Cowie, H. & G. Engineer, U.S.C. & G. Survey

(Shortage of funds made it impossible for the LYDONIA to operate on a cruising basis during the winter of 1931-32 and she remained at Norfolk, Virginia. Advantage was taken of her partial lay-up to use the personnel to coordinate the numerous schemes of triangulation in Hampton Roads and in each of its several navigable tributary streams. A considerable portion of this control has been established by the U. S. Engineers and while, for the most part, it is of satisfactory accuracy and well marked, the existing connections were not adequate for computing and adjusting them on our datum. The LYDONIA'S assignment to this work came at an opportune time for the new first-order Atlantic Coast arc had just been completed and reconnaissance was about to be made for a first-order arc up the James River. This enabled Lieut. Comdr. Cowie to so lay out his coordinating scheme as to permit connections to be made to it by the first-order party when towers were erected in connection with the observation of the first-order James River arc. This arc has recently been observed and all connections necessary to adjust the entire net on the 1927 datum have been made. The accompanying sketch shows how the coordinating scheme binds together all of the small third-order schemes and is in turn connected to the first-order Atlantic Coast and James River arcs.) Ed.

During the winter of 1931-32 the party on the LYDONIA was assigned the project of coordinating all previous triangulation in the vicinity of Norfolk, Virginia. This called for second-order triangulation to tie in all previous York of the Coast Survey, the 17. S. Engineers, and the James River Bridge triangulation, as well as to provide for future connections with first order triangulation on the James River and at Chesapeake Bay entrance. It was furthermore stipulated that this survey should be made in as economical a manner as possible, no tall signals to be erected if they could be avoided. This made it necessary to occupy existing structures such as lighthouses, water tanks and high buildings, with the natural result that main scheme figures were somewhat irregular although of required accuracy.

Connections were desired at each end of existing triangulation schemes up each river. To make line connections to these small schemes from the large main scheme in some cases necessitated strengths of figures of only third-order accuracy. Line connections at the heads of some of the rivers were not practicable since these would have required 100-foot towers and weak figures. At these places azimuths were carried through and base lines measured to give a length check.

One of these locations was at Great Bridge, Virginia. Second-order station RICHMOND was to be connected to third-order stations CAN and LOCK 1912 and to first-order station GREAT BRIDGE 1932. Regular quadrilaterals could not be used without tall signals. Single triangles were used in


TRIANGULATION
IN THE VICINITY OF NORFOLK VA.
1931 - 1932
FIRST - ORDER SCHEMES
BY C. D. MEANY AND R. D. HORNE
COORDINATING AND HARBOR SCHEMES
BY G. D. COWIE
STATUTE MILES
NAUTICAL MILES
KILOMETERS
WISE 1906
BACK RIVER L.H. 1852
GRANDVIEW
DENBIGH ECC.
BACON
HALSTEAD
SMITHFIELD
WHITE SHOALS L.H. 1870
TANK NO. 1
NEWPORT NEWS NORTH BASE 1927
LAND
THIMBLE SHOAL L.H. 1918
CORN
TANK-FT. MONROE
NEWPORT NEWS SOUTH BASE 1927
FISHING 1927
COE
HOLLOWAY
CANDY ISLAND 1932
NEWPORT NEWS MIDDLE GROUND L.H. 1903
GARRET 1912
CAPE HENRY L.H. 1887
STORY
GRAIN
NANSEMOND RIVER L.H. 1882
MOND (TANK)
CRANEY ISLAND WEST BASE 2 1903
CRANEY ISLAND L.H. 1903
BLACK STACK 1929
BAYVILLE CHY. 1913
WATERWORKS CHIMNEY
WEST NORFOLK TANK
SLEEPY HOLE TANK
PORTSMOUTH TANK
GLEN ROCK
NORFOLK WEST BASE 1931
NORFOLK EAST BASE 1931
LASSITER
CAROLINA
CONNECTION WITH U.S.E.D. SCHEME ON NANSEMOND R.
SUNRAY 1918
DIRECTION REDETERMINED BY C. D. MEANY — 1932
TRAVERSE OF 1918
WOOD 1918
ST. JULIENS
DEEP CREEK
FENTRESS 1931
PUNGO 1931
NORTH LANDING 1931
RICHMOND
GREAT BRIDGE 1931
TO HICKORY
TO BOSSON
76° 30′
76° 20′
76° 10′
76° 00′
37° 00′
36° 50′

C.& G.S. 457

part of the connection, but in each case a base line measurement was made of one side of the triangle. In the sketch showing this connection, the lines LOCK-PATH and PATH-GREAT BRIDGE were measured in the usual manner of base line measurement.

At the head of Eastern Branch of the Elizabeth River the connection was a line connection, but rather weak. To improve this, a base line was measured and connected with two of the old 1913 stations nearby.

At the head of the Nansemond River where a connection was desired with the work of the U. S. Engineers, two methods were open. One, to connect by triangulation using several tall towers - the other, to connect by traverse using several smaller towers. The latter method was used after some time had been spent on reconnaissance for a triangulation connection.

Starting from station SUFFOLK of the 1918 Primary Traverse, the line was carried to stations JACK, 1932, and BLUD, 1932. From them a single triangle connection was made with station NBP (U.S.E.), and the azimuth of the line NBP - NBO determined. As a line connection could not be made economically at this point, a base line measurement was made of the line NBU - NBS, nearby. The 1918 traverse line had been connected with third-order work on the south branch of the Elizabeth River and in 1932 with first-order work of C. D. Meaney.

The length connections with previous work were satisfactory. The azimuth and position connections in a few cases indicated that some previous work was as much as twenty feet out of position.

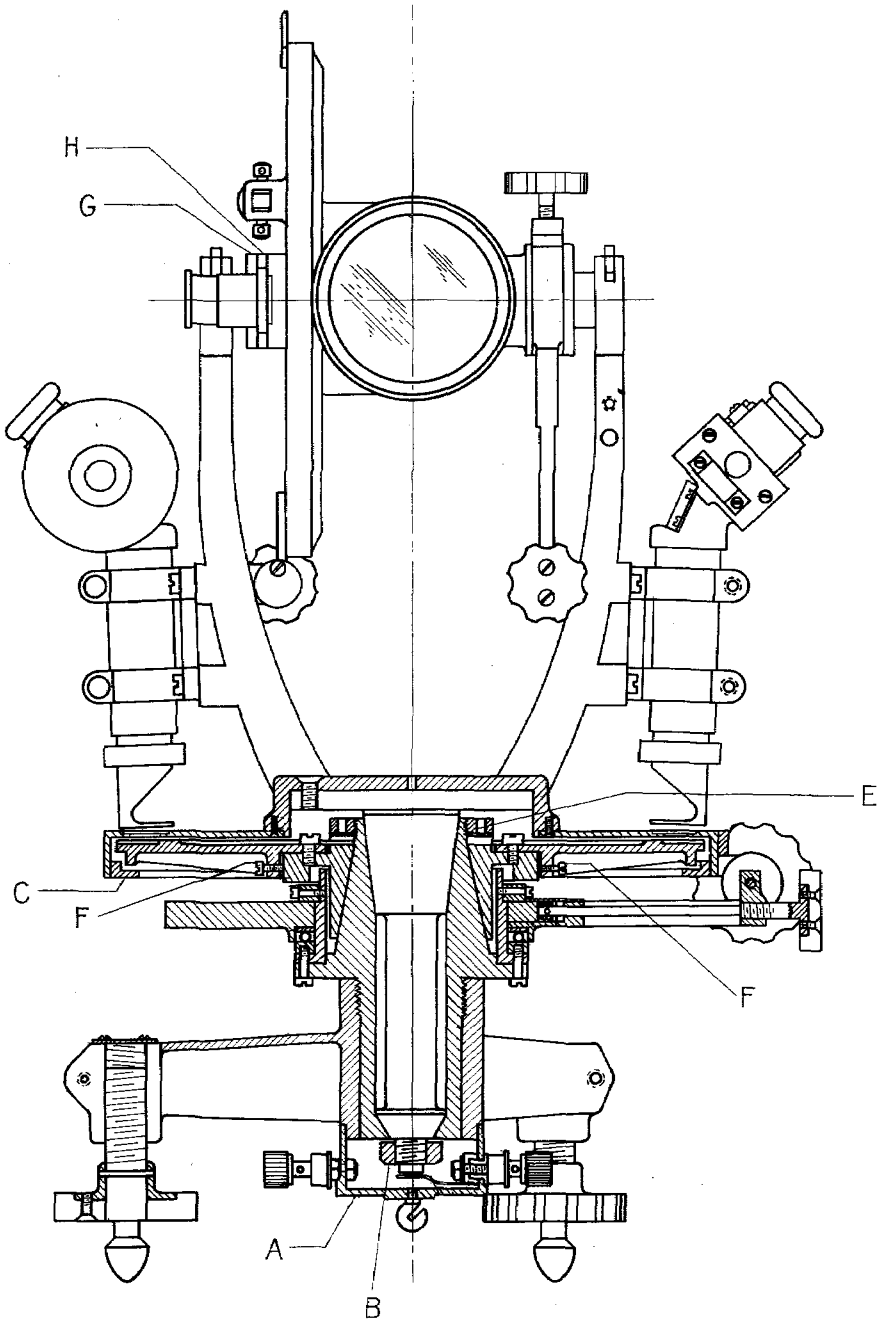
In making use of tanks and lighthouses it was found that set-ups on the balconies were undesirable. Difficulty was had in closing triangles and it became necessary eventually to occupy the tops of the tanks. It was found that in most cases the instrument could be mounted over the center of the tank and the observer could stand or kneel on portable ladders hung from the top of the tank. These set-ups, while awkward for the observer, were sufficiently stable to permit the required accuracy of observing.

Observing was done with the new Parkhurst 6-½-inch, second-order direction theodolite or with a 7-inch Berger repeater. The former was much more satisfactory. Lights or helios were used on the long lines. On the shorter ones pole targets were used. On very short lines a piece of white cord, with a black background, was sighted on.

About 150 points were located and about three times this number can be recomputed and placed on the same datum.

Two sketches of the new Parkhurst 6-½-inch second-order theodolite are shown on the following pages.

PARKHURST
6 1/2 SECOND ORDER THEODOLITE



To remove Alidade

Turn Contact Cup A to left and detach. Not necessary to disconnect electric wires. Remove Nut B. Note if Guard Ring C is present. If so, turn to left in same manner as Cup A, and remove. (In most instruments this ring is omitted).

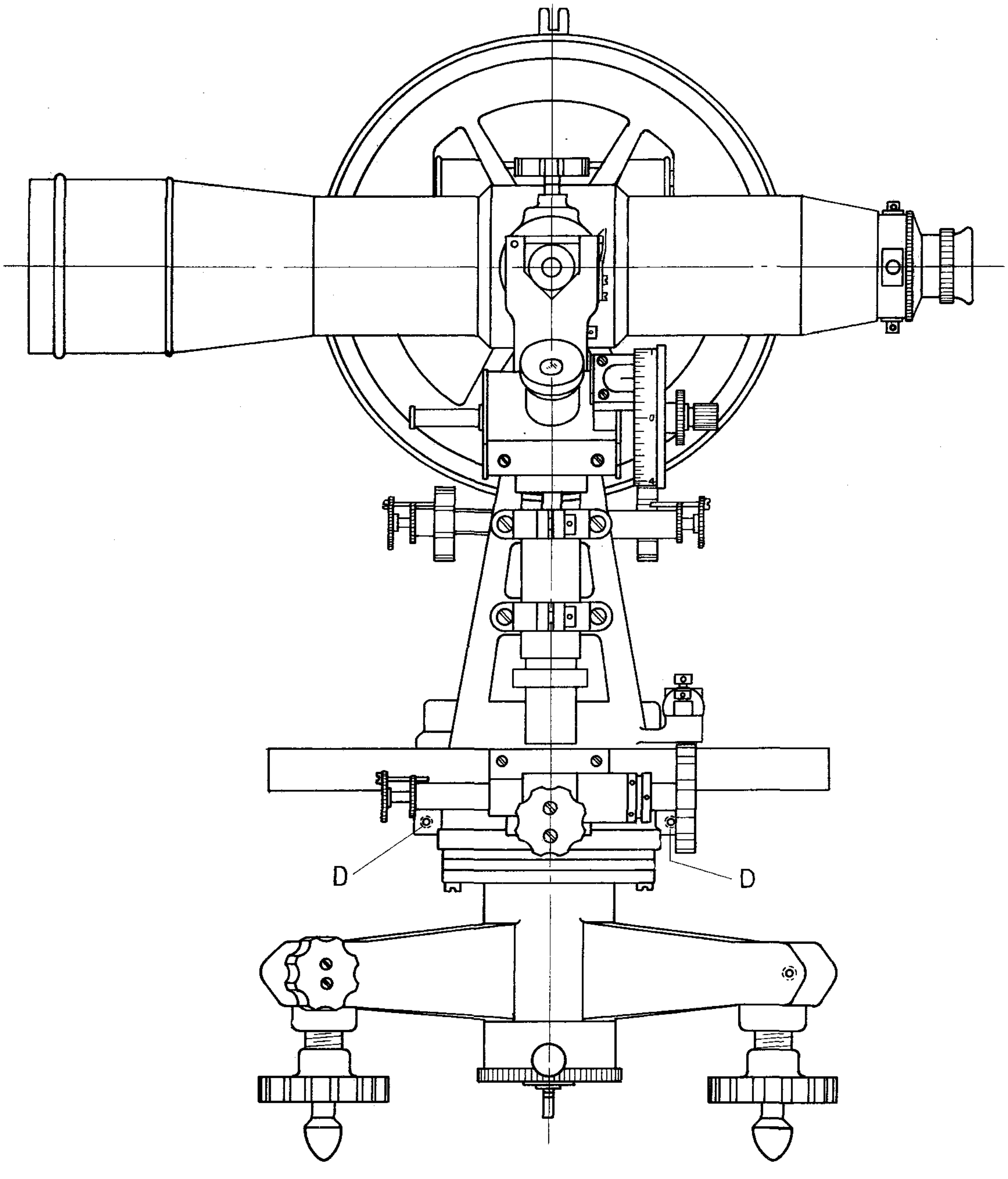
Lift Alidade straight up, carefully. If it appears to stick, it is probably due to the suction of the oil. *Turn Alidade back and forth, lifting up slightly. Don't turn if it binds, but press upward on* lower end of vertical axis.

Circle may be removed for cleaning and oiling by removing Nut E. Under no conditions, disturb Screws F, as they control the eccentricity adjustment.

To clean Vertical Circle, remove Nut G, Reading Glass Holder H, and lift off carefully. Dust with camel's hair brush.

Verniers may be reached by removing two screws holding Slow Motion Lug and one screw at top of Circle just under finger for Striding Level. Guard Ring can then be lifted off without disturbing Level or other parts.

PARKHURST
6 1/2 SECOND ORDER THEODOLITE



To clean clamp, loosen both Screws D which do not come all the way out, and pull halves of clamp apart. Clean carefully, oil and replace. When oiling either Clamp or Vertical Axis, clean with lint-free cloth, and use only light, clean oil as furnished with instrument.

Do not touch fingers to graduated surface of circle. Use camel's hair brush for dusting.

Do not tighten clamp screws too hard. It is not necessary.

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ALUMINUM MOUNTED TOPOGRAPHIC SHEETS*

J. C. Partington, Jr. H. & G. Engineer, U.S.C. & G. Survey

During the summer of 1932 three aluminum mounted sheets 24" x 30" were used for a topographic survey along the north shore of Long Island Sound. These sheets were the first of their kind used by the writer and a report is herewith submitted.

The projections, on a scale of 1:10,000, were laid down and verified on these sheets in March, June, and July of 1932. Distances of 7,000 meters and 5,000 meters were placed on the sheet normal to each other at the same time as each projection was made. In December, 1932, the projections were again checked and found to be correct. The distances of 7,000 meters and 5,000 meters were scaled again in December and it was found that the maximum error was 2 meters. This error is probably due to enlarging of the holes in the paper rather than to actual distortion of the sheet.

Each sheet was used in the field for approximately one month. Very little rain was encountered during the season, but occasionally a sheet would become damp from mist. At these times the sheet was measured and showed no distortion. It was also found that the aluminum mounted sheet does not become soft in damp weather and is more impervious to water than the Whatman paper.

The advantages of the aluminum mounted sheet as compared with the Whatman sheet are as follows:

1. No distortion.
3. Can be used in strong winds.
5. More impervious to water
4. Details can be inked more clearly.

On the aluminum mounted sheet traverses can be run with confidence and cuts can be made to pass through a point. Three point fixes are likewise more accurate than on a distorted sheet. The aluminum mounted sheet should be especially advantageous in planetable triangulation and in locating distant peaks by cuts.

The aluminum mounted sheet presents less wind surface and there is no flapping of the rolled portion of the sheet as in the old type of Whatman paper. Water does not cause the sheet to wrinkle or take a permanent warp, a condition so common with the Whatman sheet. On account of the finer texture of the paper, the aluminum mounted sheet has a better surface for inking than the old type of paper. The finer texture of the paper, however, causes more glare to the topographer when the sheet is exposed to the sun and this is the chief disadvantage of the sheet.

The new type of aluminum mounted sheet has been changed so that the sheet does not fasten to the planetable board by screws as formerly. The

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*For additional reports of tests on aluminum sheets, see June, 1932, Bulletin, page 30.

new sheet has a working surface of 30" x 23" which increases the effective area by 4 per cent. This sheet is backed by Bristol Board having the same qualities of expansion as the opposite side of the sheet. This sheet could be fastened to the planetable board by means of a metal clamp along the edge of the board with a wing-nut on the under side for tightening. It has also been suggested that a heavy rubber band be stretched along the edges of the sheet and table for holding the sheet to the board. The metal clamps would probably be preferable if the planetable is subjected to rough usage on account of the added protection to the edges of the sheet.

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TALL WOODEN TRIANGULATION TOWERS

(Extract from Season's Report of C. A. Egner on survey of Chowan River. Reference: Field Engineers' Bulletin, June, 1932)

****Many valuable things were learned in the building of these towers by a personnel already unusually experienced in such work.

(1) A 4" x 4" leg section is heavy enough to support a tower 120 feet high IF (a) tower be symmetrical so that the legs are true colums, (b) lower two bents are not greater than 12 ft. and 10 ft. with 2" x 4" diagonals used throughout these two bents, (c) 1" x 4" lacing strips are used in first two bents. (b) and (c) give stability and rigidity.

(2) Towers must be symmetrically and properly guyed though not heavily so, No. 10 galvanized wire is heavy enough.

(3) Tripods with four sided outer scaffolds provide the best structure.

In one case a tower 84 feet high was constructed as two tripods, outer and inner. There is a slight saving in lumber, but not so much as one would suppose since the outer tripod must be appreciably larger to give clearance. The main objection to two tripods is the difficulty in guying symmetrically without interference.

(4) Speed of erection is primarily determined by the number of available "top" men.

It was found that a party of 1 officer and 5 men was greatly superior to 1 officer and 4 men as the additional man on the scaffold speeded things up very much by making it less necessary for a man to move from one corner to another, which always meant a loss of time.

(5) Short leaf pine, in the south, is best. While its life is shorter than long leaf, it lasts long enough and is much lighter, takes nails better, dries more quickly and warps less. Poplar, if straight, is good scaffold lumber.

(6) No attempt should be made to frame more than 40 feet on the ground before erection. If tried it will mean a loss of time in raising and very likely a sprung or twisted structure. In fact, the most symmetrical structures resulted when only the first bent was framed on the grounds

THOMAS ALEXANDER HARRISON (1853-1930) - A TRIBUTE

Charles H. Deetz
Cartographic Engineer, U.S.C., & G. Survey

A brief tribute to a former Coast Survey officer, who received his early training in our bureau, may be of interest not only from the fact of having received here his foundation in drawing and art expression, but also from the impress of his services upon the development of art, and their resulting benefit to mankind.

Thomas Alexander Harrison was born in Philadelphia in 1853. He entered the field service of the Coast Survey and served as Aid from 1874 to 1878; but, like Whistler, also of the Coast Survey, left for Paris to study art. He entered the Ecole des Beaux Arts in 1878 and was a pupil of Gerome. His early career was very similar to that of Whistler in inviting friction with his superiors, matters which need not be related here as both he and Whistler achieved international fame in later years.

A number of topographic sheets of the rugged coast of Maine and placid Florida attest his adaptability to the pursuit of art. His last duties in astronomical work along California's coast added to that knowledge of landscape and the sea which was reflected in his later art career. As stated by himself, "In my case, the delight in the simple and unconscious motif — often the lonely motif — is perhaps the result of my far-away Coast Survey life."

Nature, which sometimes lends an irresistible bias to the mind, averted the doom of a doubtful future scientific career in the work of the Coast Survey. Born an artist, his natural inclinations were to devote himself entirely to that talent for which he was soon to become so eminently distinguished. It was the urge so beautifully expressed in the lines of John James Ingalls, entitled:

Opportunity

Master of human destinies am I!
Fame, love, and fortune on my footsteps wait.
. . . .
I knock unbidden once at every gate!
If sleeping, wake — if feasting, rise before
I turn away. It is the hour of fate.

Having followed his star to Paris, Harrison soon became associated with leaders of modem and progressive ideas in that city. He valiantly held his own with all of them. In the realm of color he was the most scholarly, and has been the means of influencing not alone his American friends but the art of the Continent. With his early training in the Coast Survey, he was able to introduce a direct and realistic transcript of nature. This is most striking in his surf pictures, in the beauty of the curling breakers and the flattened waves chasing each other in their successive curves over the smooth sands under poetic conditions of light and color.

By his searching study of the phenomenon of wave formation and the reflections of sun, moon, and clouds upon the ever-changing surfaces of the incoming waters, he has given us a new kind of picture and has made himself a master in this kind of subject. He is one of the best marine painters of his time, and as a painter of surf has no equal, his fame resting upon this line of art. To seize such phenomena of nature in their completeness — things so fickle and so hard to arrest because they will not wait and pose — he was the best of them all. He was the first to grasp marine colors technically. The rendering of the waters, the crystal transparency of the billows, the vibration of lights were so extraordinarily faithful that one was tempted to declare the water of others absolutely solid compared with this elemental essence of moisture. The heaving and subsiding waters, the foaming revel of the waves, the enchantment of distance in landscape and sky in sequence of color, are all characterized with grace in a new technique.

Among his earliest paintings, and still one of his best works, was a figure-piece which was called "Chateaux en Espagne," It was sent to the Paris Salon in 1882 and attracted attention for grace of line and color.

Another painting, entitled "Le Crepuscule." represents a marine view under the effect of moonrise. It attracted great attention at the Salon, and received a prize of $2500 at the American Art Association, New York, in 1887.

In one of his finest subjects, "The Wave," now in the Pennsylvania Academy, the hue of the foam and curdle are described, "not white as the older painters would have represented them, but attenuated tones of the same blue which pervades the mass of water" -- blues delicate in fine nuances like mother-of-pearl or opal. This painting is described as having a subtlety of detail and a sensitive rendering of the loveliness of the ocean in one of its softer moods. Excellent photographic reproductions of it are available by one of the art corporations. The painting "En Arcadie" should also be mentioned as it unquestionably has been the popular favorite in the American artist section of the Luxembourg gallery of Paris.

Through his early success at the Salon, he made the acquaintance of Bastien-Lepage, well known painter of portraits and rustic subjects, who became his intimate comrade. Like the latter, he belonged to what is known as the out-of-doors section of French art and spent most of his summers on the coast of Brittany. Widely known in the Montparnasse art colony where he was regarded as the dean of American painters, he died in his studio October 13, 1930. He had lived in Paris for nearly half a century and his paintings are found in many of the noted galleries of two hemispheres.

He received medals from the Pennsylvania Academy of Fine Arts, Philadelphia, San Francisco, and from Munich, Brussels, Vienna, and elsewhere. He became Chevalier in 1889 and Officer of the Legion of Honor in 1901, and Officer of Public Instruction by the French Government. In the roll of honor of American artists, his name is worthily placed among the first, not alone because he has been so profusely medaled and decorated, but because his art is important, his style individual, and his influence so considerable.

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EDITORIAL FROM KETCHIKAN, ALASKA, CHRONICLE
Friday, October 21, 1932
THE COAST SURVEY

We wonder if the people of this district realize the great debt of gratitude that they owe to the Coast and Geodetic Survey. Its operations year after year have gradually brought to the charts the accurate information needed by the thousands of boatmen in this district.

None will dispute the magnitude of the work. It must be done with great care, so that the most surprising thing about it all is that so much work has been so well performed in the years that have passed.

Only this season, for example, the EXPLORER under command of Captain G. C. Jones has made a detail survey in the Duke Island vicinity. The southern coast of the island, as a result, will undergo considerable change on the next charts to be issued, thereby giving accurate and valuable information to the trolling fleet or to others using those waters.

Not only that, but the crew of the vessel has spent considerable time endeavoring to determine the exact nature of the magnetic disturbance in that district which deflects compasses so greatly as to cause serious accident to those unaware of the magnetic field. Information to be given on that subject alone is well worth the survey.

On the whole, we believe that Ketchikan really does appreciate the work that has been and is being carried on. But it is well to remind ourselves of its worth occasionally else we take it too much for granted. That is why it was good of the Chamber of Commerce to pass its resolution commending the work of the EXPLORER'S crew. In that commendation, we believe all those who live in the district will join wholeheartedly.

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NEW TYPE OF SIGNAL LAMP

A new type of signal lamp of small size for use on short lines is now carried in stock. Some officers will recall the lamps made up a few years ago in which a flashlight was mounted in a temporary wooden box. As this sort of lamp seemed to meet a genuine demand, a new lamp was designed. It consists of a focusing head-lamp which is identical with the usual focusing flashlight reflector element. This is mounted in a wooden box and has the same design of connecting bolts which are used with the regular signal lamps, so that these small lamps may be used in conjunction with them. The reflector may be moved to a considerable angle in the vertical plane by means of a handle which extends to the back. The lamps are normally furnished with a 6-volt bulb and current is supplied from the usual battery source, through a couple of binding posts mounted in the lamp, which have non-detachable heads.

TREATMENT OF ROCKS ON HYDROGRAPHIC SURVEYS

A. L. Shalowitz, Cartographic Engineer, U.S.C. & G. Survey

It frequently happens that survey sheets coming into the office carry conflicting information regarding the character of certain rocks, as for example, the topographic sheet might refer to a rock as "Bare 6' at M.L.L.W." and the hydrographic sheet will refer to the same rock as "Bare 8' at H.W." With an approximate 9-foot range of tide, there is a discrepancy of 11 feet between the two notes. Obviously it is impossible to reconcile such differences in the office. Even with the most reasonable interpretation an element of uncertainty always remains. To assist the verifier in such cases, as well as in other matters pertaining to rocks, certain practices have been adopted in the Section of Field Records which it is desired at this time to restate:

1. The locations of rocks bare at high water and rocks awash being visible are as a rule accepted as correct on the topographic sheet and are seldom modified by the hydrographic survey.

2. The locations of sunken rocks are accepted as correctly indicated on the hydrographic survey and only in exceptional cases are they modified by the topographic determination.

3. Rocks and other hydrographic data indicated on the boat sheet but having no other authority such as the topographic sheet, the sounding records or the descriptive report are usually transferred as such to the smooth sheet.

4. Descriptive notes relating to rocks bare at high water are generally accepted from the topographic sheet and only in cases where there is unmistakable evidence that they are incorrect are they modified by the hydrographic survey.

5. Notes relating to rocks awash giving the amount they bare at the plane of reference are taken from the hydrographic survey except in those cases where the notes in the sounding records are ambiguous, in which case the topographic description is accepted.

6. Notes relating to sunken rocks or breakers appearing on the topographic survey are always subject to modification by the hydrographic survey.

7. All hydrographic or topographic information appearing on the hydrographic smooth sheet but not on the boat sheet, and if unsupported by the sounding records, the topographic sheet or the descriptive report, is usually removed from the sheet. It is therefore necessary that any such information obtained by the field party subsequent to the regular prosecution of the survey be given special mention in the report on the sheet.

Regarding the matter of recording notes relating to rocks, it is suggested that all notes in the sounding records be entered so as to refer to the rocks as of the time when they are actually observed and not what they would bare at some plane of reference. This practice would avoid a great deal of confusion when the sheet is verified in the office. It is a simple matter for the cartographer to compute the amount that a rock will bare at M.L.L.W. when the height of the rock at a certain stage of the tide is given, but when the note reads "rock bares 5 feet H.W." and the height of the tide at the time is considerably below H.W., there is always a possibility that the plane of reference has been confused, particularly when that note can not be reconciled with information from another source.

As a corollary to the above it follows that when cuts are taken to locate a rock, the rock should never be referred to as "rock awash" unless it is actually awash at the time the note is entered in the sounding record. If it is desired to refer to the same rock at a lower or higher stage of the tide, it would be better to designate it as "rock near ⊙ "Al" or by some other identifying term instead of by "rock awash near ⊙ "Al." Unless this is done, confusion is inevitable. A case that has recently come to the writer's notice referred to a rock as "awash" at three different stages of the tide, to wit, at low water, at 6 feet of tide and at 9 feet of tide. Where several cuts are taken that do not intersect in a point, such notations frequently raise the question whether one or more rocks are intended.

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NOTES ON THE USEFULNESS OF MISCELLANEOUS SURVEYS AND MAPS AND THEIR APPLICATION TO CHARTS

(The following is quoted from a letter to one of our field stations regarding the usefulness and application to charts of miscellaneous surveys and maps. This information supplements to some extent that contained in Circular Letter No. 3 (1928) which is also reproduced here. Proper evaluation, on the part of field officers, of material of this nature, coupled with sufficient information to apply that which appears useful for charting purposes, would reduce materially the problems of the over-burdened section of the Chart Division which handles this phase of chart correction.) Ed.

The blue-prints forwarded are for the most part lacking in common points, making it difficult, if not impracticable, to apply them to the chart. In many cases they apply to areas which are shown only on small scale charts and the resulting corrections are almost imperceptible.

An examination of a blue-print and a comparison with the chart should easily determine whether there are sufficient common points to meet the requirements. In case you obtain blue-prints which are lacking in such control, it is suggested that you locate the necessary points, if practicable; otherwise keep a record, either on a chart or in some manner, and when a sufficient number of such changes has accumulated in any area, a detailed recommendation for a resurvey is indicated.

However, if a print contains vital information which should be shown immediately on the charts, even an approximate position is better than none. In judging the importance of any information, do not exaggerate the importance of topographic details. -- information regarding streets, wharves, etc., is not nearly as important as information regarding depths in channels, obstructions, etc. The correct location of a single landmark is of more importance than correct layout of streets.

It is not safe to assume that street intersections shown on the chart can be used for common points to apply extensive or important additional information, because such details have often been applied in approximate positions from other blue-prints with inadequate control. In fact, triangulation stations are the only points which can be used with assurance.

Summarizing, if a print shows important differences in depths, channels, etc., which would require immediate charting, send it in at once whether it complies with the requirements or not, taking such steps as may be practicable to obtain additional information. If the information is of sufficient importance and we can not chart the blue-print in detail, we would place a note on the chart or resort to some other expedient.

If the blue-print contains only topographic details, it should comply approximately with the requirements for our own topographic sheets. If deficiencies in control, etc., can not be supplied, the print is of no use to this office and should be retained in your office as a basis for recommendation for new surveys. We have found that very few prints by other organizations meet these requirements.

In regard to prints showing proposed work, we have found from experience that it is dangerous to use them even when accompanied by a statement that the work has been completed. It is therefore highly desirable that surveys after completion of the work be obtained where practicable.

A print received at this office is examined with the assumption that the officer sending it in has examined it and considers that it contains information to be charted — practically a recommendation that the information be charted. For this reason, even though a cursory examination indicates that the print is either unchartable or of little charting value, a careful examination and comparison are required before it can be rejected. Such consideration frequently consumes more time than the application to the charts of a whole survey. Unless field officers use considerable discretion in eliminating unessential and inferior data, this unprofitable work causes serious congestion in a section in which the growing congestion has been repeatedly pointed out in the Annual Reports.

CIRCULAR LETTER NO. 3 (1928)

Wherever blue-prints of plans of improvements, street layout, or maps of a similar nature, are obtained by a field party in connection with the revision of a chart, or topographic sheet or as supplement to a new topographic field sheet, an examination shall be made on the ground to determine and note which features shown on the plan represent actual conditions. Those features which do not exist but are projected only or which have been altered in location during construction shall be so marked on the plan. Explanatory notes shall be made wherever necessary for a complete understanding of the conditions at the time of the survey.

Checks on the accuracy of the plan will depend upon the type of plan and the features shown. Features which are for the use of the navigator are important and must be located by the topographer independently from the plan. A sufficient number of points on the plan must be determined to enable the cartographer to orient and adjust the plan to the chart. Three determined points, separated as widely as possible and forming a well conditioned triangle, give excellent control. These points must be tied into control points either previously established or located by the topographer at the time.

The topographer or chief of party shall state over his signature the fact that an examination has been made on the ground and the actual existing conditions have been noted on the plan. The date of the examination shall be shown.

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UNUSUAL APPLICATION OF THE WIRE DRAG

An unusually interesting application of the wire drag was the location on January 6, 1933, of an airplane which had crashed into the waters of Broad Sound off the entrance to Lynn, Mass. The accident happened on December 29 about 4:00 P.M., and, in an endeavor to locate the plane and recover the bodies of the two passengers who had presumably gone down with it, every possible type of towing apparatus except the wire drag had been used by the Coast Guard and private agencies working almost continuously but without success. Heavy wire cables were towed between two Coast Guard patrol boats and various arrangements of grapnels, nets, etc., had been tried.

After suitable arrangements, Captain N. H. Heck and Lieutenant (j.g.) J. C. Partington arrived at Boston on Friday morning, January 6, ready to undertake the search. They were met by Lieut. Commander K. T. Adams, in charge of the Boston Field Station, who had in the meantime arranged with the Coast Guard for the use of vessels and personnel. Wire drag equipment had been taken to Lynn by truck. The boats used were two 75-foot Coast Guard patrol boats, rather large for the work but with adequate personnel. All those who have done wire drag work will appreciate the very great difficulty of setting out a drag with two large boats without any facilities for setting out or picking up the wire. However, the drag was gotten out, but through lack of sufficient experienced personnel, went aground on a charted rock. It was cleared and by two o'clock it was hard and fast on some object in the vicinity of where the plane was supposed to be.

An accidental injury temporarily incapacitated Captain Heck, but the tow boat was put in place and the diver went down. After Captain Heck's return from Lynn where he secured medical treatment, he sounded in the vicinity and probably placed a lead on the plane. When the drag was taken up 200 feet of ground wire were left attached to the plane.

A severe gale suspended operations Saturday, but they were resumed on Sunday morning. A considerable area had been dragged when the diver brought up a piece of the plane where the drag had caught on Friday and the search was ended. The wire was caught on the plane about 8 feet off the bottom, a fortunate circumstance since, owing to the flat, rocky bottom, it was impossible to bring the wire too close to the bottom. The part of the plane which struck was badly wrecked, but the after-part was intact and little damaged so that there was plenty for the wire to catch on. Though only one of the two bodies was recovered, this, of course, had no bearing on the success of the operation of finding the plane.

Extract from Boston Post, January 9, 1933.

**** The locating of the plane proved a singular triumph for the United States Coast and Geodetic Survey, called in following seven days of fruitless combing of the harbor. A dragging device, invented by Captain N. H. Heck of Washington, D. C., was sent to the sceme from Stamford, Conn., arriving here Friday.

"Within two hours after arrival, Captain Heck and Lieutenant J. C. Partington, also of Washington, both attached to the United States Coast and Geodetic Survey, located the wrecked plane. Because of rough weather Saturday, however, divers were unable to go below. With a calm sea, yesterday, the plane was quickly placed." ****

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PECULIAR REFRACTION CONDITION AT BEAR MOUNTAIN, N. Y.

C. A. Egner, H. & G. Engineer, U.S.C. & G. Survey.

Anticipating the customary "anvil chorus" which always arises when a reason is ascribed to an experience in the field which is quite incapable of proof, let it be here stated in advance that no defense will ever be made in support of the following:

BEAR was last summer a station of the Hudson River Second Order Scheme of triangulation. A scaffold 30 feet high was erected on the highest point of this mountain, which is about 1,450 feet high and fairly round on top, so that in all directions the ground sloped somewhat downhill from the station. The height of scaffold was sufficient to clear surrounding trees though no doubt the foliage accentuated the refraction and heat waves on some lines.

The Hudson River at this point is narrow and canyon like and to the southeastward takes a sharp bend to the west, broadening out in the vicinity of Peekskill. Anyone who has taken a boat trip in this locality in windy weather is well aware of the violent air currents (called willy-wahs by some) through this canyon. Directly across from Bear Mountain is a prominent headland known as Anthony's Nose which rises directly from the river to about 900 feet.

It always happens that clear weather is encountered in this area only during a westerly or northerly breeze, haze and smoke from New York and the large cities of New Jersey being blown over these mountains by any southerly breeze. It results, therefore, that triangulation observations are possible in daytime only during breezes from the former quadrants.

Lines from the station fall from due north around through the east to nearly due south. The prominent headland, referred to above, Anthony's Nose, divided the stations half and half roughly on an east-west line.

Mr. Sammons, the first observer on this station, had a perfectly clear, sunny day with a strong due west breeze. This breeze, therefore, struck normal to the north and south lines and at an angle to the diagonal lines. The observations were completed in daylight and all locked good from the way the angles agreed and the horizons closed. Pointings were made on helios on two stations, on poles on the remainder.

When the triangles were computed around this station, there was consternation when some closed as much as 17 seconds in error. Analysis to locate the trouble, in spite of the apparently good observations at Pear Mountain, indicated much of the error to be there. However, other stations being easier of access, were reoccupied first with no indications of trouble elsewhere except in a minor degree.

Mr. Bull reoccupied Bear Mountain on a clear, calm day, but was unable to point on all stations. He found, however, that the large errors were at the station.

In all, five reoccupations of this station were made, but in no case were the conditions as favorable as on the day Mr. Bull observed; other days had westerly or northwesterly winds in varying degrees. A mass of observations, some good, some bad, resulted. In the final results many were rejected. Least squares, which some wit characterized as "a happy means of putting errors where they don't belong" may disclose that some good ones were rejected and vice versa.

The interesting part is that it appears that the wind in conjunction with the atmospheric condition obtaining in the river below actually bent the lines, and more interesting is the corollary conclusion that this effect, as disclosed by the triangle closures, acted in proportion to the angle made with the direction of the wind. Anthony's Nose split the field; directions on north lines being made greater, on south lines made less.

As made clear in the first paragraph, there is no disposition to argue over the conclusions. Perhaps at some future date science will have arrived at a basis for applying "windage" to theodolite observations. How simple, and convenient, for poor, distressed triangulators!!

PLOTTING AND ADJUSTMENT OF THE 1932 R.A.R. BUOY CONTROL SCHEME ON GEORGES BANK

W. D. Patterson, H. & G. Engineer, U.S.C. & G. Survey

The determination of buoy positions for the season of 1932 differed from the work of previous seasons* in that the positions were determined graphically instead of by computation, and the work was finally tied in to fixed shore positions and was adjusted to these positions.

Observations consisted of the determination of distances between buoys by R.A.R. methods and the determination of azimuths between buoys by astronomic methods. These methods have been fully described in previous reports. All observations were recorded, computed and abstracted on the standard forms developed by Lieut. E. B. Roberts. These forms were helpful in simplifying and coordinating the work of the four ships engaged on this project.

The lengths of all sides and diagonals of each figure were obtained by R.A.R. and in several cases overlapping distances were determined. This excess of observed lines was a great help in plotting the positions graphically. Azimuths were obtained between as many buoys as was practicable. It was originally planned to have at least one azimuth in each quadrilateral, but due to capricious weather conditions, we had some quadrilaterals with no azimuths while others had several.

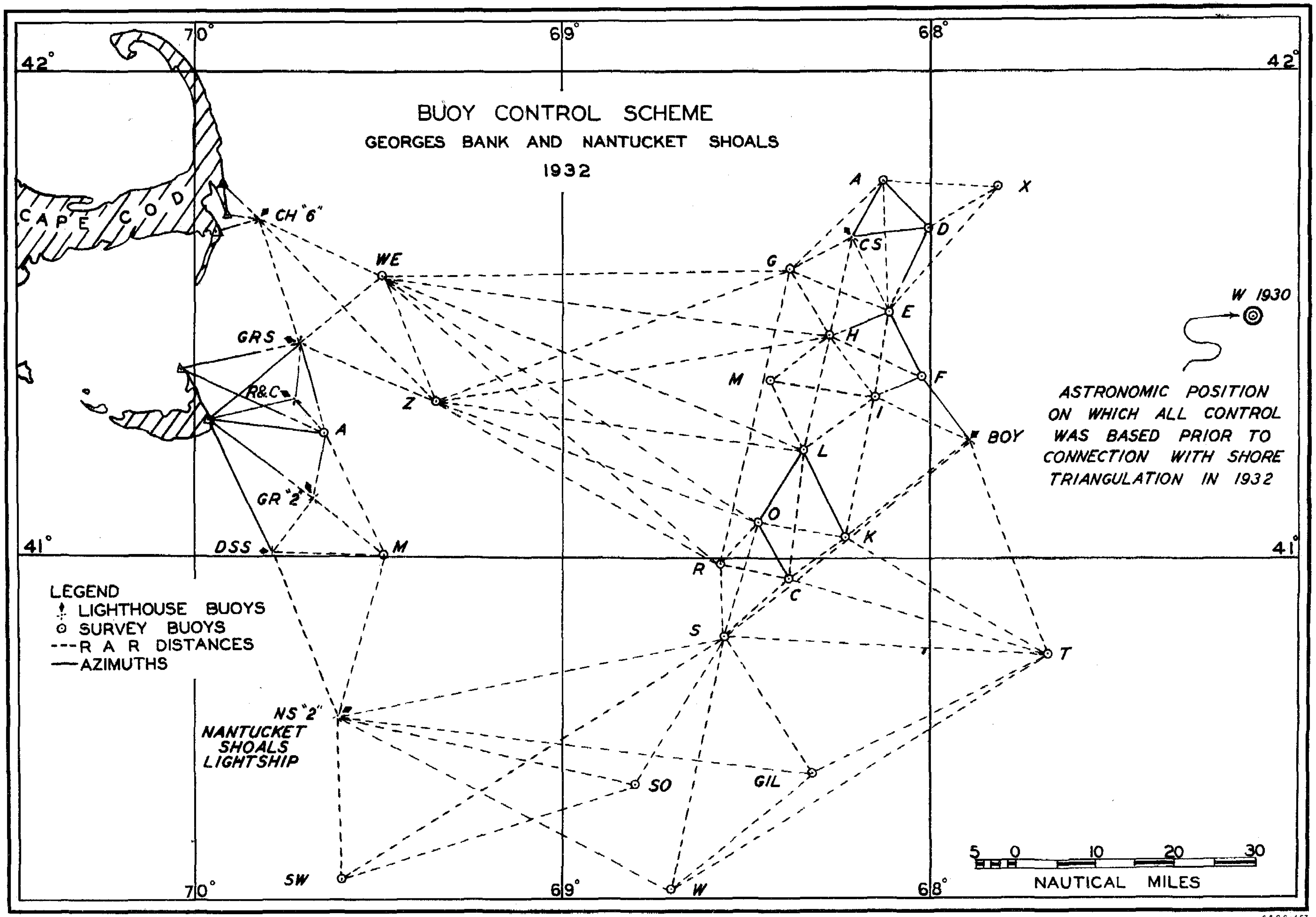
On the inshore end, the buoy triangulation was tied in to lighthouse buoys which were located by theodolite cuts from shore triangulation stations.

Plotting: To avoid distortion the buoys were plotted on an aluminum plate. This plate, 60" x 100", was large enough so that the entire season's triangulation could be plotted on a scale of 1:100,000.

Referring to the accompanying plate, the inshore buoys CH6, GRS, R & C, A and GR2 were plotted first. These were located by theodolite cuts from triangulation stations ashore and by astronomic azimuths observed between the buoys, and their positions were computed. From these positions, buoys WE, Z, M, DSS and NS2 were plotted graphically by the bombed distances and the single azimuth to DSS. The locations of all these buoys, with the exception of NS2, were regarded as fixed since their locations were strongly determined from known shore positions.

The fixed base WE-Z was too short to extend the triangulation offshore; consequently the offshore triangulation was plotted independently. The 1931 positions of "CS" and "Boy" were used and their positions plotted. These were lighthouse buoys left over from the previous season. A third lighthouse buoy left over from the previous season was not recovered. From the positions of "CS" and "Boy" the entire offshore triangulation was plotted graphically. Equal weight was given to azimuth

*Field Engineers' Bulletin No. 4, December, 1931, page 17 (1931 season)
" " " " 3, June, 1931 " 57 (1930 ")


BUOY CONTROL SCHEME
GEORGES BANK AND NANTUCKET SHOALS
1932
70°
69°
68°
42°
41°
CAPE COD
CH "6"
WE
GRS
R&C
A
Z
GR "2"
DSS
M
NS "2"
NANTUCKET SHOALS LIGHTSHIP
SW
SO
GIL
W
S
T
R
C
O
K
L
M
H
I
G
CS
A
D
X
E
F
BOY
W 1930
ASTRONOMIC POSITION ON WHICH ALL CONTROL WAS BASED PRIOR TO CONNECTION WITH SHORE TRIANGULATION IN 1932
LEGEND
LIGHTHOUSE BUOYS
SURVEY BUOYS
R A R DISTANCES
AZIMUTHS
5 0 10 20 30
NAUTICAL MILES
C.&G.S.-457

lines and distance arcs in determining buoy positions.

Closure and Adjustment: The offshore triangulation, which was based on astronomic fixes taken at buoy "W" during 1930, was extended inshore to buoys WE, Z and NS2. The positions of these buoys as determined by the offshore triangulation differed from their positions as fixed from shore by less than l/4 mile. The offshore triangulation was 330 meters too far east and 175 meters too far south of buoys WE and Z. The discrepancy at NS2 was somewhat greater in longitude but less in latitude. Since there was no check on the shore location of NS2 and since this location depended also upon a weak determination of DSS, the discrepancy here was not used in the main adjustment.

The adjustment was made by scaling all the offshore positions as plotted, except SO and SW, and adding 175 meters to the latitude and 330 meters to the longitude of each position. A small discrepancy still remained between the corrected position of NS2 and its shore location. This was adjusted by giving more weight to the shore location. The positions of SO and SW were then plotted graphically from the final positions of S and NS2. This placed the entire season's work on the shore datum.

Accuracy of Work: The work on Georges Bank was begun in 1930 at buoy "W", lying about 150 miles offshore, which was located by a series of careful astronomical observations. Buoy locations were extended from this position by R.A.R. distances and astronomic azimuths. Triangulation based on the position of buoy "W" was again extended in 1931 and 1932, and was finally tied in to shore positions with the closure as given in the preceding paragraph. This closure may be considered to be an error in the astronomic determination of "W", or an accumulated error in the R.A.R. triangulation, or both. However, all subsequent astronomic fixes taken during 1930, 1931, and 1932 indicated that our buoy positions were approximately correct in latitude, but about l/4 mile too far east in longitude. This indicates that most of the error lies in the original determination of "W" or in the determination of the positions of the first few buoys after leaving "W". In any case, the smallness of the closure shows that R.A.R. triangulation is surprisingly accurate and is incomparably more accurate than the methods formerly used in offshore surveys.

During 1931 the relation between buoys "CS" and "Boy" was determined by three intervening quadrilaterals. In 1932 work was begun at buoy "CS" and extended through three new quadrilaterals to buoy "Boy" and the new position checked exactly with the previous year's position.

The graphical determination of buoy positions was adopted this year since it afforded a quicker determination of the positions and consequently less delay in the work and since it afforded a quick and easy way to locate errors in distance or azimuth. In most of the small figures the distance arcs and azimuth lines to a buoy met at a common point or gave a very small triangle of error. Occasionally a distance or azimuth would be considerably in error and this could be checked by plotting through adjacent figures to the same point. The accuracy of graphical plotting is well within the probable error of distance and azimuth determination and this method seems especially well adapted to the complex figures that are necessary for this kind of work.

Out of approximately ninety distances determined, only five were entirely rejected and given no weight in the plotting of positions. Out of approximately thirty azimuths observed, only two were rejected and given no weight.

Causes of Errors: The errors in distance can be caused by assuming a wrong velocity of sound, or by an error in computing the relations between hydrophone or bomb and the buoy anchors. There is very little chance that the observed distance in seconds is in error. The great accuracy of the entire Georges Bank triangulation proves that our velocity tables with the use of the mean bottom temperatures are as near correct as could be desired. Consequently, the only appreciable source of error in the observed distance is in the determination of the mean bottom temperature. In the small triangulation figures the distances between buoys checked extremely well. It is believed that in the few cases where the distances failed to check in the small figures the error was in the reduction to buoy anchors. In the large figures, where the lines were long and passed over a considerable range in depth, there was usually a fairly large triangle of error at each buoy location. It is believed certain that this error is caused by incomplete knowledge of the bottom temperatures along the lines.

Astronomical azimuths appear to be about equally as accurate as R.A.R. distances and were given equal weight in the plotting of buoy positions. The average discrepancy between azimuths observed at both ends of a line was about 6 minutes. Two azimuths were rejected. In one case the azimuth failed to check the back azimuth by 26.8 minutes and in the second case by 64.9 minutes. In both cases the forward and back azimuths were plotted separately and the bomb distances readily indicated which azimuth was in error. Errors in astronomical azimuths can be caused by poor observations or by errors in reducing the observed azimuth to the buoy anchors. The chance for observational errors will be reduced by observing on the sun, or star, when it is low in the heavens.

Summary: The principal source of error in R.A.R. distances is in the lack of adequate bottom temperature information. In large triangulation figures, bottom temperatures should be obtained at various points along the lines between the buoys. This is especially important if the range of depth between the buoys is large or if there are changing currents as on Georges Bank where the flood brought warm water from the south and the ebb cold water from the north.

A large source of error in astronomical azimuths is in the observations. It is believed that this will be decreased by making observations when the sun, or star, is low in the heavens, preferably at or near amplitude.

With accurate observations of azimuth and distance it is essential that the observations be correctly reduced to the buoy anchors. More care should be used in observing and computing the data for these reductions.

In the plotting of the 1932 buoy triangulation there were errors in final distances and azimuths which appeared to be due to inaccurate reduction to anchors.

The velocity of sound tables, when used with the mean bottom temperature, appear to be about as accurate as could be desired for this work. This is shown by the remarkable good closures obtained over a large area.

The graphical determination of buoy positions by plotting on an aluminum plate has several advantages over the computation of positions. This is especially true when the scheme is very extensive and the figures complicated. When positions are to be determined graphically, it is best to observe as many overlapping distances as practicable.

COMMENTS ON THE ABOVE

W. E. Parker, H. &. G. Engineer, U.S.C. & G. Survey
Commanding Ship HYDROGRAPHR

In transmitting this report, which I consider an excellent discussion on the subject, I wish to add a few observations on the sources of errors or rather of unavoidable errors inherent to this kind of work in a locality like Georges Bank.

I believe that the failure of a line (side or diagonal) in a quadrilateral to meet two other intersecting lines at or near a point is due largely to an error in selecting the correct velocity for the sound waves along that line. Some of the error is undoubtedly due to mistakes in reducing bombed distances to buoy anchors, but I think the large discrepancies, especially in the long sided figures, are due to wrong velocities.

On Georges Bank the water temperatures are very erratic. We have found that temperatures vary considerably at the same depth in places not far distant from each other, that within a few hours there may be a change in bottom temperature as great as four degrees centigrade, that at times warmer water may lie under colder water - in short, that there is no stable temperature gradient on Georges Bank such as we may expect elsewhere.

As an illustration, the LYDONIA found at buoy G, depth 12 fathoms, bottom temperatures varying from 8.6 to 10.6 degrees within four hours, and at buoy Y2, depth 33 fathoms, bottom temperatures varying from 9.1 to 11.8 degrees within seven hours, and the GILBERT found at buoy A, depth 31 fathoms, bottom temperatures changing from 7.1 to 11.2 degrees within six and a half hours.

These changes are extreme and unusual, but are nevertheless indicative of what may be taking place somewhere along a line that is being measured by bombed distances. If at one of the buoys between which the distance is being measured, no harm would result, as we always observe temperatures at the times of bombing, but if between buoys, we would have no knowledge of such deviation. The velocity selected for that line would be that consistent with the mean of the bottom temperatures at the two buoys and would be incorrect to the extent that intervening temperatures caused a deviation from that mean.

The temperature changes given above might cause errors of 7.4, 9.7, and 15.3 meters per second, respectively, and in a line of which the time of transmission of the compression wave is 30 seconds, by no means a long line compared to many that we measured last summer, errors of about 220, 290, and 460 meters, respectively.

The fact that we got very few large disagreements indicates that we rarely missed the correct velocity by an appreciable amount, but I believe we have found an explanation for most of the disagreements and especially those in the largest figures.

I suggest also that those differences in the bomb times between a pair of buoys that caused some concern the first season (1930) may be explained by undetected changes in bottom temperature at one or both of the buoys or between buoys. I have observed that when bombing was extended over a long time and especially when it was interrupted so that there was a considerable time interval between the first and the second groups of bombs, the bomb times of each group might be in close agreement among themselves but in considerable disagreement between groups.

I believe that the excellent closures that we usually got in quadrilaterals, as described by Lieut. Patterson, where often each side and diagonal were computed on a different velocity; that the agreement in distances between buoys as bombed at different times and even during different seasons; and finally that the close tie-in made on shore control show that in computing bomb distances we are not much in error when we accept a velocity based upon the mean bottom temperature along the line to be measured.

In the matter of astronomic azimuths, I think the error is usually introduced in reducing them to the buoy anchors. When the buoys are so close that the distant buoy can be seen, it is possible to place the observing ship squarely on range with the two buoys at the instant of observation. Then, unless the buoys have widely different scopes, the azimuth between buoy anchors would usually be nearly the same as between buoys at the instant of observation. But when the buoys are so far apart that it is possible only to observe upon a ship anchored near a buoy from a ship anchored near the other buoy, then it is difficult to transfer the observed azimuth to buoy anchors with any degree of accuracy. And, of course, the nearer the ships are to each other the greater will be the error by this method.

The graphical method of treatment, described by Lieut. Patterson, has the great advantage over the mathematical treatment, with adjustment, in that it shows readily and quickly which lines and azimuths disagree with the others. This is especially true when cross lines and overlapping figures have been bombed, as was done last season.

We thought that the best way to treat such disagreement was to reject the disagreeing lines on the assumption that they contained some such errors as described above rather than to force the lines which appeared to be in close agreement to an adjustment with the questionable lines, as usually the observations showed no justification for assigning different weights to those lines.

* * * * * * * * * * * *

From Prof. F. P. Shepard, University of Illinois.

**** I Wish to thank you for the opportunity which I had this summer to accompany the ships to Georges Bank. The results have proven very interesting to me. I confidently believe that the work of your survey is going to open up an entirely new line of attack on some of the most absorbing and difficult problems of geology. The work is giving for the first time some really detailed information concerning the remarkable series of submarine canyons which cut the continental slopes off most of the coasts of the world. Those discovered this summer must surely have been cut by rivers originally, and since they extend to at least 7,000 feet in depth, they must have been formed at a time when New England was elevated into a great plateau.

Seeing such ships as the Europa crossing over the network of valleys, as we did last summer, gives some idea of the practical value of obtaining exact configurations of these features.

Specimens obtained during the summer have also supplied me with valuable information. Several samples taken from the anchor of the OCEANOGRAPHER were particularly interesting as they revealed the character of sediment which underlies the surface veneer of sand and gravel on Georges Bank. The underlying sediment is similar to that found over much of the deep portions of the Gulf of Maine.

May I thank you also for the receipt of a copy of the Bulletin of Field Engineers and of the new chart of Georges Bank. I find the bulletin very interesting, especially because so many phases of my work are closely connected with the work of the Coast Survey.****

* * * * * * * * * * * *

AN UNIQUE STATION MARK

(Extract from a letter from Chas. Pierce in charge of a party extending coastal triangulation along the California coast.)

We have recently recovered a silver ten cent piece, series of 1858, which was used to mark triangulation station INDIAN 1872, just south of San Luis Obispo Bay, California. This piece is still in good condition, but slightly dented from pressure of nail on bottom of pole over this mark. The silver dime was set into a drill hole in a stone below the surface of the ground and found intact.

In case this unique mark is desired for a historical record at the office, I shall be pleased to forward it upon notice from the office.

DETERMINATION OF VELOCITY OF SOUND ON GEORGES BANK

JUNE 1 1932

SHIP HYDROGRAPHER

W.E. PARKER COMDG.

BOMB NO.	SHEAVE DIST. FMS.	TIME SEC.	REMARKS
	0	0	
1	516	0.99	REJECT
2	774		N.R.
3	921	1.12	
4	1038	1.29	
5	1201		N.R.
6	1347	3.10	REJECT
7	1498	1.87	
8	1654	2.06	
9	1799	2.21	
10	1953	2.40	
11	2500	3.07	
12	3002	3.72	
13	3501	4.32	
14	4000	4.98	
15	4498	5.57	
16	4698	5.83	
17	4898	6.08	
18	5097	6.30	
19	5296	6.55	
20	5498	6.80	
21	5697	7.01	

NOTE: REJECT -SEE GRAPH

N.R.-NO RETURN

BOMB NOS.	DISTANCE BETWEEN - FATHOMS	TIME DIFF SEC.	VELOCITY FMS/SEC.
3-14	3079	3.86	797.67
4-15	3460	4.28	808.41
7-16	3200	3.96	808.08
8-17	3244	4.02	806.96
9-18	3298	4.09	806.36
10-19	3343	4.15	805.54
11-20	2998	3.73	803.75
12-21	2695	3.29	819.15
	-----	----	------
TOTAL	25317	31.38	6455.92

MEAN VELOCITY = 25317/31.38

= 806.788 FMS/SEC

= 1475.457 M /SEC

*COR. CURRENT = + 0.75 M /SEC

EXP.VELOCITY = 1476.21 M /SEC

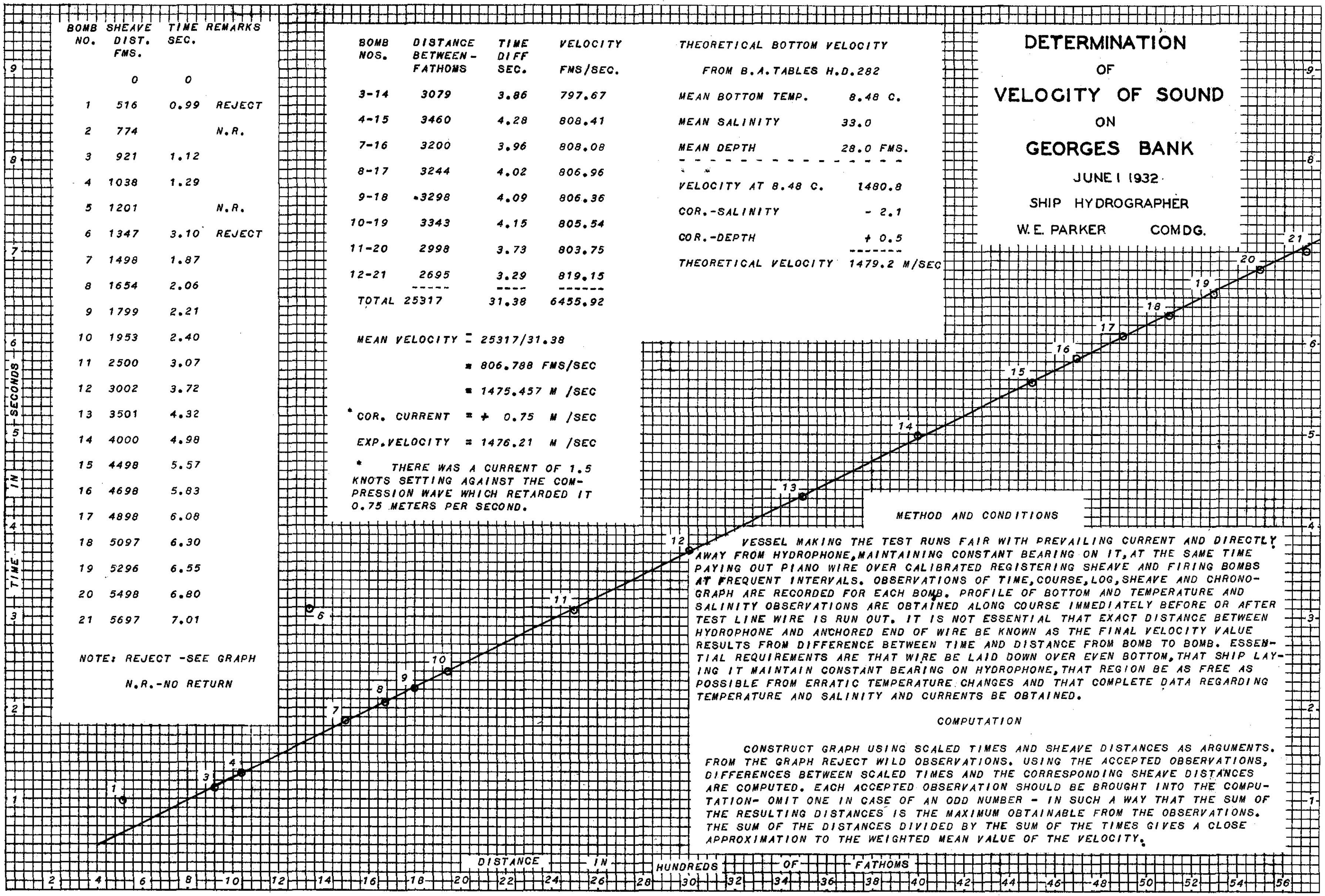
* THERE WAS A CURRENT OF 1.5 KNOTS SETTING AGAINST THE COMPRESSION WAVE WHICH RETARDED IT 0.75 METERS PER SECOND.

THEORETICAL BOTTOM VELOCITY

FROM B.A.TABLES H.D.282

MEAN BOTTOM TEMP.	8.48 C.
MEAN SALINITY	33.0
MEAN DEPTH	28.0 FMS.
VELOCITY AT 8.48 C.	1480.8
COR.-SALINITY	- 2.1
COR.-DEPTH	+ 0.5

THEORETICAL VELOCITY	1479.2 M/SEC



METHOD AND CONDITIONS

VESSEL MAKING THE TEST RUNS FAIR WITH PREVAILING CURRENT AND DIRECTLY AWAY FROM HYDROPHONE, MAINTAINING CONSTANT BEARING ON IT, AT THE SAME TIME PAYING OUT PIANO WIRE OVER CALIBRATED REGISTERING SHEAVE AND FIRING BOMBS AT FREQUENT INTERVALS. OBSERVATIONS OF TIME, COURSE, LOG, SHEAVE AND CHRONOGRAPH ARE RECORDED FOR EACH BOMB. PROFILE OF BOTTOM AND TEMPERATURE AND SALINITY OBSERVATIONS ARE OBTAINED ALONG COURSE IMMEDIATELY BEFORE OR AFTER TEST LINE WIRE IS RUN OUT. IT IS NOT ESSENTIAL THAT EXACT DISTANCE BETWEEN HYDROPHONE AND ANCHORED END OF WIRE BE KNOWN AS THE FINAL VELOCITY VALUE RESULTS FROM DIFFERENCE BETWEEN TIME AND DISTANCE FROM BOMB TO BOMB. ESSENTIAL REQUIREMENTS ARE THAT WIRE BE LAID DOWN OVER EVEN BOTTOM, THAT SHIP LAYING IT MAINTAIN CONSTANT BEARING ON HYDROPHONE, THAT REGION BE AS FREE AS POSSIBLE FROM ERRATIC TEMPERATURE CHANGES AND THAT COMPLETE DATA REGARDING TEMPERATURE AND SALINITY AND CURRENTS BE OBTAINED.

COMPUTATION

CONSTRUCT GRAPH USING SCALED TIMES AND SHEAVE DISTANCES AS ARGUMENTS. FROM THE GRAPH REJECT WILD OBSERVATIONS. USING THE ACCEPTED OBSERVATIONS, DIFFERENCES BETWEEN SCALED TIMES AND THE CORRESPONDING SHEAVE DISTANCES ARE COMPUTED. EACH ACCEPTED OBSERVATION SHOULD BE BROUGHT INTO THE COMPUTATION- OMIT ONE IN CASE OF AN ODD NUMBER - IN SUCH A WAY THAT THE SUM OF THE RESULTING DISTANCES IS THE MAXIMUM OBTAINABLE FROM THE OBSERVATIONS. THE SUM OF THE DISTANCES DIVIDED BY THE SUM OF THE TIMES GIVES A CLOSE APPROXIMATION TO THE WEIGHTED MEAN VALUE OF THE VELOCITY.

C&G.S. 457

Form R-234 AZIMUTH SIGHT FOR HYDROGRAPHIC CONTROL

USC&GSS LYDONIA, G.D.Cowie Com'd'g. Lat. 41-22.5 Long. 68-00.75

Date June 24 Buoy F bears 323°T. dist. 649 m. Hor. scope 84 m.

Astro. object sighted Moon ☽, bearing 184 °T., H.I. 24½ ft., Watch No. 136

Horizon object sighted Bridge OCEO, bearing 248°T., Dir. cur. (S.H.±180) 163 °T.

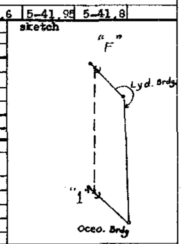
Anchor of buoy F is distant 400 m., bearing 217 °T. from horizon object

Incl.∡ by G.D.C., sext. #740, I.C. -1.5. Vert.∡ by K.G.C sext. #___, I.C. +1.5

	(1) h m s	(2) h m s	(3) h m s	(4) h m s		(1) deg min	(2) deg min	(3) deg min	(4) deg min
W	4 43 03	4 45 46	4 46 32	4 48 06	obs. h	42 58.5	42 35.6	42 33.3	42 32.3
C-W	- 6.2	5.2	5.2	5.2	I. C.	+ 1.5	1.5	1.5	1.5
C.T.					s. d.	- 15.2	15.2	15.2	15.2
C.C.	5 7.1	7.1	7.1	7.1	h_o	42 24.8	42 21.3	42 19.6	
G.C.T.	9 43 03.9	9 45 46.9	9 46 32.9	9 48 06.9	H.P.(moon) Corr.				
Eq.T.									
RAMS+12	18 7 44	18 7 44	18 7 44		h_c (moon)				
Table 3	1 35.6	1 36.2	1 36.4	1 36.7					
G.A.T.					Incl. ∡	71 35	71 35	71 00	
G.S.T.	3 52 23.7	3 55 07.1	3 55 53.3		I. C.	- 1.5	- 1.5	- 1.5	
Long. W.	4 32 03	4 32 03	4 32 03		s. d.	- 15.2	- 15.2	- 15.2	
L.A.T.									
L.S.T.	23 20 20.7	23 23 04.1	23 23 50.3		V_o	71 38.3	70 56.8	70 43.3	
R.A.	23 10 23.3	23 10 28.2	23 10 29.6						
L.H.A.	0 9 57.4	0 12 35.9	0 13 20.7		declin.	5-42.6	5-41.9	5-41.8	

	(1)	(2)	(3)	(4)
Log cos. V_o	9.49833	9.51381	9.51872	
Log cos. h_o	9.86823	9.86864	9.86865	
Log cos. V_c	9.63010	9.64517	9.64989	
V_c	64-44.6	63-47.1	63-28.6	
Az.astro.body	183-23	184-18	184-33	
Dip corr.	-3.1	-3.1	-3.1	
Az.hor.object	248-04.5	248-02.0	247-58.5	248-02
				Mean

sketch



From azimuth tables

H.A.	Lat. = 41 δ = -5	δ = -6	δ = 5.7	Lat. = 42 δ = 5	δ = 6	δ = 5.7	Lat. = 41-22.5
0-10	176-32	176-36	176-35	176-36	176-39	176-38	176-36
0-15	174-49	174-54	174-53	174-55	174-59	174-58	174-55

1 m = 20.4'

Observed az.	248-02
Near end corr.	-3-33.5
Dist. end corr.	+1-02.6
Az. ⚓ to ⚓	245-31

ECCENTRIC REDUCTION

	Stations	a	log sin a	log s (meters)	log sin a / s	log of reduction	c (min)
Ecc.sta. LYD Bridge d = 73 m. log 2.8641 colog sin 1' 3.5363 sum 6.4004	Buoy ⚓	0°	—	11320	—	—	—
	OCEO Brdg	286	0.9828n	4.0538	5.9290n	2.3294n	-213.5
Ecc.sta. OCEO Brdg d=400 m. log 2.6021 colog sin 1' 3.5363 sum 6.1384	Buoy ⚓	0°					
	Lyd Brdg	31	9.7118	4.0538	5.6580	1.7964	+ 62.6

(R-234)

(OVER)

Form R-228 ABSTRACT OF BUOYS PLANTED

U.S.C.& G.S.S. LYDONIA, George D.Cowie Com'd'g.

Name	1932 Date	Depth fms.	Location Lat.	Long.	Cable (fms.) between buoys	Chain	Cable	Horiz. scope meters	Description Banner	Flag	Anchor lbs.	Remarks
"G"	10-8	20-3	41-05.6	69-41.6	18 ft	6	30	47.5	Single screen	White Red	3 car couplers	
"H"	10-8	21-2	41-04.6	69-41.9	18 ft	10	30	53	Double screen	Black White	"	

Form R-229 BUOY TO BUOY DISTANCES BY BOMB

U.S.C.& G.S.S. ____________, ____________ Com'd'g.

Date ____________, 193__ At buoy ____________

Sta. Ship ____________, at buoy ____________, Az. true ______

Time	Bomb No	S.H.	Dir. cur.	BUOY BEARS FROM BOMB p.c.	Dev. Var.	True	Vert.angle Yds.-range finder	Dist. m.	HYDROPHONE BEARS FROM BUOY ANCHOR Degrees true	Dist. m.	Remarks

Form R-229 COMPUTATION OF DISTANCE

Bomb no.	Temp.	Sal.	Depth	Velocity	Bomb time sec.	Bomb distance	Reduction to anchor buoy	buoy	DISTANCE anchor to anchor

Form R-232 ABSTRACT OF DISTANCES BOMBED

Buoy to buoy

U.S.C.& G.S.S. ____________, ____________ Com'd'g.

Project ____________, Locality ____________, Date ______

From buoy	To buoy	Date	Velocity	Average depth	Distance meters	Remarks

Form R-230 ABSTRACT OF TEMPERATURES AND SALINITIES with THEORETICAL VELOCITIES for SOUND IN SEA WATER (From British Admiralty tables)

U.S.C.& G.S.S. LYDONIA, George D.Cowie Com'd'g.

1932 Date	Time	Depth fms.	Lat.	Long.	SURFACE Temp.	Sal.	Velocity	BOTTOM or DEPTH Temp.	Sal.	Velocity	Remarks
6-21	10-50	12	41-35½	68-22½	10.9	32.86	1487.5	10.8	32.86	1487.5	Buoy "G"
	13-20	12			-	-	-	10.5	-	1486.4	"
	15-10	12			-	-	-	10.2	-	1485.3	"
	17-15	12			11.2	32.88	1488.5	9.8	32.92	1483.9	"

Form R-231 ABSTRACT OF ASTRONOMIC AZIMUTHS

U.S.C.& G.S.S. LYDONIA, George D.Cowie Com'd'g.

Project HT-107, Locality Georges Bank, Date, 1932

Date	From buoy	To buoy	Method	Azimuth	Remarks
10-8	H	GR_2	Sun Azimuth	10° 20.0'	Use to compute position of H
10-8	H	G	Sun Azimuth	11 27.0	Use as a check.
10-8	H	I	Sun Azimuth	188 51.8	Use as a check.

Form R-233 ABSTRACT OF CURRENTS OBSERVED

U.S.C.& G.S.S. LYDONIA, George D.Cowie Com'd'g.

STATION Buoy "F"

1932 Date	A.M. Time	Lat.	Long.	CURRENT Direction deg. true	Strength knots	WIND Direction points	Velocity m.p.h.	Remarks
6-24	4-00	41-22.5	68-00¾	84	0.8	NW	32	
	4-30			113	1.1	NW	28	

Form R-101 ASTRONOMIC SIGHT FOR HYDROGRAPHIC CONTROL

Body Observed * Venus Date June 11 A.M. P.M. D.R. Lat. 41° 41.5' Long. 67 59.5

Rating of sight Place Ship's Time 75th mer

Ship's Head ____° Log Reading ____

Bearing of Body Pelorus ____ - - Buoy "D" - - - True Course ____

Variation ____° Height of Eye 24.5 ft

Sextant # ____

Buoy ____ bears 311 °True 458 meters distant. Watch # 136

Ship's Head 336 ° True: Scope of buoy 74 meters.

	WATCH TIME hr.	min.	sec.	TIME INTERVAL m s	OBSERVED ANG. INTERVAL m s m dec	COMP. ANGLE INTERVAL m dec	ERROR OF OBS.		OBSERVED ANGLE °	'	"
	7	17	50						15	19	05
	7	18	23						15	14	55
	7	18	57.5						15	07	30
	7	19	27						15	02	30
	7	19	58						14	56	20
	7	20	34.5						14	50	35
Sum	43	55	10.0					Sum	90	30	55
Av.W.T.	7	19	11.7					Av.O.A	15	05	09.2
C - W	0	00	00.0					i.c.		+	30
C.T.	7	19	11.7					arc.corr.		+	18
C.C.	5	00	02.2						15	05	57.2
G.C.T.	0	19	13.9	June 12 date				Ht.eye,etc.	-	08	24.0
Eq.t.									14	57	33.2
RAMS+12	17	20	25.3					Hor.par.		+	25.0
Table III			03.3					Cor.Obs.Angle	14	57	58.2
G.A.T.											
G.S.T.	17	39	42.5	date							
Long.W.	4	31	58.0					* Lat.Corr.			
L.A.T.								Latitude			
L.S.T.	13	07	44.5								
R.A.	7	05	50.9								
L.H.A.	6	01	53.6								

* For use with Polaris
¢ For use with Meridian and Ex-Meridian Sight

Cor.Obs.Angle 14°57'58.2" log sec 0.01449

t.	90	28	15	--log hav -- 9.70254	--log sin 9.99999		
Lat.	+ 41	41	30.0	--log cos -- 9.87317			
dec. +	23	22	54.2	--log cos -- 9.96279	--log cos 9.96279		
				θ --log hav -- 9.53850	log sin 9.97777		
				θ --nat hav -- 0.34554	Azimuth 288° 10.5		
L.-dec.	18	18	35.8	--nat hav -- 0.02531			
Cal.Z.	75	01	51.4	--nat hav -- 0.37085			
Cal.Alt.	14	58	08.6				
Obs.Alt.	14	57	58.2				
Diff.		00'	10.4" away				

Azimuth by Tables 288 °

Observed by K.G.C
Recorded by C.M.
Computed by K.G.C.
Checked by G.D.C.

(Over)

(R-101)

Form R-227 RELATION OF SHIP'S BRIDGE AND HYDROPHONE TO BUOY ANCHOR

U.S.C.& G.S.S. LYDONIA, George D.Cowie Com'd'g.

Date June 26 1932 Buoy "L" Hor. Scope 89 m. Lat. 41-13 Long. 68-20.5

Time	Dir. Current	BUOY BEARS FROM SHIP: p.c.	Dev. Var.	True	Vert.angle yds.-range finder	dist. meters	HYDROPHONE BEARS FROM SHIP: p.c.	Dev. Var.	True	Vert.angle yds.-range finder	dist. meters	FROM BUOY ANCHOR: Bridge bears degrees true	dist. meters	Hydrophone bears degrees true	dist. meters
6-00	67	252	-16	236	420	384	75	-16	59		71	58	470	58	543
6-30	97	252	-15	237	422	386	93	-15	78		71	64	457	66	526
7-00	114	255	-16	239	441	403	124	-16	108		71	68	458	73	512
7-30	135	256	-16	240	436	399	142	-16	126		71	71	428	78	473
8-00	134	257	-15	242	429	392	149	-15	134		71	73	427	81	467
8-30	140	256	-15	241	425	389	157	-15	142		71	73	414	81	442
9-00	153	257	-15	242	422	386	159	-15	144		71	75	395	84	426
9-30	160	256	-15	241	395	361	172	-15	157		71	75	358	86	377
10-00	154	257	-14	243	395	361	172	-14	158		71	77	370	87	388
10-30	174	256	-15	241	390	357	178	-15	163		71	75	334	87	342
						370	187	-16	171		71	77	355	89	356
						363	208	-18	190		71	76	327	88	305
						360	231	-18	213		71	68	292	77	240

FORMS
FOUND USEFUL
ON
GEORGES BANK
SURVEY

C.&G.S. 457

CANYONS SOUTH OF GEORGES BANK

F. P. Shepard, Professor of Geology, University of Illinois

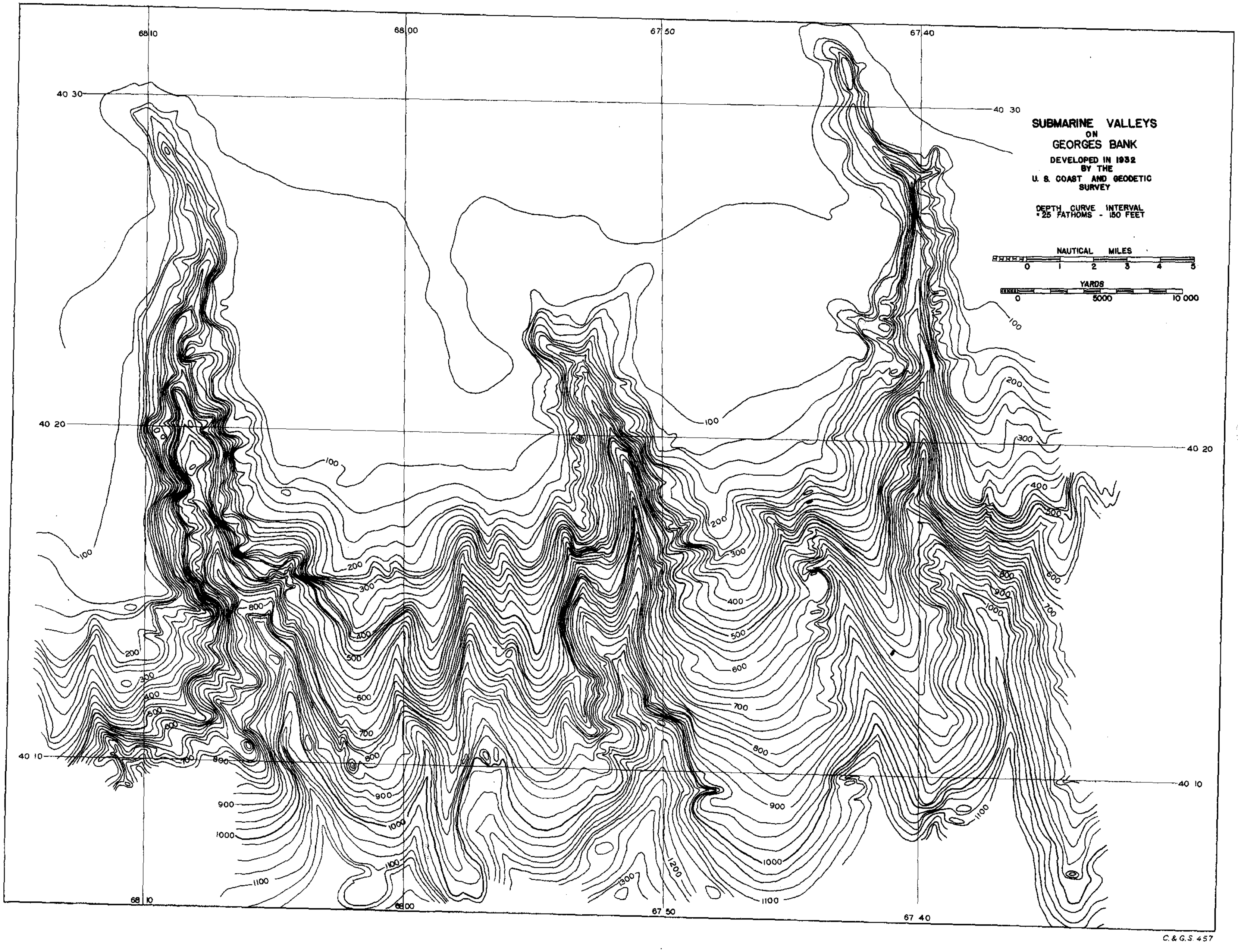
The survey of Georges Bank by the U. S. Coast and Geodetic Survey during the last three summers besides developing valuable information for navigational purposes and for the fishing industry has made large contributions to pure science. The remarkable organization and utilization of radio-acoustic sound ranging and of echo soundings in this offshore charting have produced the accuracy and detail essential for the interpretation of submarine topographic features.

The continental slope beyond Georges Bank has been found to contain a topography which, were it elevated above the sea, would be one of the scenic wonders of the world. Seven great canyons have been discovered, all penetrating for more than a half mile below the adjacent slopes and twenty-four others all appear to have been cut at least a thousand feet into the sea floor. When it is recalled that the famous Yellowstone Canyon is no more than a thousand feet deep and the Royal Gorge only slightly deeper, the significance of these submarine features becomes apparent. To find features truly comparable on land we have to turn to the Grand Canyon of the Colorado.

The origin of land valleys is generally not difficult to determine. Most of these valleys have been cut by stream erosion, but others are formed by movements of the earth's crust which have allowed blocks to subside in reference to adjacent areas. Still others have been excavated at least to some extent by glaciers and others are partly the result of the collapse of the roofs of subterranean caves. Sea floor canyons might have been formed by any of these processes, provided in the case of river cutting that the area was formerly above water. In addition, submarine currents might have been of some importance.

The shapes of the canyons should serve to differentiate between these processes in the case of submarine canyons in the same way that they do on land. Some of the Georges Bank canyons have been surveyed in sufficient detail so that their characteristics are readily determined. A study of the contours on the accompanying plate shows that the canyons are V-shaped in cross section, have sinuous trends, have a considerable number of tributaries entering them at grade, and, in general, slope outward almost continuously. These characteristics are those of river cutting and are decidedly not those of any other process. Therefore it seems almost certain that the continental shelf must have been elevated many thousands of feet during the canyon cutting stage. The relatively low rolling country of New England must have been part of a high plateau perhaps resembling the Colorado plateau of the present day.

Another deduction which may be made from these canyons is that they were submerged before the development of the present continental shelf, perhaps many millions of years ago, and that they have probably been filled with sediments and reopened in post glacial times by great landslides which carried the sediments down the slopes into the deep ocean basins. The basis for the first deduction is that the outer margin of the conti-



SUBMARINE VALLEYS
ON
GEORGES BANK
DEVELOPED IN 1932
BY THE
U. S. COAST AND GEODETIC
SURVEY
DEPTH CURVE INTERVAL
=25 FATHOMS - 150 FEET
NAUTICAL MILES
YARDS

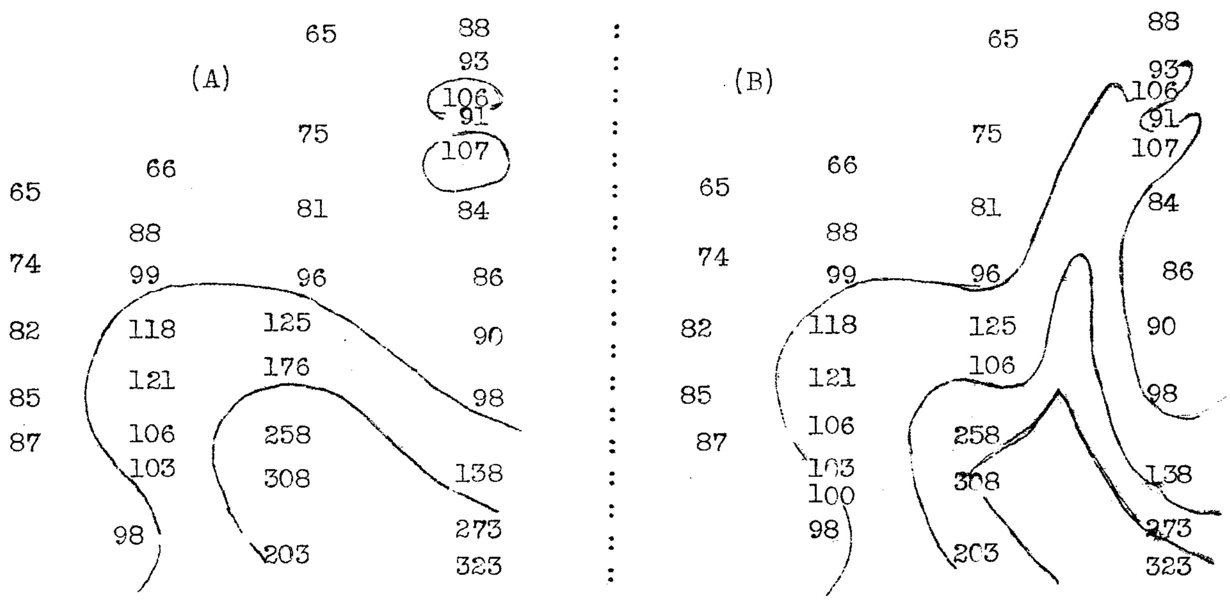
C.&G.S. 457

mental shelf in this area lies at the same general depth as is found for the shelves over most of the world. Such depths must have been developed under conditions of stability. They probably represent the level of wave cutting when the sea level was lowered several hundred feet by the glaciers of the last glacial period. It is evident that any part of the shelf which has been greatly uplifted or depressed since that time must lack these accordant marginal depths. Therefore the valleys must have been formed before the development of the shelf. Furthermore, during the cutting of the shelf large quantities of sediment would have been washed into the drowned valleys. Also when the glaciers stood on Georges Bank to the north, as is now known to have been the case, it seems probable that large quantities of sediment were washed out across the shelf and were lodged in these valleys. If the valleys became filled in these ways, they must have been reopened. Submarine landslides have been suspected in many places by cable companies and there is some evidence that one actually occurred in 1929 opening up Corsair Gorge, the northeastern most of these canyons (see this bulletin for June, 1931, p. 87). Such slides usually accompany earthquakes and probably attain very large proportions greatly modifying the ocean floor, as appears to have happened after the great Japanese earthquake of 1933.

Contouring Methods

In the construction of the contours shown on the accompanying plate, about 3,000 soundings were used. In some places where sounding lines were closely spaced, contours could be drawn without difficulty, but elsewhere the interpolation of contours required considerable care and knowledge of submarine and land topography was employed to make the contours trend in the most probable directions.

Shelf edge depressions: An example of how familiarity with submarine topography may be a means of improving the drawing of contours is shown below where alternative methods of constructing the 100-fathom curve are presented. The second interpretation (B) was thought to be the more probable for the following reasons:



1. If the first interpretation (A) were correct, the isolated inner deep would constitute a depression 30 fathoms below its surroundings. Such depressions are not unusual within a glaciated portion of the con tinental shelf like the Gulf of Maine and would not be surprising on the shoaler morainic portions of Georges Bank, but the outer part of the shelf has not been glaciated and only very minor depressions are found in it, none of them having depths greater than 55 fathoms.*

2. The second interpretation is favored by the finding of a series of similar indentations of the 100-fathom line along most of the outer portion of the shelf in this area.

3. The fact that this valley has been shown to have a branch further west does not invalidate this eastern indentation because stream valleys usually have several branches at their heads and other valleys in the vicinity have more than one branch.

4. The general trend of the outer portion of this canyon suggests that its head extends towards the zone in question and that the branch to the west is less important.

<u>Tributary valleys</u>: There are two ways or more of detecting the presence of tributary valleys where soundings are not sufficiently numerous to prove their presence. If a line of soundings run transverse to the general valley trend shows two notches in a certain area while another line directly outside shows only one, the probability is that the two valleys have merged and the contouring should be done with this in mind. Where lines of soundings run down the sides of the main valleys, the finding of depressions in the slope probably signifies tributaries coming into the main valleys. In contouring these it should be borne in mind that tributaries ordinarily join main valleys at small angles with their apexes pointing down stream.

<u>Contour projection into scarcely sounded areas</u>: In drawing contours into areas where sounding lines are widely spaced, an attempt should be made to make the contours assume the same general shapes as in adjacent well sounded areas, except when there is reason to believe that a topographic change intervenes. The southeast portion of the accompanying plate is a case in point. Here we have valleys and ridges inside and, to the west, evidence that the valleys extend out to the limits of the charting. It is only reasonable to conclude that the valleys extend also into this poorly charted area. In drawing the contours into this section greater simplicity is shown than probably exists, but there was no basis for the drawing of the minor irregularities which are demonstrated elsewhere.

<u>Hills in the outer valleys</u>: In some places along the outer portions of the submarine canyons, lines of soundings show rises along the valley floors. These rises might be interpreted as the confluence of tributary

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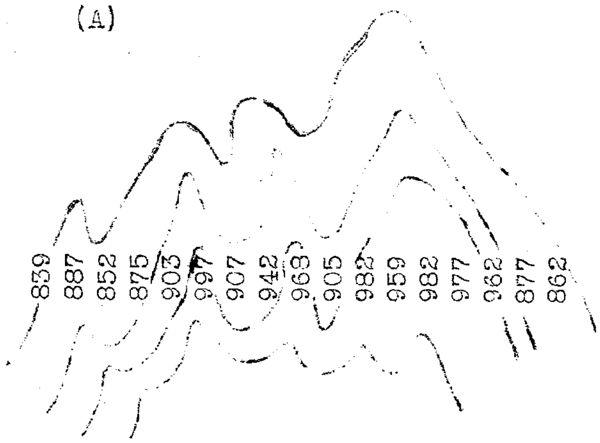
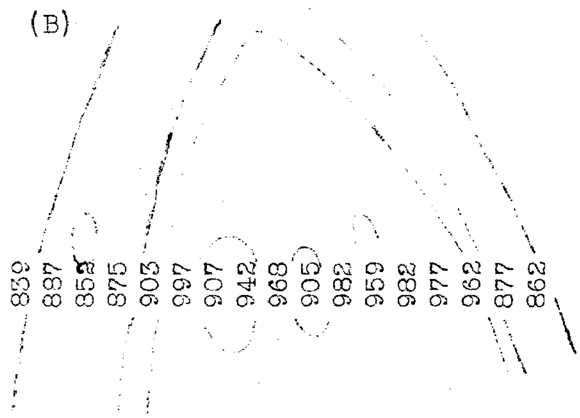
* These minor depressions are probably due to the building of offshore bars by the waves when the sea stood near the margin of the shelf during certain glacial epochs.

valleys (figure A, below) or as isolated hills within the valley (figure B). In some localities off the west Coast there is evidence for the latter interpretation for such rises. Also it is to be expected that there should be hills in the outer courses of the canyons if they have been reopened by landslides. The material dislodged from above would be expected to pile up on the outside. Accordingly, in such a situation, it seems advisable to draw contours like those in figure B.

(A)



(B)



RAPID METHODS OF DETERMINING APPROXIMATE SPHERICAL EXCESS IN TRIANGLES

(I) C. I. Aslakson

The nomogram shown on the accompanying plate has been found convenient for computing the spherical excess on reconnaissance maps for field triangle closures. It was used on my party in Texas and found to save much time. Constructed for a single value of "m", it was found to give spherical excess values which were as close as the elements of the triangle could be scaled from the blue-prints.

The construction is simple. The outer scales, "A" and "B", are taken directly from a 20-inch slide rule. Scale "C" is the square scale on this slide rule. It is midway between "A" and "B" and is adjusted vertically by the amount of the constant multipliers which represent the factor "m" and the factors necessary to reduce "m" as expressed in meters to statute miles. The method of using: the nomogram is shown on the plate.

(II) E. O. Heaton

For those who may prefer a formula for computing the approximate spherical excess, there are three formulas given below:

e = .0066 x twice the area of a triangle in square statute miles or (.0066 x base x altitude in statute miles).

$$e = \frac{\text{Area of triangle in square miles}}{100} + 1/3\ \frac{(\text{Area})}{(\ 100)}$$

e = One second for every 75 square miles of area.

Of these three formulas the first one was handed down to me by Commander Garner about 13 years ago and I have found it to be the quickest and most satisfactory of any I have used. I believe it has been used more extensively in the Division of Geodesy than any of the other methods. In addition to the fact that it is the quickest and most convenient formula to use, it is also slightly more accurate than the others.

In order to illustrate the accuracy of each formula and Lieutenant Aslakson's graph, the excess of a large triangle with 30 mile base and 30 mile altitude has been computed from the formula e = ab Sin C xm and compared with the approximate results below:

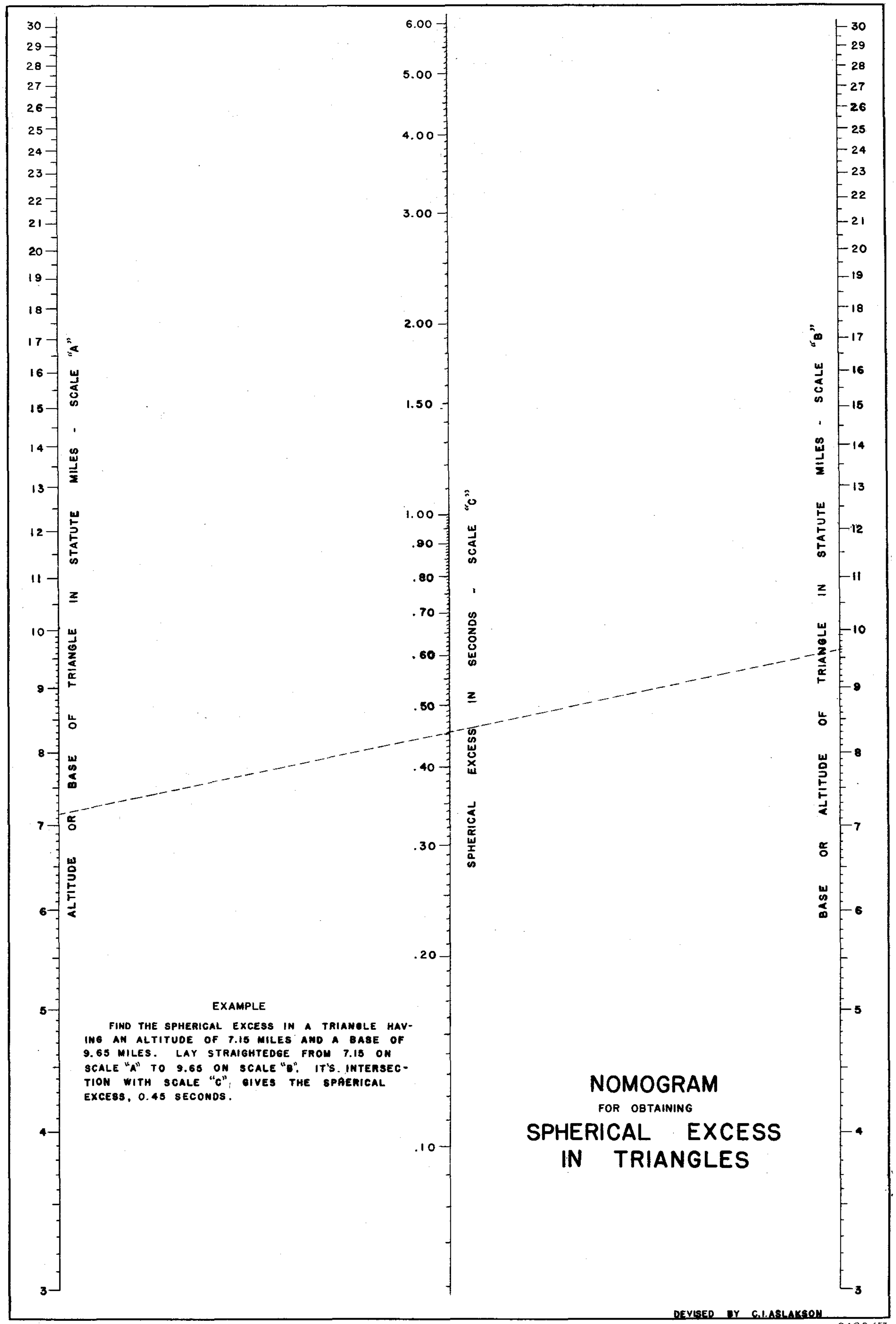
$$e = ab\ \text{Sin}\ C \times m = 5''.92$$

$$e = .0066 \times \text{twice the area} = 5''.94$$

$$e = \frac{\text{Area of triangle}}{100} + 1/3\ \frac{(\text{Area})}{(\ 100)} = 6''.00$$

$$e = \text{One second for 75 square miles} = 6''.00$$

$$e = 5''.90 \text{ from the graph.}$$


ALTITUDE OR BASE OF TRIANGLE IN STATUTE MILES - SCALE "A"
SPHERICAL EXCESS IN SECONDS - SCALE "C"
BASE OR ALTITUDE OF TRIANGLE IN STATUTE MILES - SCALE "B"
EXAMPLE
FIND THE SPHERICAL EXCESS IN A TRIANGLE HAVING AN ALTITUDE OF 7.15 MILES AND A BASE OF 9.65 MILES. LAY STRAIGHTEDGE FROM 7.15 ON SCALE "A" TO 9.65 ON SCALE "B". IT'S INTERSECTION WITH SCALE "C", GIVES THE SPHERICAL EXCESS, 0.45 SECONDS.
NOMOGRAM
FOR OBTAINING
SPHERICAL EXCESS
IN TRIANGLES
DEVISED BY C. I. ASLAKSON
C.&G.S. 457

(III) C. I. Aslakson

The first formula given by Lieutenant Heaton, or e = 2/3 Alt. x base, is probably most commonly used, is convenient, and gives good results for field use. However, the same elements, altitude and base, as used in the nomogram, must be scaled. It is, therefore, convenient to place the scale of miles on the edge of a straightedge, scale the altitude and base, and transfer the straightedge directly to the graph to read the spherical excess.

A graph of this type is often a convenience when a large number of readings are needed and there are two variables. Anyone who has used a graph which calls for "reading across to scale A, down to scale B, and over to scale C, etc." usually prefers to make a simple mathematical calculation. Graphs can often be simplified by using logarithmic scales. Reading from such a graph is slightly simpler than using a slide rule.

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North Carolina State Highway Commission
Raleigh, N. C.

August 25, 1952.

Major Wm. Bowie, Chief,
Division of Geodesy,
U. S. Coast and Geodetic Survey,
Washington, D. C.

Dear Major:

I received, yesterday, the June Bulletin of the Association of Field Engineers of the U.S.C. & G.S., and wish to express my appreciation for the space which you devoted to my paper on Control Surveys.

I also was greatly impressed with the article on "By-products of the Chowan River Surveys", page 90. I think the decision of the U.S.C. & G.S. to spend a little more money on this survey so as to make it accurate, permanent, and an integral part of our state net was most commendable. It is just one more demonstration of the almost uncanny foresight of your Bureau, and it shows that you practice what you preach. You have made of this survey a thing of value for all time to come - useful in a hundred different ways. This article ought to be published in Civil Engineering to demonstrate the by-product value of controlled surveys.

I am pleased to note that you are nominated (and therefore elected) as a member of the Executive Committee of our A.S.C.E. Division, and I sincerely hope you will continue as Chairman of the Committee - for without your able guidance the Division could scarcely function.

With kind personal regards, I am

Cordially yours,
(Sgd.) Geo. F. Syme
Senior Highway Engineer

SECOND INTERNATIONAL POLAR YEAR PROGRAM

E. W. Eickelberg, H. & G. Engineer, U.S.C. & G. Survey

The first polar year program was held fifty years ago in 1882-1883. Our present knowledge of magnetic variation in the Arctic is based largely on the observations of this first expedition, which was determined upon by International Polar Conferences at Hamburg, Berne and St. Petersburg, acting on the suggestion of an Austrian naval officer and Arctic explorer, Lieut. Karl Weyprecht. Its purpose was to improve our knowledge of Arctic meteorology and magnetism and to study their effect on and their relation with other regions of the earth. Twelve countries took part, occupying 14 stations, two of which were in the Antarctic.

Our own country occupied stations at Pt. Barrow, Alaska, and Fort Conger (named after Senator Omar D. Conger) Lady Franklin Bay, Grinnell Land. The Fort Conger station under command of Lieut, (now Maj. Gen.) A. W. Greely, Signal Corps, U. S. Army, was the farthest north of all the Arctic expeditions. Much exploratory work was carried out in addition to the observations in meteorology, astronomy, gravity, tides and magnetism. The Coast and Geodetic Survey instructed the observers and reduced the results of observations in gravity, tides and magnetism.

A brief account of the Greely expedition is given here to encourage field officers who have not done so to read the account of this expedition because of the many examples of resourcefulness in overcoming almost impossible situations. It is taken from volume 1 of Lieut. Greely's report on 'International Polar Expedition, U. S. Expedition to Lady Franklin Bay and Grinnell Land.' The book is obtainable from the Coast and Geodetic Survey library and probably from city libraries.

The account of the expedition is a wonderful record of accomplishment under most trying circumstances. The party of twenty-five was landed on August 14, 1881, and immediately proceeded on its program of observations. By the first of September the harbor was frozen over. At the end of the first year preparations were made to leave upon the arrival of the expected relief ship. Not disheartened by the failure of the relief vessel to appear, the party prepared to spend another year and continued their work of exploration, collection of specimens and scientific observations. The conditions under which this work was carried on can be better realized by an examination of the average monthly temperatures over the period of two years. The monthly averages range from 37.2° Fahrenheit to -46.5° Fahrenheit. There were only six months when the temperature averaged above freezing, and then only slightly.

At the end of the second year of isolation, the relief ship failing to make an appearance, the party abandoned their station and on August 9 set forth in a steam launch and three smaller craft. After fifty days afloat and adrift on ice, during which time the launch and one whaleboat were abandoned, the party finally reached shore September 29 about 200 miles to the southward of their station. The party of twenty-five made camp at Cape Sabine after a reconnaissance which disclosed the sinking of their relief vessel on July 29. They had hoped to be able to cross Smith Sound to Greenland when ice conditions permitted. This condition never materialized, and the party gradually diminished in numbers, due principally to starvation, until at the time of their rescue on June 22, 1884, only seven were found alive in pathetic condition, helplessly trapped under their storm collapsed tent without sufficient strength to free themselves. Their last food, taken forty hours previously, consisted of oil tanned sealskin and lichens.

It is almost unbelievable that human beings could survive the conditions of squalor, misery, and starvation which are described by Lieut. Greely and others of his party in the report on this expedition. Through all these vicissitudes their scientific records and collections of specimens were preserved intact and delivered in safety to the rescue party.

The second international polar year program is now in progress, fifty years after the first polar year program. It is a cooperative effort on the part of thirty-three nations, occupying seventy-five stations all over the world. Twenty-five of these stations are in the Arctic regions, while the others are permanent observatories at which special observations will be made in cooperation with the polar year program. Simultaneous observations of meteorology, terrestrial magnetism, atmospheric electricity, earth-currents, aurora, and Kennelly-Heaviside layer are being made, all according to a prearranged schedule and, wherever possible, with uniform type of equipment.

Included among these numerous stations are several high altitude (mountain) stations, and at many other stations meteorological observations are obtained at high altitudes by sending up radio-sondes, which automatically send radio messages of the readings of temperature and pressure as they ascend. These are received at the base stations and recorded. The instruments are equipped with parachutes to make safe landing and recovery more probable after the hydrogen balloon bursts.

The U. S. Station, known as the College-Fairbanks Polar Year Station, is being operated jointly by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism, the Naval Research Laboratory, the Alaska Agricultural Gollege and School of Mines, the Signal Corps of the Army, and the Coast and Geodetic Survey. This is a typical polar year station and the observational program covers the following:

1. <u>MAGNETIC OBSERVATIONS</u>

(A) Three sets of magnetic variometers each furnishing continuous photographic recording of declination, horizontal intensity and vertical intensity. The ordinary magnetic observatory has but one set of these instruments, but in order to obtain a complete record in the polar regions where the magnetic elements are greatly disturbed, two variometers of different sensitivity are provided and a third variometer, of normal sensitivity but with a rapid moving recorder, is provided to give an open time scale. The latter furnishes a record by which the time of sudden magnetic changes can be accurately scaled and time intervals of short period changes can be measured. It, however, loses the accuracy in the quantitative measurements for which the slow recorders are provided. The records of these self-recording instruments are supplemented by absolute magnetic observations taken twice weekly, with an earth inductor for the determination of dip and with a magnetometer for declination and horizontal intensity. These absolute values control the values of the datum or base lines of the recording instruments.

(B) Mitchell Loop Vertical Intensity Apparatus - This apparatus measures the voltages induced in a loop of wire by the changes in the vertical intensity of the earth's magnetism. The wire-loop encloses an area of approximately 180 acres and is insulated from the earth. The terminals of the loop are connected to a sensitive galvanometer and photographic records are made by a light beam reflected from a mirror on the moving coil of the galvanometer. The day's record is photographed on a roll of paper approximately 3-1/4 inches wide by 50 feet long, thus furnishing an open time scale from which the periods and times of fluctuations can be accurately determined.

2. EARTH-CURRENTS AND ATMOSPHERIC ELECTRICITY

Since electricity and magnetism are known to be closely related, it is necessary in any study of the earth's magnetism to include the study of the electrical condition of the atmosphere and the natural electrical currents within the earth.

As early as 1847 it was found that at times serious interference with telegraph messages and sometimes damage to instruments were caused by earth-currents, since for the sake of economy of wire the telegraph circuits are made to use a ground return. The Carnegie Institution of Washington, through its Department of Terrestrial Magnetism, has pioneered in this field in this country and has developed the necessary self-recording instruments.

(A) Earth-Current Observations - The earth-current installation at College consists of galvanometric recording of the potential differences of pairs of lead electrodes buried in the ground one mile apart, one pair in the north-south and the other in the east-west direction; thus the true directions of the currents flowing in the earth's surface can be determined. This continuous photographic record is controlled by daily calibration observations.

(B) Atmospheric Electric Observations-

a. Continuous recording of the potential gradient near the surface of the earth. It is a measure of potential difference between the earth and a point in the air. A small steady current flows from the air to the earth, varying with location, season, hour of the day and with weather conditions.

b. Electrical conductivity of the atmosphere. The conductivity of the air is measured by noting the rate of potential drop of an electrically charged cylinder concentrically surrounded by a relatively large earthed tube through which a current of air is forced.

The conductivity of the atmosphere has an annual and a diurnal variation. It varies also with the amount of dust or fog present, being larger when the air is clean and dry.

In addition to continuous records of conductivity, potential gradient and earth-currents, an Aitken nuclei count and an ion count are made daily.

3. AURORAL WORK

Working under a grant from the Rockefeller Foundation and in cooperation with the Carnegie Institution of Washington, the Alaska Agricultural College and School of Mines is making various auroral observations. The principal work consists in making simulteneous photographs of the aurora from two camera stations about 14 miles apart, this distance being accurately determined by triangulation. Cameras are of special type and for simultaneous exposures communication is done by means of radio. By having a common background of stars in the photograph's of the aurora the parallax can be measured and the elevation determined. Other data are obtained and recorded every half hour throughout the night, such as forms of the aurora, duration of the display, intensity, approximate area of sky covered, weather conditions, etc.

4. RADIO OBSERVATIONS

These observations consist of continuous registration of the height of the Kennelly-Heaviside layer or the radio ceiling and of the magnetic and auroral effects on radio transmission and reception. This work is being carried on at Fairbanks cooperatively by the Naval Research Laboratory, the Carnegie Institution of Washington, through its Department of Terrestrial Magnetism, the Coast and Geodetic Survey, and the Signal Corps of the Army. This station is carrying on auroral work in connection with the Pt. Barrow meteorological and magnetic station and auroral spectroscope work is also included at Fairbanks.

The Pt. Barrow magnetic station of 1882-1883 is being reoccupied this year through cooperative efforts on the part of the U. S. Weather Bureau, the Signal Corps of the Army, the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the International Polar Year Commission.

The T. S. Weather Bureau is making special meteorological observations at its numerous stations. This, of course, is one of the major divisions of the polar year program.

The Coast and Geodetic Survey, in cooperation with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the Mountain States Telephone and Telegraph Company, is making observations of earth-currents at the Tucson Magnetic Observatory, the telephone company providing two long distance telephone lines for that purpose. The American Telephone and Telegraph Company is making similar observations, independently, at New York City, Hamilton, Maine, and Wyanet, Illinois. Some work is also being done by individuals at their own expense and funds for some of the polar year work were donated by an interested benefactor.

From all the results obtained from these observations it is hoped that a well organized attack can be made on the many problems still to be solved in the fields of meteorology, terrestrial magnetism and electricity, communication disturbances, and to further our knowledge in weather conditions over possible arctic routes of air travel.

The following poem was copied from the "Farthest North Collegian," student publication of the Alaska Agricultural College and School of Mines, located at College, Alaska, the site of the Polar Year Magnetic Station. In it Mr. Linn very ably gives his impressions gained while attending the "open house held for the benefit of the local community to inspect the polar year work and equipment.

The Polar Year

The fellows in the Polar Year
Had open house one day;
I went to see their things and hear
Just what they'd have to say.

They had three sheds wrapped up in wool
And built with copper nails
(Since iron has magnetic pull
And queers the fine details).

They had some pillars of concrete
Sunk ten feet in the ground
To give the instruments a seat
That wouldn't move around.

I went into the littlest shed--
(The line that boy did shoot!)
Potential magnets there, he said,
Are measured absolute.

Then at the second shed I tried
(I don't remember which)
It took six doors to get inside
Where it was dark as pitch.

About a dozen instruments
Presenting quite a site
Made magnetistic measurements
Upon a beam of light,

While fifty prisms and a half
All made it jiggle some,
And then they got its photograph
With paper on a drum.

One building more I went to see,
And I was getting good;--
There was no visitor but me
That really understood.

They had a little fan to blow
The air into a coop.
They had a funny radio
Hooked on a Mitchell Loop.

They measured ions in the air
And currents in the earth
And differential radiance there
For all that they were worth.

I don't know what they're looking for,
These scientific men,
But hope they find it all before
They go back home again.

—Phil Linn.

PERSONNEL OF U. S. POLAR YEAR EXPEDITIONS, 1932-1933.

Pt. Barrow, Alaska
C. J. McGregor, U. S. Weather Bureau

College-Fairbanks Polar Year Station at College-Fairbanks, Alaska
Dr. C. E. Bunnell, President, Alaska Agricultural College and School of Mines.

V. R. Fuller, Professor of Physics, Alaska Agricultural College and School of Mines. In charge of aurora observations,
W. W. Walton, Aurora Observer.
Everett R. Johnson, Magnetic Observer, U.S. Coast & Geodetic Survey
Harold F. Bennett, Magnetic Observer, U.S. Coast & Geodetic Survey
W. W. Spencer, Student Observer, U.S. Coast & Geodetic Survey
Kenneth L. Sherman, Physicist, Carnegie Institution of Washington
Dr. H. K. Maris, Physicist, U.S. Naval Research Laboratory
C. E. Johnson, First-class Radio Man, U. S. Navy
C. Marcus, Electrical and Radio Engineer, U.S. Signal Corps
H. J. Thompson, Meteorologist, U. S. leather Bureau
R. L. Frost, Asst. Meteorologist, U. S. Weather Bureau
Frank Pollack, Air Pilot, Special Flights, U. S. Weather Bureau

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RECOVERY OF AN IMPORTANT TRIANGULATION STATION

(Extract from a letter of C. D. Meaney engaged in observing the new Atlantic Coast first-order arc of triangulation)

In accordance with a telegram from the Director, a station was established near the old station Joscelyne. The position of this station was computed; then an inverse solution to determine the distance and direction from Joscelyne to Joscelyne 2 (1932) was computed. Mr. Wardwell and one man were sent to recover the old station at Joscelyne and obtain a distance and direction from Joscelyne 2 (1932).

After digging a hole about two and one-half feet in diameter they recovered the old station. The recovery of this station is a practical example of the accuracy obtained in triangulation. The owner of the property was very much excited about finding the station. In order to allow digging on his property he demanded damages of $2.00. However, when the mark was recovered, he withdrew his demand. A "darkey" standing nearby remarked, "You men ought to get a premium."

* * * * * * * * * * *

(Extract from a letter from R. D. Horne in charge of observing first-order James River arc of triangulation)

We are tying-in to some of the city of Richmond triangulation just now and several nights we have been unable to make six ampere bulbs show through the smoke for even the comparatively short lines that we were observing over. The cold air seems to hold smoke down like a blanket. To-day has warmed up and a light northwest air has cleared the air wonderfully. I expect that summertime is the best time for city triangulation. Last summer we were in a very populous district, coming from Long Island across Brooklyn and Jersey City and had very little trouble with smoke.

NOTES FOR THE IMPROVEMENT OF LISTS OF GEOGRAPHICAL POSITIONS AND FOR SUBMITTING PROGRESS SKETCHES

(The following notes relating to geographical positions are taken from regulations recently issued to the mathematicians of the Division of Geodesy. They should be helpful to all field parties submitting triangulation data. Almost daily our parties and outside engineers are furnished triangulation data in the shape of photostatic copies of unadjusted field computations. For this reason, particularly, field parties should not feel that, since their triangulation is subsequently to be adjusted, their computations need not be carefully checked or neatly and uniformly submitted. On the other hand, they should endeavor, in so far as possible, to make their field computations comply with the requirements of the Division of Geodesy for adjusted work.) Ed.

In order that the manuscript forms of the lists of geographic positions may be used directly as originals for photostatic copies to be furnished engineers and others requesting the data, and in order that time shall be saved in revising these lists for publication, it is necessary that certain rules shall be followed in preparing the lists.

Computers and mathematicians should read carefully Chapter 7 of Special Publication No. 138.

Nothing is gained in an attempt to save time if the time saved must all be spent later in revision. Lack of neatness and carelessness are a reflection on the mathematician doing the work.

Eternal ink should be used for making out all lists of geographic positions and the names and figures should be written carefully and legibly. The names of the stations should be followed by the dates of establishment and the dates of recovery and by the abbreviations d. for described, m. for marked, n.d. for not described, etc. The state in which each station is located should also be indicated if all the stations on the page are not in the same state. The locality, datum, and state (or states) should always be inserted at the top of each page in the blanks provided. It should be remembered that the lists of geographic positions form the final record of the triangulation computations, that photostatic copies are frequently made in answer to requests for information and to send to the printer when the triangulation is published, and that too great care can not be taken in making them neat and legible.

The mathematician making out a list of geographic positions and the one checking it should inspect the position computation to see that the latitudes and longitudes agree on the two sides of the computation, and that the azimuth to one station plus the first angle of the triangle equals the azimuth to the other station. The angles of a "no check" triangle should be checked from the lists of directions as well as the logarithms of triangle sides which appear in only one triangle. The list should also be carefully scanned for errors that may easily be discovered by inspection, such as mistakes in the degrees and minutes of the positions, back azimuths which do not differ by approximately 180° from the forward azimuths, the number of figures in a length which do not correspond to the characteristic of the logarithm, etc.

In listing names of triangulation stations, especially those of various objects used as intersection points, the following method should be used: Write first the name of the town or locality, next the name of the building or other object, and then the point observed upon; for example,

O'Fallan, municipal water tank, finial. (Mo.)

Names of common objects should not be capitalized. The words "church", "river", etc., should not be capitalized unless accompanied by their distinguishing names.

Make sure that the names in the azimuth column correspond to the names in the first column.

Decimal points should be placed so that they will not be overlooked. More space should be allowed between the digit of the unit's place and the digit of the tenth's place in a number. In other words, give the decimal point some room also, so that a digit will not be written over it obscuring the decimal point altogether. A zero should be written in front of a decimal point in any number less than unity.

Check marks should not be bold nor made over a figure. One figure is often mistaken for another on the photostatic copies because of check marks made too boldly and made over or too close to the figures. It is suggested that for check marks colors of short wave length, such as green and blue, be used so that they will not show too plainly on the photostatic copy. The colors of long wave length, such as yellow and red, show too plainly on the photostat.

When checking a list of positions, corrections should be made lightly in pencil, then the list should be returned to the one who originally made it out. After he has agreed to the change, the incorrect value should be erased and the correct value put in its place in ink. Crossing out the incorrect value and writing the correct value above it crowds the figures so that they can not be easily read on the photostat. In addition, such practice gives an impression of slovenliness.

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PROGRESS SKETCHES

As related to the above Regulations, the suggestion is made, in order to simplify office procedure, that field parties submit their season's progress sketches in advance of their season's report and triangulation computations, and that they request such blue-prints as will enable them to transmit copies of all of them as a part of the season's report and, in addition, a copy of the triangulation sketch with the computations.

In the case of the season's report, unless this is done, the blue-prints have to be bound into the report at some later date, perhaps after it has been routed through the divisions in an incomplete form. In the case of the triangulation sketch, if a blue-print of it accompanies the computations, the work of the mathematician in charge of the files is somewhat simplified.

Several parties are now following the procedure outlined, resulting in an appreciable saving of time as well as more systematic routing and filing of reports and records.

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GEODETIC DIPLOMACY

(From Empire Survey Review, October, 1932)

An Ordnance Survey triangulation party composed of a sergeant and sapper, out on a small job the other day, managed to extricate themselves from a tight corner rather neatly. Now, it is the usual custom of the Ordnance Survey to obtain permission from the farmer or occupier of land before starting digging or other operations upon it; cut, as this takes up much time, there is a tendency on small jobs to "chance it." On this occasion the party "chanced it." The digging was proceeding merrily when the farmer appeared on the horizon in the devil of a temper. The sergeant, however, had got wind of the wrath to come. When the farmer was within earshot, the sergeant's supposititious feelings found vent, volubly frequent and painfully free, more or less in the following language: "I wish the blankety fools who sent me on this blankety job were in blank; fancy the blighters expecting me to find a blankety brick that was blankety well planted here about the time of the blankety Flood!" This inflammatory soliloquy somewhat took the wind out of the old man's sails. Not only did it succeed in turning away wrath, but it even created a sympathy so keen that he forthwith peeled off his coat and gave the party a hand with the digging. He actually managed to find the brick himself and was so elated with his success that he invited them over to the farmhouse for a mug of ale.

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FROM THE HYDROGRAPHER, U. S. HYDROGRAPHIC OFFICE

In connection with U. S. Naval surveys in Central American waters, it is desired to consider the application of radio acoustic ranging for locating ship's position while taking soundings and other oceanographic observations.

In view of the development and successful use of the radio acoustic ranging method of location by the Coast and Geodetic Survey, it is requested that this office be furnished with such information as may be available regarding the necessary equipment including specifications and approximate cost.

Detailed information as to the best procedure in the use of the equipment as derived from the experience of the Coast Survey will also be appreciated.

NOTES ON BUBBLE SEXTANTS AND GYRO-HORIZONS

(The following notes are from a letter received by Captain Rude from Professor H. N. Russell of Princeton University.)

The extremely interesting papers on the Georges Bank Survey, which you so kindly sent me, have reached me here on my vacation. I have read them with very lively enjoyment and I wish to express my very hearty thanks for them. I am greatly impressed by the Bulletin of the Association of Field Engineers of the U.S.C. & G.S. You may all be justly proud of it as an expression both of the admirable work of your Service and of its equally admirable spirit.

The Georges Bank survey is of such great scientific interest that I hope that it may be possible in the future to extend it across the Gulf of Maine to the Maine coast.

May I make a few remarks about bubble sextants (suggested by those on page 17 of the Bulletin for June, 1931). I had a great deal of experience with these while developing the navigation of airplanes in 1918-19. The late Professor Willson of Harvard designed a bubble sextant which, for an observer on a steady base, gave an average error of about 1.5 minutes for a single altitude. It was perfectly easy to operate. By using a smaller bubble, I believe that the accuracy could be improved.

In an airplane the average error is increased to 10 minutes or more, due to the lateral accelerations which occur even with the best piloting. At sea I found that the roll of the ship introduced errors of a degree or more even in fairly smooth weather. (This was on the Cunard S.S. Carmania, 20,000 tons). To get rid of this error, which arises from the horizontal accelerations, the observer should be as near the metacenter, about which the roll takes place, as he can get and still see the sky. The bridge is the worst place. In consequence, I am rather skeptical of the *French gyro-horizon, which gives an error of 2 minutes regardless of sea and roll. To do this one must have a very long, free period of oscillation - several times that of the ship's motion - and I do not see how such an instrument will work well if held in the hand.

An English Naval officer, in discussing a little paper of mine on this matter, once said that their solution was to order another ship in a convoy with him below the sun, measure down to her water-line, take her distance with a range finder and then calculate the dip. But this would be useless in foggy weather.

If a gyroscopic pendulum mounted in gimbals and properly damped could be constructed so as to have a period of three or four minutes and to carry a plane mirror horizontally at its top, the problem might be solved. Such an instrument would be heavy but might be permanently mounted above the chart-house of a liner or on a survey ship and used as an artificial horizon

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*Bulletin, Association of Field Engineers, June, 1931, page 17.

FATHOMETER OPERATION IN SHOAL WATER

R. P. Eyman, H. & G. Engineer, U.S.C. & G. Survey

During the season of 1932 the PATHFINDER was engaged on what proved to be a very interesting piece of work along the north coast of Luzon, P.I., as regards the operation of the fathometer in shoal water areas.

A large area of comparatively shoal water (9 to 20 fathoms) extends along the north coast from Aparri eastward toward Port San Vicente throughout which the slope is extremely gentle. The bottom, "level as a floor", is composed of fine, gray sand. This area is about 25 miles long in an east and west direction and about 6 miles wide. Three hydrographic sheets, scale 1:20,000, were required to show the survey.

It was soon found that, with the close spacing of sounding lines required to develop the area, a large number of hand lead soundings would be necessary before reaching the 15-fathom curve where the fathometer (electric oscillator type) could be used satisfactorily. In order to check the operation of the fathometer in shoal water and, if possible, to speed up operations in the vicinity of the 15-fathom limits, a large number of direct fathometer readings were recorded simultaneously with the hand lead depths. These comparisons were started in depths of 9 to 10 fathoms and continued in the later work to from 18 to 20 fathoms.

After studying the results of several days' comparisons, it appeared that with only a small correction applied to the fathometer readings, this instrument could be depended on to give reliable results throughout this limited depth range (9 to 20 fathoms). Consequently, the sounding operations were materially speeded up when a depth of 13 to 15 fathoms was reached by running alternate lines with the fathometer and the intermediate lines with the hand lead (with direct fathometer comparisons) . It may be said here that the area of 13 to 15 fathoms comprised more than one-third of the total area.

Sounding operations will be seen to be thus divided as follows:

9-13 fathoms, hand lead (with fathometer comparisons)
13-15 fathoms, alternate hand lead (with comparisons) and fathometer
15-20 fathoms, fathometer (with numerous direct comparisons)

The interesting feature of this work is the remarkable reliability of the fathometer readings as shown in the following tables of comparisons and analyses. A total of 1,768 comparisons were made giving a mean correction of -0.6 fathom to be applied to the fathometer reading and with 70 per cent of all comparisons within one-half fathom of the mean and 89 per cent within three-fourths fathom.

Table 1 shows the number of comparisons on the various sheets, the percentage of comparisons to various corrections, and mean corrections for each sheet and for total area. Sheet No. 1 shows the largest number of comparisons due to the fact that a comprehensive study of comparisons was desirable to ascertain within what limits the fathometer could be expected to operate with satisfactory results while comparisons on the other two sheets were made only in sufficient number to give indications of the continued reliability of the instrument and/or any changes in its operation.

Table 2 gives an analysis of these comparisons showing variations at 0.1 fathom intervals from the mean correction in percentages for the total number of comparisons and cumulative percentages for all comparisons within the same intervals.

TABLE I
Fathometer Comparisons
in 0.1 fathom Group Intervals
Percentages in each Group

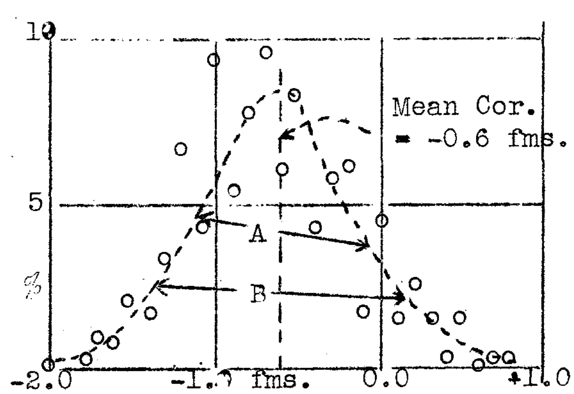
V.C. Fath. fms.	No. comparisons on hydro. sheets: #1	#2	#3	Total	Percent of total
-2.0	2		1	3	0.2
-1.9					
-1.8	6	2		8	0.4
-1.7	13	5		18	1.0
-1.6	8	7		15	0.9
-1.5	15	18	2	35	2.0
-1.4	28	2		30	1.7
-1.3	47	17		64	3.6
-1.2	59	61	1	121	6.9
-1.1	54	22		76	4.3
-1.0	102	63	3	168	9.5
-0.9	75	21	1	97	5.5
-0.8	93	37	9	139	7.9
-0.7	94	58	19	171	9.7
-0.6	77	27	4	108	6.1
-0.5	102	36	11	149	8.4
-0.4	63	14	4	81	4.6
-0.3	74	24	7	105	5.9
-0.2	78	20	14	112	6.3
-0.1	21	5	6	32	1.8
0.0	44	28	10	82	4.6
+0.1	24	5		29	1.6
+0.2	23	20	4	47	2.7
+0.3	11	13	2	26	1.5
+0.4	2	5	1	8	0.4
+0.5	12	10	4	26	1.5
+0.6	2	1		3	0.2
+0.7	1	4	2	7	0.4
+0.8	3	2	3	8	0.4
Total	1133	527	108	1768	100
Mean cor. fms.	-0.7	-0.7	-0.4	-0.65	

TABLE II
Analysis of Comparisons in
Percentages from Mean Correction
(Mean correction = -0.6 fm.)

Var. from the mean (-0.6 fm.) fms.	Percent within interval from mean	Cumulative percent in interval from mean
0.0	6.1	6.1
± 0.1	18.1	24.2
0.2	12.5	36.7
0.3	11.4	48.1
0.4	15.8	63.9
0.5	6.1	70.0
0.6	11.5	81.5
0.7	5.2	86.7
0.8	4.4	91.1
0.9	3.5	94.6
1.0	1.3	95.9
1.1	2.5	98.4
1.2	0.6	99.0
1.3	0.4	99.4
± 1.4	0.6	100.0

Correction Probability Curve

A = % of cor. within $\frac{1}{2}$ fm.
B = % " " " $\frac{1}{4}$ "



ECHO SOUNDING
The Graphic Recorder

G. T. Rude and K. T. Adams, H. & G. Engineers,
U. S. Coast and Geodetic Survey.

If the average man were asked along what lines the most progress had been made during the current depression he would probably be at a loss for an answer or would perhaps say that there had been no progress. However, if a scientist, engineer, or one closely connected with the scientific world, were asked the same question he would unhesitatingly reply that the most progress had been made in scientific research.

The Graphic Recorder, as developed in this country, has emerged from the depression and the Submarine Signal Company, in addition to this instrument, has perfected certain improvements and innovations connected with the Fathometer in which the members of the Field Association should be extremely interested. And this is especially so inasmuch as the installation of one of these instruments on the Ship OCEANOGRAPHER has been approved for the near future and may quite probably be in progress by the time this article appears in print. In our enthusiasm, we venture to predict that efficient and economical operation will be advanced by the installation of these new instruments on many of our other vessels.

In order to bring readers historically up to date in regard to the developments of echo sounding as used by the Coast and Geodetic Survey, a short review of the different types of Fathometers with their outstanding characteristics seems advisable.

The first Fathometer used by this Bureau was installed on the Ship LYDONIA late in 1925 and was the type 312. Since that date type 312 or some modification thereof has been installed on a large percentage of our ships and is at present a part of the equipment of the following: SURVEYOR, DISCOVERER, PATHFINDER, PIONEER, GUIDE, FATHOMER, LYDONIA* and OCEANOGRAPHER*.

Fathometers of type 312 originally contained a mechanical relay, which everyone except the most junior officers will well remember on account of the difficulty of keeping this relay in adjustment. We believe there are no mechanical relays now in use on our ships, all circuits having been changed so that relays are unnecessary. The outstanding characteristics of type 312 are the use of a tuned oscillator for all depths and the graduation of the dial from zero to 100 fathoms for the visual red light method and from zero to 600, and multiples thereof, for the aural white light method.

The next radically different type is number 412, the prominent features of which are the use of a small striker and a dial graduated from zero to 130 fathoms for the visual red light method. There is no aural white light method and this type is therefore restricted to lesser depths

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*It will be noted that these vessels each have two Fathometers, types 312 and 412.

in which the echo is loud enough to actuate the fast red light. Type 412 is now a part of the equipment of the following ships: GILBERT, WESTDAHL, NATOMA, OCEANOGRAPHER, and LYDONIA. The first three are ships of a smaller size which are not expected to sound offshore and the latter two are equipped with two Fathometers.

The most recent type of Fathometer is number 515 which is really two instruments in one. The principal features of this type are the use of a large striker and a separate amplifier for the visual red light method, with the dial graduated from zero to 125 fathoms; and in addition the use of an oscillator with separate amplifier for the aural white light method, with a dial graduated from zero to 500 fathoms and multiples thereof. At this date the HYDROGRAPHER is the only ship having type 515 as a part of her equipment.

Type 480 Fathometer is similar to type 515 except that it is limited to visual red light soundings at fast speed and that the dial is graduated from zero to 130 fathoms instead of from zero to 125 fathoms as is the case in type 515. It uses a striker and has no aural white light method of sounding. In type 480 the signal is emitted once each two and a half seconds and thus 24 soundings a minute are obtained. This particular type of Fathometer is not installed on any of our ships.

The Graphic Recorder type 505 is an attachment which automatically makes a graphic record of the depths obtained by the red light and which can be used with Fathometers types 515, 480, and 431; as it is now constructed it can be used with these three types only and for recording soundings obtained by the fast red light only. Mechanical difficulties which will be discussed later in this article preclude any other use without further development. Recently between Boston, Massachusetts, and Yarmouth, Nova Scotia, the authors inspected the operation of the Graphic Recorder #505, in use on type 480 Fathometer with an amplifier of type 484. All description of operation must therefore be understood to apply to these instruments unless mention is made of some other type.

The graphic record is made on a red paper coated with thin white wax similar to that used with the latest portable automatic tide gauges. This paper is in long rolls about seven inches wide and carries an overprint scale indicating the depth by vertical lines at five fathom intervals and the time by arcs at five minute intervals. The paper is led vertically across the face of the instrument; it is fed at a speed of one inch in ten minutes, and since 24 soundings a minute are obtained, there are 240 recorded soundings per inch or enough to make a solid graph. The vertical lines indicating five fathom intervals of depth are slightly more than l/4-inch apart, which makes each fathom of depth represented by a linear distance on the graph of slightly less than l/16-inch.

From our observation it is possible to estimate visually, at the time of sounding, depths to the nearest half fathom and time to the nearest half minute and it is probable that, after the record is removed from the instrument, depths to the nearest 1/4 fathom and time to the nearest l/4 minute can be readily obtained by using a suitable transparent scale.

The recording stylus is carried on a revolving arm which is mechanically coupled to the motor of the Fathometer and must revolve at the same relative speed at which the disc is revolving. This arm carries a magnet element which holds the stylus away from the paper at all times except when actuated by an impulse in the amplifier; this impulse causes the stylus to drop on the paper momentarily. Of course where it touches the paper it removes the wax, making a short mark, the beginning of which is the record of the sounding.

The magnet element in the revolving arm is actuated by the same circuit which causes the neon tube to light and in very much the same manner. It is incorrect to visualize the neon tube as operating the recorder, the fact being that the circuit operates both the neon tube and the magnet element at the same time. No doubt need be felt about obtaining a complete record of the red light soundings for, as a matter of fact, the graphic record can be made on a slightly weaker signal than that necessary to light the neon tube.

In comparing Fathometer type 480 and the Graphic Recorder with the Echometre* which was inspected by one of us about a year ago, we judge that in depths of less than 130 fathoms there is not much difference in operation. It is true that the graphic record of the Echometre is not limited as to depth but that limitation of the present Graphic Recorder appears comparatively easily overcome. The advantage of the Echometre lies in the ultra-sonic feature and the fact that exterior noises will not cause strays. Our inspection of the Graphic Recorder showed practically no strays within the limits of the depths reached, but there are possibilities of strays when sounding greater depths or when on a ship on which there is more noise.

In operation the present instrument is so simple there is little explanation possible. There are no adjustments to be made. There is a start and stop switch button and there are no rheostats. Once properly adjusted the instrument needs no attention and graphically records a profile of the ocean floor. On the return trip from Yarmouth, which was a night run of about thirteen hours, we watched the instrument until about midnight when we turned in leaving the Fathometer in operation. In the morning an examination of the record showed a practically perfect graph, all depths from 5 to 130 fathoms being recorded without one sounding missed, and without strays, although at times the depths increased and decreased rapidly owing to the extreme irregularity of the bottom of the Gulf of Maine.

The graphic records made on our trip and other records which we have examined show practically no strays. What a relief this is, only officers who have had long experience with the older types of instruments can appreciate. However, this is probably to be credited to the striker and a good installation and can not be considered a feature of the Graphic Recorder, which must and does record whenever the neon tube flashes.

* For description, operation and record see Field Engineers' Bulletin #4, December, 1931, page 81.

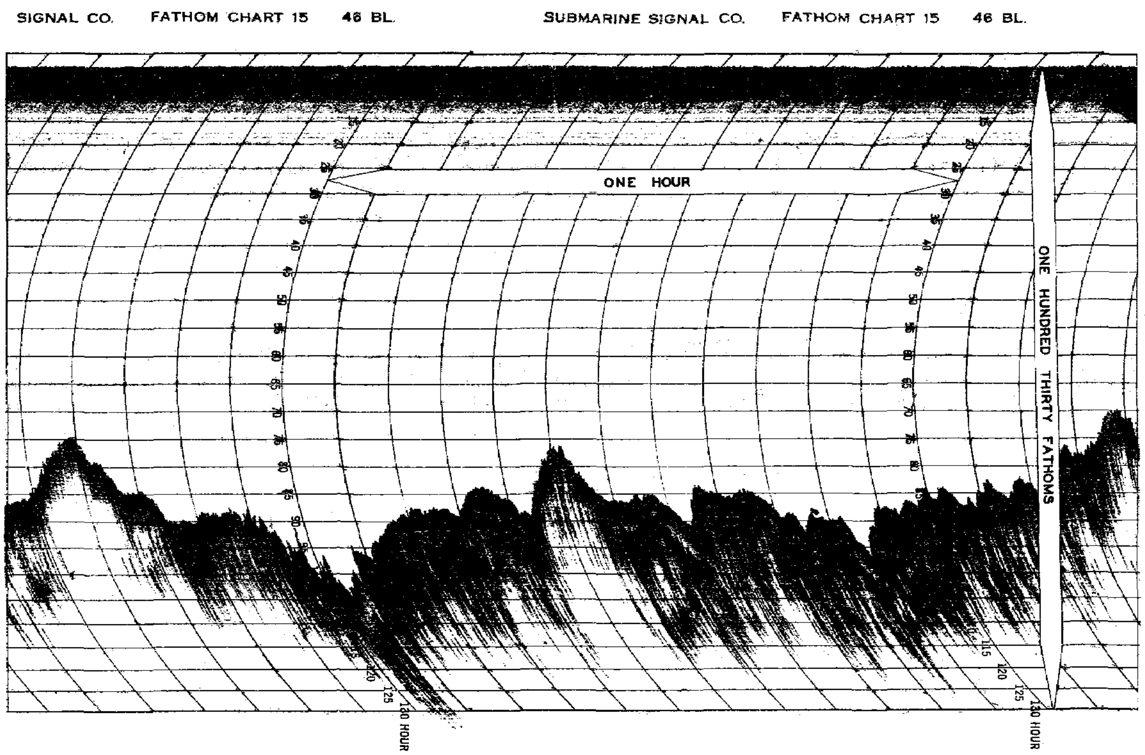
The record made on the S. S. YARMOUTH (see accompanying plate) shows the outgoing signal as well as the depth as indicated by the return echo. This feature would be very valuable to us, as it would always give the depth as indicated by the interval between the two signals, and would eliminate uncertainties due to the gradual changing of the time of the outgoing signal which in some installations has given trouble. We are informed, however, that it is not always possible to show both outgoing signal and the return echo when using the automatic sensitivity control, this depending somewhat on the amount of shielding possible in installation.

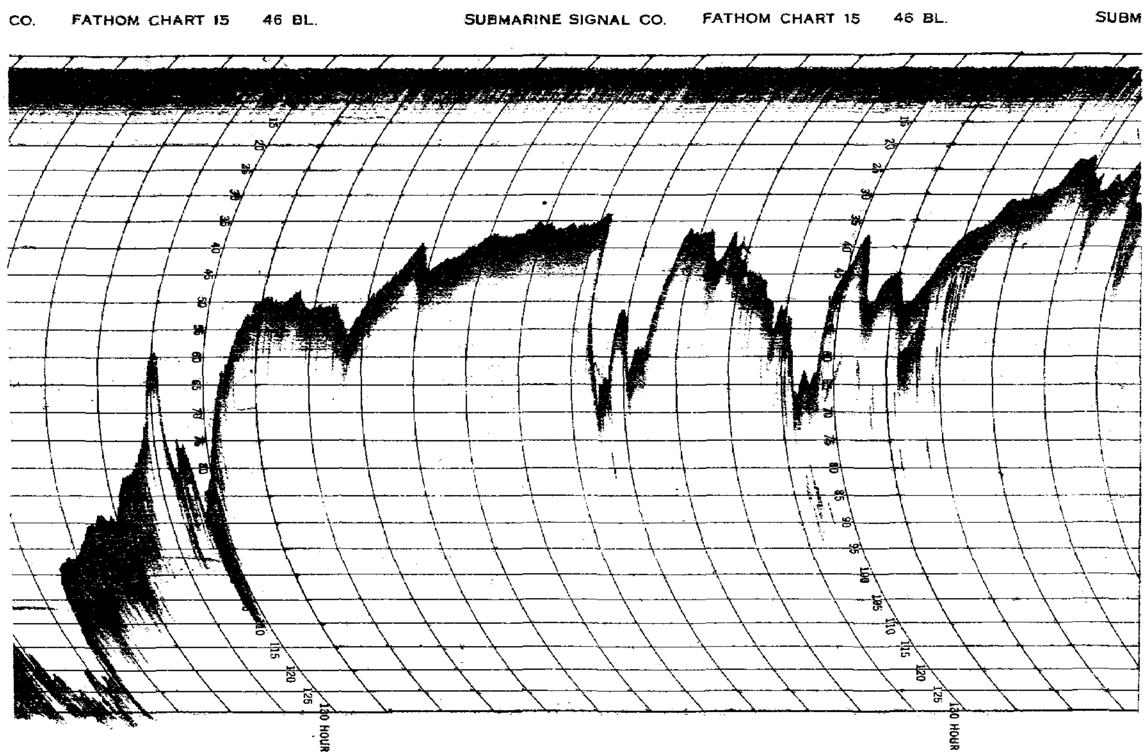
The automatic sensitivity control is not standard equipment on any type Fathometer at the present time. It, however, was in use on the instrument inspected and its performance was practically perfect. It is so much better than a manually operated rheostat that we recommend that it be specified as a part of any Fathometer which is obtained by this Bureau in the future. A manually operated rheostat can be installed for use in case of possible failure of the automatic control. The automatic control varies the sensitivity to just the exact value needed to actuate the red light, no more nor less, and is certainly more perfect than any manual adjustment can be. This perfection of adjustment eliminates strays almost entirely so long as the received echo is above the noise level, and it also eliminates the necessity of any attention on the part of the operator.

The equipment as designed at present is limited to depths of 130 fathoms and to one paper feed speed of 6 inches an hour. However, there are possibilities for modifications along several lines if they are found desirable in the instruments used by our Bureau.

The first modification which occurs to us is that it would be practically possible to have one, two or three more revolving arms each carrying its own magnet element and recording stylus and each succeeding arm set exactly at right angles to the next preceding arm. With these multiple arms, the present arm would record soundings from zero to 130 fathoms, the second from 130 to 260 fathoms and so on in multiples of 130 fathoms. This would be mechanically simple, the one apparent difficulty being that a different scale of depth graduations would be necessary for other arms after the first, on account of the fact that the beginning of the present scale is distorted to make allowance for the horizontal distance between the hydrophone and oscillator. This difficulty might be overcome by having two scales printed on the paper, which would probably be confusing, or better, by using, for depths over 150 fathoms, a transparent template with the correct scale of graduations for those depths.

Another modification, probably desirable, is that of having more than one paper feed speed. A faster speed would space the soundings less closely with a more accurate determination of the time, which would be advantageous in uneven bottom or in areas comparatively close inshore, while a slower speed could be used in offshore areas or over even bottom.





SPECIMEN COPIES OF THE SUBMARINE SIGNAL CORPORATION'S GRAPHIC RECORDER NO. 505

RECORD OBTAINED ON BOARD THE S. S. YARMOUTH
BETWEEN BOSTON AND YARMOUTH
THE RECORDER CAN BE USED WITH TYPE 480, 515, OR 431 FATHOMETERS
ON THE "FAST RED LIGHT METHOD", IT USES A PAPER FEED
SPEED OF ONE INCH IN TEN MINUTES AND RECORDS
24 SOUNDINGS A MINUTE OR 240 TO THE INCH

C.&G.S.-457

We also consider that it would be quite desirable to use the Graphic Recorder with the so-called slow red light. This is impossible with the present model because the revolving arm is mechanically coupled to the motor and, as is well known, the motor runs at a constant speed whether the fast or the slow red light is in use. Therefore, to use the slow red light with the recorder it would be necessary to provide means for slowing the speed of the revolving arm in the same ratio as the speed of rotation of the disc is slowed. This slow red light method, assuming the revolving arm were slowed down, would also necessitate another scale of depth graduations on the paper. With the multiple arms, as described above, however, the slow red light might be used without any other modification, except that some means would be necessary for indicating on the paper which arm was recording, in order that the proper constant could be added to the sounding as recorded.

A necessary additional feature is one which will permit the recording of the time of a "fix" directly on the record. Officials of the Submarine Signal Company assure us that it will be quite simple to have a push button to hold the stylus down so that it will draw a line entirely across the paper. This would indicate the "fix" but it would not identify it. Therefore, there should be some means of marking these positions at the time so that the graphic record could be correlated with the record of positions. It might be possible to install a consecutive numbering stamp so that the position numbers can be stamped on the record.

Of course, for our work it will be necessary to have a speed indicator on each instrument so as to show at all times that the speed is constant.

There are various advantages to a graphic record, among which are the following:

(a) The record is made regardless of the attentiveness of the observing officer or whether or not there is an observer. The graphic record made on our inspection trip showed several shoal areas, the least depths of which could easily have been missed by visual methods. After a change of our sounding routine it is probable that one officer's services on the bridge can be eliminated.

(b) The graphic record shows the extremes of the pinnacles and depressions, both as to depth and as to time, bringing the irregularities of the bottom to one's attention visibly and forcibly in a way that no numerical record can ever succeed in doing. The numerical record of soundings has the additional disadvantage that, in averaging, it may have smoothed out some of these irregularities. An actual case taken from the graphic record showed where the depth shoaled quite rapidly from 77 fathoms to 65 fathoms. The base of this pinnacle was passed over in 55 seconds and the summit in about four seconds, so that there were only 14 soundings on the shoal of which only two showed the least depth. It is questionable whether this least depth would have been obtained by visual methods.

(c) A comparison of any one sounding is always possible with one or several on each side of it and there should be no doubt as to whether a sounding is correct or not.

(d) The actual record can be preserved so that at any time in the future if doubt should arise as to a certain sounding it can be checked. At present any one sounding is a very fleeting thing. It is visible a very small fraction of a second and then gone forever. Thereafter it is preserved through verbal and written channels which can be in error.

(e) Final soundings can be scaled from the graphic record under the best conditions and any desired amount of time can be taken to obtain accuracy. Under present methods final soundings must be obtained at the instant of sounding and the red light must be read in the very small fraction of a second that it is visible.

The present routine of sounding and recording will no doubt have to be modified in some respects when using the Graphic Recorder and the following ideas immediately occur to one:

Transparent templates for accurate scaling of depths and times will be necessary and probably these should be of glass, rather than celluloid, with the scale on the under side and the graduations made in the finest lines possible. These can be similar to the templates used in scaling radio acoustic ranging distances.

A method must be adopted of correlating the sounding record with the graphic record. Will it be necessary to record the scaled soundings in the sounding record or can they be put directly on the smooth sheet? The requirements of the Chart Division will probably dictate this. Shall just the critical soundings, that is, the deepest and the shoalest, be recorded in an area of uneven bottom, or shall soundings at regular intervals be recorded with the critical soundings in addition?

A method of handling and filing the graphic records must be developed. The waxed paper will stand considerable handling without becoming too mutilated, but it should not be handled unnecessarily, probably some system of filing the records in rolls must be adopted and they of course can not be subjected to too much heat.

Can the services of one officer, he who usually reads the Fathometer, be dispensed with on the bridge? Soundings can be estimated by eye both as to depth and time closely enough for the boat sheet and in fixed position work; at least, the officer taking left angle can usually read these off between positions.

We hope that this description of the new Graphic Recorder will make its appearance eagerly awaited and that the mere suggestions above will incite officers to think along these lines, so that with the adoption of the new instruments the most desirable routine in connection with its use can be quickly adopted.

THE TIDE AND CURRENT SURVEY OF NEW YORK HARBOR

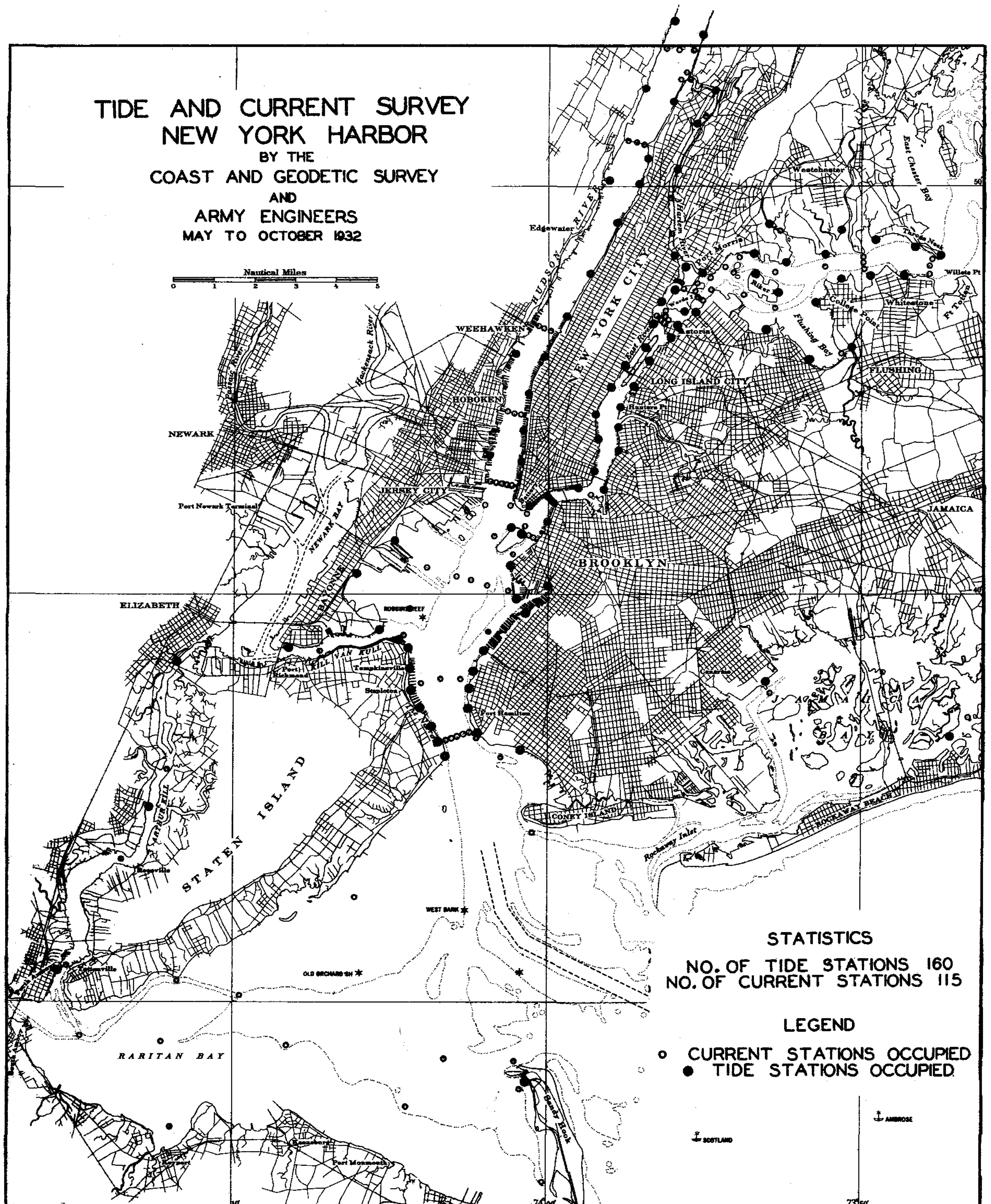
I. E. Rittenburg, H. & G. Engineer, U.S.C. & G. Survey

The object of this survey was to secure a comprehensive tide and current survey of New York Harbor and adjacent waters in order to furnish data that would permit the determination of the time, velocity, and direction of the current at any desired point; the relationship of the time of slack water and strongest velocity of the current in the waterways; the computation in advance of the turning of the current throughout the waterways; any local peculiarities of the current with reference to shipping, harbor engineering and sanitation; the determination of the tidal conditions throughout the waterways; the tidal flow on the ebb and the flood in the various sections of the waterways; all information in general that would be of value to the public in the determination of the tides and currents; and to find out what changes, if any, had taken place in the characteristics of the current and tidal streams since the previous survey in 1922.

Because of the peculiar characteristics of the tidal and current streams of the waterways of the New York Harbor area, any comprehensive survey of these waters which would actually cover the area adequately would of necessity be a large undertaking and its cost would be prohibitive for the Coast and Geodetic Survey alone, on the regular annual appropriations. This year an unusual opportunity was presented by the City of New York Employment Committee allotting sufficient funds to employ several hundred men to read tide staffs, day and night, for about five months.

Cooperating with the U. S. Engineers and the City of New York Employment Committee, a tide and current survey was made this past season, which, when combined with previous work of this nature in the New York area, completely covers the waterways of this harbor. In addition, data were obtained from which the changes in the tidal and current streams, due to continual dredging and building, can be ascertained. In general, the division of the work outlined among the City of New York Employment officials, the U. S. Engineers, and the Coast Survey was that the men paid by the City of New York secured tidal observations by reading tide staffs located at various places and working under the direction of the U. S. Engineers. These tide staffs were numerous enough so that when the results have finally been tabulated and reduced, there will be available data from which an exact knowledge of just what happens in New York Harbor tides will be had. The U. S. Engineers obtained current observations at four cross sections, which were to be observed for relatively long periods, located near Hell Gate, off the Battery in the East River, off the Battery in the Hudson River, and in the Narrows. The observations were made from their barges and one station in each of the cross sections was occupied for a period of one month. These monthly stations served as the control stations and will be analyzed harmonically.

The Coast Survey Launches, ECHO, RODGERS, and MITCHELL constituted the mobile section of the work, occupying and observing the stations at which short series of observations were to be obtained. In addition, 19 automatic tide gauges were to be installed and run for varying periods of time. Due to the manner in which the work was planned and allocated


TIDE AND CURRENT SURVEY
NEW YORK HARBOR
BY THE
COAST AND GEODETIC SURVEY
AND
ARMY ENGINEERS
MAY TO OCTOBER 1932
Nautical Miles
0 1 2 3 4 5
STATISTICS
NO. OF TIDE STATIONS 160
NO. OF CURRENT STATIONS 115
LEGEND
CURRENT STATIONS OCCUPIED
TIDE STATIONS OCCUPIED
NEWARK
ELIZABETH
JERSEY CITY
HOBOKEN
WEEHAWKEN
Edgewater
HUDSON RIVER
NEW YORK CITY
LONG ISLAND CITY
BROOKLYN
JAMAICA
FLUSHING
Whitestone
Westchester
Flushing Bay
Astoria
CONEY ISLAND
ROCKAWAY BEACH
Rockaway Inlet
STATEN ISLAND
RARITAN BAY
Port Newark Terminal
NEWARK BAY
Port Richmond
Tompkinsville
Stapleton
Fort Hamilton
Tottenville
Rossville
Port Monmouth
Sandy Hook
ROBBINS REEF
WEST BANK
OLD ORCHARD SH
SCOTLAND
AMBROSE
Willets Pt
74°00'
73°50'

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to the respective organizations, no overlap or duplication of effort developed throughout the entire season.

On June 10, 1932, the entire party sailed from Woods Hole, Mass., where the launches used had been stored, for New York, stopping at Oyster Bay, N. Y., to install a gauge and at Willets Point, N. Y., to inspect another gauge. The party arrived in New York on June 15, 1952. Field work was begun on June 20, 1932, and ended on October 8, 1932.

The party consisted of the above mentioned three launches. Aboard each of the launches were 1 officer, 1 gasoline engineer, 1 cook, 1 coxswain and 5 observers. The observers stood regular watches in rotation of 6 hours on and 12 hours off, which worked much better than the regular 4 on and 8 off.

In general, the observations were made in accordance with Special Publication No. 124, Instructions for Current Surveys. Below is listed the deviations from this manual as practiced for the past few seasons.

Instead of using the taffrail pelorus as described on page 6 of the above mentioned publication, a 5-inch diameter boat compass was secured to the deck by means of a section of brass pipe about 5 feet high. A pelorus was then fitted over the compass and all bearings to the current pole were taken with this pelorus. This gives the advantage of a direct bearing on the current pole being obtained rather than having to relate the bearing obtained with the taffrail pelorus to the compass and then add or subtract 180 degrees. After dark a focusing flashlight will pick up the current pole ordinarily, but where the velocity of the current is so strong that the pole is too far away from the observing boat, the pole can be hauled in until the flashlight can illuminate the pole for taking the bearing.

With regard to meter observations, it has been found that for current velocities up to 3 or 3½ knots, the weight and winch described on pages 7 and 8 of the above mentioned publication can be dispensed with. This winch only adds one more piece of apparatus for the observers to stumble over at night. In velocities of less than two knots, the 15-lb. weight furnished with the meter was found sufficient to hold the meter vertical. With greater velocities the 15-lb. weight was replaced by the 25-lb. weight, also furnished on requisition. It is my belief that in currents of greater than 4 knots velocity, nothing will hold the meter vertical unless the heavy weight described on page 8 and intended for use with the winch should be placed on the bottom. This, of course, would either necessitate the anchoring of the launch fore and aft or the raising and lowering of the weight near the time of slack water or whenever the launch is about to swing. Even with the heavy weight on the bottom it is doubted whether the meter can be kept at a consistent depth in these very strong currents as there would be a tendency for the meter to "climb" the cable due to the bight which the pressure of the current would cause on the meter cable.

It should be remembered that the description of the meter and instructions for the care of the meter, page 9, Special Publication No. 124, apply only to what is now called the old type meter. This meter is shipped from the office in a box resembling a suitcase. The new type meter will be shipped in a box resembling a chronometer case. The meters are slightly different, especially in the contact point used and the pivots and bearing assembly. The pivot points were inspected daily to insure against using a worn pivot and the bearing cleaned about once during a watch to prevent rust and friction resulting from rust.

A great help in hearing the "clicks" of the meter developed by one of the members of the party last year is to make a mould of ordinary cup grease around each binding post on the outside of the meter. This increases the loudness of the contacts, probably by preventing shorting across from one binding post to the other.

It was found this past season that stop watches equipped with non-breakable crystals, rather than with glass crystals, gave much better results. Heretofore much trouble was experienced in the stop watches stopping after having run a few seconds, crystals breaking, or the watch refusing to run at all. There was always a shortage of stop watches. This season, however, stop watches were furnished with non-breakable crystals and for some reason or other only one watch gave any trouble throughout the entire season.

It is thought that a few hints in the locating of trouble which might occur would not be amiss here. There are only five causes which stop the proper functioning of the current meter. A great deal of time can be saved by knowing what to look for. Below is listed the procedure usually followed in repairing the wiring and the meter, given in the order of importance.

1. Make sure that all connections of the wiring are good. This can be done by a glance and a touch at the batteries, meter and sounding machine.

2. Make sure the contact point is actually making contact in the chamber. This can be done by taking the chamber top off, pouring out the oil in the chamber which exposes the contact point to full view.

3. Test the earphones and make sure they are in good condition and properly connected.

4. Then test the batteries and make sure that they have not run down. This is very unlikely as one set of batteries will usually last a full season, but in doing this all connections are automatically tested and tightened.

5. If the trouble is still unlocated, the chances are that there is a break in the meter wire from the sounding machine. As this break is usually in the meter end of the wire, ordinarily cutting off a few feet of wire at that end will suffice. However, there are times when it is necessary to cut off twenty or thirty feet of this wire. The meter wire being covered with insulation, it is of course almost im-

possible to locate the exact place where the wire is broken, but after rewiring the meter, simply put the meter in the water and if it works it is fixed.

Sometimes it so happens that the meter will work perfectly on deck but as soon as it is dropped into the water the clicks have either disappeared or are very faint. This is due to either a poor connection or the meter wire having become thoroughly soaked with salt water, causing a short circuit. Proceed as above and the trouble will be eliminated.

GRAVITY DATA ON THE NILE DELTA

In a progress report, showing the work done in Egypt during the years 1927-50, printed in 1931, is an account of the gravity work done on the Nile Delta.

As is well known, the deltas of the great rivers of the world have been built up of enormous amounts of sediments which, presumably, are an extra load on the earth's surface. The question of whether or not this load has been compensated for by a depression of the crust into subcrustal space has been debated for many years. Some claim that the equilibrium of the crust is restored while others, especially among the geologists, claim that the crust of the earth is strong enough to hold up the added weight.

This report shows that a station was established at Cairo, another one at Baltim, at the extreme northern limit of the delta, and three other stations very nearly equally spaced between the extreme stations. The report in question contains this sentence: "The anomalies all indicate that the whole mass of the Nile Delta is practically in a state of isostatic equilibrium."

The anomalies for four of the stations are positive and negative for the other, although one of the anomalies has a value of only +.001 gal. The largest anomaly is at the extreme northern tip of the delta, at Baltim, where it is +.051 gal. An anomaly of that size could be caused by an excess of rock of normal density, about 1500 feet in thickness. It is reasonably certain that the thickness of the delta material under Baltim is from 10,000 to 20,000 feet so, even with such a large anomaly as is found, most of the mass representing the debris deposited by the river has been balanced by the depression of the crust.

For some years the publications of the Coast and Geodetic Survey have indicated gravity anomalies in "dynes", but there is a wide use now of the term "gal", one gal being equivalent to one dyne or one centimeter per second per second. It is probable that the term gal will be adopted for use in the observations of the Coast and Geodetic Survey in the future.

CONTROL SURVEYS OF ROCHESTER NEW YORK, AND ATLANTA, GEORGIA.

Earl O. Heaton, H. & G. Engineer, U.S.C. & G. Survey.

(The article by Lieut. R. W. Woodworth appearing in the December, 1951, Bulletin on "Triangulation Gadgets for City and Harbor Control Surveys" elicited favorable comments from engineers, both within and outside the Service. While the responsibility for city control surveys, as such, rests on the cities concerned rather than on the Federal Government, it is a common occurrence for our first order and harbor control schemes to cross or embrace portions of large cities. Recent cases are the cities of New York, Norfolk, Richmond, and Detroit. It seems appropriate, therefore, that our engineers should be familiar with the average requirements of city control surveys and with the special problems that arise in connection with them. Mr. Heaton here gives us some very useful information based on an extensive experience on that class of work. Ed.)

In 1935 the U. S Coast and Geodetic Survey executed a geodetic control survey of the City of Rochester, New York, in cooperation with the City Bureau of Map and Survey. Then again in 1926-1927 a similar survey was made for the City of Atlanta, Georgia, in cooperation with its Public Works Department.

Both of these projects were requested by the cities and were undertaken by the Coast and Geodetic Survey principally for public education along these lines, and also as a test far specifications, which were drawn up for this type of work by the Division of Geodesy of the Coast and Geodetic Survey. These specifications will be enumerated later and comments made as to their suitability for the work.

The primary purpose for which the City of Rochester wanted a geodetic survey was for the control of a new set of assessment maps which it was having made. Each city lot was being resurveyed and reassessed, and it soon became apparent that a control survey would be necessary. This control survey would then place all other surveys on the same datum plane, so that eventually the coordinates of each individual parcel of land, as well as its geographic position, would be known.

The primary purpose for which the City of Atlanta wanted the survey was for the control of a new topographic map and also to control the cadastral survey which was being started. The topographic map was to include the entire city and its environs. It was to be used in the designing of new sewage disposal plants and for remodeling and enlarging the antiquated sewer system, which was rapidly becoming inadequate. With an accurate topographic map of the entire area in question the drainage could be properly studied and designs made to fit present and future conditions.

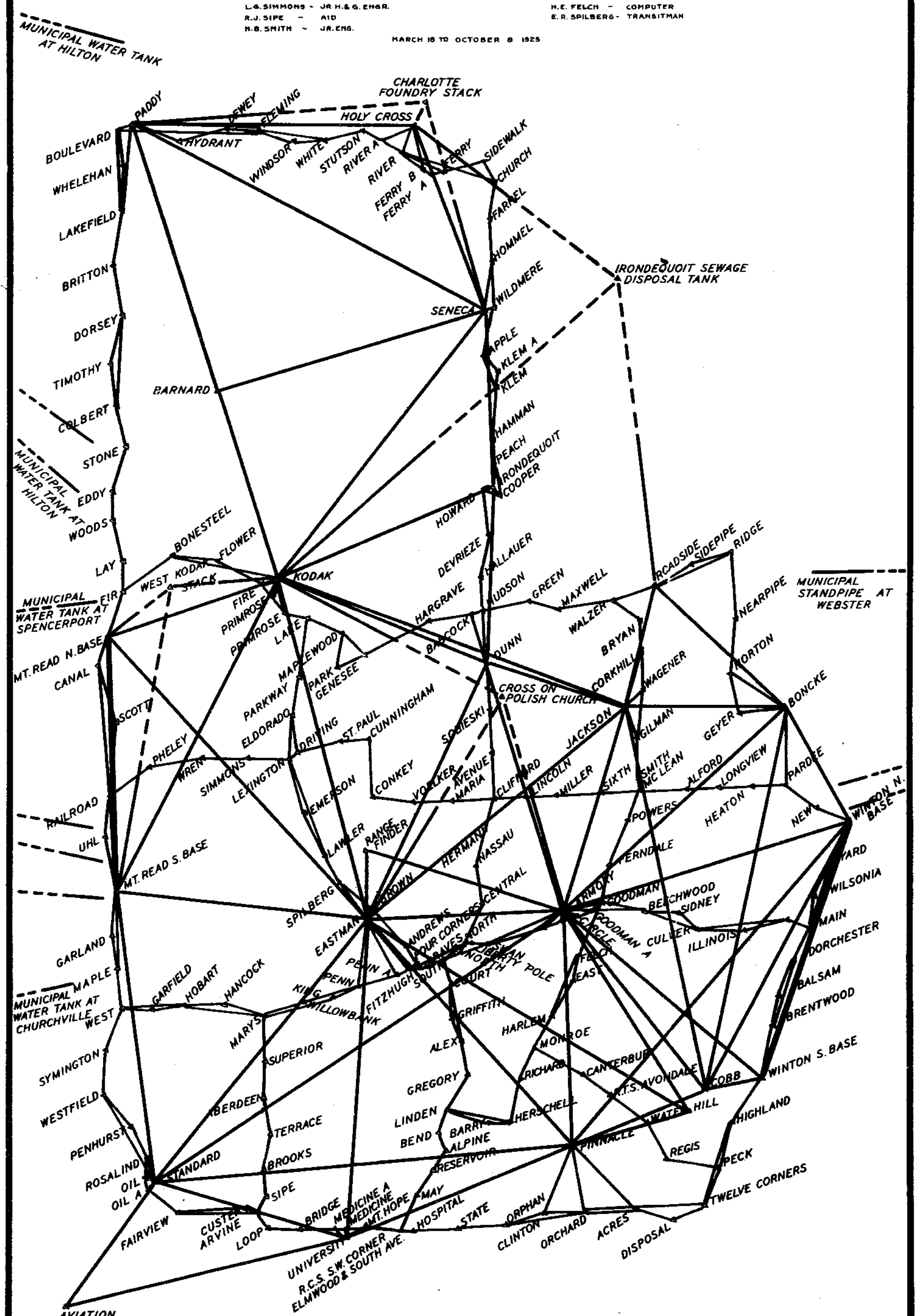
Another important use of geodetic control for cities is for the control and coordination of the underground mapping of water mains, gas mains, electric conduits, subways, etc. It seems that most cities have

U.S. COAST AND GEODETIC SURVEY

PROGRESS SKETCH SHOWING FIRST ORDER TRIANGULATION AND TRAVERSE SCHEME FOR CITY OF ROCHESTER N.Y.

U.S.C. & G. PERSONNEL		CITY PERSONNEL	
E.O. HEATON	— JR.H.& G. ENGR. CHIEF OF PARTY	L.D. LAWLER	– TRANSITMAN IN CHARGE
A.H. WAGENER	– JR.H.& G. ENGR.	B.B. CLARKE	– TRANSITMAN
D.B. PHELEY	– JR.H.& G. ENGR.	H.E. FELCH	– COMPUTER
L.G. SIMMONS	– JR.H.& G. ENGR.	E.R. SPILBERG	– TRANSITMAN
R.J. SIPE	– AID		
N.B. SMITH	~ JR.ENG.		

MARCH 16 TO OCTOBER 8 1925



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been very negligent about keeping adequate records of underground construction projects. If all such projects were properly coordinated to the control survey, it would eliminate untold confusion in underground developments. As an example of the sad state of affairs existing, I might mention that I know of one case where a city street was excavated for new construction and an old abandoned sewer was discovered. The city had no record of this sewer.

It is easy, even for the layman, to understand that if all survey projects are properly coordinated into one large scheme, with all coordinates known, millions of dollars worth of litigation will be eliminated. Property lines are then fixed forever and are not subject to the constant changes occasioned by surveys which depend upon uncorrelated control points.

SPECIFICATIONS

The specifications for geodetic control, as executed on the Rochester and Atlanta surveys, were as follows:

Triangulation: The summation R_1 and R_2 between bases, as defined on pages 12 to 25 of Special Publication No. 26 of the U. S. Coast and Geodetic Survey, should be not greater than 60 and 90 respectively. If it is necessary to do so, a broken base may be used, provided the terminal stations are intervisible and the loop closure of observed angles is made, and provided also that no considerable element of the measured base has an inclination of more than 15° to the final projected line.

Each base should be measured with an actual total error from all sources of not to exceed one part in 300,000, and with a probable error of not more than one part in 1,000,000. The measurements of each base should be made with at least three invar tapes, so used as to give an accurate and equal intercomparison of their effective lengths on the measurement. The tapes should be standardized at the Bureau of Standards both before and after the two bases are measured. In order to secure the accuracy stated above, it is advisable that the uncertainties due to the measured temperatures and tensions, to the grade corrections derived from measured elevations of the tape ends, and to the marking of the tape ends should be eliminated to such an extent that the error from no one source shall exceed, for the entire base, more than one part in 800,000. Whenever an error tends to be systematic and to be greater in magnitude than the amount stated above, such a method of measuring should be adopted as will tend to eliminate it from the final mean of the measured lengths.

Methods should be used on the main scheme triangulation which will give an agreement of better than one part in 100,000 between the measured length of the base line and its length as computed through the triangulation from the base on the opposite side of the city, after the side and angle equations have been satisfied by the least square adjustment. Since this agreement can not be known until after the triangulation is entirely completed, it is suggested that methods of observing be adopted, which will secure a triangle closure of not to exceed 3", with an average not greatly in excess of 1".25, which should give a probable error for a direction of about 0".75. Special attention must be paid in selecting times for observing when the adverse effect of horizontal refraction will not be marked.

The principal lines of the triangulation scheme should generally be from 1 to 5 miles in length. It is desirable to have some overlapping of figures whenever the strength of the entire set will be materially strengthened thereby. As uniform a distribution of precise stations over the area as possible should be secured with an average of about one for each five square miles of area. The stations on the outer lines of the scheme should be so chosen as to permit of expansion of the scheme outward at a future date.

In addition to the precise occupied stations a supplemental precise station for each square mile of area should be determined by intersection from at least three stations of the main scheme, these supplemental stations to be distributed as uniformly over the area as possible. Observations upon these supplemental stations should be made with such methods as will give a probable error for a direction not greatly in excess of 1".

Traverse: Since it is upon the precise traverse stations that the city engineer must rely for connections to his subordinate control lines, particular care must be given to the location and measurement of the traverse.

The traverse lines between connections to precise triangulation stations should contain not more than 15 angle stations each. The ends of the traverse lines should be connected to the triangulation in both position and azimuth. Additional connections in position should be made between the traverse and supplemental triangulation stations whenever opportunity presents itself, but accurate connections in azimuth can usually be made only to triangulation stations which have been occupied.

The precise traverse lines should be distributed over the area with as much uniformity as practicable, and, in general, should not be more than one mile apart. Traverse within the one mile squares will be of a lower order of accuracy and will not constitute a part of the present work. Long narrow loops should be avoided and when the distance between two traverse lines is less than 15% of the distance around the loops which have those lines as component parts, a connecting traverse line should be run across the loop. Where two lines of precise traverse cross each other they should invariably have an angle station at the intersection.

When a connection in azimuth is to be made between a precise traverse and a precise triangulation station, the angle observations for the connection should have an error of not to exceed 2".0, and the connection in distance should have an error of not to exceed 0.05 ft. with a check determination of the distance. The chief function of the triangulation is to provide proper position and angle control for the precise traverse, and for that reason the connections between the two systems should be as strong as can be made economically.

The precise traverse stations should be spaced along the traverse lines at a distance apart of not to exceed 500 yards. Often two precise traverse stations on the same line, not adjacent, are intervisible, in which case the azimuths should be carried through the line by the fewest stations, avoiding the shortest lines of sight. Care should be taken, however, that no considerable portion of a supplemental line makes an angle of more than 25 degrees with the line of the main scheme upon which it is to be projected.

Accuracy: The precise traverse system will be composed of two sets of lines. The first set will consist of those to be included in the first adjustment, which will be intimately connected with the main scheme triangulation and will divide the area up into blocks three or four miles across. The second set of precise traverse lines will divide these large blocks into smaller blocks containing about a square mile, and will be adjusted into the precise traverse lines forming the perimeter of the block.

The angle measures on the lines to be held in the first adjustment should be made with such accuracy that the correction per angle to close a loop of the precise traverse will not greatly exceed $2''.5 \sqrt{a}/a$, where a is the number of main angle stations on the line. On lines to be held in the second adjustment the correction per angle to close the loop should not greatly exceed $3''.5 \sqrt{a}/a$, where a has the same significance as above.

Precise traverse lines included in the first adjustment should be given two precise measures with invar tapes. These two measurements should have an agreement better than 10 mm. $\sqrt{K}$, where K is the number of kilometers in the line. Extreme care should be taken to eliminate systematic errors on the traverse measurements, or at least to eliminate their effect from the mean of the measures.

Precise traverse lines included in the second adjustment need be given but one precise measurement with an invar tape, but a rough check measurement should be made with a steel tape to detect any blunders before the computations are made.

A precise traverse line included in the first adjustment, starting from a point of the adjusted triangulation, should close in position upon another point of the adjusted triangulation within one part in 25,000 of the length of the traverse line, after all tape corrections and angle corrections for loop closure have been applied. If the first closing error in position is greater than one part in 25,000, either the angle or tape measurement must be strengthened until the required agreement is secured. On lines of the second adjustment, the closing error in position upon an adjusted point, either traverse or triangulation, should not exceed one part in 20,000 of the length of the line, after the tape corrections and angle corrections for loop closure have been made.

Leveling: Specifications for leveling are given in Special Publication No. 140 of the U. S. Coast and Geodetic Survey.

COMMENTS ON SPECIFICATIONS AND RESULTS OBTAINED

The preceding specifications proved to be very nearly what is needed for the control survey of the average city, and the limits of accuracy specified can be obtained without excessive cost.

It might be well, however, to make the summations of R_1 and R_2 between bases lower than those specified. If they did not exceed 50 and 80, respectively, it would be much easier to carry the observations through between bases to result in an agreement of 1 part in 100,000. It will be seen from the following statistics that this agreement was not quite attained on either of these projects.

Paragraph 5 was not followed on these surveys, because the terrain was quite flat and the traverse could be accurately carried for long distances without appreciable error. However, in hilly cities these additional triangulation points would be necessary for furnishing more frequent checks on the traverse.

Table of Results in Rochester and Atlanta

Triangulation	Rochester	Atlanta
Number of triangles	37	68
Average triangle closure	0".93	1".03
Probable error of an observed direction	0".46	0".66
Agreement between bases	1/92,000	1/73,000
Traverse		
Number of miles	56	55
Number of stations	186	205
Number of measured angles	310	315
Average correction per angle	1".8	1".4
Number of sections taped	309	S08
Average length of sections taped	460m	420m
Average correction per section taped	1/75,000	1/120,000
Bases		
Number of bases measured	2	2
Probable error of measured bases	1/5,700,000	1/2,100,000
	1/2,900,000	1/2,100,000
Levels		
Number of miles		60
Number of bench marks		200
Maximum loop closure		10.2mm

RECONNAISSANCE

In making the reconnaissance for the triangulation, the first thing to be decided upon was the most suitable location of the base sites. To make a proper selection of these sites it was first necessary to go over the entire city area and make a thorough study of the topography. After this study had been made, it was found that two bases on each of these projects would be sufficient. These were placed outside of the city, and on opposite sides, so that the main scheme triangulation would pass over the city and be directly controlled by them.

After the base sites were selected a search was made for tall buildings of permanent construction which could be used as triangulation stations to avoid building a great number of tall signals. Tall signals are expensive, and, in addition, it is often desirable to, have stations on buildings because they may be more convenient for use by the local engineers on any program of triangulation expansion.

In the selection of triangulation stations, the two most important features kept in mind were: permanency of the mark and conditions of refraction which might possibly cause trouble in making observations. When buildings were used, great care was exercised in choosing those of a reinforced concrete type or well built stone structures such as new school buildings, new office buildings, new apartment houses, or occasionally a concrete water tower. School buildings were the most convenient structures to use because they belonged to the city and were open at all times to the party. When the roof of a privately owned building is to be used, it is often difficult to obtain the owner's consent, and then later, when the observations are being made, many delays and inconveniences result in gaining access to the roof.

While making reconnaissance for city triangulation the problem of lateral refraction must constantly be kept in mind. Large factory stacks must always be kept quite distant from any of the lines to be observed, unless these lines can be observed on holidays when the fires are out. Likewise, trees, buildings and other obstacles must also be avoided.

Before making the traverse reconnaissance, the various city departments engaged in city development should be consulted in order to ascertain if there is any preference regarding streets to be used for traverse and also to learn what future plans for development have been made. If it is immaterial which streets are used, then those streets should be selected which have the least amount of grade, trees, curves, traffic, etc.

In most cases it was found best to have the traverse lines follow along the sidewalk, for, in following this course, the only interference to the work was caused by pedestrian traffic and traffic at occasional street crossings. The sidewalk was also found to be the most stable and satisfactory support for the taping tripods. These tripods placed on a hot asphalt pavement will sometimes settle and ruin the measurement.

In selecting the stations for traverse, great care must be taken in locating them where they will be of the utmost value to the local engineer and also where they can be permanently marked. Whenever practicable, the stations should be placed at street corners where it will be an easy matter for the city to make ties to its street corner monuments and also where it will be an easy matter to turn angles in any direction on the intersecting streets.

Ordinarily those stations which are placed in the line of the sidewalk can be considered more permanent than any others, because the sidewalk line is practically the only part of a city street where manholes, electric conduits, water pipe , sewers, etc., are not laid extensively. Even when it is planned to place marks in the sidewalk line it is well to consult the city planner first, to find out if there are any widening plans for this street, and, if so, the marks can be selected with this in mind. In cases of widening it was thought best to place the mark in the pavement about 15 inches below the surface and covered by a manhole cover.

In Rochester, the city retained a 1-foot strip of land between the sidewalk and all private property. Marks were often placed in this strip, in localities where buildings were set well back on their lots and where it was believed that future building activities would not be carried on in close proximity to the walk.

Each city has its own system of underground development with which the man doing reconnaissance should become thoroughly familiar. For example, in Atlanta practically all water mains are placed 6 feet from the east and north curbs of the streets and nearly all of the main sewer lines are at the center of the street. If such details are known, a great amount of extra work digging holes for marks will be avoided.

OBSERVING STANDS AND MARKING TRIANGULATION STATIONS

In building observing stands on semi-permanent structures great care was taken in their construction so that the instrument would have a stable support. Whenever it was found necessary to use roofs of wooden construction, the instrument stand was placed directly on the roof and was weighted down with heavy weights or sandbags. Then the observers' scafford was supported on the walls and copings in such a manner as to be entirely independent of the instrument stand or roof.

The station marking was accomplished in various ways, depending upon the type of building used. If the roof was of reinforced concrete construction a Coast and Geodetic Survey standard disc triangulation tablet was set in a drill hole in the concrete with two standard disc reference marks set on the copings. On buildings of wooden construction the standard Coast and Geodetic Survey disc was screwed to the roof. The shank was first sawed off and then three holes were drilled in the disc by which it could be screwed to the roof. In cases where marks were placed on wooden roofs or semi-permanant structures a standard concrete monument with two reference marks were also placed on the ground near the building. The ground marks were then connected to the roof mark, as described later in this article, so that they would hold the position in case the wooden roof was destroyed, or the mark displaced by re-roofing operations. Whenever water tanks were used for occupation a small drill hole in the platform served as the temporary station. This hole was then plumbed down to the ground by means of a vertical collimator and a standard concrete monument was set to hold the position permanently.

The mark which Lieut. Woodworth describes in the December, 1931, Bulletion of the Association of Field Engineers for marking stations on roofs is an excellent one.

MARKING TRAVERSE STATIONS

On the Rochester survey the permanent traverse marks and triangulation marks on the ground were marked in the following manner: A galvanized iron pipe 5 inches in diameter and 4-1/2 feet long was fitted with a standard Coast and Geodetic Survey triangulation screw cap at its top and a 9-inch diameter flange at its base. This pipe was then filled with concrete and allowed to stand until the concrete was set. A hole was then dug 5-1/2 feet deep, 10 inches square at the top and 16 inches square at the bottom, and concrete was poured into this hole surrounding the pipe. This mark weighed approximately 850 pounds. In the majority of cases, the bronze cap was placed about 8 inches below the sidewalk, or surface of the ground, and a heavy manhole cover 16 inches in diameter, bearing the letters U.S.C. & G.S., was placed above it for protection. Where it was necessary to place marks in the roadway the hole was dug deeper and the mark was dropped down to a depth of 18 inches below the cover. These were excellent marks, but they proved to be quite expensive. The type described below, which was used on the Atlanta survey, was considerably cheaper and probably just as good. All permanent ground marks placed in the city should be covered with a manhole cover.

In Atlanta the stations were marked in the following manner: First, a 1-inch twisted iron rod 5 feet long was welded to the shank of the standard Coast and Geodetic Survey disc. This was then placed in a hole in the ground and concrete was poured around it, so as to form a monument 8 inches in diameter on top, 15 inches in diameter at the base and 5 feet long. When located in fields or in the sidewalk, the surface of the mark was placed 8 inches below the surface of the ground, or walk, and a cast iron manhole cover bearing letters U.S.C. & G.S. was set in cement above it for protection. This cover was 12 inches in diameter and 8 inches deep, weighing approximately 100 pounds. Marks located in the roadway had their tops 13 to 15 inches below the covers. This type of mark weighed approximately 600 pounds.

Whenever marks were placed in the sidewalk, or pavement, a quick-setting cement was used. This would allow the traffic to pass over it again very soon.

TRIANGULATION OBSERVATIONS

All horizontal directions in the main schemes were observed at night and it was also found best to observe all second order angles at night.

Several sets of daylight observations were observed at one second-order station without obtaining the desired result, which was later easily-obtained at night. Intersection points and vertical angles were observed in the afternoon.

The instruments used were the same as on any other work of first order accuracy. They were as follows: The 12-inch Coast and Geodetic Survey model theodolite and the Hildebrand 8-inch theodolite for horizontal direction measurements, the 7-inch Berger theodolite for vertical angle measurements, the vertical collimator for plumbing high observing stands, automatic lighters and standard electric signal lamps for use as targets. In using the standard triangulation signal lamp it was tried with a frosted glass, in order to eliminate any possible eccentricity in the reflection of the light. This was found to be impracticable because the intensity of the light was then too weak to be visible over the smoky and hazy lines encountered in city work.

The automatic lighters were found to be a great help where it was necessary to have signal lamps on top of corporation buildings which are usually closed at night. By using the automatic lighters, these lamps could be posted in the afternoon with the lighting device set so that the light would be automatically turned on at sundown, or any other hour that is desired.

Sixteen positions of the theodolite circle were used in measuring horizontal directions and these were found to be sufficient to obtain the specified triangle closures. It was found, however, that much greater care was necessary in centering and pointing the signal lamps on this work than is necessary on large scheme work. It is believed that practically all of the large triangle closures which were encountered were caused by improper pointing of these lights.

When permanent triangulation marks were set on the ground to hold the position of a semi-permanent roof mark, the ground mark was first plumbed up and marked by a small nail on a movable scaffold which extended out from the roof. A direction and distance were then measured to the nail from the roof point in order to determine its position. The position of the nail would then represent that of the ground mark. In transferring the ground point to the scaffold, two transits were first adjusted, so that the bubble error would be very small. They were then set at right angles to each other, at some distance from the ground mark, and two observers made simultaneous pointings from this mark to the nail in the scaffold, with the instruments in a direct and reverse position. Meanwhile a man on the roof, directed by the two observers, moved the scaffold until the nail was in the proper position and then made it fast. Great care must be taken with the transit levels in this operation. For example, if an instrument one minute out of level is placed 100 feet distant from a ground mark, making a 45-degree angle with the point on the roof, the displacement in transferring one to the other is about .03 feet. With the two instruments and the precautions taken, it is believed that such points on these two surveys were transferred with an accuracy of .01 foot.

BASE LINE MEASUREMENTS

The instruments used on these base measurements were the same type as those used on other first order bases, with the exception of the portable taping tripods. On city streets where it was not possible to drive stakes, to supply three supports for the tapes, these portable tripods were used. These tripods are made of iron, with a weight of about 50 pounds, which is sufficient to hold them firmly in place while the taping is being done. They have a rigid base, with a ball and socket arrangement at their top supporting the marking table which may be moved to any desired position along the line of measure before it is clamped in place. This marking table is faced with wood, to which copper strips may be nailed for marking tape ends. At one end of the table there is a hole, through which the mark on the copper strip may be quickly and accurately transferred to the ground.

On sections of the bases where portable tripods were used, the sections were first marked out in a semi-permanent manner, so that no time would be lost while the invar base tapes were in use. This marking was done as follows: An old 50-meter invar tape was laid flat on the pavement, or sidewalk, to determine distances for placing tripods. Then the line was determined for them by using a 4-inch theodolite, and the tripod positions were marked by railroad spikes driven into the pavement, or by crosses cut in the cement. A square was then painted around each of these points and the tape length number was marked with white police paint. With these points well marked the taping and leveling parties could easily identify each tape end in the section.

After the tape ends were marked, or staked, the entire length of the base, the taping was started. It was found that by using seven of these tripods the party could be kept moving without delay and still leave one tripod in the rear each time to hold the measurement in case either of the two forward tripods became disturbed. The height of each tripod above the ground marker was measured by the rear contact man on the tape measurements, by using a small 5-meter steel pocket tape and this was recorded in the taping record, to be used in the reduction of grade corrections. Wye leveling, also for grade corrections, was then run over the tripod positions marked on the ground.

In making base measurements, it would be well, if convenient, to test the spring balance after the measurement of each section.

TRAVERSE TAPING

The traverse taping to be held in the first adjustment was measured with the same types of instruments and methods as those used on the base line measurements. In each case a forward and backward measure was made with the invar tapes.

The taping to be held in the second adjustment was measured in only one direction with the invar and was roughly checked by recording the measurements made when the sections were laid out.

Most all traverse taping was done in the daytime, although some of it which passed through the most congested districts was done at night when the traffic was at its minimum.

While working within the city limits it was found best to have a policeman with the party at all times for protection of the tape. Even with such care, a tape will often become kinked so that it will be necessary to compare it at least once a week with a standard tape which is not used for field measurements. While working in suburban areas, the services of a state trooper for patrol purposes were valuable. In these areas automobiles move at a fairly rapid rate and can only be stopped by an officer.

ANGULAR MEASUREMENTS ON TRAVERSE

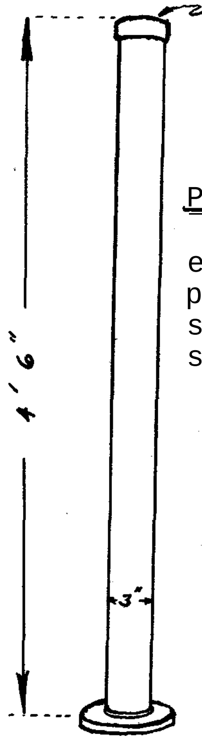
Most of these angular measurements were made at night, using small specially constructed lamps as targets. These lamps were also used occasionally over short lines for daylight observations when the weather was dark and cloudy. The daylight observations on traverse proved to be satisfactory when it was possible to make them.

Two direction theodolites were used on this work. One was a 5-1/2 inch Heyde and the other a 6-1/2 inch Fennel. Each of these was equipped with a tripod which was used in all cases, except where it was necessary to elevate the instrument more than the ordinary height of about 4 feet. In such cases a stand of the requisite height was constructed of ordinary lumber and an aluminum plate was used on its head to furnish a stable surface for the support of the instrument.

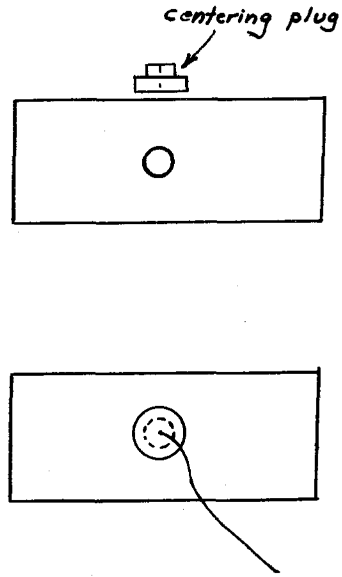
The desired accuracy was obtained with either of these two instruments, but the Fennel was found to be by far the most dependable and satisfactory of the two. It was much more sturdy than the Heyde and held its adjustments much better.

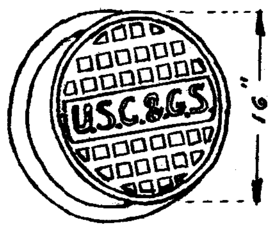
In practically all cases of bad angular loop closures on the traverse, the trouble appeared to be due to blunders, carelessness and errors caused by large vertical angles rather than to atmospheric conditions. In some cases lines passed very close to the sidewalk for nearly their entire length, but no closure trouble resulted.

The signal lamps used on this work were new devices of special construction, built in the field in accordance with specifications drawn up by the writer. This type of lamp consisted of a small box in which a 3-cell flashlight could be placed. Then to avoid eccentricities, the center of the reflector was placed directly above the center of the screw, by which the lamp was centered ever the station mark. Various sizes of openings were tried for the light to shine through, but an opening about one inch in diameter was found to be the most satisfactory. Flashlight batteries were unsatisfactory, because of their short life and excessive cost, and, therefore, all lamps were wired in such a manner that ordinary 1.5 volt dry cells could be used.



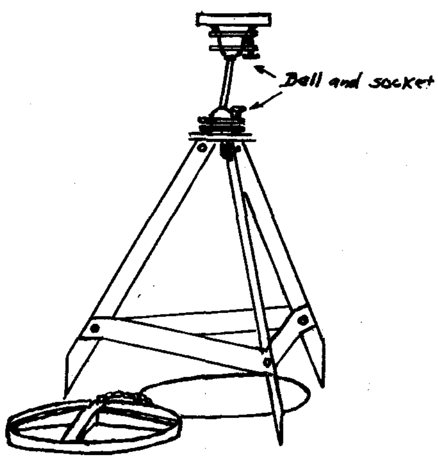
PIPE FOR STATION MARK--
This pipe was embedded in concrete post 5 ft. long, 10" square at top and 16" square at the base.

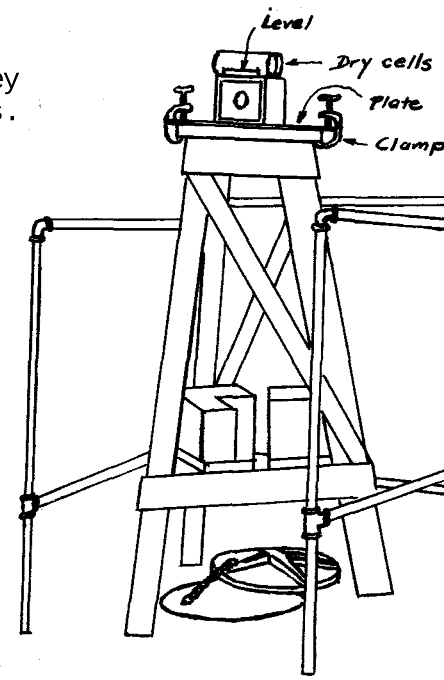




DEVICE FOR CENTERING LAMPS--
Top-- Plate with plug removed.
Bottom-- Plug and plummet line inserted in plate.

MONUMENT COVER --
Cast iron cover used on Rochester survey for protection of marks.





TAPING TRIPOD --
Taping tripod centered over station mark.

TRAVERSE SIGNAL --
Traverse lamp centered over station ready for observations.

C.& G.S.-457

Another new device was designed in the field for the purpose of accurately centering the signal lamps over the marks to be observed upon. An error of 0.1 inch in centering the traverse lights would cause several seconds' error in angular measurements on some lines and would result in an error of 1 second on lines of average length. It is therefore readily seen that these lights must be centered as accurately as possible. This device consisted of a thin brass or iron plate with a hole in its center the exact size of the centering screw in the base of the lamp box. A brass plug was then made with a hole the size of a plummet line at its center, the plug being of such a size that it would fit snugly into the hole in the plate. Three clamps were used for clamping the plate to the top of the lamp stand. In centering the lamp, the plummet string was threaded through the plug and the plug was then placed in the hole in the plate, the latter being loosely clamped to the top of the lamp stand. The plate was then shifted around until the hole was plumbed over the mark and was then firmly clamped. The plug and plummet string were then removed and the centering screw of the lamp was placed in the hole and the lamp was tightened down by a wing nut beneath the plate. Then a small level was used on top of the lamp box to make sure that the center of the lamp was exactly vertical over the mark.

The lamp supports used were tripods constructed of ordinary lumber and were centered over the marks as described above. After the lamp was centered, the stand was weighted down with about 150 pounds of weight and a collapsible iron frame constructed of ordinary gas pipe was placed around it to keep it from being bumped or disturbed by the curious or careless pedestrian. The frame was copied from the type used by the gas and electric companies for guarding open manholes in the street.

At all stations to be held in the first adjustment, 12 positions of the circle were observed with the Fennel or Heyde, and at stations of the second adjustment, 8 positions were observed.

CONNECTIONS BETWEEN TRIANGULATION AND TRAVERSE

In the original selection of triangulation and traverse stations, coincident points were used whenever possible so that it would not be necessary to make any connection between them. However, where triangulation points were established on buildings, it was necessary to connect them to the traverse by using one or two small triangles containing as a side one of the measured lines of the traverse. In such connections it was necessary to take great care in the instrument levels because of the highly inclined angles. On connections with much inclination, stride level readings were recorded and the angles corrected for the inclination.

NEWSPAPER PUBLICITY

At the beginning of these surveys the local newspapers were given articles regarding the work every few days for the purpose of educating the public in what was being done. Such articles were found to be very beneficial as the work progressed. Everyone who read the daily papers learned enough about the work so that most people were very careful about interfering with field operations and did not annoy the men to any great extent by asking unnecessary questions.

GEOGRAPHIC POSITIONS OF LOCAL INTEREST

In Rochester several extra geographic positions were determined upon request, since they did not entail a great amount of extra work and were of general interest to the community. The first of these was requested by the Rochester Historical Society. This society wished to have an old landmark named the Liberty Pole permanently marked and located. A fancy bronze tablet furnished by the society, with a Coast and Geodetic Survey standard disc at its center, was set and a short ceremony was performed by the mayor and other members of the society. The next point of general interest was located in the Municipal Avaiation Field, to be used in case a proposed air mail route should be established there. Several ranges were also determined for Bausch and Lomb Optical Company over which they could test the large range finders which they manufactured for the Army and Navy.

TOTAL COST OF PROJECTS

The entire cost of field and office work on the Rochester project was $21,000 and the comparative cost in Atlanta was $36,258. Although the two projects were quite similar in extent, the cost of the Atlanta work was much the higher, due largely to the fact that the Atlanta work was done in the winter and the Rochester work in the summer.

GENERAL CONCLUSION

Considering the low cost of geodetic control and the important position it holds in the development of all cities, it is believed that more benefit can be derived from such an expenditure than from nearly any other expenditure that a city may make.

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City of Detroit
Department of Public Works
City Engineer's Office

The Secretary, June 14, 1932.
Association of Field Engineers,
U. S. Coast & Geodetic Survey,
Washington, D. C.

Dear Sir:

We have been informed that valuable information on instrument setups for City Control Work may be found in the December, 1931, issue of the Association of Field Engineers' Bulletin.

We would greatly appreciate having a copy of this issue for use in our City Control work here.

Yours very truly,
(Sgd.) Joseph S. Stringham,
City Engineer.

UNITS FOR RECORDING, REDUCING AND BLOTTING SOUNDINGS

A. L. Shalowitz, Cartographic Engineer, U.S.C. & G. Survey

At the suggestion of Commander Sobieralski a study was undertaken of the various provisions in the Hydrographic Manual dealing with the subject of recording, reducing and plotting of soundings, with a view to assembling in some convenient form all the rules applicable thereto, and which at present are scattered throughout the many pages of the Manual.

EXPLANATION OF TABLES: The tables submitted have been prepared in a form that should lend themselves to quick and ready application. They are arranged in accordance with the sounding method used. This seemed a logical and convenient classification since the various corrections required differ for the type of sounding apparatus used. The arrangement also permits a ready comparison of the differences in the rules for the east and west coasts. The column headed "Soundings charted" has been included as a matter of general information, and is an interpretation of the rules laid down in Special Publication 66, "Rules and Practice Relating to Construction of Nautical Charts."

While some of the provisions of the Manual have been clarified, no new practices are proposed. Hence these tables should not be construed as superseding any of the provisions of the Hydrographic Manual but should be considered in the nature of a codification of existing provisions and therefore in harmony with the prescribed practice. If departures are noted, they are inadvertences and should give way to the provisions in the Manual. It should be understood that whenever greater accuracy in the entry, reduction and plotting of soundings is required than is indicated in these tables, it will be fully covered by special instructions.

PLOTTING HALF FOOT SOUNDINGS: Special mention should be made of paragraph 153 in the Manual dealing with the plotting of half foot soundings. This paragraph more than any other has been variously interpreted by the field parties, often resulting in refinements that have no practical value and only add to the labors of all concerned.

The purpose in calling for half feet was three-fold: First, to avoid the danger, through the application of the rules concerning the entry of lead line and tidal corrections, of shaving off one foot from channel depths where one foot is quite significant; secondly, to avoid the dropping of half feet in large bodies of shoal water of considerable navigational importance, such as the waters of Biscayne Bay, Florida, where a reduction of a half foot would mean a substantial decrease in the effective depth of the area, but it was not intended to apply to every shallow bay or cove however unimportant; and, finally, to permit a more accurate delineation of the low water line in those areas where large flats extend for a considerable distance offshore.

ENTRIES NOT COVERED BY HYDROGRAPHIC MANUAL: Since the preparation of the Hydrographic Manual there has grown up a practice of applying an index correction to fathometer soundings in addition to the normal correction for temperature and salinity. These two corrections, index and

TABLE I

HAND LEAD SOUNDINGS

(Atlantic and Gulf Coasts)

DEPTHS USED	SOUNDINGS ENTERED	CORRECTIONS		SOUNDINGS REDUCED	SOUNDINGS PLOTTED	SOUNDINGS CHARTED
		Leadline	Tidal			
Up to 15 fathoms. (Par.31)	Fathoms and feet. (Par.32) Fathoms and half feet in smooth shallow water. (Par.33) Greater accuracy covered by specific instructions. (Par.32)	Half feet up to 10 fathoms. (Par.133) Whole feet for greater depths and in open ocean areas. (Par.133) Omitted if less than 1% of depth below reference plane. (Par.133)	Same as Lead line. (Par.134)	Whole feet. Fractions of foot to be shown when they result from reduction. (Par.136)	Whole feet except where survey is beyond limits of charts plotted in feet, when fathoms to be used. (Par.153) Half feet in special cases or where required by special instructions. (Par.153)	Whole feet generally. Feet and quarters in special cases. When survey falls on chart expressed in fathoms Pacific Coast rules apply.
(Pacific Coast)						
Same as above.	same as above.	Same as above.	Same as above.	Fathoms and feet. Fractions of foot to be shown when they result from reduction. (Par.136)	Fathoms and sixths to 6 5/6 fathoms. Fathoms and quarters from 7 to 10 fms. whole fathoms in greater depths. Exception: Where sheet falls On chart plotted in feet when latter is to be used. (Par.152)	Fathoms and quarters to 7 fathoms. Fathoms and halves 7 to 8 fathoms. Whole fathoms in greater depths. Fathoms and sixths in special cases. When survey falls on chart expressed in feet Atlantic Coast rules apply.

Paragraph numbers and pages refer to the Hydrographic Manual (edition of 1928).

TABLE II

WIRE SOUNDINGS

(Atlantic and Gulf Coasts)

DEPTHS USED	SOUNDINGS ENTERED	CORRECTIONS		SOUNDINGS REDUCED	SOUNDINGS PLOTTED	SOUNDINGS CHARTED
		Sounding apparatus	Tidal			
15 fathoms and over. Occasional soundings of less depth permissible. (Par.31)	Whole fathoms. (Par.32) Half fathoms under 25 fathoms when deep water extends close to shore. (Par.33)	Whole fathoms. (Par.133, 32) Half fathoms when soundings are entered to half fathoms. (Par.133, 32) Omit if less than 1% of depth below plane. (Par.133)	Whole fathoms. (Par.134, 133, 32) Half fathoms when soundings are entered to half fathoms. (Par.134, 133, 32) Omit if general depths exceed 100 fathoms. (Par.134)	Whole feet. (Par.136)	Whole feet except in offshore work where charts show soundings in fathoms, when latter is to be used. (Par.153)	Whole feet or whole fathoms, depending on the chart.
(Pacific Coast)						
Same as above.	Same as above.	Same as above.	Same as above.	Whole fathoms generally. (Par. 136, 32) Half fathoms under 25 fathoms when deep water extends close to shore. (Par.136, 32)	Whole fathoms. Exception: Where portion of sheet falls on chart showing soundings in feet when latter unit is to be used. (Par.152)	Whole fathoms or whole feet, depending on the chart.

Paragraph numbers and pages refer to the HydrographiC Manual (edition of 1928).

TABLE III

PRESSURE TUBE SOUNDINGS

(Atlantic and Gulf Coasts)

DEPTHS USED	SOUNDINGS ENTERED	CORRECTIONS		SOUNDINGS REDUCED	SOUNDINGS PLOTTED	SOUNDINGS CHARTED
		Sounding apparatus	Tidal			
15 to 100 fathoms when prescribed by specific instructions. (Par.31) Exception: Not to be used over important bars or where exact depths are required. (Par.34)	Half fathoms to 40 fathoms. (Par.32) Whole fathoms for greater depths. (Par.32)	Half fathoms. (Page 110) Omit if less than 1% of depth. (Par.133) Tenth fathoms for comparative soundings. (Page 110)	Half fathoms. (Page 110) Omit if less than 1% of depth. (Par.133, 134)	Whole feet. (Par.136)	Whole feet. Exception: In oceanographic work or offshore soundings that fall on charts plotted in fathoms, when latter unit is to be used. (Par.153)	Whole feet or whole fathoms, depending on the chart.
(Pacific Coast)						
Same as above.	Same as above.	Same as above.	Same as above.	Half fathoms to 40 fathoms. (Par.136, 32) Whole fathoms for greater depths. (Par.136, 32)	Whole fathoms. Exception: Where portion of sheet falls on chart showing soundings in feet, when latter unit is to be used. (Par.152)	Whole fathoms or whole feet, depending on the chart.

Paragraph numbers and pages refer to the Hydrographic Manual (edition of 1928).

TABLE IV

ECHO SOUNDINGS

(Atlantic and Gulf Coasts)

DEPTHS USED	SOUNDINGS ENTERED	CORRECTIONS				SOUNDINGS REDUCED	SOUNDINGS PLOTTED	SOUNDINGS CHARTED
		Echo	Slope	Index	Tidal			
15 fathoms and over when prescribed by specific instructions, (par.31) Less may be authorized. (Par.34) Exception: Not to be used over important bars or where exact depths are required. (Par.34)	Half fathoms for depths under 100 fathoms. (Far.32) Whole fathoms for greater depths. (Par.32) Tenths of fathoms for comparative soundings. (Page 110)	Whole fathoms (Pages 117 and 118) Omit if less than 1% of depth. (par.133)	Whole fathoms (Spec.Pub. 165, page 23)	Not provided for in Manual	Half fathoms for depths under 100 fathoms. (par.133, 134, 32) Omit if general depths exceed 100 fathoms. (Par. 134)	Whole feet. (Par.136)	Whole feet except in oceanographic work or offshore soundings beyond. limits of charts plotted in feet, when fathoms to be used. (Par.153)	Whole feet or whole fathoms, depending on the chart.
(Pacific Coast)								
Same as above.	Same as above.	Same as above.	Same as above.	Same as above.	Same as above.	Half fathoms for depths under 100 fathoms. (Par. 136,32) Whole fathoms for greater depths. (Par.136, 32)	Whole fathoms except where portion of sheet falls on chart showing soundings in feet, when latter unit is to be used. (Par.152)	Whole fathoms or whole feet, depending on the chart.

Paragraph numbers and pages refer to the Hydrographic Manual (edition of 1928).

velocity, are in reality a part of the same correction, namely "correction to sounding apparatus" and should fall within the rule applicable to such corrections (paragraph 133). But in the final application of such corrections it would seem that the two corrections should be first combined and then the rule of 1% per cent applied. This would avoid the possibility of a sizeable correction being omitted which might occur if the rule is applied independently to the component corrections.

CONCLUSION: From a study of the tables submitted, it will be evident that the whole system of handling sounding data from their inception in the field to their final application to the charts is a complicated and confusing problem. Simplification is desirable, and it is possible that with further thought and study a more unified practice could be worked out without sacrificing necessary degrees of accuracy. The form in which the subject is here being presented should help flash up inconsistencies and unnecessary refinements. However, the whole matter is one in which the cumulated thought and ideas of all having occasion to deal with such problems should be solicited.

ADDENDA TO ABOVE

The failure to include in Tables II and IV the general provision that "tidal corrections less than 1% of the depth below the reference plane may be omitted" should not be considered a modification of paragraph 134 of the Manual. Its omission was unintentional.

* * * * * * * * * *

Extract from Season's Report
G. C. Mattison, Commanding Ship PATHFINDER
Palawan Island, P. I.

**** All plotting of the soundings was done on sheets on which had been constructed the arcs representing the loci of the sextant angles of the objects observed on. This is the second season that this system has been used, and it certainly has proved of great value. Almost all shoals were developed by maneuvering the vessel to keep one angle constant while running each line. One observer conned ship by almost continuously watching his sextant angle, changing course slightly when necessary. As the vessel traveled at such slow speed, and the directions of wind and current were usually in different quadrants, this was the only satisfactory way to cover the ground neatly with closely spaced lines. The observers became quite adept at putting the vessel on line at the beginning and then easily kept it on line with only slight changes of course, usually only a few degrees.****

A RAPID METHOD OF SWINGING SHIP

R. P. Eyman, H. & G. Engineer, U.S.C. & G. Survey.

A method of swinging ship between two well determined ranges is described below. Complete originality is not claimed as a somewhat similar method was tried a number of years ago in San Francisco Bay on the NATOMA.

In this instance the PATHFINDER was swung in Manila Bay, northward from the breakwater, and about $2\frac{1}{2}$ miles off the Pasig River Lighthouse, between the ranges 'Pasig River L.H." - "San Sebastian Church, N.E. Spire" (true bearing, 85°25') and "Pasig River L.H." - "Ice Plant Stack" (true bearing, 93°08'). The area for the swing was in about seven fathoms of water and clear of traffic. It is seen at a glance that the difference of the two bearings is nearly 10°, and it was thought that while the vessel was between the two ranges a close estimate could be made by eye of the position of the lighthouse with respect to the other two back range objects at least to the nearest tenth of the total distance.

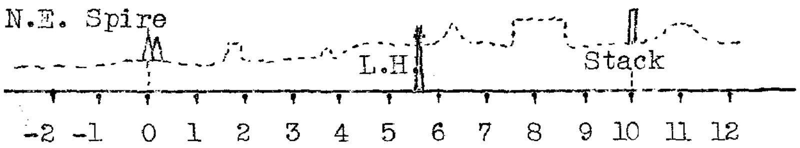
In practice, the ship was swung with one officer taking compass bearings on the lighthouse and three other officers estimating independently the position of the lighthouse with respect to the back ranges. It is noteworthy that these three estimates were invariably very close, and as the officers estimated to hundredths instead of tenths, the mean of all three estimates was used, giving a value believed to be accurate to within 0.03 of the distance or, in other words, to about l/4 of a degree. It has since been suggested that two sextant angles could be taken, one between the two back ranges and the second between one back range and the lighthouse thus giving a much more accurate determination of the light with respect to the back ranges. It is also of interest to note that on several headings the ship passed a little distance outside the range area, but the officers were able to estimate the position by "exterpolation."

A table was made up in a unit of ten divisions, calling one range "zero" and the other range "ten", with each division equal to one-tenth the difference between the two bearings. This table was extended both ways beyond the ten units to take care of any positions outside the range area.

No.10 = 93°08' = 93.1°
No. 0 = 83 25 = 83.4
Diff. = 9°43' = 9.7° (One tenth of this = 0.97°
(One hundredth " = 0.097°or 0.1°

Table

-2 = 81.5°	7 = 90.2°
-1 = 82.4	8 = 91.2
0 = 83.4	9 = 92.2
1 = 84.4	10= 93.1
2 = 85.4	11= 94.1
3 = 86.3	12= 95.1
4 = 87.3	13= 96.0
5 = 88.3	
6 = 89.2	



Ex.: Estimated position of Lighthouse =5.6
From the table, Pos. No.5 = 88.3°
From above 0.6 = 0.6°
True bearing, Pos. 5.6 = 88.9°

NOTES ON RECOVERING AND REMARKING STATIONS

J. S. Bilby, Chief Signalman, U.S.C. & G. Survey

(In response to a request from the Chief of the Division of Geodesy, Mr. Bilby has submitted the following notes. It is believed they will prove helpful to field parties engaged in searching for old stations. Ed.)

Method of Remarking: The question of stamping the dates on recovered stations is one that has come up several times, but it seems that nothing definite has been decided upon and there is nothing on this point in the general instructions for marking stations.

Several years ago when this question came up, it was decided that, when old stations were recovered and remarked with a standard tablet, the name of the station and the date when established should both be stamped on the tablet and, when such marked stations were reoccupied in connection with new work, the date of reoccupation should also be stamped on the tablet. It was also decided that when stations were marked with tablets and stamped with the name and date of each station at the time it was established and the station was reoccupied in connection with new work at a later date the date of reoccupation should also be stamped on the tablet. This method has been followed on all the work with which I have been connected during the several past years. This method is good, as far as it goes, but it does not cover the question of

Remarking: I have always favored the plan of remarking all stations with standard tablet marks, if they have not been so marked when established. When such stations are recovered and remarked, the name of the station, the date established and the date remarked should be stamped on the tablet. If such stations are reoccupied at a still later date, that date should also be stamped on the tablet. These dates should also be stamped on all the reference marks. Such a method would give a clear record of the work done at such stations and the local engineer, when sending in a request for data, would, for instance, ask for data for "STATION SMITH, 1867, 1918, 1932" and give the locality.

Recovering Old Stations: In regard to recovering old stations which were established 30 to 60 or more years ago, I wish to say that when the recovering and remarking of all stations along an arc are taken up, the officer in charge of such work should be furnished all available data that will in any way give a clew. The published descriptions and positions of all the stations should, of course, be furnished. Such data are good, as far as they go, but such information often falls short of giving a starting point in recovering the stations where all surface marks have been destroyed. Years ago, before the card system was adopted, descriptions of stations were written by longhand in the record books. Often a description covered two or more pages; many little details were given by the field engineer in the description which he knew would be of assistance but which seemed of little importance to the man in the office who had never been engaged in field work and who had no experience in recovering stations. The office man was directed, in preparing data for publication, to PACK words and to omit all detail that did not appear to him to be essential. The result was the omission of many small details which would be of much assistance to the man in the field in recovering a station where all the surface marks had been destroyed.

For example: Before I started the work of recovering stations from St. Louis westward to Colorado, I was furnished all the original volumes of reconnaissance descriptions of stations as well as the original volumes containing descriptions of the occupied stations and I had these with me for reference on the work, in addition to the publication containing the compiled descriptions. Fifty per cent or more of the surface marks had either been destroyed or covered over, but in nearly every case, some information given in the original description, which had seemed unimportant and was therefore omitted from the printed description, led to the recovery of the stations. Therefore, the volumes containing the descriptions as originally prepared by the officer in the field should be furnished to the officer in charge of recovering and remarking old stations.

As you know, I usually depend on my instinct in finding my way around and this applies especially to the recovery of old stations. If the station marks are visible, the stations are of course easily recovered. However, if all surface marks have been destroyed or covered up, the local guide that claims he can point out the EXACT SPOT where the station mark was located will nine times out of ten indicate a spot that proves to be anywhere from several feet to a hundred yards or more away from the actual location of the station.

Old stations, established some 30 years or more ago, in a level timbered country where it was necessary to erect wooden towers were usually located near the road. That was before improved highways were built and the roads followed the ridges and divides, usually going over or very near the top of the highest points on the ridges and hills. In many cases, it will now be found that the timber has been cut and that the land is in cultivation and often that no trace of the old road can be seen. In this case, one should take a spade and turn up the soil at intervals of several feet until the change of earth indicates the old roadbed, which can then be easily traced for any desired distance. The original description refers, of course, to the road then in existence.

In a region where stations were established on hills and no towers were built to elevate the instrument, the hills were usually timbered and it was necessary to cut lines of sight to adjoining stations. If the station was established 35 or 40 years ago, no trace can now be found of the cleared line except on a hill where the old trees have not been cut since the station was established. Therefore, when looking for an old station on a hill, it should be remembered that all lines had to be cleared when it was established. In such a case it is advisable, after reaching the top of the hill, to stroll around, smoke a pipe and visualize what the other party did when locating the station in order to avoid as much clearing as possible and to place the station in the best position to give clear lines.

In the good old days, each chief of party marked his stations and wrote his own descriptions, usually making a sketch of the hill, etc. As each chief of party had his own way of doing such things, a study of his method will often assist in the recovery of the old station.

My experience has convinced me that the terra cotta tile, filled with concrete into which a tablet station mark is set, is one of the poorest (if not the very poorest) methods of marking a station. The tile is easily broken, the small cylinder of concrete soon crumbles and thus the mark is lost. A good, heavily-galvanized iron pipe is far more durable. I recovered stations in the spring of 1932 along the Florida coast that I marked in 1910 with galvanized pipe and the pipe seemed good when the stations were recovered. They were heavy 3-inch pipe, well-galvanized, 4 feet long, set 30 inches in the ground and projecting 15 inches above the surface. Iron pipes were ordinarily used for reference marks. Marks established along the coast, set in grass, scrub palmetto, etc., should project about 15 inches above the surface. When possible, the marks should be set in a block of concrete at least 12 inches square on top, with a slope of 2 inches, projecting 12-15 inches above the surface, with at least 30 inches below the surface. The cost of material and the time spent in making such markers would be very little compared with the cost of time spent in recovering old stations or establishing new ones, due to poor marking with tile or other unstable kind of mark.

Where stations are on hills and it is not possible to transport material for concrete blocks in which to set the marks, the heavy type of iron pipe, heavily galvanized, would, I believe, last 100 years or more. The pipe should be filled with concrete and the inside diameter of the pipe should be the same as the diameter of the tablet station mark. The station mark is then set inside the pipe, with the top or face of the tablet flush with the top of the pipe. To anchor the pipe, drill two holes through the pipe about 1-1/2 inches from the bottom and insert a half-inch galvanized rod about 8 inches long through the holes, horizontally, fill hole in ground with cement above the anchor. If such marks are on a hill, not suitable for cultivation, the pipe should project about 12 inches above the surface.

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United States Naval Academy
Annapolis, Maryland
Department of Navigation

The Director, August 26, 1932.
U. S. Coast and Geodetic Survey,
Washington, D. C.

Sir:

We find the Bulletin of the Association of Field Engineers of the United States Coast and Geodetic Survey of great value to us in our work of instructing midshipmen in navigation and surveying.

We should very much appreciate receiving a copy of each issue.

Very truly yours,

(Sgd.) Russell Willson,
Captain, U. S. Navy.