NO. 9

FIELD ENGINEERS BULLETIN

U. S. COAST & GEODETIC SURVEY

DECEMBER 1935

S. Westerly view from Harrow.

From Prince's Bay Light

OBSERVING PARTY OF UNITED STATES COAST SURVEY ONE HUNDRED YEARS AGO

TWO SKETCHES BY JOHN FOLEY MADE BETWEEN 1817 - 1841 SHOWING HASSLER'S FAMOUS CARRIAGE IN THE FIELD. THE LARGE THEODOLITE IS IN THE CARRIAGE.
STATION HARROW WAS ON NORTH SHORE OF LONG ISLAND AT HEAD OF HEMPSTEAD HARBOR. PRINCE'S BAY WAS APPARENTLY WHAT IS NOW KNOWN AS PRINCESS BAY, STATEN ISLAND.

U. S. COAST AND GEODETIC SURVEY
FIELD ENGINEERS BULLETIN NUMBER 9
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Opinions, recommendations or statements made in any article, extract or review, contained in this Bulletin, do not necessarily represent official policy.

PLANE COORDINATES

The first requirement of an accurate map is a projection. A map without a grid system to confine the plotting and scaling of detail to relatively small areas can have little value except for very restricted purposes. Attempts to reproduce projectionless maps invariably result in further loss of accuracy.

To a Coast Survey officer the polyconic and Mercator projections are every day affairs and the use of geodetic positions on these projections becomes so much of a routine matter with him that he is quite apt to be intolerant with anyone who hesitates to accept them.

For a number of years an effort was made to encourage surveyors and engineers to use geodetic positions and polyconic maps. The results were discouraging. While taking a keen interest in precise methods and recognizing the need of a coordinate system that could be used over large areas, their interest lagged when position computations were discussed.

Finally having learned that popularizing geodetic positions with surveyors and engineers generally was a hopeless task, plane systems were adopted for each state and the computation of plane coordinates of the triangulation stations in each state was started. In general, the Lambert conformal projection with two standard parallels is employed for states having their greatest extent in east and west direction and the transverse Mercator projection for states having their greatest extent in a north and south direction.

The State of New Jersey has shown special interest in the new system. It has broadened the practical value of the system by computing plane coordinates of every minute intersection of parallels and meridians. This simplifies appreciably the transfers between geographic positions and plane coordinates and makes it very simple for our field parties to lay down the state grid on our polyconic projected survey sheets. The U. S. Engineers at Philadelphia have adopted the New Jersey system for their surveys of the Delaware River. This means that the river from Trenton to the Delaware Capes can be placed on one plane coordinate system, replacing what at one time required three separate systems none of which had anything in common with other Federal, State or local systems.

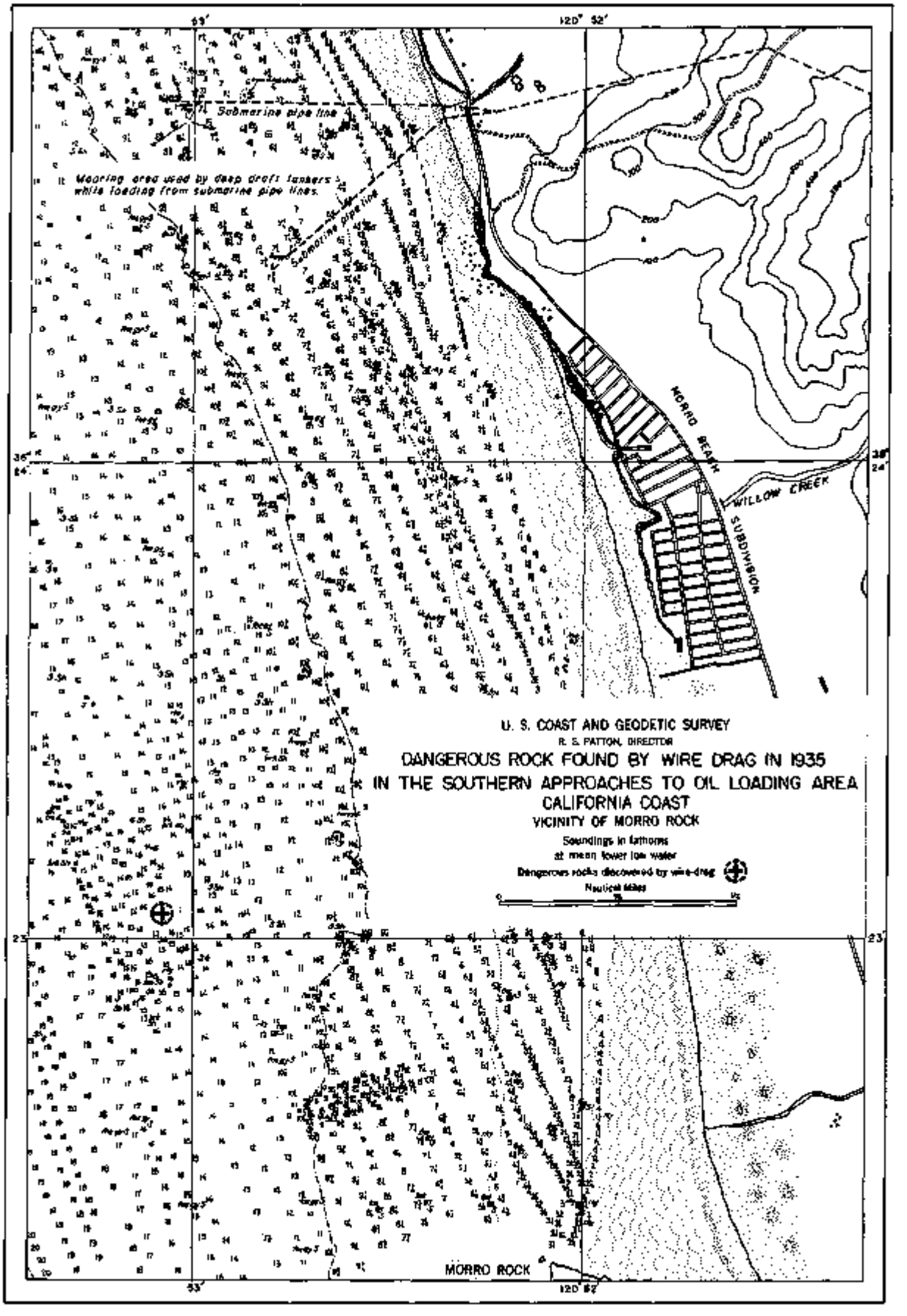
VALUE OF THE WIRE DRAG AGAIN DEMONSTRATED.

The value and necessity of wire drag surveys along the Pacific Coast were strikingly demonstrated this season when the Ship GUIDE discovered five uncharted pinnacle rocks in the approaches to Chetco Cove, Oregon. The Cove and its approaches had been carefully surveyed in 1928. The lines were closely spaced and there was nothing in the hydrography to indicate the presence of dangers.

The incident came about in the following manner. The owners of a large timber holding had made charters with a steamship company engaged in foreign trade, to load logs at Chetco Cove. The first steamer put on the loading berth, a Norwegian vessel, struck an uncharted rock of 25 feet in a locality where the chart showed over 50 feet. As the result of this accident the Master refused to take the ship to the loading berth and anchored some distance offshore at a point where there was no shelter from the prevailing northwesterly winds. Due to the exposure of this anchorage the loading was slow and the operators lost in logs, demurrage, wages etc., about $5,000. In the meantime the shipping company announced that they would place no more vessels on the loading berth until an examination was made to prove that no other uncharted dangers existed in this area.

An appeal was made to the Coast and Geodetic Survey and the Ship GUIDE, Captain F. H. Hardy, was instructed to proceed to Chetco Cove and make the necessary survey. The area was swept with the wire drag and in addition to the one pinnacle rock upon which the vessel struck, four other rocks with less than 30 feet on them were found. Captain Hardy, however, was able to find a safe passage for approaching the Cove and laid out an unobstructed area in sheltered waters for a loading berth.

The second ship was due at Chetco Cove on July 20, and the wire drag work was finished on July 19. This ship arrived, was moored in the place designated by Captain Hardy and the loading proceeded without incident. The other ships arrived on scheduled time and were also loaded without trouble and the shipping program of the season was thus completed. The manager of the timber holding company expressed his appreciation to the Director for the valuable assistance rendered by the GUIDE and stated that by reason of Captain Hardy's work a whole community, dependent on these loading operations, had been maintained in a self supporting status during the summer.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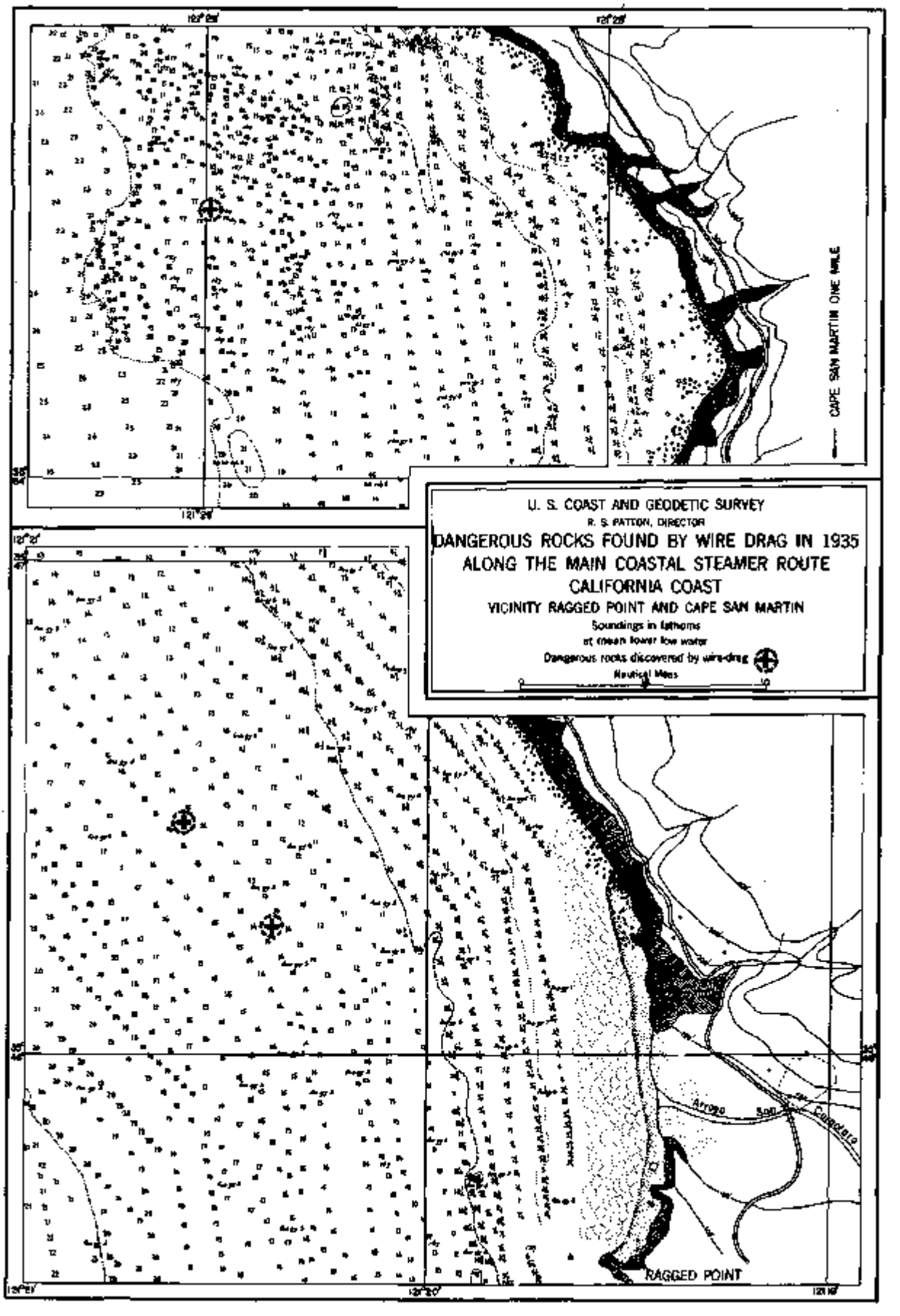
R. S. PATTON, DIRECTOR
DANGEROUS ROCK FOUND BY WIRE DRAG IN 1935
IN THE SOUTHERN APPROACHES TO OIL LOADING AREA
CALIFORNIA COAST
VICINITY OF MORRO ROCK
Soundings in fathoms
at mean lower low water
Dangerous rocks discovered by wire-drag
Nautical Miles
Submarine pipe line
Mooring area used by deep draft tankers while loading from submarine pipe lines.
MORRO BEACH
SUBDIVISION
WILLOW CREEK
MORRO ROCK
120° 52'
53'
35° 24'
23'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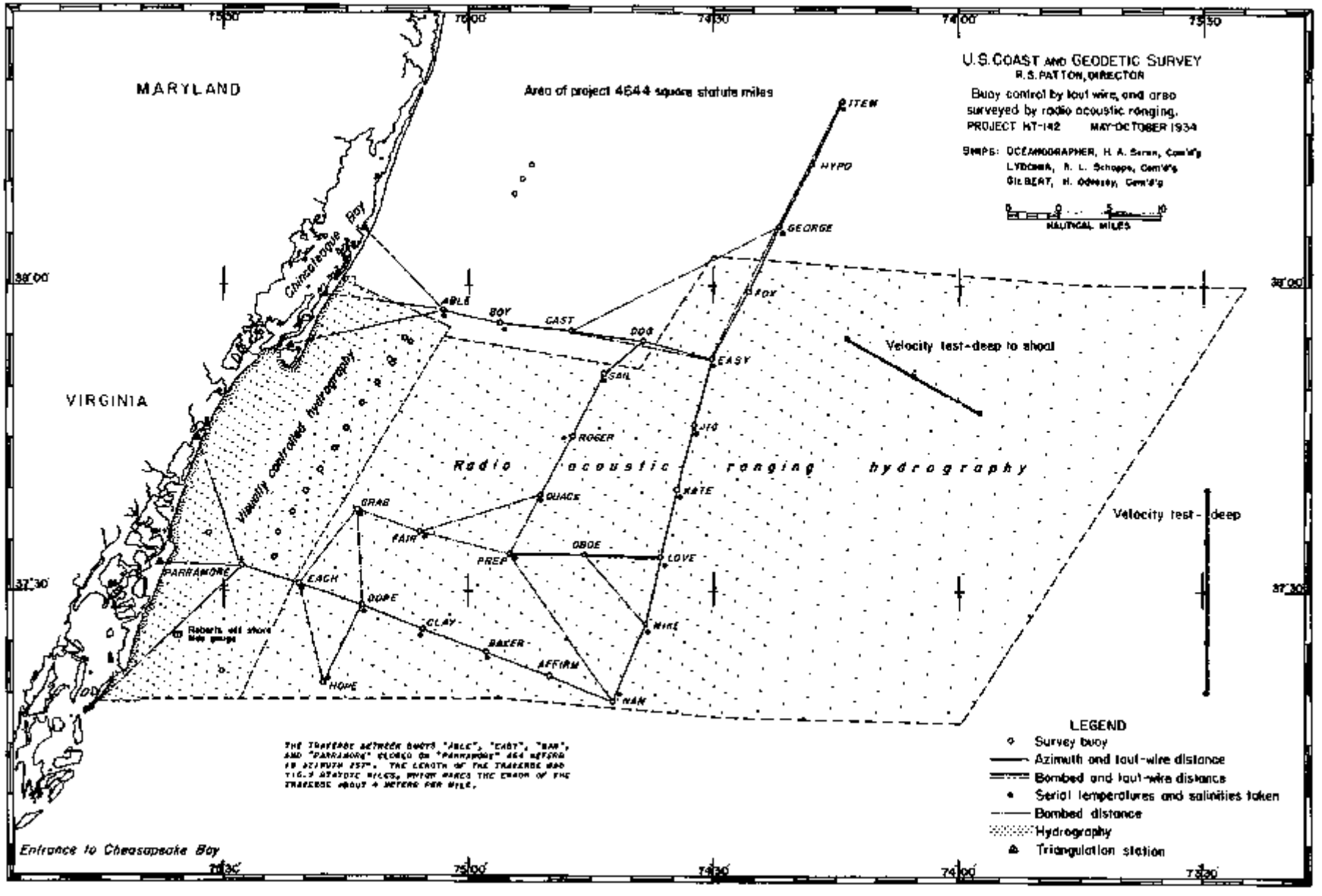
R. S. PATTON, DIRECTOR
DANGEROUS ROCKS FOUND BY WIRE DRAG IN 1935
ALONG THE MAIN COASTAL STEAMER ROUTE
CALIFORNIA COAST
VICINITY RAGGED POINT AND CAPE SAN MARTIN
Soundings in fathoms
at mean lower low water
Dangerous rocks discovered by wire-drag
Nautical Miles
CAPE SAN MARTIN ONE MILE
RAGGED POINT


U.S. COAST AND GEODETIC SURVEY
R.S. PATTON, DIRECTOR
Buoy control by taut wire, and area surveyed by radio acoustic ranging.
PROJECT HT-142 MAY-OCTOBER 1934
SHIPS: OCEANOGRAPHER, H. A. Seran, Com'd'g
LYDONIA, R. L. Schoppe, Com'd'g
GILBERT, H. Odhesley, Com'd'g
NAUTICAL MILES
Area of project 4644 square statute miles
MARYLAND
VIRGINIA
Chesapeake Bay
Visually controlled hydrography
Radio acoustic ranging hydrography
Velocity test-deep to shoal
Velocity test-deep
ITEM
HYPO
GEORGE
FOX
ABLE
BOY
CAST
DOG
EASY
SAIL
JIG
ROGER
KATE
QUACK
GRAB
FAIR
PREP
OBOE
LOVE
PARRAMORE
EACH
DOPE
CLAY
BAKER
AFFIRM
WIRE
HOPE
NAN
Roberts old shore line group
THE TRAVERSE BETWEEN SHOTS "ABLE", "CAST", "BAR", AND "PARRAMORE" CLOSED ON "PARRAMORE" 464 METERS IN AZIMUTH 257°. THE LENGTH OF THE TRAVERSE WAS 11.9 STATUTE MILES, WHICH MAKES THE ERROR OF THE TRAVERSE ABOUT 4 METERS PER MILE.
LEGEND
Survey buoy
Azimuth and taut-wire distance
Bombed and taut-wire distance
Serial temperatures and salinities taken
Bombed distance
Hydrography
Triangulation station
Entrance to Chesapeake Bay
75°30'
75°00'
74°30'
74°00'
73°30'
38°00'
37°30'

TAUT WIRE AND SUN AZIMUTH TRAVERSE
ATLANTIC COAST - MARYLAND AND VIRGINIA

H.A. Seran, H.& G.Engineer, U.S.C.& G. Survey, Commanding Ship OCEANOGRAPHER

During the 1934 season a party of the U.S. Coast and Geodetic Survey Ships OCEANOGRAPHER, LYDONIA, and GILBERT, operating off the Maryland and Virginia coasts, determined the positions of the control buoys for the off shore surveys by taut wire measurements and sun azimuths. A line of buoys, whose positions could be determined by observations on shore signals, was established from an inshore buoy near the northern limits of the season's work, extending off shore to the maximum depth in which the station ships could anchor, thence southward to the estimated limit of the season's work, thence shoreward to a connection with Parramore Banks whistle buoy whose position also could be determined by observations on shore objects. This main line of buoys thus formed a closed loop similar to a closed traverse and permitted a very accurate determination of the positions of the individual buoys in the loop by means of taut wire measurements and sun azimuths between buoys.

A secondary spur consisting of a single line of buoys was run northward from the northeast comer of the loop and a secondary loop was run within the main control loop. In both these cases the positions of the individual buoys were determined in a similar manner as was used in the main loop.

Four supplemental buoys were established, the positions of which were determined by comb distances only, from buoys in the main and secondary loops.

The general control scheme for the 1934 season, showing the relative positions of buoys, is indicated on the sketch. Buoys Able and Parramore were located by sextant fixes on shore objects. All other buoys were located by taut wire and sun azimuth measurements.

In developing the control scheme the buoys were first planted as nearly as possible in the desired positions by dead reckoning methods. Reciprocal sun azimuth observations were made at the time of planting the buoys whenever conditions permitted. After a series of buoys had been planted a continuous taut wire measurement was made over the entire series.

In making the taut wire measurement the ship was placed on range with the line of buoys and the wire put overboard about 1½ miles from the first buoy. The wire was anchored with an 80 pound shot, and the ship steamed at a speed of about 9 knots. When the wire was first put overboard it was allowed to run out freely, but as the first buoy was approached the drum brake was gradually applied to give and maintain a tension of approximately 38 pounds. A sheave reading was taken as each successive buoy was brought on the beam. Care was exercised to so start the run that no appreciable course changes between buoys were necessary.

Plotting

On the completion of the taut wire and azimuth measurements over a series of buoys, the buoy positions were obtained by plotting the data on a 1:80,000 scale aluminum sheet. The positions of those buoys at the shore end of the scheme, located by sextant fixes, were computed. All other buoy positions were determined graphically.

Loop Closures and Adjustments

The main control loop started from a shore fix at buoy Able, and was carried by taut wire and azimuth through the chain: Boy, Cast, Dog, Easy, Jig, Kate, Love, Mike, Nan, Affirm, Baker, Clay, Dope, and Each to a shore fix, at Parramore Banks whistle buoy.

Buoys Fox, George, Hypo, and Item were located by taut wire and azimuths with buoy Each as initial point.

The main loop closure on Parramore Banks buoy was 464 meters, in azimuth 254 degrees, from the shore fix on Parramore buoy. The total length of the loop was 115.2 statute miles; the error of closure being 4*0 meters per mile.

In adjusting the main loop all buoys, excepting Able and Parramore, were moved in azimuth 74 degrees, and in distance the fractional part of the total

closure which equaled the ratio of the distance from Able to the total length of loop. The distance in meters which each of the buoys was moved in adjustment is given below:

Boy	26.4	Jig	153.6	Affirm	316.8
Cast	58.4	Kate	184.0	Baker	348.0
Dog	91.2	Love	216.0	Clay	377.6
Easy	123.2	Mike	248.0	Dope	408.0
		Nan	285.6	Each	437.6

Buoys Fox, George, Hypo, and Item were moved 123.2 meters, azimuth 74 degrees, the adjustment given buoy Each.

A secondary loop was carried by taut wire and azimuth from Dog through Sail, Roger, Quack, Prep, and Oboe. Oboe was connected to Love by taut wire (no azimuth), and to Mike by bomb distance. The closure on Love was 15 meters and on Mike 20 meters. These closing errors were so small that no adjustment was made.

Buoy Fair was located by bomb distances from Quack, Prep, and Nan. Buoy Grab was located by bomb distances from Dope and Each. As subsequent hydrography showed a poor length check between Fair and Grab, the taut wire and azimuth traverse, Each to Grab to Fair was run. The taut wire and azimuth determination of Grab checked the bomb determination from Dope and Each, but the position of Fair so determined was 236 meters, 78 degrees from the position of Fair as determined by bomb distances. Fair was moved in adjustment from its taut wire and azimuth position 118 meters, 275 degrees. Grab was moved from the taut wire and azimuth position 118 meters, 291 degrees.

Observing Azimuths

As the buoys were spaced about eight miles apart it was necessary to use two ships to observe the azimuth between them. The ordinary procedure was for each ship to take station with its bridge on the range of the two buoys. Constant radio communication was maintained between the two ships. When both ships were on station, the observations on the sun were made reciprocally if possible. Under the best conditions three officers are necessary on the bridge engaged in such work -- one to control ship, one to observe the vertical angle of the sun, and one to observe the oblique angle between the sun and the other ship. If the officers were available, 2 or 3 would be used to observe each angle.

There is enclosed an abstract showing the reciprocal azimuths observed. It will be noted that the average amounts to about 8 minutes of arc or about 3½ meters per mile (perpendicular to the line or measurement). This error through a long series of measurements probably would be of a compensating nature.

Distance Comparisons and Closing Error

There is enclosed a comparison of inter-buoy distances as determined by taut wire measurements and by bombed distances. The closing error of 464 meters in a distance of 115 miles is well within the allowable error for a topographic traverse, even though appreciable variations in the scope of the buoys might occur.

Comparisons of Distances
as determined by Taut Wire Measurements and Bomb Distances.

From buoy	To buoy	Date	Velocity	Average depth	Distance meters	Taut wire distances
Fox	Easy	4-26	1470.7	30 fms	14140.5	
Fox	Easy	5-1	1474.7	30 "	14227.5	
				mean	14184.0	14180
George	Easy	4-26	l470.0	26 fms.	27079.7	27164
Hypo	Easy	4-26	1469.8	29 "	39589.7	39632
Item	Easy	4-26	1470.4	30 "	52140.7	52132
Cast	Easy	5-1	1472.2	22 fms.	25841.3	25862
Oboe	Love	7-2	1478.2	34 fms.	13857.	13890

Abstract of Astronomic Azimuths

Date 1934	From buoy-	To buoy	Azimuth	Remarks
5-23	Mike	Love	12-03	plotted
	Love	Mike	191-55	check
5-24	Love	Kate	13-36	plotted
	Kate	Love	193-43	check
	Kate	Jig	14-13	plotted
	Jig	Kate	194-32	check
	Jig	Easy	14-41	plotted
	Easy	Jig	194-46	check
7-2	Nan	Mike	22-41	plotted
	Mike	Nan	202-59	check
7-13	Quack	Prep	207-11	plotted
	Prep	Quack	27-10	check
	Roger	Quack	207-21	plotted
	Quack	Roger	27-26	check
	Sail	Roger	207-10	plotted
	Roger	Sail	27-02	cheek
7-24	Clay	Dope	292-26	
	Dope	Clay	112-26	

FROM OUR BRITISH COLLEAGUES IN INDIA

A copy of "Geodetic Triangulation" by Captain G. Bomford, R. E., Survey of India, has been received recently in the Library and Archives of the U.S. Coast and Geodetic Survey. It is an attractive publication in bound form, and forma the part I of the Handbook of Professional Instructions for the Geodetic Branch, printed at Dehra Dun in 1931. Our field officers will be interested in a number of the paragraphs which have been selected at random by the editor of the Bulletin.

On the order of triangulation

"According to its quality, triangulation is known as primary, secondary, and tertiary or minor, in primary triangulation the average triangular error will vary from about 0.3" in the best work up to about l.0". In secondary triangulation it may be as great as 3", but the best secondary series are sometimes better than the worst primary. In the Survey of India, primary and secondary triangulation is termed geodetic and is carried out by the Geodetic Branch, while minor triangulation is carried out by the topographical parties." . . . . .

Signals and Station Marks

"Well-built stations. - It is most important that the stations of geodetic triangulation should be marked by permanent structures, so that the positions of the majority of them can be found and identified (if possible to within one inch) after an interval of 100 years. With this object in view the stations are carefully built according to standard patterns, and are handed over to the local authorities, who report on their condition every year. Considerations of speed, economy or difficulty of access should not lessen the care which is given to the building of the stations. The less accessible the site, the greater is the risk of destruction; and, if anything, the more care must be given to the original building."

"Trestles and portable towers have been extensively used in the United States Coast and Geodetic Survey, where their use has resulted in rapid and inexpensive work of fair accuracy, although not with triangular errors averaging much below one second. But in America transport is generally far easier than in

India, and skilled mechanical labour more easily obtained. (See U. S. Coast and Geodetic Survey, 'Reconnaissance and Signal Building,' and see 'Bulletin Geodesique,' April 1928, Annexe 12, for reference to the Bilby portable tower).

"When a portable trestle is moved to another station, it will generally be necessary to provide a mast to carry the signal to which observations will be made. A suitable structure is the Hunter portable mast. The mast is made in 10-foot sections, and it can be raised to 100 or even 150 feet in a few hours. It can be used as an opaque signal by day, or a helio may be directed from the ground to a mirror on top of the mast. At night a powerful petrol lamp can be hoisted to the top. Owing to difficulty in aligning the lamp, no reflector can be used, but the lamps were seen at a distance of 20 miles in the Rangoon Series.

"The pickets holding the guys of these masts must be very firmly fixed in the ground, as any give in the anchorage will change the centering. Inaccuracy and possible inconstancy of centering probably make it impossible to attain the highest precision of angular measurement with these masts.

"The site of a trestle station must be permanently marked by a structure similar to that marking a hill station, as described below. It is neither necessary nor possible to centre either mast or trestle over the permanent mark, but the centering error must be accurately measured (distance and azimuth) so that corrections can be applied to the observed angles.

"Trestles of local material will be built by the reconnoitering detachment. Portable trestles will generally be erected by the observing detachment.

"Hill stations.- The hill station is the type of station most commonly built, and which should seldom be departed from.

"Where the surface is composed of rock, a dot surrounded by a concentric circle is cut on the solid rock in situ: otherwise, a large stone similarly marked is buried in the ground. Over the mark a short cylindrical pillar of strong masonry is built to a convenient height not less than 18 inches, and of 40 inches diameter: on the upper surface of this pillar another mark-stone is inserted, and fixed truly vertically over the lower one: an intermediate mark-stone should also be embedded in the pillar if it is 3 feet or more in height. A masonry wall 18 inches thick is built surrounding this pillar, and separated 3 inches from it. Round this wall is built a platform of earth and stones. The dimensions of this platform should be at least as large as the observatory tent, and it will generally be found convenient to make it somewhat larger; 12 feet x 12 feet will prove a suitable size. The annular space round the central pillar is for the purpose of isolating the instrument and preventing any shake caused by the observer's movements; it should be filled in with earth or loose sand. The distance between the two mark-stones should be recorded, but all measurements and observations should be referred to the upper mark-stone, and are so recorded in the angle books. In alluvial country where stone is scarce, it will be better to mark the circle and dot on bricks, as flat dressed stone is likely to be stolen by the inhabitants of such districts for domestic purposes. This kind of station is known as Type A, and should be built whenever a 12-inch theodolite is used.

"When a wild theodolite is used the station should be as above but the pillar should be of only 30 inches diameter. This type is known as Type D.

"In secondary triangulation the 18-inch masonry wall may be dispensed with. Type C.

"Auxiliary Marks. - At all geodetic triangulation stations three auxiliary marks should be provided, by which the station may be identified if the original mark is lost. Each should consist of a triangle with a central dot, deeply cut on solid rock if possible, or failing this on large stones embedded in the ground. They should be between 10 and 50 feet from the station. Their distances from the station and from each other should be recorded to the nearest inch, and the angle at the station subtended between each of them and some other G. T. station, should be measured to the nearest few minutes, the theodolite being directed on to them by means of its sight.

"The horizontal distances from the auxiliary marks to the station are of most use if the station is destroyed. The most convenient way of obtaining them is by pointing the theodolite at each in turn, reading the vertical angles, and at the same time stretching a tape from the axis of the theodolite to the mark.

"As a further precaution the circular pillars should be built carefully with the mark-stone as the centre; so that if a large portion of the circumference is found intact, the centre may be accepted as the old station within an inch or two.

"Centering of upper mark-stones. - The method of adjusting mark-stones is as follows: - Let the external part of the platform be built up to the intended height of the upper mark, and place upon it four heavy stones in such a manner that threads stretched diagonally between them may intersect near the centre. Adjust these threads to correspond with a plumb-line suspended over the lower mark, and when the coincidence is complete, mark the four exterior stones by pencil lines, or lines scratched with a knife. Arrangements must now be made for protecting these stones, either by covering them over, or appointing a man to watch each, while the pillar in the centre is being built up nearly to the level of the next mark-stone, which is then adjusted to correspond with the cross-threads, and fixed in cement.

"Construction of protecting cairn. - When the last helio squad leaves the station they should erect over the pillar a well-built calm of large stones, six feet in diameter and six feet high. In country where no stone exists, it must suffice to pile up a rather larger mound of well-beaten earth or old bricks. 'Khalasis' should be instructed to make well-shaped, symmetrical cairns, centered over the station mark. The necessary materials should be assembled near the station before the observing party leaves it, to ensure that an adequate cairn is eventually erected.

"Handing over to local officials. - The stations must be handed over to the headman or senior official of the village in whose lands it stands. The transfer forms 1, 2 and 3 Transfer are made out and signed by the Survey Officer and local officials. One copy will be kept by the latter, and the other two copies will be sent to the Director, Geodetic Branch, who will keep one copy and send the other to the District Officer in whose district the village lies. If the observer is in the field, a copy should also be sent to him."

Some of the officers of the U. S. Coast and Geodetic Survey who have staggered many a weary mile in mountain triangulation under the old 12 inch theodolite should appreciate this paragraph:

"Strength of detachment. - The normal strength of an observing detachment (excluding reconnaissance detachment) is one observer, one recorder, eight signal squads of four men each, and fifteen men with the observer if a Wild theodolite is used, or eight more for a 12-inch theodolite. Some increase will be required if trestles and masts are extensively employed. In Burma and other countries with strange languages an interpreter will be engaged."

It is interesting to note that the very appropriate term "satelite station" is used in place of the conventional "eccentric station" in our nomenclature. The manual is most interesting, and readers will be impressed with the thoroughness with which the Survey of India is being made, and the precautions that are being taken to insure the preservation of the marks and consequently the future value of the data.

TRIANGULATION IN MISSOURI (1927 DATUM), SPECIAL PUBLICATION NO. 186, by Walter F. Reynolds, Senior Mathematician, has 178 pages and 17 illustrations including sketches. This is the sixth publication by States of triangulation results on the 1927 datum. Results have already been published for the States of Oregon, Colorado, Kansas, Louisiana, and Arkansas. In all of these states as well as in Missouri, considerable work has been done since these first volumes were sent to the printer, and naturally a second volume will be required for each State when the triangulation of the State is complete. The volume named at the head of this paragraph is a splendid example of the form in which the Coast and Geodetic Survey is now presenting triangulation data to the public. In general it is much the same form that has been used in past years, but there have been some minor changes worth noting. Some little variations in the form of presenting geographic positions have been ironed out, and a very acceptable form secured. A condensed style for the writing of descriptions of stations has also been developed and is being used. Great improvement has been made in the index sketches, which are extremely well exemplified in the present volume, particularly in those sketches which show the intricate work along the Mississippi River. These sketches were prepared in New York by members of Lieut. Pfau's field party, and under the direct supervision of Mr. McCombs.

THE "PATHFINDER" IN THE TYPHOON OF 1905.

R. R. Lukens, H. & G. Engineer, U.S.C.& G. Survey
Assistant Chief, Division of Hydrography and Topography

On September 25-26, 1905, one of the most destructive typhoons ever recorded, swept across the Philippine Archipelago, and among the numerous vessels in the path of the storm was the Coast and Geodetic Survey Steamer PATHFINDER, Ferdinand Westdahl commanding.

The PATHFINDER was at work on the east coast of Samar and was in the direct path of the dreaded center, which passed over the ship about 8:00 P.M. on September 25 with a barometer reading of 27.12, which at that time was the lowest ever recorded in the Philippine Islands.

Several vessels in the path of the typhoon were lost with nearly all hands, and of all the ships in the vicinity of Samar, only one, the Coast Guard Cutter Basilan, was able to return to Manila under her own power. The Basilan succeeded in reaching a typhoon anchorage and the commanding officer, after dropping his anchors, went full speed astern on his engines for a half hour or more to work the anchors deep in the mud. The Basilan came through safely but had a one-pounder gun mount blown away and at times almost capsized when the force of the wind struck her abeam.

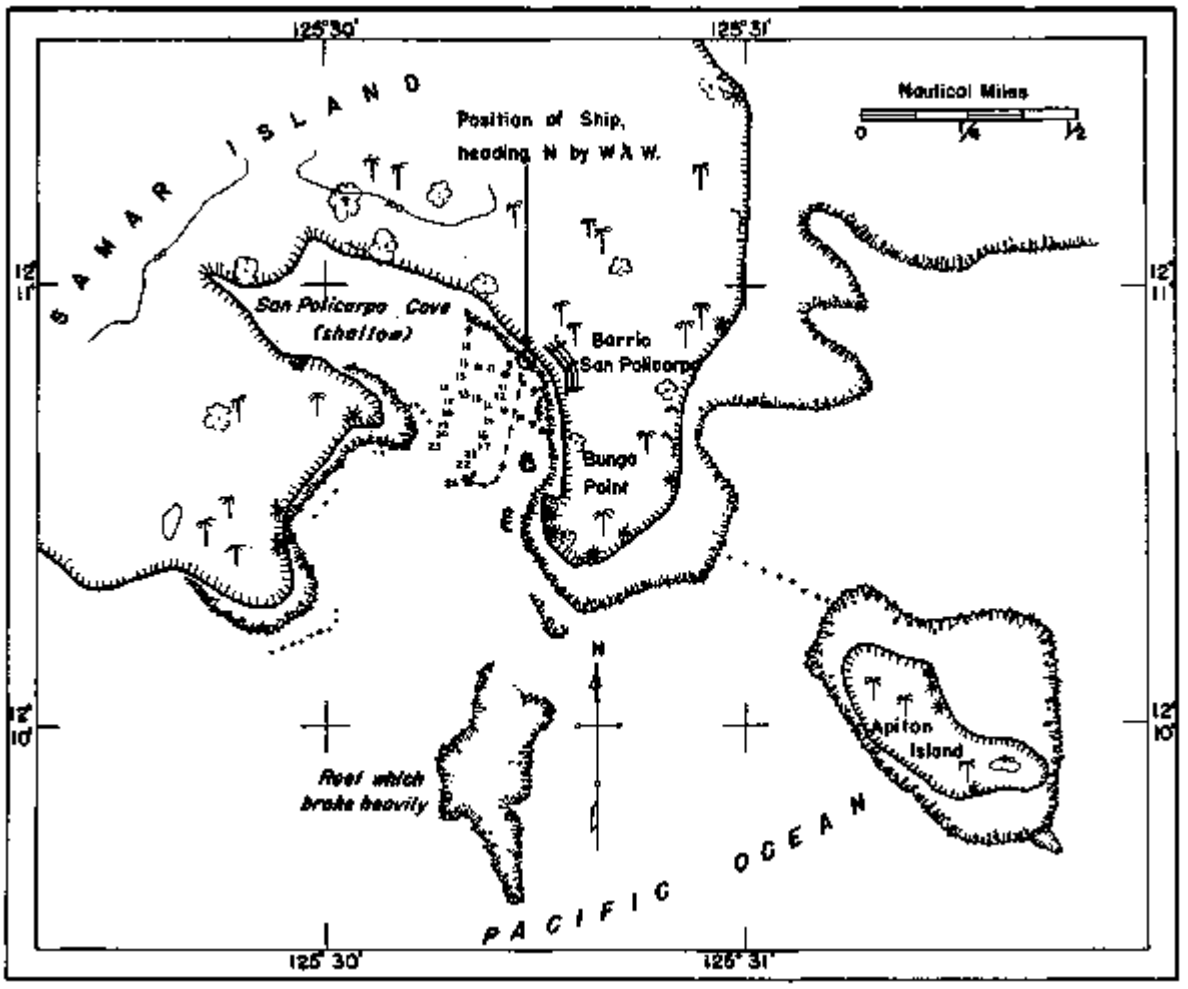
The following description of the experience of the PATHFINDER is based on the ship's log and the official report by Captain Westdahl:

On Sunday, September 24, the PATHFINDER was at anchor off Apiton Island, about two miles southeast of San Policarpo Bay on the east coast of Samar. The weather was clear to cloudy with northerly winds gradually increasing from force 2 to force 5. At 4:00 P.M. squalls became frequent, but the barometer stood at 30.10, which was about normal. During the night the wind increased somewhat, but the barometer remained stationary at 30.00 from 4:00 A.M. to 8:00 A.M. It then began to drop slowly and the PATHFINDER got under way for San Policarpo Bay to pick up a steam launch and then run to Bactol Island about six miles south of San Policarpo Bay for shelter from the bad weather which was evidently approaching.

The typhoon, however, was much nearer than conditions indicated. This, of course, was before the days of wireless and every ship master had to make his own forecast from the appearance of the weather and the performance of his own barometer. The ship anchored temporarily in a small hole in the entrance to San Policarpo Bay and the launch was hardly hoisted when the typhoon burst upon them, beginning with tremendous peals of thunder and lightning, and rain squalls from the north - northeast. The wind was blowing force 8 and with vision obscured by the blinding rain squalls, Captain Westdahl realized that he would be unable to get to the safer anchorage at Bactol Island. He did manage to steam ahead and let go another anchor, but was able to pay out only thirty fathoms of chain due to the proximity of the reef on his starboard hand.

San Policarpo Bay, in addition to being strewn with reefs, is wide open to the whole Pacific to the south. About one-half mile south of the anchorage was a reef which partially sheltered the bay, and over this reef tremendous breakers were smashing in from the Pacific. The wind being northerly, the ship trailed towards this murderous reef. Should the vessel drag and strike the reef, all hands would no doubt be lost, as the northerly wind would drive any survivors from the land. Steam was raised on both boilers and the engine started to relieve the strain on the anchor chains. First slow ahead, then half ahead, and finally at 6:00 P.M. the engines were put at full speed ahead with the full power of both boilers, the wind blowing from the northwest with full hurricane force and the barometer fairly tumbling in its descent. Long before this the officers realized that they were in the direct path of the oncoming typhoon and that their situation was desperate.

At this time when the wind had reached its full force and was so strong that men could get about the decks only by crawling on their hands and knees, the waters became so foul with leaves and debris that the circulating intake began to stop up, with the consequent heating of the condenser. To stop the engine would probably have meant the total destruction of the ship and the loss of all on board. The chief engineer however managed somehow to keep her going and the ship was held to her anchors and kept clear of the seething cauldron on the reef just astern.



Sketch copied from original by Captain Westdahl,
showing positions of PATHFINDER before and after stranding.

At 7:37 P.M. the barometer reached its lowest point, 27.12, and at 7:40 the wind suddenly slackened to about half its former force. This was the center or "eye" of the storm and lasted two or three minutes. At 7:45 the wind suddenly shifted to the west with full hurricane force. Realizing the danger of striking the reef to starboard as the ship swung, the helm was put hard to starboard, and the engine at full speed ahead in an attempt to clear the reef, but in swinging, the ship struck aft and the engines were stopped. The vessel now shipped a heavy sea, which washed the whaleboat and dinghy inboard, nearly demolishing both boats. When the PATHFINDER struck in making the swing, the anchors were started and the hurricane winds drove her inshore, bow first, dragging her anchors and cables.

At 8:00 P.M. the wind shifted to the south and, according to an entry in the log book, "it was impossible to ascertain the position of the ship on account of the darkness and the awful force of the wind."

By this time it was apparent that the ship was aground and was gradually being worked further inshore by the terrific wind. The wells were sounded frequently and the ship appeared to be tight. By midnight the wind began to moderate and the barometer stood at 29.81, rising rapidly.

As dawn broke on the morning of September 26, it was found that the ship was hard aground on the northeast shore of the cove and was almost up in the cocoanut trees. The PATHFINDER was headed inshore, and at low water there were five feet at her stern, while it was bare at the forefoot.

A survey of the damage showed that the propeller blades were broken and bent, the stern frame broken, and the rudder hopelessly damaged. In addition, two

boats were stove in and the awnings, although they had been carefully furled, were blown to shreds. Even the flag pole at the stem had been blown away.

Captain Westdahl dispatched a telegram via Oras Bay where there was a military post, describing his plight with a request that the commanding officer forward it by one of his small steamers to the nearest telegraph office.

The ship's force then built a small wharf and lightered the coal ashore in preparation to floating the ship. By using bamboo as pontoons and carrying out anchors astern, the PATHFINDER was hauled off into deep water on October 1. Work was started on rigging a jury rudder, and on October 5 the vessel started back to Manila in tow of the tug ROBERT K. The tow arrived in Manila on October 8, and soon thereafter the PATHFINDER was undergoing extensive repairs at Cañacao.

The following officers were attached to the PATHFINDER at the time of this typhoon:

Ferdinand Westdahl, Commanding
C. M. Sparrow, Assistant
J. M. Coleman, First Watch Officer
H. L. Mason, Mate
L. M. Hopkins, Chief Engineer
C. G. Quillian, Aid
F. T. Lawton, Aid
W. L. Curtis, Surgeon
A. H. Hunnycut, Chief Writer

Captain Westdahl, a fine gentleman whose memory is revered by all who knew him, passed away at San Francisco, California, in 1919.

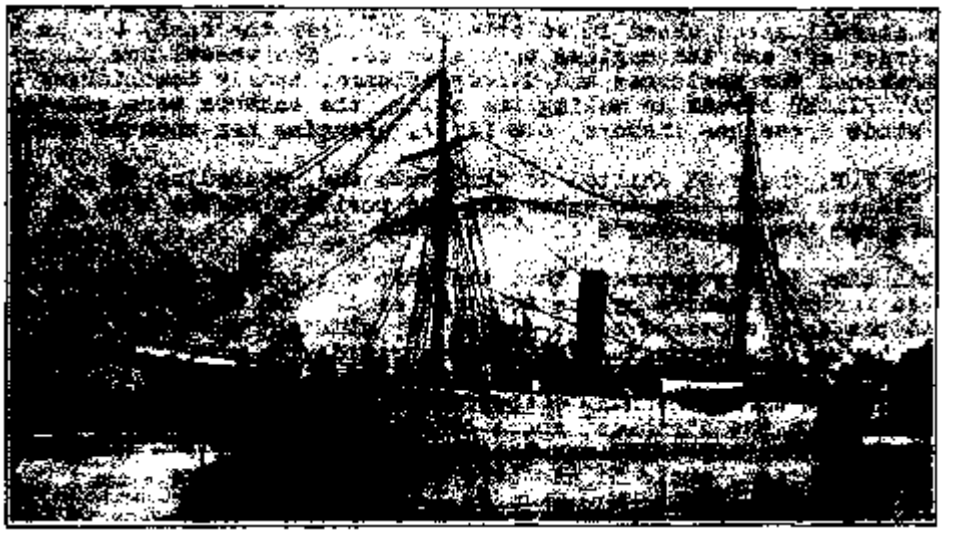
Jerry Coleman, from whom the writer and probably many other officers learned much of practical seamanship, was in the Lighthouse Service for many years and is now retired, living on the West Coast where he devotes his time to his art work - oil painting and water colors.

C. G. Quillian, for many years has enjoyed the more calm and peaceful life of an insurance man in Seattle, Washington; while Chief Hopkins is Superintendent of Lighthouses at Norfolk, Virginia.

A. H. Hunnycut, well known to the many officers who have served on the PATHFINDER is now serving as Chief Writer of the FATHOMER.

No information is available concerning the present whereabouts of the other officers.

The PATHFINDER surviving many typhoons since 1905, was actively employed in the Philippine Islands until June 30, 1933 when she was laid up due to lack of funds. She is now tied up in the Paaig River at Manila.



The PATHFINDER with original rigging.

THE DIAL NAVIGATORS*

By Captain Felix Riesenberg

An old sailor admiral, now retired, once grumbled to me about the newer officers. "When I ask one of them what the force of the wind is he runs into the chart room and looks at the anemometer dial."

This sums up a vast faith and belief in the infallibility of dials. According to this school a clock face always tells the right time.

Undoubtedly the marvelous new instruments of navigation - the gyro compass, the fathometer, the radio direction finder, the radio time signals, the radio compass stations - add greatly to the safety of navigation. But all of these scientific developments are only tools added to the equipment of the navigator.

The danger in dependence upon dials comes in when dials displace the constant checking and vigilance, more necessary now than ever before. Vessels steam faster, are of greater draft, are usually high-sided, subject to the force of the wind and the set of currents as never before.

The need of checking compass bearing and courses, of constantly verifying the deviation and true pointing of the compass, whether magnetic or gyro, becomes increasingly important. A navigator may find his compasses right during all of the years of his experience, and then, on some night, he may find them off, or he may neglect the precaution and find his ship piled on a reef. What happened at the time of the grounding of the steamship HAVANA on Matanilla Shoals may be brought out. But this is only one case of many. The whole issue of this paper could be filled with a list of strandings due to neglect, or to some unforeseen set of tide, or current, or wind. Then there is always the element of human error.

Once it was considered necessary that all courses be checked, as many times as possible, before setting them.

One of the old axioms of the navigator, particularly the master, was never to be certain of the position of his vessel, especially when approaching land. Old-timers I have been shipmates with kept the bridge many hours in advance of sighting lights expected. I have heard of people who now turn in and leave word to be called when so and so is sighted. This happened when the transport NORTHERN PACIFIC fetched up on Fire Island shoal.

Compass bearings, checks and comparisons, as recorded in the compass log, should be inspected at the end of each voyage by the authorities ashore, unless, of course, these "marine superintendents," as they sometimes call them, are graduate port stewards or common office boys who know nothing whatever about ships or navigation. Some day stockholders in steamship companies will ask the directors if their ships are being managed by men who are qualified seamen or not.

The dial navigators are also inclined to avoid all unnecessary (as they call it) exertion. There is not enough use of the hand lead, which should be used whenever a steamer is entering or leaving port, be the weather what it will, just for practice. The use of the old "dipsea" lead should be revived, as a further matter of seaman-like drill, requiring quickness and team-work. On a cold night it is considered disagreeable work.

One of the greatest mistakes of the modern navigating world is the huge steam-heated wheelhouses, full of dials and gadgets, and completely insulated from the wind and weather. The officer of the watch, up in the stifling warmth of these hothouses, becomes drowsy, and what is going on outside is a matter of guess-work. The closed-in wheelhouse is right for the helmsman, as a protection; but on a bridge designed for safety of the people on board and the ship itself the watch should be kept in the open, to windward, on a straight bridge, giving a full view ahead and on either beam, a bridge designed with wind deflector dodgers and open to every sound, whether of other ships' whistles or horns, or whether of breakers. The officer who looks ahead over the sea through nothing but air, can see white caps, the breaking of seas over obstructions, and, what is more, he stays awake during his watch. If I had my way I would scrap every closed-in steam-heated bridge in the name of safety at sea.

* By courtesy of the Nautical Gazette.

Most first-class ships now carry two officers of the watch. The junior is the only one with business in the wheelhouse. The senior officer signs the night orders and the bridge log at the beginning of his watch and at the end, before he relieves the watch, and after he has turned it over to his relief. I can imagine the riot that would have ensued if at any time the famous Captain Jamieson had popped up on the bridge to find the senior watch officer warming himself in the wheelhouse.

Radio bearings are sometimes less than reliable; soundings are not an infallible guide, nor are sights always to be depended upon, and as indicated, the course steered may not be the course made over the ground, and the distances logged on the various patent dials may be over-running or under-running. There is only one real safety, one dependable guard against every kind of mishap, and that is the lookout, by a qualified officer, on his toes, out on a weather-open bridge, summer or winter, keeping wide-awake.

I would like to see more seamanship used in the navigation of vessels.

In recent years I have made a few trips, as we call them, on steamers. It has been my custom to talk with the officers, visit the bridge, and generally hang around saying next to nothing, while admiring their snug quarters and damning the boats and deck gear. So many of these new officers, watch officers, positively look pale. I suppose it's the indoor life.

Another matter, once taken up by Captain Selwyn Day, in London, is the habitual overfeeding of modern ship's officers. The passengers can stand it for a cruise, or a trip, but the system is killing when indulged in year after year. So many of the inside men get pot-bellied and grow bald, and many of them die of indigestion and attendant ills. When you see these newer officers, or navigators, at the many inquiries they often look like the proprietors of small delicatessen stores, not like sailors.

FIELD METHOD OF CHANGING SCALE OF TOPOGRAPHIC FEATURES

Warren L. Moore, Surveyor. (Party of Earl 0. Heaton)

Hydrographic field parties often find it necessary to change the scale of the shore line, etc. of a plane-table or aerial photo topographic sheet before using it for boat or smooth sheets. The process described here has several advantages over the method of subdividing into small rectangles in that it is much faster, probably more accurate and eliminates the necessity of having construction lines on the topo sheet.

This method will be readily understood from an examination of the accompanying sketch. Assume that Fig. 1 is a section of shore line occupying one minute of latitude and two minutes of longitude at a scale of 1:20,000 and it is desired to reproduce it at a scale of 1:10,000. First draw (or trace) the necessary parallels and meridians at a scale of 1:10,000 on a piece of tracing paper, represented in Fig. 2 by M'N'O'P'Q'R'. Place the tracing paper on the original sheet so that M'N' coincides with AB and M'R' with AF. Then draw rays (or construction lines) from the common corner M' thru all critical points of the original shore line as seen thru the paper and as many other rays as are necessary to secure accurate control for sketching. Then use hairspring dividers to double the distance from the vertex to the original shore line along each ray and sketch in the shore line using these control points. The transfer to the boat or smooth sheet may then be accomplished by the usual methods.

It should be noted that any common corner (intersection of a parallel and meridian) may be used as the vertex for the construction rays. Fig. 3 is intended to show that part of the shore line from Fig. 1 was expanded on the same tracing paper as in Fig. 2 but from a different vertex. Fig. 3 also illustrates the best practice, which is to keep the contruction rays as short as possible and their intersections with the shore line as near as possible to a right angle.

This method may be used to increase or decrease the scale in any proportion, but it will be necessary to use proportional dividers as hairspring dividers are best only for exact doubling of the scale. It is especially convenient to use this process in irregular changes of scale, such, for example, as would be encountered in expanding aerial photo topography from a scale of 1:20,000 with a scale factor of .95 to a scale of 1:10,000. To do this, it is necessary to adjust the proportional dividers so that one minute of longitude (or latitude) on the aerial photo projection will fit one side of the dividers while one minute of longitude (or latitude) at a scale of 1:10,000 will fit the other side of the dividers. The rest of the process will be evident from the foregoing.

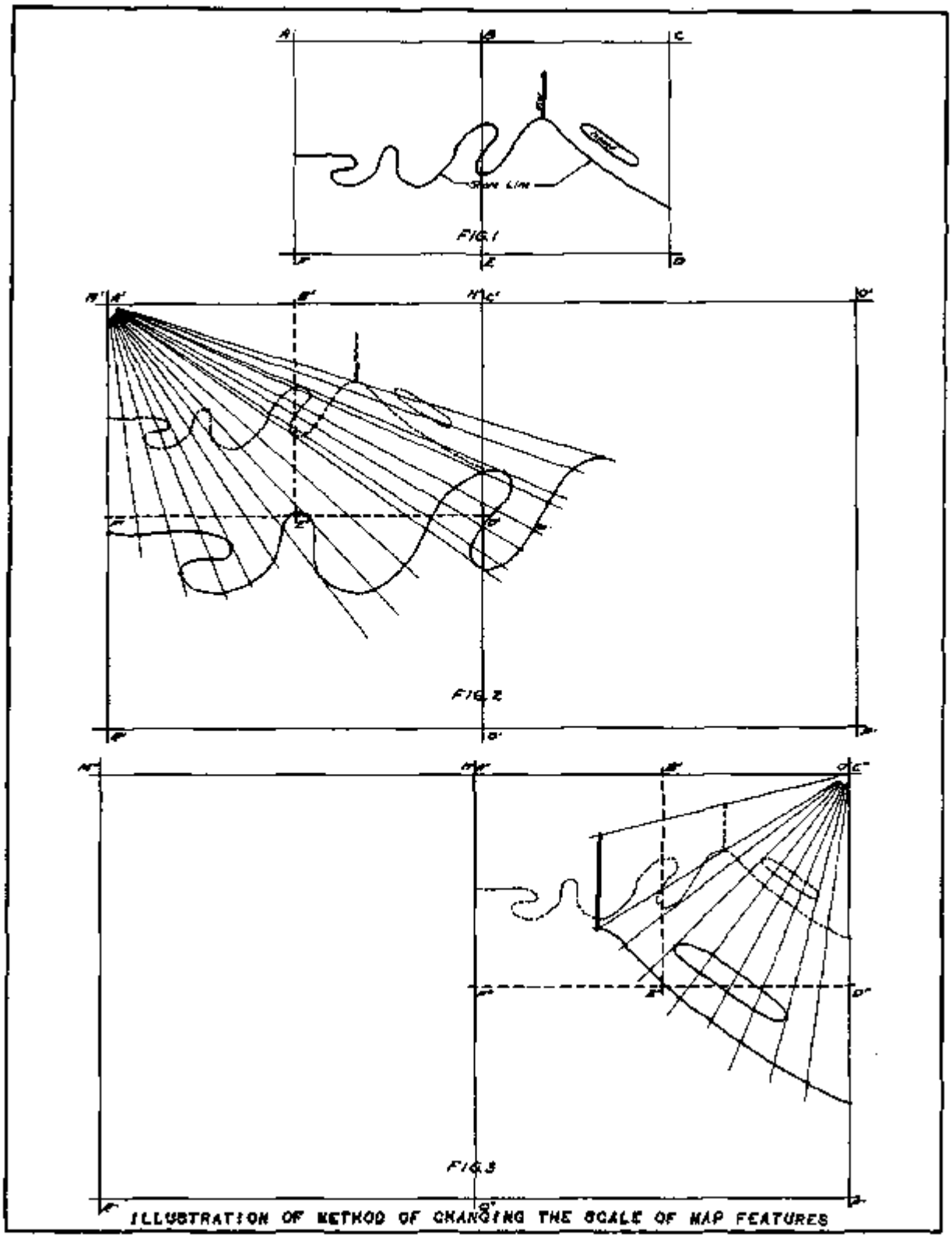


ILLUSTRATION OF METHOD OF CHANGING THE SCALE OF MAP FEATURES

A BIBLICAL ACCOUNTING OF TEE USE OF THE LEAD-LINE

Paul C. Whitney, Chief, Division of Tides and Currents,
U. S. Coast and Geodetic Survey.

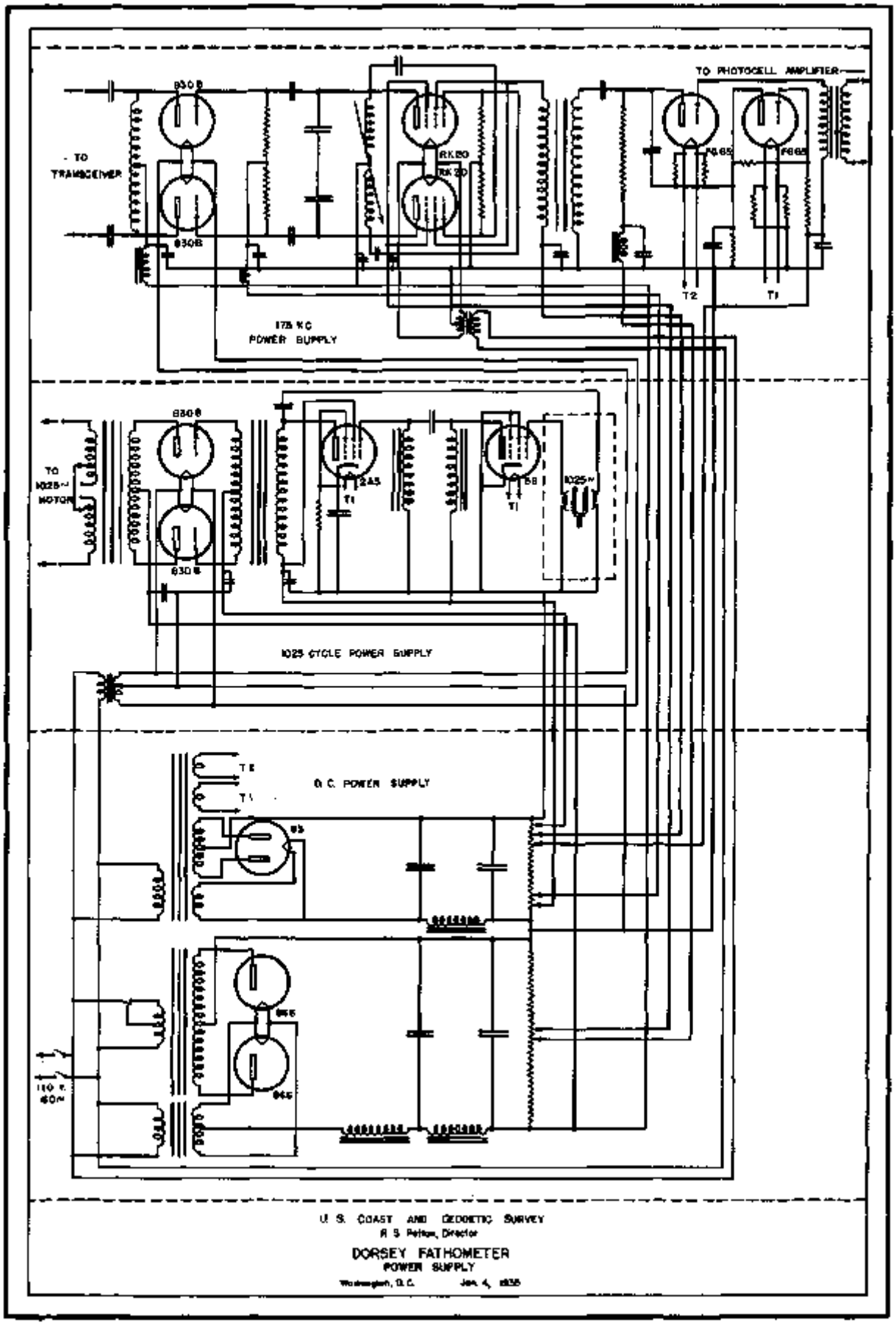
Probably one of the earliest records of sounding as an aid in navigation is found in the Bible, in the Acts of the Apostles.

From biblical history, it was in A. D. 59 that Herod Agrippa II, King of Chalcis when St. Paul was a prisoner in Palestine, ordered him to be sent to Rome to appear before Caesar. St. Paul, in company with other prisoners, embarked in an Adramytian ship, which was engaged in the coasting trade, and after touching at Sidom sailed under the lee of Cyprus and then crossed to Myra. Here the prisoners were transshipped into one of the large ships that carried com from Alexandria to Rome. After sailing slowly along the coast for many days, on account of light baffling airs, the vessel came opposite Cnidus, and not being able to hold on to the usual course to the south point of Morea, as the winds were to the westward and northwestward, a course was made for Crete. Working westward under the south coast of Crete, an anchorage was made at Fair Havens, a roadstead which still retains its ancient name. The ship remained here until October and, as the stormy season was near at hand, Paul evidently having been consulted as to the time of departure recommended remaining at Fair Havens until a more propitious season, but was overruled by the Centurion, who sided with the Captain and Sailing Master. With a light southerly breeze blowing the ship left Fair Havens but hardly had rounded Cape Metala when it ran into severe gales which struck down from the Cretan Mountains. The ship sought temporary shelter under the Island of Clauda, where ropes were passed under the ship's frame to hold together her straining timbers. Fearful of being blown into the Syrtis or Great Quicksands, the ship's head was brought as near as possible into the wind and was hove-to under sufficient canvas to keep her steady. In this condition, she drifted through the Adria Sea, lying between Malta, Italy, Greece and Crete. On the first day the freight was thrown overboard, and on the second, the crew and passengers joined in throwing the spare gear into the sea. Then followed days of anxiety, during which all hope was abandoned, but the ship's company was sustained by the cheering courage of St. Paul. The rest is adequately expressed in the 27-29 verses of the 27th Chapter of The Acts:

> "But when the fourteenth night was come, as we were driven up and down in Adria, about midnight the shipmen deemed that they drew near to some country:
>
> "And sounded, and found it twenty fathoms: and when they had gone a little further, they sounded again, and found it fifteen fathoms.
>
> "Then fearing lest they should have fallen upon rocks, they cast four anchors out of the stern, and wished for the day."

Subsequently, however, the ship having become quite unseaworthy, she was beached on the Island of Malta, at a place now reasonably identified as a neck of land projecting toward the Island of Salmonetta, which shelters St. Paul Bay on the northwest.

No doubt, but for this precaution of sounding (we wonder what they used for a lead line), the ship would have been totally wrecked with a loss of life. However, the entire company of 276 souls was landed safely in Malta, where the Bible states they remained three months.


TO PHOTOCELL AMPLIFIER
TO TRANSCEIVER
830B
830B
RK20
RK20
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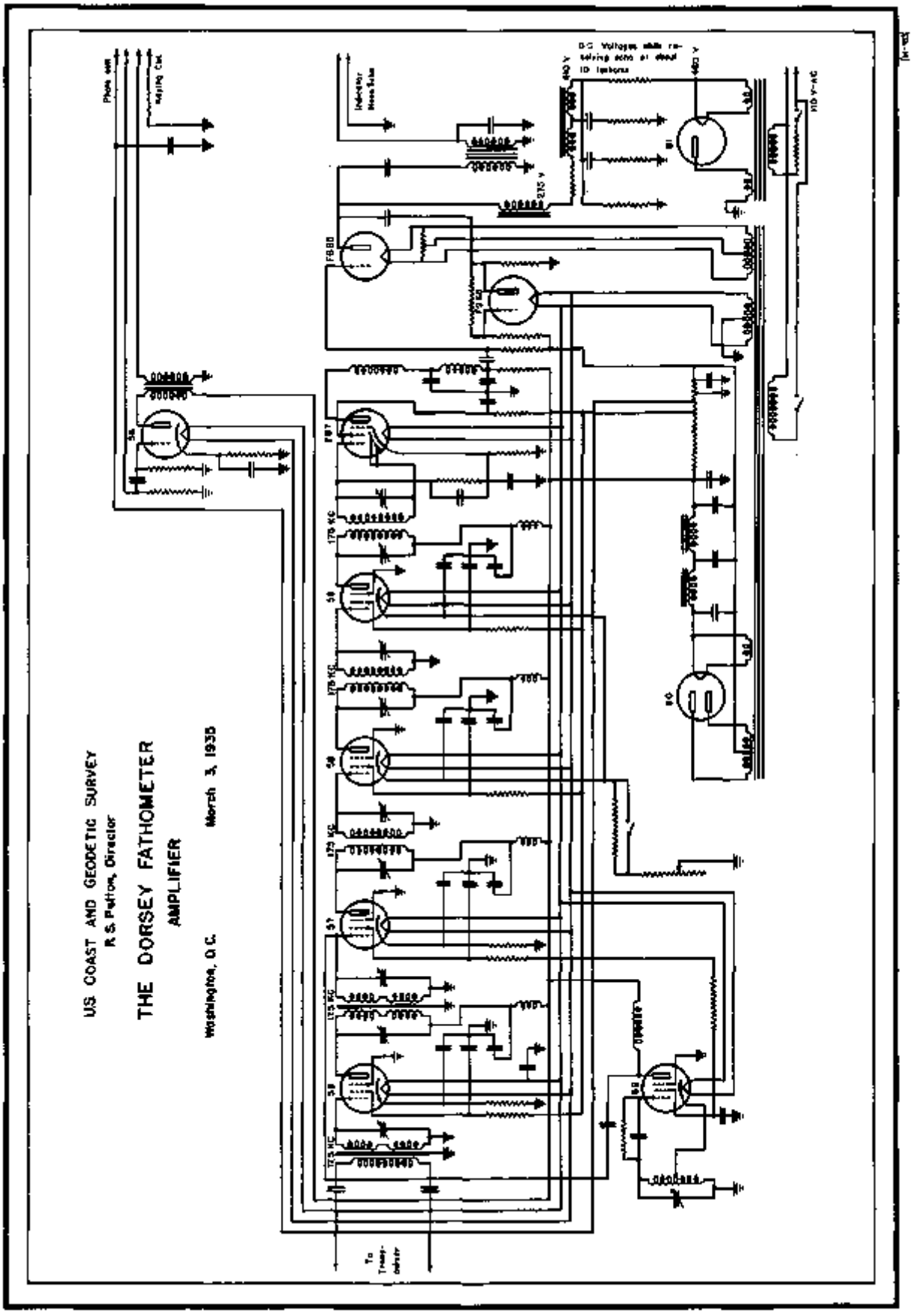
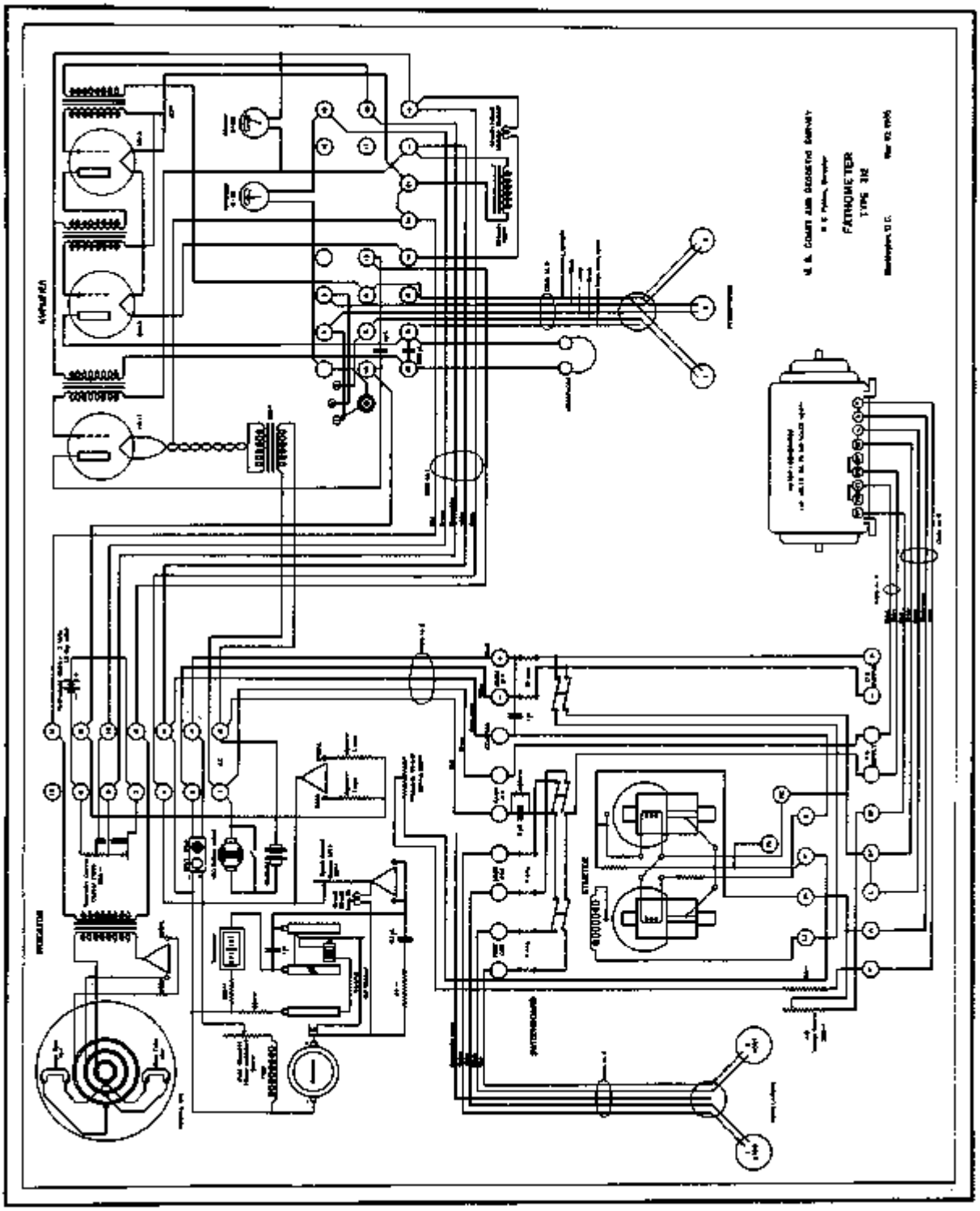
T2
T1
175 KC POWER SUPPLY
830B
830B
TO 1025~ MOTOR
245
T1
58
T1
1025~
1025 CYCLE POWER SUPPLY
D. C. POWER SUPPLY
T2
T1
83
866
866
110 V. 60~
U. S. COAST AND GEODETIC SURVEY
R. S. Patton, Director
DORSEY FATHOMETER
POWER SUPPLY
Washington, D. C.
Jan. 4, 1935


U.S. COAST AND GEODETIC SURVEY
R. S. Patton, Director
THE DORSEY FATHOMETER
AMPLIFIER
Washington, D.C.
March 3, 1935
Phone set
Keying Ckt.
Indicator Neon Tube
To Transducer
D.C. Voltages while receiving echo at about 10 fathoms
460 V
215 V
110 V-AC
175 KC
125 KC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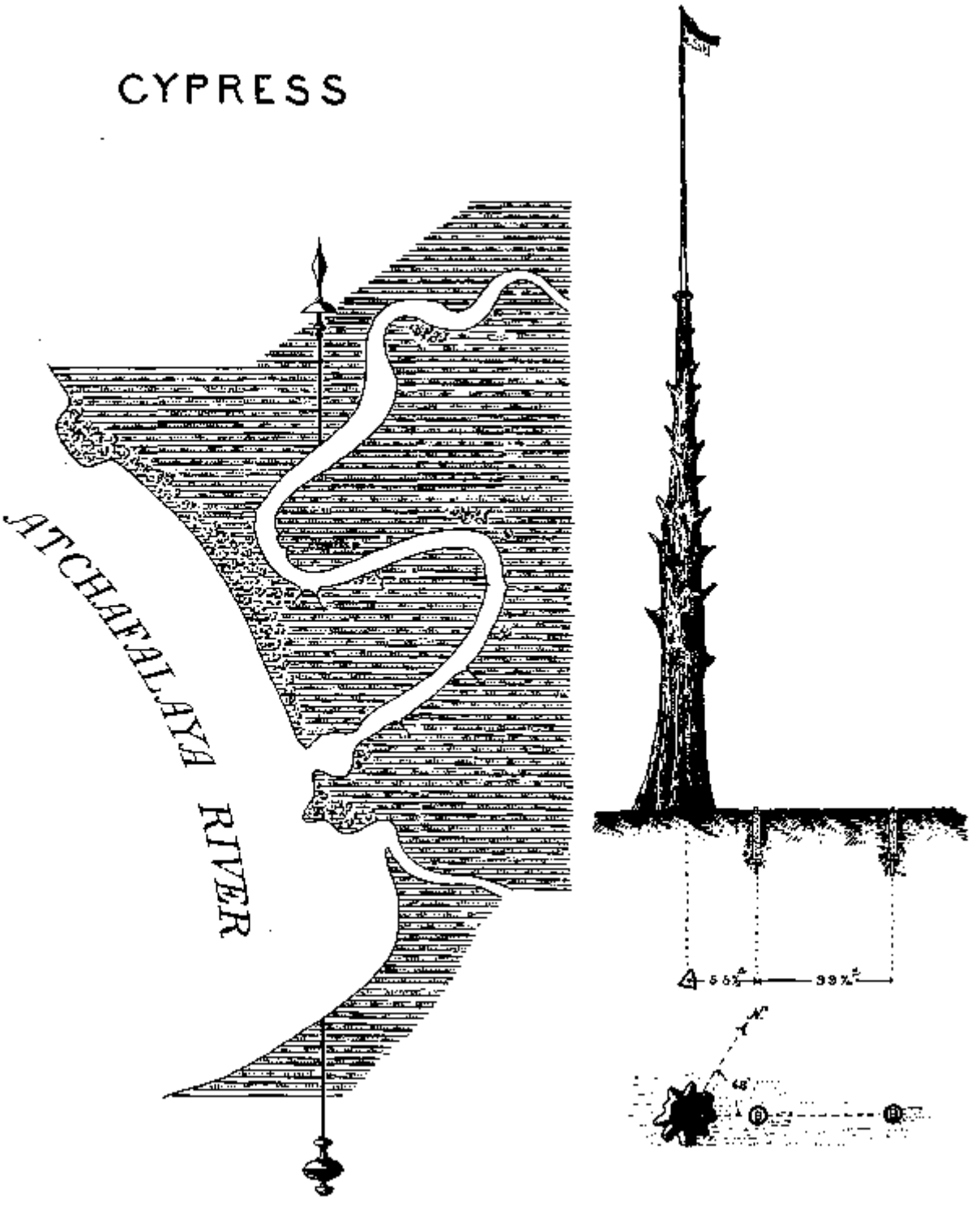
FATHOMETER
TYPE 312
Washington, D.C.
Mar 10, 1950
INDICATOR
STARTER



Sketch from the Description of Stations Record, U. S. Coast and Geodetic Survey, Atchafalaya Bay and River, 1888 (Louisiana) Vol.I, p.13. Assistant C. H. Sinclair, Chief of Party.

(THE TITLE ON U. S. COAST AND GEODETIC SURVEY TOPOGRAPHIC SHEET NUMBER 45)

Section of U. S. Coast and Geodetic Survey Topographic Sheet No. 45, on original scale with enlargement of upper part of race course. (Title for this sheet is on preceding page). This sheet was done on rough surface drawing paper in 1835, 36, 37 and is 96 inches by 49 inches in size, 1:20,000 scale.

A PROJECTOR FOR TRANSFERRING DETAIL FROM ODD-SCALE PHOTOGRAPHIC COMPILATIONS TO HYDROGRAPHIC SHEETS

S. B. Grenell, Jr. H. & G. Engineer,
U. S. Coast and Geodetic Survey

The air-photo project, sheets for which were compiled at Savannah, Georgia, by a field party of the U. S. Coast and Geodetic Survey, covered a strip of coastline approximately fifteen miles wide extending from the vicinity of Beaufort, South Carolina to the St. Johns River, Florida. The entire project covered an area of 3051 square statute miles embracing 5414 statute miles of shoreline. At approximately the same time that photo compilation was begun, five separate combined operations parties took the field within the project area. These field parties had immediate need for the shoreline for hydrographic sheets, so the photo compilations were rushed through with shoreline only; the other detail being left to be added at a later date.

Except for a narrow strip of single lens photographs along the Inside Route, which were enlarged to true 1:10,000 scale, the photographs varied from the standard scales by 6 to 9 per cent. This made it impossible to transfer the detail to true scale hydrographic sheets by the usual tracing paper method. The next procedure was to forward the compilations to the Washington office as soon as the shoreline was completely traced in order that true scale photostats could be made. This procedure was very unsatisfactory for several reasons. The Chart Division was so rushed under the expanded program that they were unable to make the required photostats immediately thus holding up work on the compilations and hydrographic sheets where the shoreline was required. Also, the photostats, when received, were frequently so badly distorted that a great deal of adjustment was required in making the transfer tracings for the hydrographic sheets. This system had a further disadvantage in that it was necessary to go over each line three times in transferring from the photostat to the hydrographic sheet thus losing considerable fine detail in the process. A further difficulty arose in making comparisons in the field between detail rodded in on the aluminum mounted control sheets and the compilations. This comparison should be made, where possible, at the time the compilation is being traced, thus avoiding a great deal of difficult erasing at a later date.

After studying the problem for some time, it was decided that a type of enlarging and reducing projector similar to a photographic enlarging machine could be designed to meet the requirements. Various crude experiments were made with cardboard boxes fitted with an ordinary magnifying glass as a lens. It was immediately apparent that the principle was sound but that an accurate lens would be required. A great deal of credit for the development of this projector should be given to Mr. T. R. Cooper, who was employed at that time as a draftsman on the party. Mr. Cooper had had considerable amateur photographic experience and owned a small 5" x 7" enlarging machine which he brought down to the office and with which further experiments were made.

Authority to construct the projector was obtained and a suitable lens was furnished by the Washington office. A second-hand camera bellows and track was purchased from a local photographer and the main projector assembly designed to fit the camera frame and lens. A lens with a different focal length would require a change in the design of the vertical track.

The lens used in the design is a double lens assembly Bausch and Lomb Optical Co., Protar, Series VII, Focus 13-3/4" and 18-7/8". The camera bellows and track assembly are Eastman View Camera 2-D, 8" x 10". The lighting unit illustrated in the accompanying sketches is a General Electric 16" High Mounting Unit No. R 1 S-500. The pipe support and ventilated extension to the reflector were made locally. Bids for the wood work on the projector were received from local planing mills and the projector built under the supervision of the writer. The reflector extension as illustrated on the print is constructed from a strip of aluminum rolled at the edges to clamp at the top on the beaded edge of the reflector and to hold a sheet of ground glass at the bottom. V shaped notches were cut in a double line along the center of the extension strip and the "tabs" bent in to form supports for a sheet of clear glass which acts as a screen to reduce the amount of heat reflected. A double row of 1" holes - above and below the glass screen - furnish ventilation and cut down the amount of heat reflected to the board. A 150 watt bulb will give ample illumination with a minimum amount of heat. A larger bulb may be used if the compilation is not left under the reflector too long.

The cost of the projector exclusive of the lens is as follows:

Second Band Camera	$25.00
Fabrication and Assembly of Projector	40.00
Reflector Unit	10.00
Reflector Extension Assembly	10.00
Reflector Support Assembly	5.00

The entire structure has been designed so that it may be dismantled and crated for shipment. This is an important factor since the projector will be used primarily in field offices which are shifted frequently. When the projector was tested out it was found to have an enlarging and reducing ratio of approximately 1 to 3 1/2 which can be extended to 1 to 4+ by sliding the movable board above the top of the vertical track.

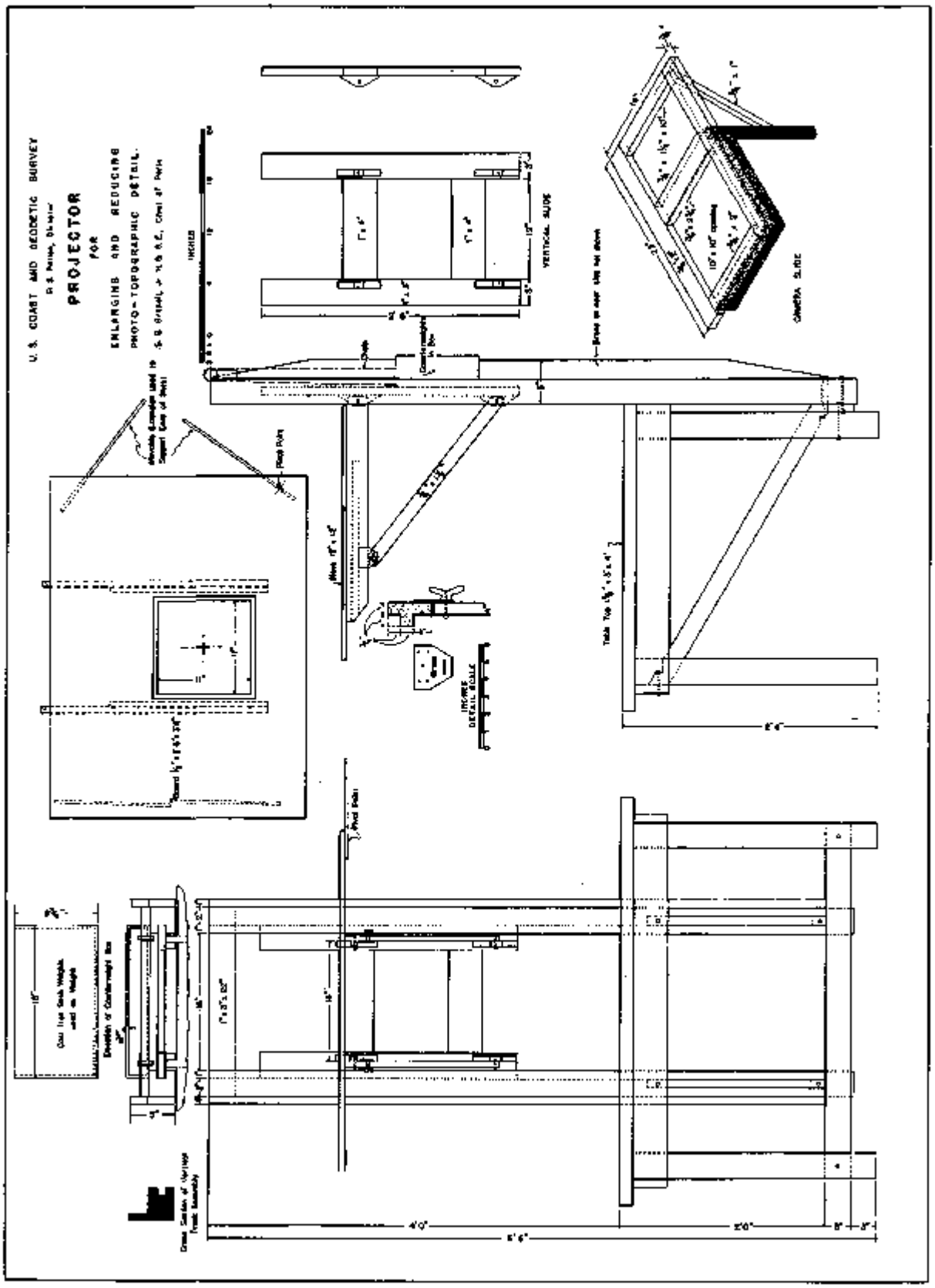
In transferring shoreline to hydrographic sheets the compilation is placed on the upper or movable board and the hydrographic sheet placed on the table. The scale is adjusted by a combination movement of board and lens until the projections match and the image is sharp. The shoreline can then be traced directly on the hydrographic sheet with no intermediate process. This can be done in a fraction of the time required to prepare tracings from photostats; the cost of photostatic reproduction is eliminated, and the errors due to photostat distortion and repeated tracing are avoided. The principal advantage, however, is in the saving in time both to the hydrographer and compiler, in that the work is done as required in the field, and no time is lost on plotting or compilation while waiting for sheets to be returned to the field.

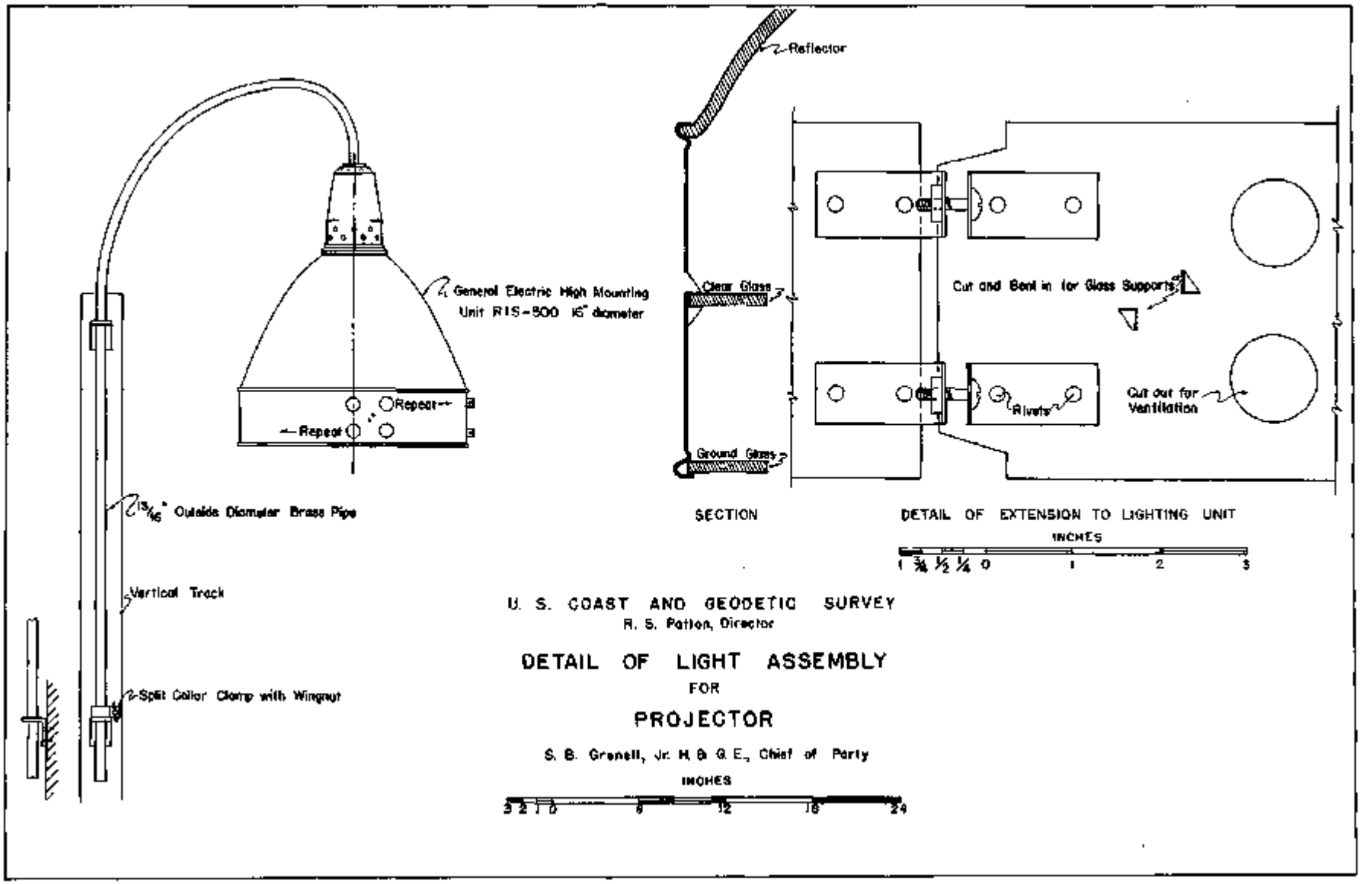
The projector was designed primarily for the transfer of shoreline but it was soon found to have other uses of only slightly less importance. All detail inked on the aluminum mounted control sheets can be quickly and accurately checked against the compilations by the method outlined above. Another important use is in the comparison of junctions between compilations of different scale. This process heretofore required tedious use of the proportional dividers which process at best was often inadequate where junction detail was intricate. Comparison with charted detail can be made in the same manner by projecting the compiled shoreline onto large scale charts of the section. This is very useful in checking structures along waterfront areas.

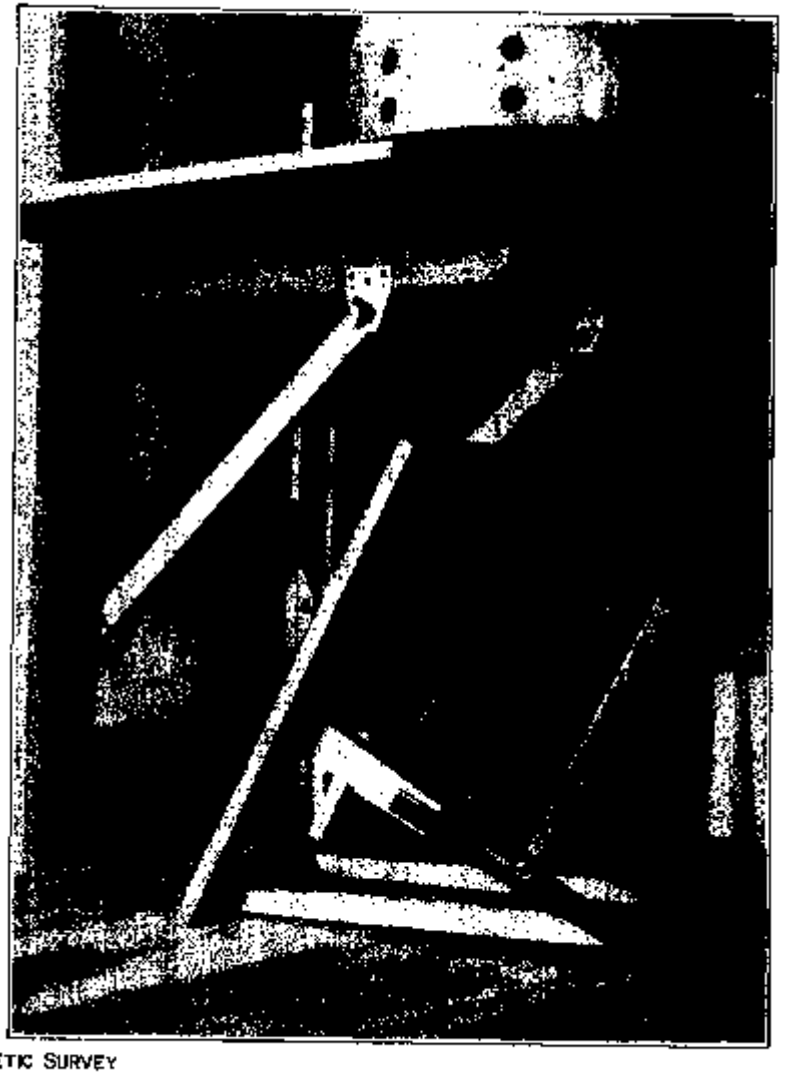
In several instances it was found that the paper of the hydrographic sheet had distorted. This distortion was generally greater in the direction of the long axis of the sheet thus "warping" the projection. This could be compensated for by "warping" the projected image of the compilation which is done by tilting the lens slightly or by shifting the lens in a horizontal plane or by both, thus making it unnecessary to adjust the sheet frequently while tracing an area.

Along the south Atlantic Coast the field topographer frequently finds areas in which it is exceptionally difficult or even impossible to carry planetable surveys for hydrographic control. This may be due to lack of precise control, unstable marsh land areas where set-ups are difficult or restricted ground visibility. Several such areas were found in Georgia, the most extensive being the Altamaha River above Darien. This river winds for a distance 21 miles through a dense cypress swamp where planetable control is impossible, so Lieutenant C. A. Egner, who was in charge of the hydrographic party, tried the following experiment.

The building party took aerial photographs of the area with them to the field, and spotted the hydrographic signals on these prints as they were built. The signal points were then carefully transferred to the mounted office prints and plotted on the compilation with colored ink by holding the surrounding radial points. This method assured a more accurate signal location than could be secured by spotting the signals on the compiled shoreline. The signals and shoreline were then projected directly on the boat and smooth sheets, and the colored hydrographic signals removed from the compilation. The field prints on which the signals were spotted were retained by the hydrographic party and forwarded with the hydrographic sheets in lieu of topographic control sheets. This system proved to be satisfactory and was used several times on the Georgia project and is being used at this time by Lieutenant J. A. Bond in the Pungo River area in North Carolina.


U. S. COAST AND GEODETIC SURVEY
PROJECTOR
FOR
ENLARGING AND REDUCING
PHOTO-TOPOGRAPHIC DETAIL.
VERTICAL SLIDE
CAMERA SLIDE
INCHES
INCHES DETAIL SCALE
Table Top
Pivot Pin
Pivot Rod
Board
Counterweight Box
Cast Iron Sash Weights used as Weights
Elevation of Counterweight Box
Cross Section of Vertical Track Assembly
4'0"
5'6"
2'0"
8"
3"


Reflector
General Electric High Mounting Unit RIS-500 16" diameter
Repeat
Repeat
13/16" Outside Diameter Brass Pipe
Vertical Track
Split Collar Clamp with Wingnut
Clear Glass
Ground Glass
Cut and Bent in for Glass Supports
Rivets
Cut out for Ventilation
SECTION
DETAIL OF EXTENSION TO LIGHTING UNIT
INCHES
U. S. COAST AND GEODETIC SURVEY
R. S. Patton, Director
DETAIL OF LIGHT ASSEMBLY
FOR
PROJECTOR
S. B. Grenell, Jr. H. & G. E., Chief of Party
INCHES



U.S. COAST AND GEODETIC SURVEY

A PROJECTOR FOR TRANSFERRING DETAIL FROM ODD-SCALE PHOTOGRAPHIC COMPILATIONS TO HYDROGRAPHIC SHEETS

S. B. GRENELL, CHIEF OF PARTY

THE LAMBERT PROJECTION

ITS ADVANTAGES FOR AIRWAY MAPS OF THE UNITED STATES

The Air Commerce Act of 1926 provided for the charting of airways and the publication of maps for safety in flying. At that time there were no aviation maps of the country, and no previous maps that could serve even as an adequate base for the addition of aeronautical data. A new type of map for aerial needs was urgently required, and to the U. S. Coast and Geodetic Survey of the Department of Commerce was assigned the technical work of investigating this field, and of compiling and publishing the new maps for the airways.

The first step was the determination of the best framework on which to delineate as true a representation of the earth's surface as is practical for this purpose. In the selection of this framework, or projection, the factors considered were:

(a) The geographic location and extent of the United States on the globe.

(b) The solution of problems of celestial navigation.

(c) The determination of position in the air by dead reckoning from accurate courses and distances.

(d) The use of radio bearings for position finding.

(e) Correct representation of topographic features visible to the airman.

(f) The junctions of all adjacent sheets on the same scale.

(g) Adaptability for use by all pilots.

After thorough investigation the Lambert conformal conic projection was selected. Although this projection was devised about 1772, it is only within the last twenty years that it has come into general use. In order to meet the need for a system of maps affording a maximum accuracy of directions and distances, the Lambert projection was adopted for the military maps used by the Allied Forces during the World War.

Since the World War, an increasing number of leading navigators and aeronautical authorities at home and abroad have come to appreciate the navigational advantages of the Lambert projection, as will be pointed out later. The reason for this is found in the fact that the same properties which make the projection so valuable for military purposes make it equally valuable for air navigation, since accurate and easy determination of distance and direction are the basic problems of all forms of navigation.

So far as is known, the Lambert projection had not been used for navigation prior to its adoption as the basic framework for the air maps of the Department of Commerce. Geographically, the United States is situated so as to afford more advantages, with fewer limitations, in the use of this projection than in the use of any other. By its use all problems of navigation can be solved quickly and satisfactorily.

The following summary is made of the advantages of the Lambert projection:

1. It permits a perfect junction between any number of maps in any direction.

2. It is unexcelled for scaling distances in all directions in the United States.

3. Its directions, or azimuths, conform very closely to directions on the earth.

4. It provides the best possible map for pilotage.

5. It affords a simple and satisfactory solution for all problems of dead reckoning, not excepting the rhumb line.

6. It affords the simplest possible means of practical great-circle navigation.

7. It is unusually suitable for celestial navigation and all problems requiring the plotting of positions.

8. It is unsurpassed for all types of radio navigation.

Reference has already been made to the increasing number of leading navigators and aeronautical authorities, at home and abroad, who have come to appreciate the navigational advantages of the Lambert projection. In the following paragraphs, representative opinions and quotations are cited.

In 1924 the National Advisory Committee for Aeronautics issued its "Technical Report No. 198: Astronomical Methods in Aerial Navigation," by K. Hilding Beij, of the Bureau of Standards. This report is the result of a thorough study of developments in this country and abroad, and is so thorough and scholarly that it has served as the genesis of practically all worth-while developments since. From pp. 43 and 44, we quote:

> "To be of service in the plotting of astronomical observations, the general map should have certain characteristics, and it so happens that these are convenient, if not essential, for the other uses to which the map may be put. The meridians should be straight lines, or very nearly so, in order to facilitate the plotting of azimuths. Furthermore, all great circles should be represented by straight or nearly straight lines. This property is essential, as often the intercept between the dead reckoning or assumed position and the position line is comparatively large. Finally, all angles should be as nearly true as possible and the scale should be the same at all points of the map and in all directions. These requirements can not, of course, be realized except approximately, However, there are several forms of projection which are suitable, provided too great an area is not shown on one sheet, an example being the Lambert conformal conic projection."

In the International Hydrographic Bulletin for February 1932, pp. 38, 39, there is reviewed an article published by Lieut. Colonel Ed de Martonne, in Annales de Geographic, Paris, January 1932. The article states that almost the whole of France was then covered by air charts at a scale of 1:200,000 on the polyhedric projection, while the French colonies were covered by air charts on the Mercator projection, at a scale of 1:3,700,000 at the equator. The article continues:

> "We now find ourselves, however, faced by the following phenomenon:- the above-described cartographic system has already fallen behind the times ..... Henceforth the standard air-chart will be on a scale of 1:1,000,000 and the general chart on 1:10,000,000 at the equator. They will be based respectively on the International One-Millionth Map of the World and the General Bathymetric Chart published by the International Hydrographic Bureau of Monaco, which latter, as is well known, is completed. Lastly, an entirely new type of document is being used for the planning and carrying-out of the great intercontinental flights, namely, Mr. Kahn's track charts or itineraries. These "strip charts", which cover the principal routes of the world, are drawn up on a particularly ingenious oblique conformal cylindrical projection; they were invented specially for orthodromic navigation, i.e. along the shortest route on the surface of the earth."

In Bulletin No. 21 of the International Commission for Air Navigation, October, 1933, P. 49, it is stated that the British, also, have discontinued 8 sheets which they had already published on the Mercator projection, at the scale of 1:3,700,000 at the equator, in favor of the French system outlined in the preceding paragraph.

The International Commission for Air Navigation has adopted the French system outlined above, plus one additional series at a scale of 1:3,700,000. - Official Bulletin No. 20, October 1932, pp. 43-45.

(Note. The projection of the International One-Millionth Map of the World, adopted as standard by the French, British, and International Commission for Air Navigation, is the Modified Polyconic. Although in general this projection resembles the Lambert, it is not conformal and lacks many of the desirable properties of the Lambert projection. The projection for the Kahn strip-charts is similar to the Lambert, but is subject to the disadvantage of curved meridians. The use of the Mercator projection is recommended by the International Commission for Air Navigation only for the series of very small scale control maps covering the entire world; for a world map the Mercator offers certain advantages, but for the United States the Lambert is superior for air navigation.)

Admiral Tonta, International Hydrographic Bureau, in the Hydrographic Review, November 1929, p. 65:

"We are convinced that in very many circumstances, the Lambert projection can, with appreciable advantage, replace Mercator's projection as a basis for nautical charts".

In "Traité des Projections des Cartes Geographiques," published in four volumes, by Driencourt and Laborde, Paris, 1932, vol. 2, pp. 94-105 and p. 215, in chapter on "Projections pour les cartes de Navigation Aerienne, the importance of projections other than the Mercator for non-equatorial regions is stressed, as well as the need for charts that will be self-contained and sufficiently accurate to utilize radio bearings without correction:

"Navigation by Radio Bearings Taken aboard the Aircraft: It seems as if these methods of navigation would have to give place in the more or less distant future to a fourth, which allows the navigator to locate himself when all other methods fail, namely, that of radio bearings taken aboard the aircraft itself on radio beacons: this is the analogue of the method of marine navigation called "navigation by bearings of points ashore." But, whereas in this latter case the bearings are almost always taken at distances short enough so that they may be identified without great error with their rhumb lines, this is not the case with the radio bearings, which may be taken upon radio beacons some hundreds of miles away; in this case the discrepancy between the rhumb line and the arc of great circle which the Hertzian waves are supposed to follow is no longer negligible; and since this discrepancy is a function of the unknown position of the aircraft, its determination requires in general two approximations. The Mercator chart is, therefore, unsuitable for this kind of navigation, at least when it is used alone. The same is true of Hilleret charts and *a fortiori* for charts on the oblique gnomonic projection: In this case the correction of the bearing depends on the direction and on the position of the aircraft with reference to the center of the chart, so that its determination still requires several approximations."

The following cartographic system is suggested by the same authors:

The Mercator projection -
between 15° south latitude and 15° north latitude.

The Lambert conformal conic projection, in three bands -

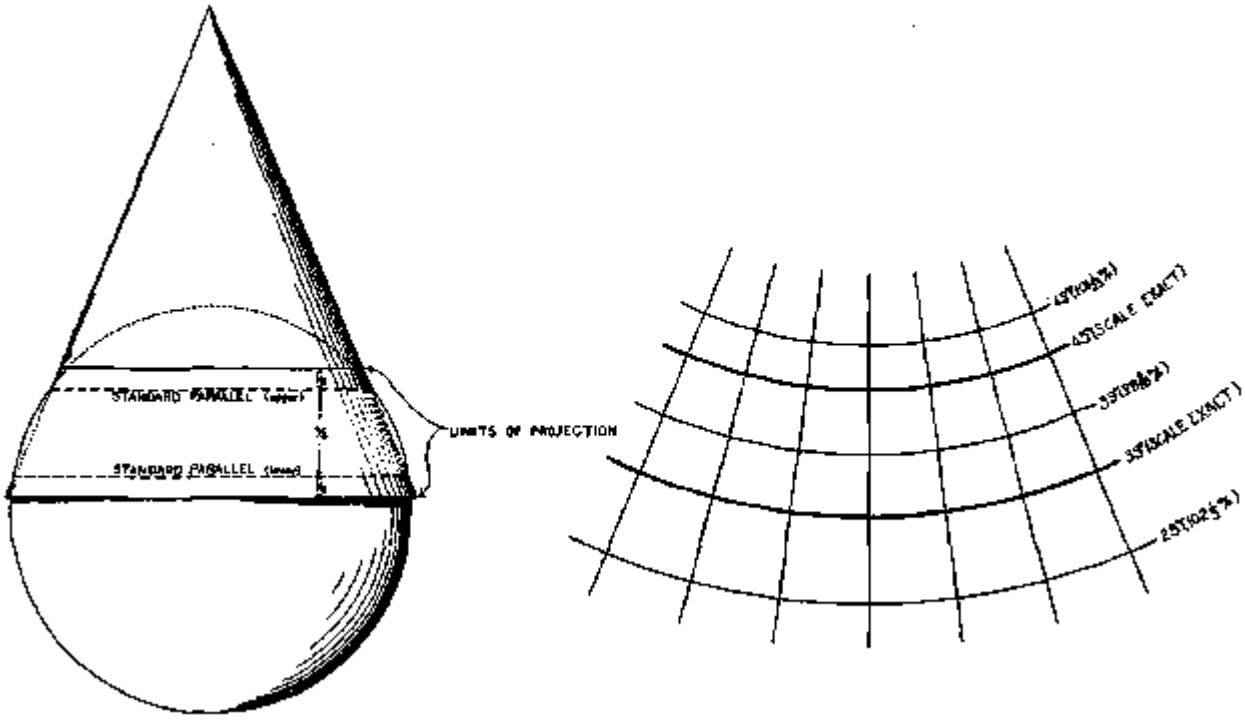
(1)	between	latitude	10°	and	latitude	40°
(2)	"	"	30°	"	"	60°
(3)	"	"	50°	"	"	80°

The stereographic projection -
from latitude 75° to the poles.

General P. de Vanssay de Blavous, Director, International Hydrographic Bureau, in an article on Navigation by Great Circle Sailing and Radiogoniometric Bearings," Hydrographic Review, November 1928, p. 49:

"The Coast and Geodetic Survey of the United States of America publishes for its coasts and for the North Atlantic, outline charts Nos. 3069 (1921), 3060 (1919), and 3070 (1918) on Lambert's conformal conical projection. On these charts, the great circles differ so little practically from straight lines that it is generally useless to make any distinction. Besides, this projection being conformal and the meridians being straight lines, the course angles are easy to measure and the distances are so little modified in the zone for which the chart is drawn up, that they can be measured as if the scale of the chart were constant."

There are other references which could be cited to confirm the advantages of this projection for present needs. The rapid development of aviation indicates possibilities for increases in speed and distance flying which will bring improvements in navigational equipment and require greater dependence on accurately constructed maps. Anticipating each forward step in the evolution of air navigation and equipment, the Lambert conformal conic projection not only meets the needs of the industry today, but provides the best framework upon which to present future cartographic advances. This conclusion has been reached from many practical tests made by the U. S. Coast and Geodetic Survey. Those particularly interested may obtain further data by addressing the Director, of the U. S. Coast and Geodetic Survey.



Lambert Conformal Conic Projection

In general, for equal distribution of scale error, the standard parallels are taken at one-sixth and five-sixths of the total length of that portion of the central meridian to be represented. With the standard parallels at 33° and 45°, as chosen for the aeronautical charts of the United States, the maximum scale error for approximately ninety percent of the country is but one half of one percent, thus allowing that extensive and most important part of the United States to be favored with unusual scaling properties. The maximum scale error of 2 1/2 percent occurs in southernmost Florida. In southernmost Texas it is somewhat less.

FISHING IN THE ALEUTIAN ISLANDS WITH A LEADLINE FOR A TOPOGRAPHIC SHEET

Ross A. Gilmore, Jr. H. & G. Engineer, U.S.C. & G. Survey.

Last summer while making a topographic survey of a portion of Beaver Inlet, Unalaska Island, Alaska, I had the misfortune to lose an aluminum mounted topo sheet overboard in 8½ fathoms of water. As I also had the good fortune to get it back again, I thought it might he of some interest to say something about the incident.

The day was very cloudy and squally (usual Aleutian weather) so that the sheet was discernible from the surface only at fleeting moments when there would be a rift in the clouds, allowing the sun to shine through and clear up the water. During one of these moments a marker buoy was planted so that the position of the sheet could be kept. Due to the character of the bottom, it was apparent that the only way to get the sheet was to pierce it and hope to pull it back to the surface.

At a time like this, nature makes all of us inventors of a sort. Two ten-penny nails were laid for about half their lengths along the opposite sides of a 30 pound sounding lead, with the points of the nails projecting downwards below the bottom of the lead. They were pounded well into the lead, and the lower end of the lead served with marline to secure the nails. The lead (attached to the lead line) was then lowered into the water, maneuvered over the sheet, raised about 5 feet and dropped, then slowly raised to the surface. This was done numerous times without success as the sheet usually could not be seen. Finally a lucky shot pierced the sheet and it was successfully raised to the surface. Due to the force necessary to pierce the sheet, two dents were made which were pounded out, taking particular care not to injure the surface of the paper.

The sheet was in the water about forty-five minutes and during this time numerous large blisters were formed by the paper swelling away from the aluminum core. If the sheet was to be of any value, it was apparent that all these blisters, or bubbles, had to be eliminated, and with care, in order to minimize distortion. The sheet was sandwiched between 2 pieces of cloth and several sheets of newspaper (to help absorb the moisture from the cloth), placed on top of a flat table and the plane table board placed on this with ten, thirty pound sounding leads on top of the board and left this way for thirty minutes. At the end of this time the cloth and papers were renewed with dry ones and the process continued. This was done over a period of six hours until all the moisture and blisters were entirely gone from the sheet. It was due to the particular care taken in drying it out that such excellent results were obtained.

The paper surface of the sheet stood up remarkably well, and except for the holes made by the nails (which fortunately happened in water areas on the sheet), the sheet suffered no bad results. The work was about nine-tenths finished at the time so that none of the work was affected by the few irregularities in the sheet. As far as could be determined, the sheet underwent no particular distortion; the overall length of the projection remained the same and the overall width appeared to be 2 to 5 meters shorter in 9900 meters. The latter may have been in the original projection layout or just usual distortion during the course of the work.

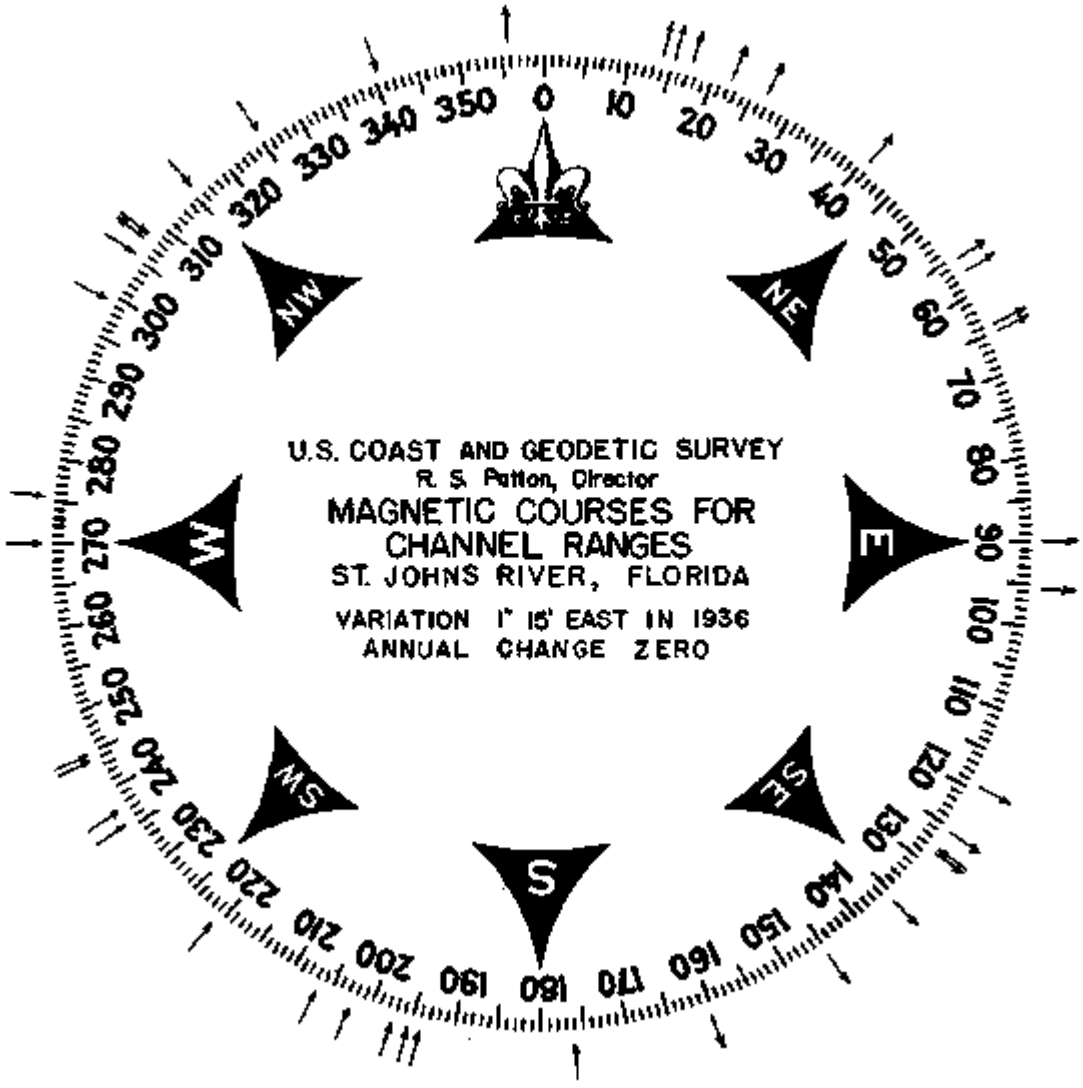
This is about as severe a test of a topographic sheet as could be imagined and speaks very well for the paper used in these sheets. No difficulty was encountered in inking the sheet.

It is recommended that some better form of sheet clamp be devised for holding the aluminum mounted sheets to the plane table board. The regular plane table board sheet clamps were being used at the time, and the accident would have been avoided had some better means for securing the sheet to the board been in use.

USE OF NAVIGATIONAL RANGES FOR OBTAINING COMPASS DEVIATIONS

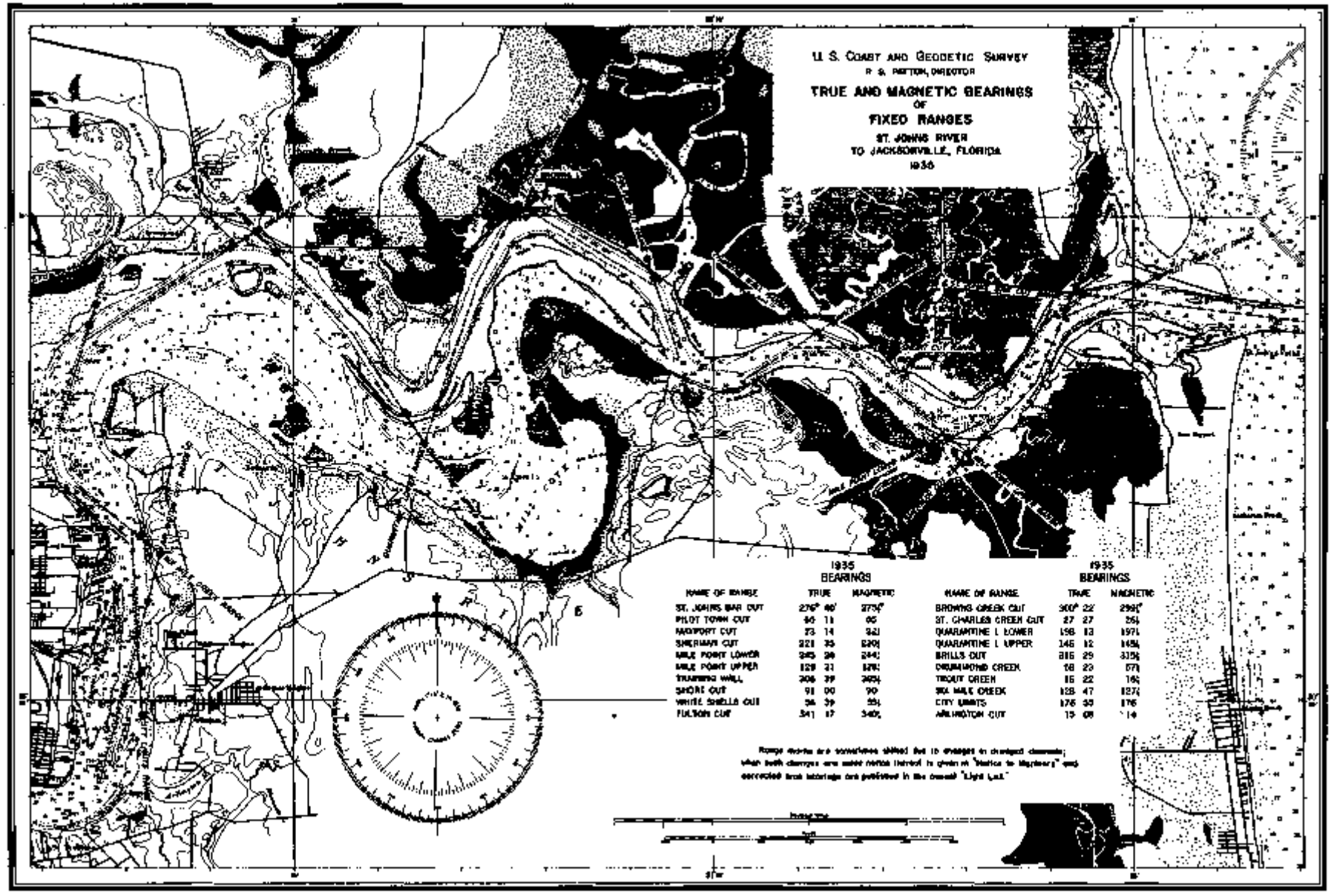
E. W. Eickelberg, H. & G. Engineer, U.S.C. & G. Survey,
Assistant Chief, Division of Terrestrial Magnetism and Seismology

An excellent opportunity for obtaining compass deviations from navigational ranges is afforded in the St. Johns River in making the passage from the sea to Jacksonville, Florida, and return. The illustration below indicates the various courses steered in making the inbound and outbound trips, shoving a fair distribution of headings along the entire circle of the compass. It will be best to



Compass card showing distribution of points obtainable by using St. Johns River Ranges. Inbound courses are shown by arrows pointing in; outbound courses are shown by arrows pointing out.

plot the deviations obtained for the various headings on a Napier diagram. The smooth curve drawn through these plotted points will furnish values of deviations for any heading or the usual deviation card, if preferred, may be tabulated from the values graphically determined on the Napier diagram. If the deviations are small, not over 2 or 3 degrees, they can be plotted on ordinary cross section paper using a considerably larger scale for the deviation than for the compass headings. In this way a deviation curve is obtained from which it is easier to read the values for tabulation of a deviation table.


U. S. COAST AND GEODETIC SURVEY
R. S. PATTON, DIRECTOR
TRUE AND MAGNETIC BEARINGS
OF
FIXED RANGES
ST. JOHNS RIVER
TO JACKSONVILLE, FLORIDA
1935
1935 BEARINGS
NAME OF RANGE | TRUE | MAGNETIC
ST. JOHNS BAR CUT | 276° 40' | 275½°
PILOT TOWN CUT | 86 11 | 85
MAXPORT CUT | 73 14 | 92½
SHERMAN CUT | 221 35 | 220½
MILE POINT LOWER | 245 30 | 244½
MILE POINT UPPER | 129 31 | 128½
TRAINING WALL | 306 39 | 305½
SHORE CUT | 91 00 | 90
WHITE SHELLS CUT | 36 39 | 35½
FULTON CUT | 341 17 | 340½
1935 BEARINGS
NAME OF RANGE | TRUE | MAGNETIC
BROWNS CREEK CUT | 300° 22' | 299½°
ST. CHARLES CREEK CUT | 27 27 | 26½
QUARANTINE L LOWER | 158 13 | 157½
QUARANTINE L UPPER | 146 12 | 145½
BRILLS CUT | 316 29 | 315½
DRUMMOND CREEK | 58 23 | 57½
TROUT CREEK | 16 22 | 16½
SIX MILE CREEK | 128 47 | 127½
CITY LIMITS | 176 33 | 176
ARLINGTON CUT | 15 08 | 14

In a like manner a vessel loading or discharging a cargo of iron or steel at Jacksonville could obtain sufficient deviations while proceeding down the river to indicate whether compensation is necessary before proceeding to sea.

Magnetic declination observations have been made along the St. Johns River in order to determine whether there is any local attraction in the vicinity of the navigational ranges which would interfere with the use of the ranges for the above purpose. The true bearings of the ranges were determined by triangulation or from the aluminum mounted topographic sheets. In the latter case, special set-ups are made on the ranges and long lines are drawn on the topographic sheet from which the azimuths are then scaled by protractor.

Similar work has been carried on along the Cape Fear River, North Carolina, by a magnetic field party.

This method of using river and harbor ranges for determining deviation is not given as an exact method, since there is some difficulty in placing the vessel on the exact heading. However, the pelorus will be a considerable help in such cases where a clear view dead ahead from the compass cannot be had.

There are, no doubt, other localities in which such opportunities are available, either for larger vessels or for smaller craft. Officers of this service are, of course, familiar with the publication "Magnetic Ranges, San Francisco Bay."

It has been recommended that the azimuths of ranges composed of natural objects or objects of a comparatively permanent nature be printed on the chart. This is in practice on some of the British Admiralty charts. Such ranges are of value in obtaining a fix as well as in the determination of a deviation on the course being steered at the time. The ranges should be checked in the field for visibility from the water area and by actually determining the azimuth from a position on the range or from triangulation positions.

Suggestions for executing work of this kind are invited.

LEAD SHOT BUOY SPACER FOR WIRE DRAG

L.W. SWANSON, JR. H.& G. ENGINEER, AND R.H. MCCARTHY, DRAFTSMAN
U.S. COAST AND GEODETIC SURVEY.

Accompanying this report is submitted a lead shot buoy spacer developed in the shore drafting office in connection with the GUIDE, which is believed to be an improvement over the celluloid or metal type buoy spacer, the use of which is explained on page 21, U.S.C. & G.S. Special Publication No. 118.

The above mentioned publication explains that the celluloid or metal strip can be bent so that the curve will take the proper shape and direction with each end buoy line touching the position of its corresponding buoy. The edge of the curve against the sheet will then show the line of the drag, while the position of each intermediate buoy will be indicated at the point touched by its corresponding line. Where the dragging is approximately a straight line with each of the towing launches maintaining the same spread a normal bight will be had and the above mentioned spacer can be used. It was found in plotting our sheets where the line of drag follows the delineation of the coast line that using the buoy spacer was cumbersome, taking one man to hold the spacer, assuming the shape or position of the drag, while another marked the buoy positions. When another person tried to check the plotting of these buoy path lines in difficult areas he assumed the shape and position of the drag and it was found that in many cases their ideas as to the proper shape of the drag would conflict. In order to check one another it was decided to drag a string of the proper length along the line of drag and note its shape in order to get a more accurate picture of the field condition of the drag. This helped some but it still was not satisfactory. After having tried several different types of buoy spacers we finally decided that the type described was fast, accurate, and gave us more nearly the actual shape of the drag as used in the field.

After the Near and Far buoy positions are plotted and the correct times of each joined, as is the usual practice, the positions of time of tide and depth changes are marked. The total time for the depth change divided by the number of buoys changed will give the time it takes to change one upright plus the time it takes to run to the next buoy. These intervals are so marked on the path travelled by the Near and Far buoys. The lead shot buoy spacer, using the proper number of buoys and the correct length of section, is placed with the N weight directly over the N buoy position and F weight directly over the F buoy position with the bight in the direction as noted in the record. The two end weights are then towed, using a tow length on each end, slowly, carefully and simultaneously to the next identically timed position. The buoy paths to be shown are then marked, drawing a short dash under the line of drag on either side of the buoy and a dash at the mark for position of buoy. The position of the drag or any buoy can be marked at any desired time. Similar lead shot buoy spacers can be made to comply with conditions required, i.e. drags composed of other lengths of sections.

Accompanying this report is a tracing showing a portion of Wire Drag Sheet 6, Season 1934, and photographs of the lead shot buoy spacer in operation. All of B day and positions 6 - 40 E day are shown for this demonstration.

The drag on B day is of length 4800 feet having 12 400 foot sections. The drag on E day is of length 9900 feet having 19 500 foot sections and 1 400 foot section for N - 1 (a string marks the N buoy on the 500 foot drag).

The photographs show the behavior of the drags while they are under unusual conditions. It would be almost impossible to plot the same course with the celluloid buoy spacer and obtain the consistent buoy paths as are obtained with the lead shot buoy spacer. A close study of the photographs will reveal the very irregular course of the drag on B day.

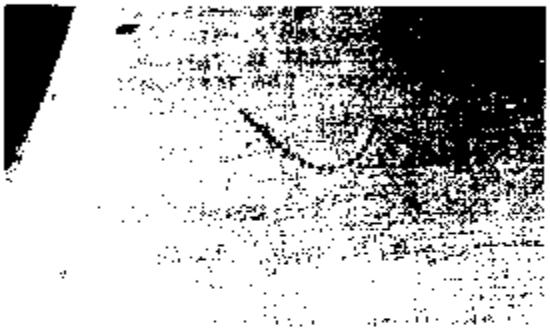
The lead shot buoy spacer is made of split shot pinched on a piece of waxed thread. (The waxing is to keep the thread from raveling). The shot are put on in order from one end to the other because the string stretches some when the shot are put on.

We realize that this buoy spacer is still a bit crude, that the string does ravel, and that some of the shot are not balanced perfectly on the string. As we have been unable to experiment more with this buoy spacer we are not in a position to recommend changes other than to use a better grade of string and still keep its flexibility, and more carefully made shot so that they will be balanced on the string.

Position 13 E day Position 7 B day

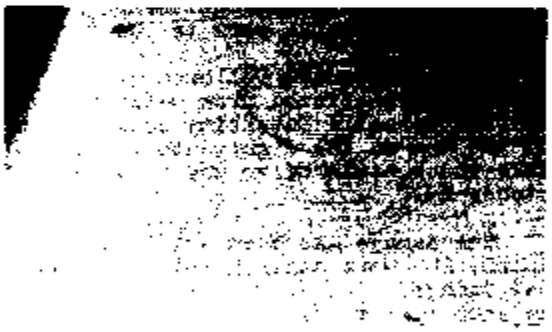
Position 24 E day Position 20 B day

Position 16 E day Position 13 B day

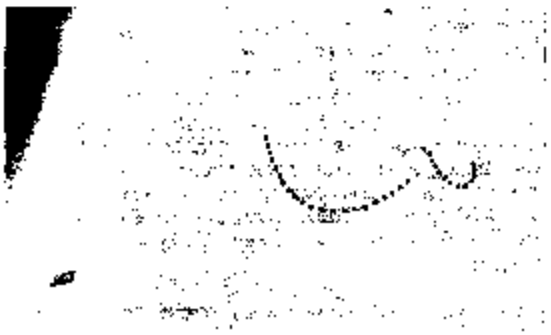


Position 26 E day Position 22 B day

Position 20 E day Position 16 B day



Position 28 E day Position 25 B day



Position 22 E day Position 18 B day

Position 31 E day Position 27.5 B day

WIRE DRAG BUOY SPACER IN OPERATION

COMMENT BY C. K. GREEN

In plotting buoy paths with section lengths and on the scale demonstrated I believe the "Lead Shot Buoy Spacer" is excellent. Because of similar friction, it naturally assumes the position of the real drag. For sections 200 feet or less it would appear that the spacing of shot would be too close for proper manipulation; in which case a celluloid spacer should be used. Since on regular drag work sections less than 300 feet are seldom used this is of small consequence. Having seen many drags in operation, I can say definitely that this spacer more nearly assumes the actual shape of the drag than does the celluloid spacer. I recommend that the field party continue to use the new spacer and that it be adopted for office checking.

COMMENT BY A. L. SHALOWITZ

I believe this instrument has possibilities, although it would be quits bothersome to make. While anything that tends to facilitate the plotting of the drag work and increase its accuracy is highly desirable, too much reliance should not be placed in the delineation of bights of drags in so far as coverage is concerned. Whenever a matter of importance arises in connection with drag work, a safety factor must be applied and the bight of the drag assumed in the position of least coverage. The instrument should be given a trial.

MONTANA EARTHQUAKE OF OCTOBER 18, 1935

By N. H. Heck, Chief, Division Terrestrial Magnetism and Seismology
U. S. Coast and Geodetic Survey.

The Montana earthquake of October 18, 1935, was followed by four distinct activities of the Coast and Geodetic Survey. Mr. F. P. Ulrich who is in charge of the seismological work in California was instructed to proceed to Helena with strong motion and vibration instruments; the instrumental epicenter was determined as the result of telegraphic reports; a large number of questionnaires were sent to persons throughout the region over which the earthquake was felt, and repetition of geodetic work in the central region of the earthquake was considered.

This earthquake followed after a large number of shocks; at least several hundred had continued from October 11. There was a strong shock (force 7 on the modified Mercalli Intensity scale which has 12 grades of intensity) on October 12 and the one on the eighteenth was force 8, about comparable to the 1925 earthquake which centered to the southeast after shocks were still in progress on October 29.

The damage has been estimated at $3,000,000. Forty residences were demolished, 200 were damaged and 80 per cent of all buildings in Helena suffered some damage. Cracks were reported in the ground to the northwest of Helena. The shock was widely felt in the mines but without damage.

The shock of October 12 did not warrant sending a party into the field since there was no assurance that a stronger shock would follow. Similar occurrences in Washington and in Colorado led to nothing important. However, the shock of the l8th was so serious that it was immediately decided to send observers into the area with strong motion and vibration instruments. Mr. Ulrich received telegraphic instructions at Fresno, California, where he was attending a meeting of the Structural Engineers Association, on Saturday morning, October 19. He proceeded at once to San Francisco, secured the needed instruments and with Mr. D. S. Carder of his party proceeded to Helena. Near Butte he ran into a heavy snowstorm and the car skidded with a narrow escape from serious injuries to both and with minor injuries to Mr. Carder and some damage to the apparatus. The ear was towed into Butte and a Forest Service truck took the party to Helena. In spite of these vicissitudes, they arrived by 5:00 p.m. Monday, October 21, and had instruments set up in the Federal Building by 9:00 p. m., less than sixty hours after the receipt of instructions at Fresno.

The instruments were put into operation and many after-shocks were recorded. It was found that most of these started with vertical motion and the regular starting device, which is a pendulum, did not operate. A spring device was im-

mediately constructed. Mr. Ulrich also made a general study of the earthquake and obtained considerable information.

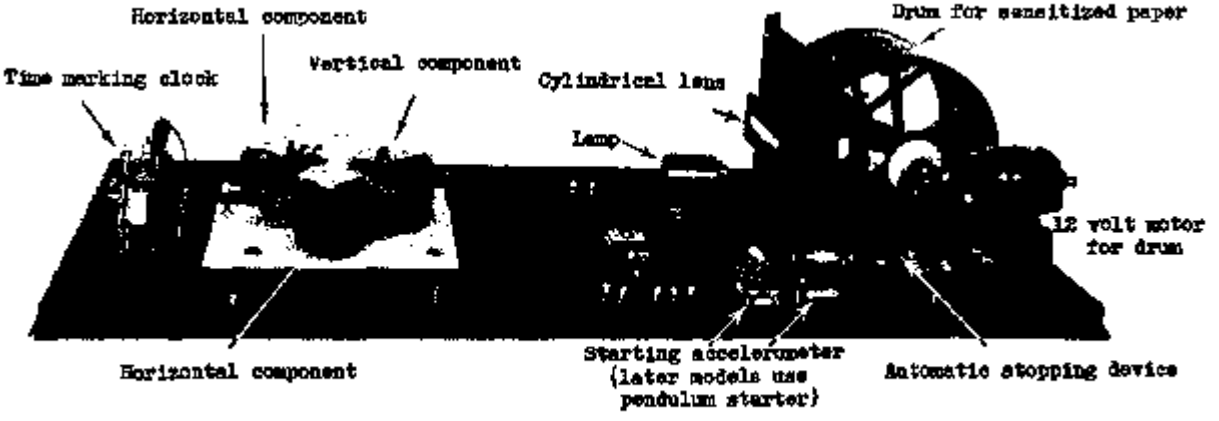
On October 29, he returned to San Francisco leaving Mr. Carder to continue strong motion observations and also determine vibration periods of buildings in connection with the rebuilding program.

The instrumental epicenter was determined as the result of reports from a number of stations obtained through Science Service, a Washington scientific news agency, reports from our own stations, and cooperation by the Jesuit Seismological Association with headquarters at St. Louis University, St. Louis, Missouri. On the basis of early reports the epicenter was placed 40 miles northeast of Helena. Later, chiefly as a result of a delayed report from our cooperative station at the University of Montana at Bozeman, it was found that the preliminary waves have abnormally low velocity in this region and that the epicenter was probably within ten miles of Helena in a northwesterly direction. This fits in well with the reported damage and cracking of the ground, and also with the vertical motion of the after-shock which is characteristic of the region over the point of origin of the earthquake.

Five hundred questionnaires were sent out from the Washington office to persons throughout the region which according to press reports felt the earthquake. This extended north to the Canadian border, south into Wyoming and west into Idaho. In addition Mr. Ulrich distributed others. The Weather Bureau automatically makes reports through its observers. When the reports are received each one is assigned an intensity and the positions and numbers are plotted on a map. Isoseismal lines (lines of equal intensity) are then drawn. A report on the earthquake and an isoseismal map are later sent to all who have cooperated by furnishing information.

There are both triangulation and precise level lines in the vicinity of Helena. Immediately after the earthquake geodetic work to determine possible changes was requested of the Bureau by Mr. Francis A. Thompson of the Montana Bureau of Mines and Geology. Before making any plans regarding this, it is necessary to know the epicenter and the region where possible surface change is indicated by ground cracks. Mr. Ulrich was instructed to obtain this information in order that the Division of Geodesy might plan additional work if needed and practicable.

Another heavy shock occurred within five miles of Helena on October 31, and an excellent record was obtained showing acceleration of 1/6 g. with a 0.2 second period.



RECORDING ACCELEROMETER

COMMON ERRORS OF INEXPERIENCED PERSONNEL IN THE COMPILATION OF AIR PHOTOGRAPHS

B. G. Jones, Assoc. Cartographic Engineer, U.S.C. & G. Survey

Beginning in 1933, the compilation of large scale line maps from air photographs by the Coast and Geodetic Survey has been expanded to include surveys of the coast line and intra-coastal waterways of the greater part of the East Coast and extensive areas of the Gulf Coast and Pacific Coast. The surveys now planned include approximately 700 maps on a scale of 1:10,000 and 1:20,000 with a few 1:5000 compilations in the vicinity of New York City. The office reviews of about 250 of these maps have been completed to date.

It is my purpose to discuss the most common errors found in the office reviews of the compilations and the methods of instruction devised to avoid repetition of those errors.

These maps are compiled by the radial line method and, except for contours, practically all detail appearing on the photographs is shown.

The maps are designed to furnish the large scale topographic surveys necessary for use with the hydrographic surveys of the Bureau and for correction and construction of charts. An endeavor is made to maintain standards of accuracy such that these compilations will serve as base maps for future revision surveys. It is proposed to construct a base map on which well defined recoverable points are located with such accuracy that they may be used for future control of one or a few photographs so that revision of localized areas can be made without extensive resurveys and without appreciable loss of accuracy. This requires that objects such as tanks, stacks, lights, and beacons, corners of wharves and prominent buildings, etc., shall be located within 3 to 5/10ths of a millimeter of their correct positions relative to the triangulation control. The instructions to the compilation parties require that recoverable objects be so distributed either by marked stations or by selection of natural objects as to furnish control points at a maximum distance of one mile apart along the waterways. In some areas the distribution of recoverable points is much closer than this. Permanent survey marks of other Federal and local organizations are connected to and shown on these compilations. The positions of these marks then furnish the necessary connecting points for application of the surveys of these organizations to the charts.

The compilations are made by field parties centrally located in the areas to be mapped. These parties are in charge of officers of the Coast and Geodetic Survey who have been specially trained in this work. When completed in the field, the compilations are forwarded to the Washington Office for reproduction. Each compilation is accompanied by an overlay sheet for names and a descriptive report. The compilations upon receipt in the Washington Office are reviewed by experienced compilers. Names are then added and the maps reproduced by photo lithography.

The compilation parties in the beginning of this project were instructed to complete and forward to the office a few of their compilations as soon as practicable. This is very desirable in beginning any extensive mapping work, particularly with inexperienced personnel. In this case the first compilations from each party were reviewed carefully in the Washington office and supplemental instructions forwarded as became necessary.

The office review of the compilations consists essentially of -

1. A check of the projection.

2. Check of the adequacy of control, of the adjustments made to the radial plot, and the density of minor control points.

3. Careful comparison with contemporary hydrographic and plane table surveys to determine whether all information is properly coordinated.

4. Check upon the completeness of detail and information needed for charting.

5. Check of the junctions with adjoining compilations.

6. Check of the geographic names shown.

7. Check upon the projection numbers shown at the margin of the compilation.

8. Check upon the number of and accuracy of location of recoverable control stations located by the compilation between the triangulation control.

We use in the office reviews a form which consists of a check list which accompanies the compilation until all items have been properly reviewed and the compilation is completed. The office review is then summarized in a report as to the completeness and accuracy of the compilation. This report is attached to the Descriptive Report which is permanently filed for future reference.

In nearly all eases the office verification of the first compilations received from the field parties showed -

1. Errors in location of details.

2. Omission of information of importance for charting.

3. Lack of uniformity in drafting. Lack of knowledge of the type of drafting which would reproduce readily by photo lithography.

An analysis of the cause of the errors found showed these to be duo largely to inexperience and the resulting lack of appreciation of the precautions required. Causes of the largest percentage of the errors noted are listed as follows:

1. Lack of sufficient control to reveal errors in the photo plot.

2. Errors in drawing projections and in inking the projection lines.

3. Errors in plotting control points.

4. Insufficient field inspection. This source of error should be emphasized. In nearly all cases of the first compilations there had been a decided tendency to trace detail which was not clear and well defined on the photographs and which should have been clarified by adequate field inspection.

5. Inaccurate mounting of five lens photographs.

6. Heavy and inaccurate marking and transfer of triangulation stations and minor control points on the photographs.

7. Drawing heavy radial lines on the photographs and in making the radial plot.

8. Location of an insufficient number of minor control points, resulting in large adjustments when tracing the detail.

9. Insufficient study of detail under the stereoscope, particularly as regards the location of buildings. Frequently shadows and perspective position of the roofs of the buildings had been included with the base.

10. The use of objects for control points which had been moved since the date of the triangulation. This was particularly true where triangulation positions of lights and beacons were used for control.

The methods devised to avoid repetition of these mistakes consisted of -

I. Sub-division of labor within the party. The chiefs of parties found early in this work that the most effective method is to have each step in the compilation performed by the men best qualified for that work. The sub-division included -

1. Drawing projection and plotting control points.

2. Checking the projection and plotting of control.

3. The radial line plot.

4. Check of radial line plot.

5. Transfer and inking of detail.

6. Review of the compilation by the most experienced compiler on the party. This review should be a close examination of the compilation and a check by placing the photographs under the celluloid to see that all points fall along the radial line from the center of the photographs.

II. Specifications that a data sheet be included in the Descriptive Report showing by whom each step in the compilations was accomplished and with the signature of the men responsible. With this sheet there is no question as to responsibility for any step in the work and the men can be held strictly accountable for poor work.

III. Specifications for the inclusion in the Descriptive Report of a review form to be signed by the Chief of Party and by the office reviewer. This form is a check list designed to force attention to the most common errors and omissions.

IV. Examples of photographs were sent out to all parties illustrating the density of minor control points required and the precision necessary in pricking radial points and drawing radial lines.

V. Copies of the office reviews containing the criticisms of the compilations were forwarded to the Chiefs of Parties with such comments as were necessary.

VI. In cases where replotting of any part of the compilation was necessary, it was returned to the field party with instructions for additional work to be accomplished.

VII. Printed copies made without retouching the negatives were returned to the respective parties as soon as possible with notes indicating the changes in drafting necessary to facilitate the reproduction.

A summary of the results obtained from these compilations to date as regards their use for the construction and correction of charts, and as regards their adequacy as base maps, is given here.

For the navigable charts complete information is required as regards any details of importance to the mariner, including the topographic details adjacent to the waterways, land marks, and aids to navigation. Such details must be located with sufficient accuracy that well defined points such as the land marks and aids to navigation, corners of wharves, etc., shall not be out of position more than 3/10 of a millimeter on the scale of the finished chart. The charts are published on scales of 1:20,000 to 1:80,000 as compared to the scales of the compilations of 1:10,000 and 1:20,000. This gives, in general, a reduction of 1/2 to 1/4 from the plotting scale, and the required accuracy is thus obtained. A few of the first compilations had to be entirely replotted. Others were partially replotted to insure that no plottable errors in important details would carry over to the charts.

The requirements for base maps are rigid because they are to be used on the same scale as plotted. To repeat, it is proposed to construct a map on which well defined recoverable points are located with such accuracy that they may be used for future control of one or a few photographs so that revisions of local areas can be made without extensive resurveys and without appreciable loss of accuracy. This requires that such points be located within 3 to 5/10ths of a millimeter of the correct position relative to the triangulation control. These requirements are rigid for any graphical method of plotting. Approximately fifty per cent of the compilations up to this time are of sufficient accuracy to be used as base maps. Those compilations which are not quite up to these standards have been restricted both by the quality of the photographs and by the inexperience of the personnel, but more largely because of the latter. These requirements are being fulfilled to a much greater extent on the compilations recently received.

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

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

PLOTTING CIRCULAR ARCS ON OFFSHORE HYDROGRAPHIC SHEETS WITHOUT USE OF BEAM COMPASS*

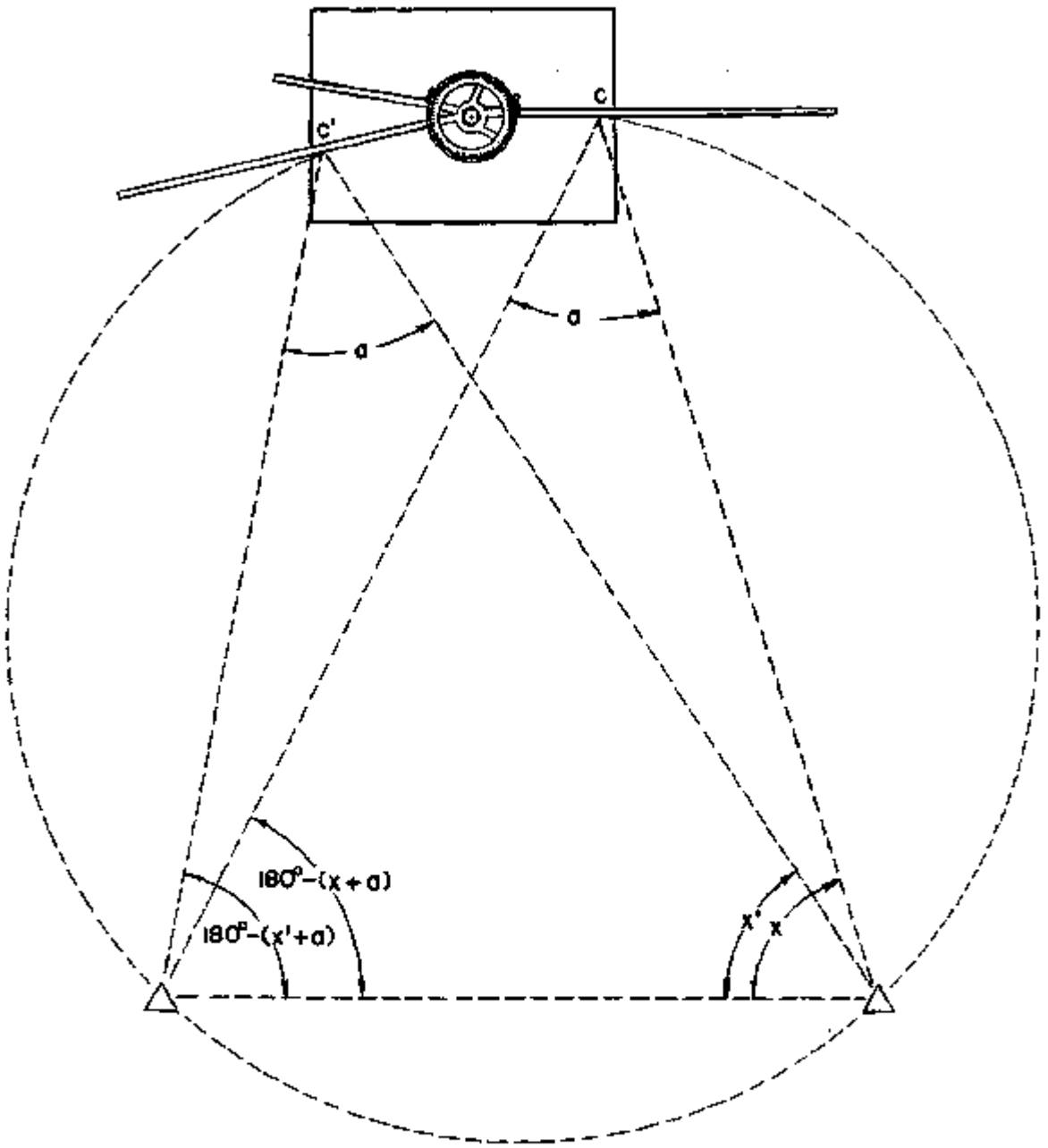
G. C. Mattison, H.& G. Engineer, U.S.C.& G. Survey

The accompanying sketch represents a hydrographic sheet, scale 1:10,000 or 1:5,000, on which visual fixes on distant objects, well outside the limits of the sheet, are to be used for control. The limits of the sheet and locations of control points are first plotted on a chart of the locality. The chart lay-out is used to aid in selecting the objects to be observed on, if there are more than three objects to choose from, and as a guide in determining the angles to be computed. The selection of objects is not limited to those comprising a three point fix, but any two pair that give good intersecting arcs may be used.

In the diagram, C and C' are two points on the arc of the angle "a" near the margins of the sheet. The angle "a" is the observed angle between objects "A" and "B". The angles x, x' and a are determined from the chart layout with a protractor. The geographic positions of C and C are then computed, and plotted on the projection. A steel protractor is used to draw the arc between C and C. The angle l80° -(x-x') is set on the protractor using the movable arm that can be closed down to a zero reading. Two pins are firmly set in the plotted positions C and C'. A pencil is centered in the protractor and the arc drawn by moving the protractor along with the arms sliding against the pins at C and C'. If the distance between C and C' is too great to permit sliding the protractor very far from the center of the sheet, a point is pricked on the section of arc half way between C and C' and a pin placed in this mid position. The protractor with the setting 180° - l/2 (x-x') is then used between the middle pin and C and C' in turn. This same method will be used to lay off on the sheet five arcs at intervals covering the sheet from top to bottom. Intermediate arcs can be laid out in a similar manner by constructing graphs of the rate of change between each of the computed arcs and plotting scaled locations of intermediate positions corresponding to C and C'. Graphs are also constructed of the rate of change of the protractor angle and are used for determining the protractor setting for these intermediate arcs.

This method is a very accurate one inasmuch as the geographic positions of the controlling arcs have been computed. It is recommended as an accurate way to check the position of the arcs on the sheets turned in by the field parties, especially if they were drawn with the beam compass. It may also be used as a guide for laying down arcs that have been enlarged photographically from another scale, as described in the hydrographic manual. The photographic enlargement can be adjusted to fit the computed locations.

* See: U.S.C.& G.S. Spec. Pub. No. 143, p.86.
"Circles for Plotting Three Point Fixes", A.M.Sobieralski; Field Engrs. Bul. No.3,p.52.
"Circles for Plotting Three Point Positions", G.C.Mattison; Field Engrs.Bul. No.6 p.81.
"Circles for Plotting Three Point Fixes", L.D.Graham; Field Engrs. Bul. No. 7 p. 91.



DRAWING CIRCULAR ARCS WITH PROTRACTOR

REPORT ON INSPECTION OF THE BOSSHARDT-ZEISS SELF-REDUCING (DOUBLE IMAGE) TACHEOMETER

By E. W. Eickelberg, H. & G. Engineer, U.S.C. & G. Survey
Assistant Chief, Division of Terrestrial Magnetism and Seismology

An interesting surveying instrument has recently been brought to this country from Germany by the firm of Carl Zeiss, Inc., of New York, and was exhibited in New York and Washington. It was inspected in use in the field by a number of officers of the U. S. Coast and Geodetic Survey.

It is interesting to note that while there are several types of double image tacheometers in use in Europe, including those of Zeiss, Hildebrand and Fennel, the principle involved is the invention of an American. Credit for this is given by Bosshardt[1] as follows: "All these double image instruments are merely adaptations of the Richards principle; Richards used a vertical rod whereas the newer instruments use a horizontal rod, which does not change the principle."

In 1894, R. H. Richards, a Boston civil engineer reported 2 on a new measuring device which he had invented in 1890. Quoting Mr. Richards:

"In my prismatic stadia, I place in front of the objective a prism or wedge of glass which half covers it. If we hold up such a prism with a narrow angle, say 1 or 2 degrees, and compare the transmitted image with the one seen above or below the prism, the former will be found to be thrown to one side by an amount varying with the angle of the prism. Speaking of the two rays as the direct ray and the bent ray, we may say that when the bisecting plane of the prism is at right angles to the line of sight, the angle between the direct ray and the bent ray will be constant for any given prism. If now we place a prism in such a position that it half covers the objective of a telescope, we shall obtain upon looking through it, two images of every object seen — one image by the direct ray, which comes through the uncovered half of the objective, the other by the bent ray which comes through the prism. The angle divergence of these two rays will be constant and unalterable, whether the telescope is directed to a near or a distant object.

"These two rays form the basis of this method of measuring and the distance from the telescope to any given point will be proportional to the space between the lines at that point. The angle of the prism for general work will be such as to produce a throw of one foot on the rod for 100 feet in distance. The planes of these prisms must be made as flat as the finest work of the best opticians can render them.

"In making an observation, we must first focus the two images, next rotate into juxtaposition and finally read the distance. That

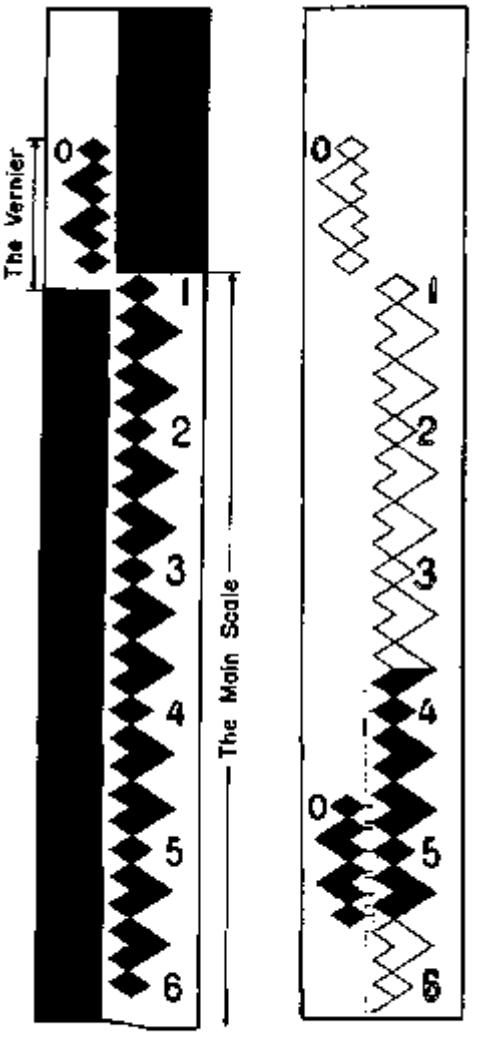


Fig. 1

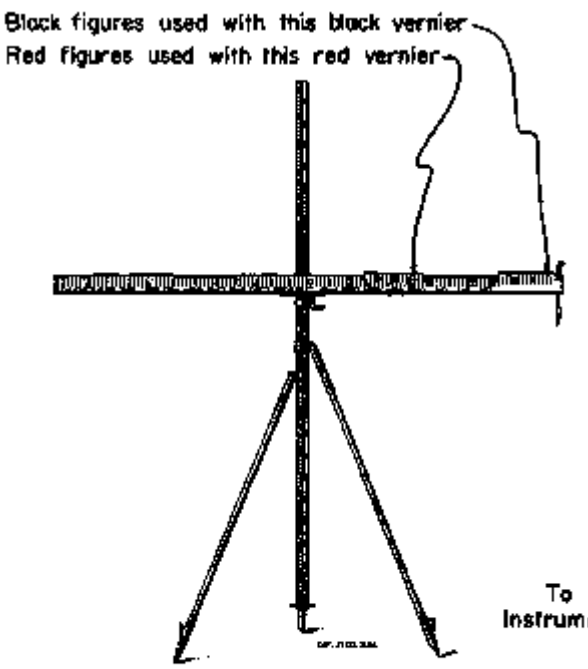
1. Karl Lademann, Zar Entwicklungageschichte der neueron Geodätischen Doppelbild-Entfernungsmesser. All. Vermess. Nachr. Vol. 45, pp. 714-723, 1953.

2. R. H. Richards, A new prismatic stadia, Jour. Assn. Engineering Soc., Vol. 13, pp. 43-58, 1894.

portion of the target which is being read is the only part that appears clear, distinct and strong. The rod is self-reading, the displaced image of the rod being read against the direct linage of a vernier painted on the rod." See Fig. 1, a and b.

Richards also devised a tape target by means of which he could read longer distances than with a rod. The tape was held horizontal and the operator moved a sliding target until it coincided optically with the target at the zero of the tape. The intercept or distance between targets was read on the tape and multiplied by the constant of the prism to obtain the distance. Richards claimed an accuracy of 1.5 feet in a sight of nearly one mile, or about one part in 3500.

The rod which is used with the Bosshardt-Zeiss instrument is shown in Fig. 2 in position for reading. The supporting struts can be lengthened or shortened by threaded sleeves near the connections with the vertical rod, and a universal bubble on the reverse side of the vertical rod indicates verticality. A white line in the center of the face of the vertical rod serves for making the horizontal angle pointing. The graduations of the rod are used to set the line of sight to the proper height of eye, and for stadia measurements by parallel hairs in the usual manner. The horizontal rod is graduated with two sets of figures, one in

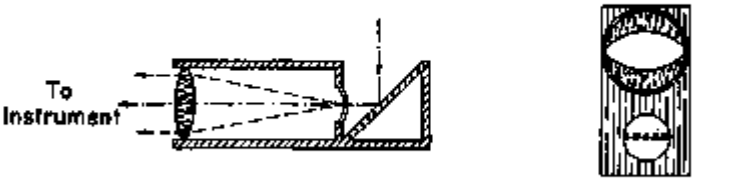


SELF READING ROD USED WITH THE TACHEOMETER

Fig. 2

Fig. 3

SHOWING A READING OF 57.40 METERS ON THE SMALL FIGURES. THE LARGER FIGURES ARE USED WITH THE VERNIER AT THE END OF THE ROD FOR LONGER DISTANCES. WHEN EXACT COINCIDENCE IS MADE BY MICROMETER SCREW B (FIGURES 6 AND 7), THE CENTIMETERS ARE READ ON THE GRADUATED HEAD OF THIS SCREW AND ADDED TO THE ROD READING AS ABOVE.



COLLIMATOR APPEARANCE OF COLLIMATOR TO INSTRUMENT MAN

Fig. 4

red and one in black, with corresponding verniers located at the respective zero points. The red figures are for short distances and the black for longer distances. Figure 3 shows the images of the staff as viewed through the telescope and prism at a distance of approximately 57.40 meters using red vernier and red (smaller) figures. Immediately under the horizontal staff and secured to it, is a small telescope (diopter) which is used to accurately place the rod at right angles to the line of sight. Attached to the diopter is a small collimator whose axis is parallel to that of the diopter. This collimator projects a bright image to the instrument when the rod is at right angles to the line of sight, thus furnishing the instrument man a check on the rodman. The collimator is shown in detail in Figure 4. When the rod is moved to the next set-up, the horizontal staff can be released and rotated so as to lie parallel to the vertical staff for convenience in carrying.

In the tacheometer (see Figures 5 and 6), Richards' single prismatic wedge has been replaced by two separate wedges which are geared to the horizontal axis of the telescope so as to change the parallactic angle as the telescope moves from a horizontal position and of such amount as to reduce the throw or displacement of the image thereby automatically reducing the inclined distance to horizontal distance. In Figure 5 K_1 and K_2 are the rotating wedge-shaped prisms, Q is

a rhomboid prism for transmitting the rays into the objective 0. The piano-parallel plate P is used when there is no coincidence at any vernier line. This plate can be rotated about a vertical axis by the graduated drumhead B (Figure 6) which displaces the line of sight parallel to itself so as to establish coincidence of the vernier lines. The reading on the drum is then added to the rod reading, each division of the drum corresponding to 1 cm. of distance. The same principle is applied in the Zeiss level to eliminate estimations of the smallest rod divisions.

Referring to Figure 7, "A"-is an adjusting screw for the mechanism which reduces inclined distance to horizontal distance. "B" rotates the piano-parallel plate for making accurate vernier coincidence as previously described and can also be set at an initial reading to take care of any personal equation of the observer. The auxiliary eyepiece "O" furnishes a means of reading both A and B verniers of the horizontal circle, the vertical angle and the tangent of the vertical angle. The latter multiplied by the horizontal distance gives the difference of elevation. Screw "D" shifts the eyepiece from horizontal circle readings to vertical circle readings, all readings being taken from the same position of the observer, and obviates the necessity of moving about the instrument. Ring "J" furnishes a means of shifting the prisms out of the field, so that a full image with the conventional vertical and stadia hairs can be obtained. This permits of a check on the observed distance by using the vertical rod as a stadia rod. A slightly tapered plate "U" is located in front of the rotating prisms and is used to make slight changes in the multiplication constant, such as reduction to length at sea level when working in regions of high altitude. This is accomplished by rotating the plate a slight amount, which results in a constant cor-

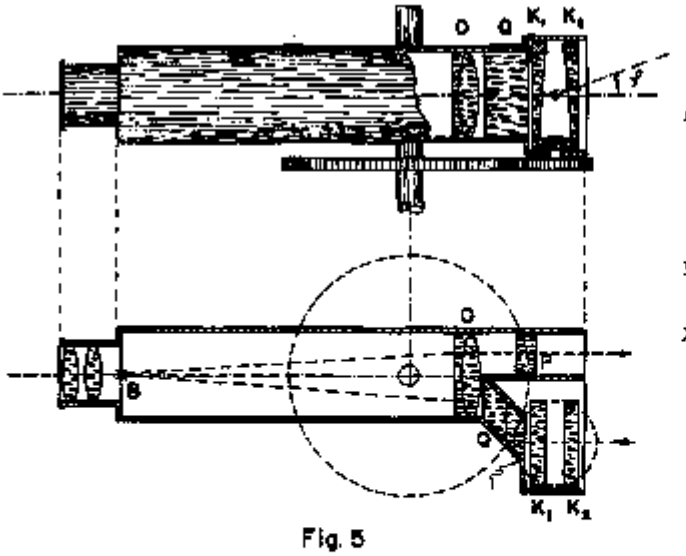


Fig. 5

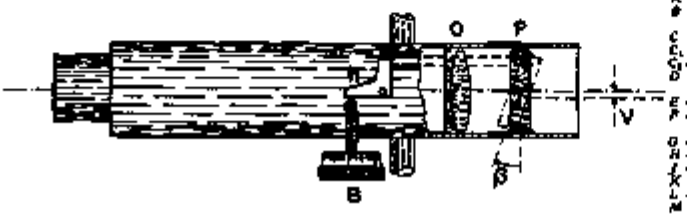
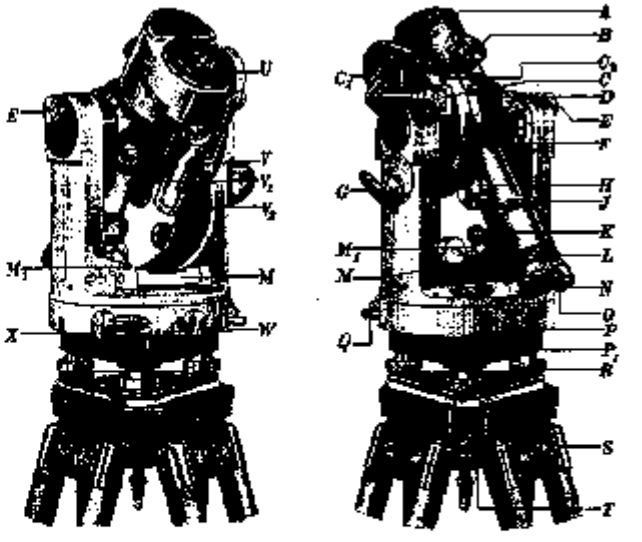


Fig. 6



A = Adjusting screw for reducing mechanism
B = Graduated drum for reading (each reading from drum for reading vernier coincident with staff reading)
C = Vertical index bubble (Collimation bubble)
C_1 = Reading prism of vertical index bubble
C_2 = Adjusting screw of vertical index bubble
D = Change over from vertical to horizontal reading
E = Clamp screw for telescope vertical motion
F = Correction (this reduction of addition constant)
G = Reflector for hori. and verti. scales.
H = Telescope focusing screw
J = Change-over ring for double or full image
K = Fine adjustment for vertical motion
L = Fine levelling screw for level C
M = Cross bubble for accurate levelling
M_1 = Adjusting screw of cross bubble
N = Telescope eye-piece with diagonic scale
O = Micro reader for both circles
P = Box bubble for approximate levelling
P_1 = Adjusting screws for box bubble
Q = Clamp for horizontal circle for angle repetition
R = Bevelled feet screws
S = Tightening screws for tripod leg sockets
T = Coupling screw with plumb line hook and thread for right plumb rod
U = Dove-tail prism for multiplication constant
V = Reversible level
V_1 = Reading reflector for level
V_2 = Level adjusting screws
W = Clamp screw for lateral motion
X = Fine adjustment screw for lateral motion

Fig. 7

rection to the parallactic angle. The remaining letters in Figure 7 are self-explanatory.

Distances up to 200 meters can be measured with a horizontal rod 2.2 meters in length. The accuracy is said to range from 1 part in 2000 under unfavorable conditions to 1 part in 10,000 under best conditions. The increased accuracy over stadia measurements is accounted for in the fact that one reads the distance at one point - the point of coincidence - rather than at two points some distance apart as in stadia. Another reason is, that in the use of the horizontal rod,

differential refraction is largely eliminated. In the ordinary stadia method with vertical rod one line of sight passes close to the ground and so suffers greater refraction than the line to the top of the rod.

Nothing seems to have been overlooked in the development of this instrument. The manufacturers maintain that the materials in the rod have been so selected that changes in the index of refraction of the wedges caused by temperature changes are counteracted by changes in the length of the rod. Equipment can be furnished whereby the rod is supported on a tripod similar to the instrument tripod, so that in moving the instrument ahead, the tripods can be interchanged.

An ingenious plumbrod (which is useful in windy weather) is supplied with the instrument. This rod is telescopic and is secured to the same point at which a plumb bob would be suspended from the axis of the instrument, the other end being placed in the station mark, the instrument is then moved about on the tripod head until a small universal bubble attached to the rod is centered. The rod is graduated so that when the instrument is in position and level one reads the height of instrument at an index on the rod.

European cadastral surveys are made with this instrument, and it is understood that it has practically eliminated the use of tapes.

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MAINTAINING A HAPPY SHIP

Bureau of Navigation Bulletin No. 226

September 28, 1935

The following question and answer is taken from papers of a student at the Officer's Cooks and Stewards School at San Diego:

> "What influence has a good mess-boy on a ship?
>
> "A mess-attendant can influence a happy ship in a great deal. Suppose I'm a Captain's boy, early in the morning I prepare everything ready and set for the old man. What he got to do is just slip in his nice well brush uniform, shiny shoes, bright brass buttons, and immaculate white hat. When he walks and pace the deck he says good morning to the executive and he is in a happy mode. Then in turn the crew is happy because the two big shots in the ship didn't raise hell because I make the first happy by doing extra work early in the morning."

COMPUTATION OF PLANE COORDINATES

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

In making available for local use the plane coordinate system adopted by a State or part of a State, it is necessary to have the coordinates of all the control stations within the area computed on that system. After the triangulation network of an area is adjusted, the plane coordinates of each triangulation station in that area are computed together with the grid azimuth from the triangulation station to a mark which may be a special azimuth mark or another triangulation station in the vicinity. These coordinates are being made available for the use of field engineers as rapidly as the facilities of the Coast and Geodetic Survey permit.

A traverse can be started from any control station by turning off an angle from the azimuth mark to the first station of the traverse. Then, when the lengths of the traverse are measured together with the angles at the various stations, the whole can be computed directly on the plane with x and y coordinates for each of the stations, using the x and y coordinates of the triangulation station as the origin. To eliminate the uncertainty of the coordinates of these stations due to the possibility of error or blunder in the measurement either of the distances or the angles it is important to end the traverse on another control point or run the traverse in a loop closing on the starting point. The discrepancy due to the failure to check, if within allowable limits, can then be distributed through the traverse.

The method of distributing this closing error can best be explained by going through an example of the computation of a traverse run between two first order control stations in Nebraska. This example is on the Lambert Conformal projection, but the method of adjustment holds true for the Tranverse Mercator projection except as noted. In this example the traverse starts at Station Prosser and ends on Station Wanda. The coordinates of the triangulation stations were furnished, together with the grid azimuths to azimuth marks, by the Coast and Geodetic Survey. At Prosser the angle was turned from Standpipe, the azimuth mark, to the first traverse station, No. 325; the angle at this traverse station was turned from Prosser to the next traverse station, No. 326; and so on through the traverse to Wanda where the angle was turned from the last traverse station No. 333, to Standpipe, the azimuth mark for Wanda.

List of observed Angles Prosser to Wanda

Station	From	To	Angle		
Prosser	Standpipe	325	50°	32'	09.3"
325	Prosser	326	220	25	02.3
326	325	327	173	07	38.3
327	326	328	166	48	27.8
328	327	329	151	23	23.1
329	328	330	242	47	27.7
330	329	331	149	03	56.5
331	330	332	149	03	56.7
332	331	333	157	17	47.7
333	332	Wanda	162	52	38.8
Wanda	333	Standpipe	130	13	41.0

The first thing necessary in the adjustment is to distribute the angle discrepancy through the traverse so that the azimuth carried through the various stations from the fixed grid azimuth Prosser to Standpipe will agree with the fixed grid azimuth Wanda to Standpipe. To the fixed grid azimuth Prosser to Standpipe of 315° 37' 27.8" is added the angle at Prosser from Standpipe to No. 325 which gives an azimuth from Prosser to No. 325 of 6° 09' 37.1". Then adding 180° to this azimuth gives 186° 09' 37.1", the azimuth from No. 325 to Prosser. To 186° 09' 37.1" is added the angle at No. 325 between Prosser and No. 326 which gives an azimuth of 46° 34' 39.4" the azimuth from No. 325 to No. 326, and so on through the traverse to the line Wanda to Standpipe. The grid azimuth of the line Wanda to Standpipe is found to be 269° 13' 37.0" as carried through the traverse, failing to check the fixed grid azimuth of 269° 13' 56.3" by - 19.3". This discrepancy of 19.3" is then divided by the number of angles through the traverse and the result applied to each of the observed angles. The azimuths are

then recomputed through the traverse, as shown in the last column of the example. This makes the azimuth of the line Wanda to Standpipe as carried through the traverse stations agree with the fixed grid azimuth. The azimuth adjustment is now complete for use in the computation of the traverse.

Computation of Grid Azimuths of Traverse Prosser to Wanda.

Prosser to Standpipe	315°	37'	27.8"			27.8"
Standpipe to 325	50	32	09.3	+ 1.8	=	11.1
Prosaer to 325	6	09	37.1			38.9
325 to Prosser	186	09	37.1			38.9
Prosser to 326	220	25	02.3	+ 1.7	=	04.0
325 to 326	46	34	39.4			42.9
326 to 325	226	34	39.4			42.9
325 to 327	173	07	38.3	+ 1.8	=	40.1
326 to 327	39	42	17.7			23.0
327 to 326	219	42	17.7			23.0
326 to 328	166	48	27.8	+ 1.7	=	29.5
327 to 328	26	30	45.5			52.5
328 to 327	206	30	45.5			52.5
327 to 329	151	23	23.1	+ 1.8	=	24.9
328 to 329	357	54	08.6			17.4
329 to 328	177	54	08.6			17.4
328 to 330	242	47	27.7	+ 1.7	=	29.4
329 to 331	60	41	36.3			46.8
330 to 329	240	41	36.3			46.8
329 to 331	149	03	56.5	+ 1.8	=	58.3
330 to 331	29	45	32.8			45.1
331 to 330	209	45	32.8			45.1
330 to 332	149	03	56.7	+ 1.7	=	58.4
331 to 332	358	49	29.5			43.5
332 to 331	178	49	29.5			43.5
331 to 333	157	17	47.7	+ 1.8	=	49.5
332 to 333	336	07	17.2			33.0
333 to 332	156	07	17.2			22.0
332 to Wanda	162	52	38.8	+ 1.7	=	40.5
333 to Wanda	318	59	56.0	319° 00'		13.5
Wanda to 333	138	59	56.0	139° 00'		13.5
333 to Standpipe	130	13	41.0	+ 1.8	=	42.8
Wanda to Standpipe	269	13	37.0			56.3
Fixed	269	13	56.3			
Discrepancy			-19.3			

The next step in the adjustment is to reduce the corrected tape distances between the traverse stations to grid distances. In the example this is started with the taped distances after they have been corrected for tape standardization, inclination, and temperature. It is first necessary to reduce the corrected taped distances to the geodetic distances at sea level as the distance between the Control Stations Prosser and Wanda is a sea level distance. To do this an elevation factor for the line is first computed. In the equation Log Ra = 5.8304093 - l/2 log A - 1/2 log B, Log A and log B are taken from the table given in U. S. Coast and Geodetic Survey Special Publication No.8. The mean latitude of the traverse loop is the argument. The latitude may be taken as the mean of the latitudes of the control stations.

The grid factors are taken from the Projection Tables. These Projection Tables, of which there is one for each state, have been prepared by the U. S. Coast and Geodetic Survey and may be obtained upon request through the Washington Office. In the example the argument used in taking out the grid factors from the tables is the mean latitude of the line between adjacent traverse stations. The

latitudes were found by plotting the traverse line on the Geological Survey topographic sheet of the area in which the traverse lies and scaling the latitude of mid-point of each section. This method can be used, however, only when an adequate map of the area is available. When a map is not available it is necessary to make a preliminary computation of the traverse using the geodetic lengths as the distances between traverse stations. The example does not show this preliminary computation, but it is made in a manner similar to that shown for the final computation. The form is self-explanatory. The latitude and departure of each distance is computed and, starting with the coordinates of the control station, the latitude and departure is added to or subtracted from the coordinates of the preceding station. The latitude and departure are added if north and east respectively, and subtracted if south and west. Then, from Table I of the Projection Tables, take out the scale factor, using the mean of the values of the y coordinates of the traverse stations at each end of the section concerned as the argument. The geodetic distance is then multiplied by this scale or grid factor to give the grid distance. As the example is on the Lambert Projection the y coordinates of the stations are used in taking out the grid factors.

Reduction to Sea Level and Computation of Grid Distance

Average Elevation 2055 ft. Elevation Factor 0.99990175

Section	Corrected Taped Distance	Geod. Dist.	Grid Factor	Grid Dist.
	feet	feet		feet
Prosser - 325	3958.752	3958.363	0.9999363	3958.111
325-326	7192.436	7191.729	0.9999372	7191.277
326-327	4156.096	4155.688	0.9999385	4155.432
327-328	5866.934	5866.358	0.9999400	5866.006
328-329	3056.766	3056.466	0.9999411	3056.286
329-330	6037.326	6036.933	0.9999420	6036.583
330-331	5333.603	5333.079	0.9999432	5332.776
331-332	6304.188	6303.569	0.9999452	6303.224
332-333	6495.734	6495.096	0.9999472	6494.753
333-Wanda	4092.182	4091.780	0.9999478	4091.566

Mean Lat. 40° 38.5'

$$\text{Elevation Factor} = \frac{Ra}{Ra + \text{Average Elevation}}$$

$$\log Ra = 5.8304093 - \tfrac{1}{2}\log A - \tfrac{1}{2}\log B.$$

$$= 5.8304093 - \tfrac{1}{2}(8.5091022-10) - \tfrac{1}{2}(8.5108029-10)$$

$$= 5.8304093 - (9.2545511-10) - (9.2554014-10)$$

$$= 7.3204568$$

$$Ra = 20{,}914950 \qquad \text{Elev. Factor} = \frac{20{,}914{,}950}{20{,}917{,}005} = 0.99990175$$

In the formula the constant 5.8304093 is the sum of the colog of the sin of 1" and the log of the reduction factor for meters to feet or 3937/1200. The derivation of this formula will be shown in Special Publications No. 194 and No. 195. These publications will be available for distribution within the next few months.

Due to the divergence of the origin of the y coordinates and the parallel of latitude through that origin on the central meridian of the Lambert Projection, the grid factors obtained by using the y coordinates instead of the latitude are exact only when the traverse lies along the central meridian, the error in the factor increasing with the distance away from that meridian. However, the discrepancy between the true grid factor and that obtained by using the y coordinates is so small that it can be neglected. In the example, the grid factor found in the Projection Tables, by using the mean latitude of the line as the argument, for the distance between traverse stations No. 325 and No. 326 is 0.9999372, while that found by using the mean of y coordinates of the two stations is 0.9999369, an error of about 1 part in 3,300,000. The distance out from

the central meridian in this case is approximately 50 miles.

For computations on the Mercator projection the x' coordinates are always used as the argument in taking out the grid factors. These are found in Table III of the Projection Tables. In using the table for the Mercator projection the x' value used should be the difference between the x coordinate and 500,000 as the central meridian is arbitrarily given that value so that none of the coordinates of the stations on the projection will have a negative sign.

For traverses up to ten miles in length it is usually unnecessary to obtain the scale factor for each section of the traverse in order to reduce the lengths to grid distances. The scale factor found by using the mean of the coordinates of each end of the line as the argument in the projection tables is sufficiently accurate.

The next step is the final computation of the coordinates and the distribution of the length discrepancies. The adjusted azimuths and the grid distances as found in the preceding paragraph are used. The x and y coordinates were computed, starting with the coordinates of Prosser through the traverse to Wanda. The difference between the computed coordinates of Wanda and the fixed coordinates were found to be +0.41 ft. for y and +1.08 ft. for x. This discrepancy is to be distributed through the y and x coordinates for the various stations. For the y coordinates, the closing error +0.41 is divided by 52,486, the length of the traverse, the result being a factor to be used in correcting each coordinate.

The distance from the initial control station to each traverse station, shown by the figures in the third column of the computation form marked with an asterisk (*), is multiplied by this factor and the result applied to the y coordinate for that particular station. In this way the closing error is distributed proportionally to the length of each section of the traverse. The discrepancy for the x coordinate is distributed through the traverse by dividing the closing error +1.08 by 52,486 and using the result as a factor for obtaining the correction to the x coordinates. The corrections are then applied in the same way as was done to the y coordinates. The adjusted coordinates for each of the stations are shown on the form.

It can readily be seen that in distributing the closing error through the coordinates of the traverse stations that the azimuths between adjacent stations would be changed from that used in computing the traverse. Therefore, when using these traverse stations as starting or closing points for other traverses, it is advisable to use a grid azimuth computed from the corrected coordinates of the stations and not that used in computing the traverses

In the example the difference between the geodetic length and the measured length of a line at about 2000 ft. elevation is of the order of 1 part in 10,000; the difference between the grid length and the geodetic length is of the order of 1 part in 16,000. The difference between the geodetic length and the measured length would be of the order of 1 part in 7000 if the elevation were about 3OOO ft. The coordinate projections for the various states are such that the difference between the grid length and the geodetic length will seldom exceed 1 part in 10,000. From this it may be seen that, except for areas of considerable elevation, the effect of applying corrections other than that of distributing the closing error of the traverse through the various stations, is of little practical importance. For control surveys, such as executed by the Federal Government and some of the larger cities where an accuracy of better than 1 part in 10,000 is desired, these corrections should be applied to determine whether the desired accuracy is being obtained. For farm surveys and the like, where such a standard of accuracy is unnecessary, the measured distances may be used in computing the coordinates of the traverse stations, all corrections being considered as closing error and distributed as such through the traverse line.

COMPUTATION OF COORDINATES

Traverse line No. Prosser to Wanda
State Nebraska - So.
Year 1954

County Hall and Adams
Month January - March

Initial Station Prosser
Closing Station Wanda

Station	Azimuth Plane	Grid Distance Feet	Log. Lat. / Log. cos Az / Log. dist. / Log. sin Az / Log. Dep.	Latitude Feet	Departure Feet	Grid Coordinates y Feet	Grid Coordinates x Feet
Prosser			3.59497248 9.99748451	-3935.25		378,552.84	2,252,598.10
		3958.111	3.59748737 9.03067767			374,617.59 -0.03	2,252,173.32 -0.08
325	6 09 38.9	3,958*	2.62816564		-424.78	374,617.56**	2,252,173.24**
			3.69398967 9.83718365	-4942.99			
		7191.277	3.85680602 9.86112668			369,674.60 -0.09	2,246,950.17 -0.23
326	46 34 42.9	11,149*	3.71793270		-5223.15	369,674.51**	2,246,949.94**
			3.50472790 9.88611172	-3196.89			
		4135.432	3.61861618 9.80540135			366,477.71 -0.12	2,244,295.46 -0.31
327	39 42 23.0	15,305*	3.42401753		-2654.71	366,477.59**	2,244,295.15**
			3.72007856 9.95173606	-5249.02			
		5866.006	3.76834250 9.84974908			361,228.69 -0.17	2,241,676.72 -0.44
328	26 30 52.5	21,171*	3.41809158		-2618.74	361,228.52**	2,241,676.28**
			3.48490356 9.99970557	-3054.24			
		3056.286	3.48519399 8.56296515			358,174.43 -0.19	2,241,788.46 -0.50
329	357 54 17.4	24,227*	2.04819314		+111.74	358,174.26**	2,241,787.96**

Azimuths are clockwise from true south
* Distance from starting point of traverse
** Adjusted coordinates

COMPUTATION OF COORDINATES

Traverse line No. Prosser to Wanda
State Nebraska - So.
Year 1954

County Hall and Adams
Month January - March

Initial Station Prosser
Closing Station Wanda

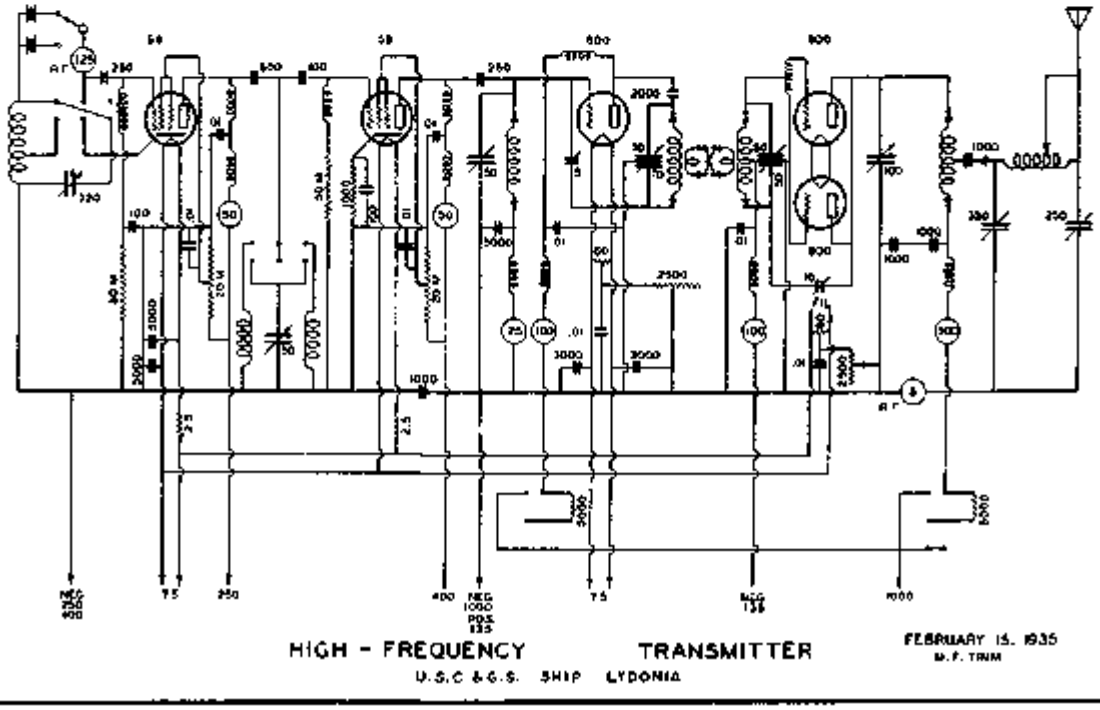
Station	Azimuth Plane	Grid Distance Feet	Log. Lat. / Log. cos Az / Log. dist. / Log. sin Az / Log. Dep	Latitude Feet	Departure Feet	Grid Coordinates y Feet	Grid Coordinates x Feet
329			3.47048909 9.68969791	-2954.53		358,174.45 358,174.26**	2,241,788.46 2,241,787.96**
		6036.583	3.78079118 9.94053538			355,219.92 -0.24	2,236,524.33 -0.62
330	60 41 46.8	30,264*	3.72132656		-5264.13	355,219.68**	2,236,523.71**
			3.66551824 9.93856490	-4629.33			
		5332.776	3.72665334 9.69583731			350,590.59 -0.28	2,233,877.11 -0.73
331	29 45 45.1	35,596*	3.42279065		-2647.22	350,590.31**	2,233,876.38**
			3.79947199 9.99990925	-6301.91			
		6303.224	3.79956274 8.31049672			344,288.68 -0.33	2,234,005.96 -0.86
332	358 49 43.5	41,900*	2.11005946		+128.84	344,288.35**	2,234,005.09**
			3.77371621 9.96115357	-5939.04			
		6494.753	3.81256264 9.60716468			338,349.64 -0.38	2,236,634.57 -1.00
333	336 07 33.0	48,394*	3.41972752		+2628.62	338,349.26**	2,236,633.57**
			3.48969414 9.87780458	-3088.12			
		4091.566	3.61188956 9.81691021			335,261.52 -0.41	2,239,318.68 -1.08
Wanda	319 00 13.5	52,486*	3.42879977		+2684.11	335,261.11**	2,239,317.60**
						335,261.11 +0.41	2,239,317.60 +1.08

Discrepancy =
X Factor = -2.05769 x 10-5
y Factor = -0.7811 x 10-5

Azimuths are clockwise from true south
* Distance from starting point of traverse
** Adjusted coordinates

RADIO STATION WTEJ, U.S. COAST AND GEODETIC SURVEY SHIP *LYDONIA*

This station, W. E. Smith Operator, handled a large amount of emergency traffic during the hurricane of August 23, 1933 at Norfolk, Virginia, together with the station on the U. S. Coast and Geodetic Survey Ship OCEANOGRAPHER. The transmitter which is used in radio acoustic ranging is at the end of the desk, left center of photograph, and a wiring diagram is shown below. This ship formerly carried the experimental call WSQ which was used during some of the development work in radio acoustic ranging.



EXTRACT FROM SEASON'S REPORT
COMMANDING OFFICER, U.S.C. & G.S., SHIP GUIDE
F. H. Hardy, H. & G. Engineer, U.S.C. & G. Survey

An officer can and should train himself to be a good mechanical hydrographer, as the most carefully developed survey is useless unless the records are such that it can be correctly shown on the hydrographic sheet. However, an officer may be a good mechanical hydrographer and it may be impossible from the finished sheet to find any just criticism of the work, but at the same time a dangerous shoal may have been missed or the least water on a shoal not obtained, which a real hydrographer would have found. The importance of the mechanical side of hydrography is brought directly to the officer's attention by the reports of the reviewers of the sheets. This has an excellent effect on improving the conditions of the records, examination of the boat sheet for indications of dangers shown on the regular system of lines, and the development of these indications. If carried too far it has a disadvantage in over emphasizing the mechanical side of the work at the expense of the practical side.

To get the least water on a shoal it is often impracticable to locate and record each sounding. The attention of the officer in charge of the launch is needed to change course, speed, etc., so as to place the boat over the highest point of the shoal. This was very well illustrated by an experience of Lieutenant Rubottom. He attempted several times carrying sounding lines over Von Helm Rock, which at that time was marked by swirls, but missed the rock each time. In order to land on top of the rock he rigged an improvised drag, using two weights connected by a wire and suspended from outriggers, one on each side of the launch. By this method he was able to locate the rock and to obtain less water than was found on the previous survey.

In comparing most of the modern surveys with the older surveys it is startling the number of times the modem survey does not obtain as shoal soundings as the older survey. Also that with the greater spacing of lines in the older surveys that so few dangerous shoals were missed. This is probably largely due to the fact that the older officers trained themselves more thoroughly than the younger generation does to read the water, and depended largely upon this ability-to locate shoals a considerable distance from their sounding lines.

WITH APOLOGIES TO HOMER, PTOLEMY, AND ARISTOTLE

United States Coast and Geodetic Survey,
Washington, D. C.

Gentlemen:

Here is something for you. What is in it for me? If I show that the rivers are flowing up hill and show that the figures concerning the curvature are not near high enough. Can I get you to read that enclosed letter carefully. I can show that the rivers are flowing up hill if the world is round and not rotating as we are taught. Can you tell how long they are teaching already that the world is round. I thought this is the best way to reach you. Now what can I hear from you. The people around here are very anxious to see it, but I would like to make something out of it. Can I hear from you very soon?

Will you please send all the enclosed papers along back, I want to take care of them.

Yours truly _____

THE NINE LENS AERIAL CAMERA OF TEE COAST AND GEODETIC SURVEY

By O. S. Reading, H. and G. Engineer, U. S. C. and G. Survey

(Paper read before the American Society of Photogrammetry on April 22, 1935).

American engineers are a rather dissatisfied lot. Instead of putting up with difficulties, we are always trying to build bigger and better machines to surmount them. We all know that there is little difficulty in plotting from an aerial photograph a house in correct position with relation to the road near which it is located. But when we have to combine a large number of these photographs into a plot which should Join another large number of photographs without discrepancies, our task becomes difficult enough to justify considerable machinery.

If we could build a camera capable of photographing a field 130° square instead of 83°, as for example the Zeiss four lens or of 52° for a single lens, we would save quite a bit of flying. If the camera were daylight loading we could even save some flying time over the five lens by eliminating returns to the base for reloading.

The ratio of number of photographs from such a camera to cover the same area at the same scale with stereoscopic overlap would be 20 to 1 for single lens, 9 to 1 for Zeiss four lens and 4 to 1 for five lens photographs.

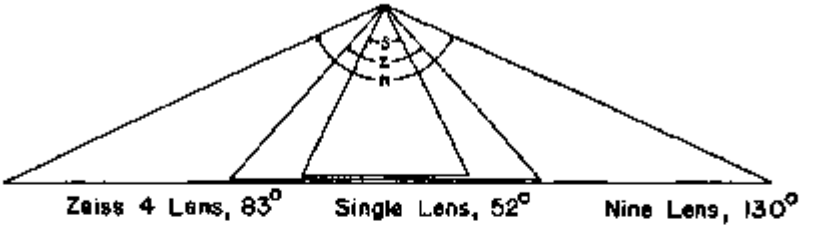
Assuming that the average error of a draftsman in drawing radial lines is 1/100 inch, the equivalent angular error of a line of the length of the air base would be about 12 minutes for single lens, about 8 minutes for Zeiss four lens and about 2½ minutes for the wide angle photographs.

If we wish to draw contours from the photographs, such a camera would have 4½ times the stereoscopic parallax of the single and of five lens and 2½ times that of the Zeiss four lens photographs. These are the advantages which will accrue from the construction of the Coast and Geodetic Survey nine lens aerial camera, should it prove successful.

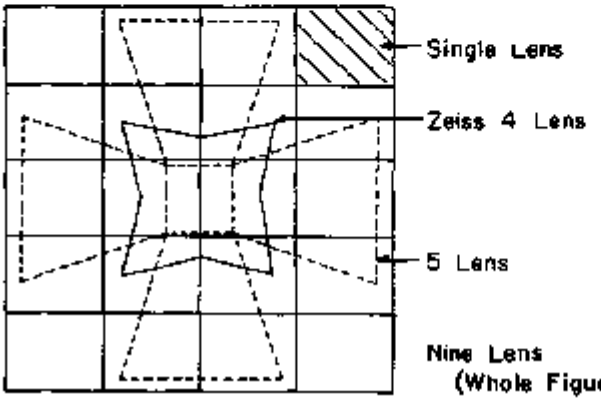
Surveyors have long appreciated the great advantages which result from increasing the area which can be photographed at a single exposure from the air. As far back as 1881 Woodbury proposed a rapidly revolving lens to expose a number of plates and to increase the efficiency of balloon photography. Several other inventors have proposed improved multi-lens cameras and in 1904 Scheimpflug designed a camera with seven lenses grouped around a central lens pointing downward. Scheimpflug also developed a transformer for reprojecting the wing photographs to the plane of the central lens. But all of these plate cameras were somewhat impractical for ordinary use both because of the difficulty of carrying and changing the large number of plates required, and because of the uncertainties of balloon navigation.

During 1917, Major Bagley, U. S. A., developed the first multi-lens camera which was really practical for air photo mapping. This camera used a single film and with its three lenses increased the width of strip which could be photographed during a single airplane flight to nearly four times that of the single lens cameras. It was a thoroughly practical apparatus which operated satisfactorily under war service conditions. With the assistance of Mr. Moffett of the Geological Survey, a transformer was developed which gave satisfactory projections of the wing chambers into the plane of the central lens. This camera worked very satisfactorily with sufficient ground control but later, when experiments were conducted to determine the minimum amount of control which could be used to give maps of standard accuracy from its photographs, it was found that the radial line plots deviated considerably in azimuth if an attempt were made to extend the plots very far beyond control. A fourth chamber was added in the period from 1923 to 1927 to increase the accuracy of the azimuth. This gave such an improvement that still a fifth chamber was added in the period from 1926 to 1929. Note the phrase "in the period." Usually several years are required from the approval of the idea or first model to the completion of a satisfactory camera. The five lens camera which we have today is a thoroughly practical apparatus whose photographs yield much more rigid plots than can be obtained from single lens photographs with the same amount of ground control. But in order to obtain sufficient overlap to use the five lens photographs in the stereoscope, it is necessary that the same number of exposures be taken along the flight strip as with a single lens camera. In order that the inter-

FIELD ANGLE



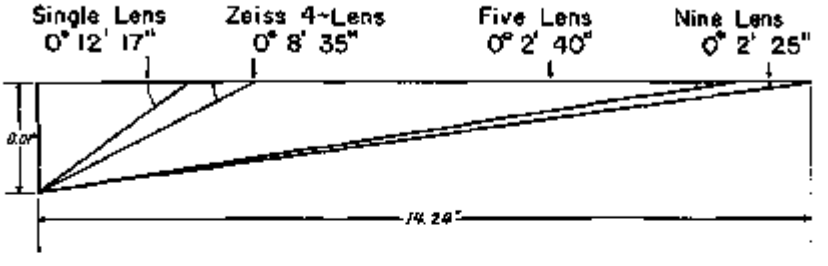
AREA COVERED AT EQUAL SCALE



NUMBER OF PHOTOGRAPHS

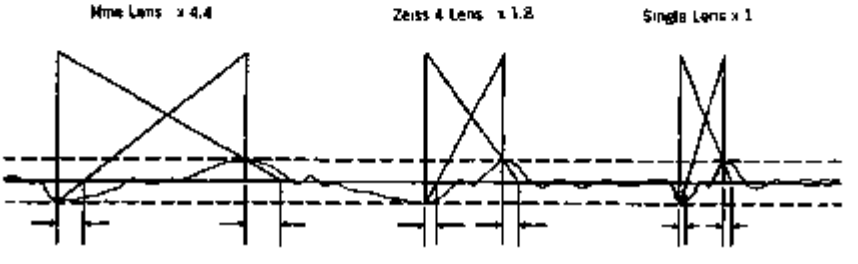
Single Lens not enlarged	20
Zeiss 4 Lens	9
Five Lens	4
Nine Lens	1

Error in angle due to 0.01" error in plotting



STEREOSCOPIC PARALLAX

(Relative displacement available for measuring differences in elevation)



sections of radial line plots, made from the outer portions of its photographs, may be well conditioned, it is necessary that the camera be rotated 45° between alternate exposures. As much as we like the five lens photographs for maintaining accuracy in the photo mapping of the Coast and Geodetic Survey, we look forward to a camera which will fill up the spaces between the wing chambers of the five lens camera, and reduce the number of photographs which we have to handle in making our plots.

In 1926 Mr. Leon T. Eliel applied for a patent on a nine lens camera which would completely photograph the whole of a square field of the same wide angle as the five lens camera. A model of a wing and the center chamber was made and took satisfactory photographs from the air. But the design resulted in a camera of excessive size if not made in a very short focal length. Largely on account of this and perhaps because of the question as to the possibility of holding the adjustment of the large number of mirrors needed in his design, no customers appeared for the camera and no complete model has yet been made. At about the same time, Photogrammetrie, Ltd., of Munich, Germany, applied for a German patent on a nine lens camera, using double reflection prisms in front of the lenses. Both Mr. Eliel's camera and the Photogrammetrie camera register all the images on a single film and transform these images to a single composite photograph. Five models of the Photogrammetrie camera have been made, only the last one or two of which have been successful in maintaining a satisfactory adjustment during the large temperature ranges encountered in aerial photography. Recently the English have built a seven lens camera of 120° field but otherwise very similar to the Photogrammetrie camera. Both of these cameras are of very short focal length. As will be seen from the sample photograph from the Photogrammetrie camera on exhibit, the short focal length entails such small images of the objects of interest to surveyors as not to be useful for mapping except on quite small scales. During the International Congress at Paris, a stereo pair of these photographs under magnification of five diameters was examined. While apparently the houses of a village could be made out and counted, it was actually quite impracticable to decide whether the apparent protuberances were straw-stacks, houses or trees. Since much of the value of aerial photographs depends upon the extraordinary amount of detailed information they afford, the sacrifice of this detail in extremely small scale photographs is not considered efficient, except in reconnaissance surveys for which economy of photo materials is extremely important.

This question of the most suitable focal length was the most troublesome of any encountered in the design of the nine lens camera. It is impracticable to do any great amount of enlarging during the transformation of the oblique negatives beyond that required to project them to the same scale as the center photograph because of limiting optical conditions of the transformer lens. For transforming the obliques at angles of 38 to 43° used in multi-lens cameras, any increase in the focal length of the transformer lens above that of the air camera introduces a marked increase in the acuteness of the transforming planes. On the other hand, a shorter focal length of the transforming lens requires an abnormally wide field. On this account, a one to one transformation is used. Moreover, the transformation requires that a horizontal object near the margin of the composite photograph be enlarged about seven times in a direction radiating from the center of a photograph and about 2½ times in transverse direction. An enlargement greater than seven times requires extreme care and unusually good exposure conditions to yield satisfactory results with present materials and technic. Considerable progress has been made recently in reducing the grain size of high speed emulsions but for average conditions encountered in the production of large numbers of photographs, it was considered best not to count on much enlargement after transformation.

It is necessary that scales at least as large as 1:10,000 and 1:20,000 be used for the Coast and Geodetic Survey topographic mapping in order that the topographic surveys may be used to furnish shoreline for the hydrographic sheets when sounding the adjacent waters. Also, it is undesirable to photograph at an altitude of less than six thousand feet because of the rough air ordinarily encountered at lower altitudes. These conditions indicated an 8¼ inch focal length for the camera. This focal length in turn limited the field angle which could be included by the camera without producing a photograph too large to be handled conveniently in plotting. A field 130° across the strip, producing a photograph of 35 4/10 inches square was decided upon. This was considered as large a photograph as could be handled in plotting since the center of the photographs must be examined carefully in many of the steps of map compilation.

It was considered essential that the aerial photographs be taken on a single film because of the difficulty of handling, setting and mounting accurately nine separate negatives and prints for each exposure. For this reason it was decided to use lenses with parallel axes, projecting their images on a single film and securing the necessary deflection of the side images by means of prisms or mirrors. Prisms, excessive in cost and size, would be required for the focal length selected and considerable difficulties would be encountered in holding the adjustment of such prisms because of the lag in expansion which would occur between the glass and the metal used for mounting them. It was, therefore, expedient to use mirrors for the deflection of the side images in the camera.

The 8¼ inch focal length would require a camera 48 inches in diameter if the double mirror arrangement, indicated in Mr. Eliel's patent, were used. Fortunately the development in recent years by Ross of England of an F4 lens, satisfactorily covering a field of 68 degrees, made it unnecessary to use a double reflection to obtain the 130 degree field for the camera. Figure 2

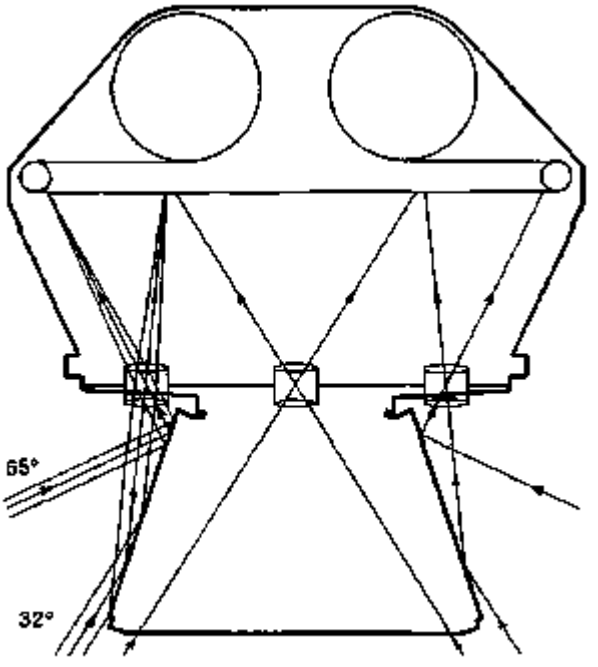


Figure 2

DIAGRAM OF COAST AND GEODETIC SURVEY NINE LENS AERIAL CAMERA

shows the general layout which was finally adopted for the camera using a single mirror in front of each side lens. The single mirrors required by this design will be 9½ inches long and about 5 inches wide. Each mirror is to be locked to the frame work by nine adjusting screws with lock nuts. The whole assembly will be adjusted by a carefully graduated focal plane plate and collimators set with a theodolite. Fortunately there are a number of old field astronomical instruments available in the Coast and Geodetic Survey which can be used for collimators without much extra expense. The mirrors are to be only 5/l6 of an inch thick but it is expected to hold them flat on the frame within 5 or 6 fringes by means of the adjusting screws. They will be adjusted to flatness as they are viewed through a quartz flat at intervals between the adjustment to the correct angles with the collimators. The frame work supporting the mirrors and lenses will be made from the same billet of metal as the mirrors, and care has been taken to use the same thickness in the cross-section of its various ribs in order that the thermal expansion may be as uniform as practicable throughout the assembly. Several experiments in chilling a test mirror and support down to the temperature of 46° below zero indicated that the mirrors will hold their adjustment through a large range of temperature. The steel to be used has 0.35% carbon and about l4% chromium with only a trace of nickel. This high chromium steel has been found by the Interferometry Section of the Bureau of Standards to have a very uniform thermal expansion, a stable molecular

structure and to afford an excellent surface for polishing. A precise adjustment of the mirrors is necessary because any error in their adjustment will double the errors on the composite photograph. The usefulness of the camera as a surveying instrument will depend almost entirely as to whether it will be practicable to hold the adjustment of its optical elements. We are encouraged by the results of the experiments and although the adjustment will be a painstaking and time consuming process, we feel optimistic about the ultimate success of the design for holding adjustment.

A second critical feature of the camera is the requirement for simultaneous exposure in the several chambers. Between the lens shutters actuated by electrical solenoids, developed by the Army Air Corps and the Fairchild Aerial Camera Corporation for the five lens camera, have been adopted for the nine lens camera. These shutters are actuated, not merely tripped, by an electric impulse and they must work simultaneously if they operate at all. The specifications require shutter speeds of 1/50 and 1/80 of a second.

We are not quite so confident about the definition in the wing chambers of the camera. The Ross lens used has satisfactory definition for one to one photographs but it has a zone between 15 and 25 degrees from the optical axis in which curvature of field causes loss in definition which may become appreciable as the images are enlarged during transformation. Since these images are likely to be somewhat poor on account of the longer light path through atmospheric haze, it may be necessary to use a different lens for the wing chambers in order to obtain better definition. The use of two different types of lenses would reduce the field of the camera. For this reason it has been decided to try the Ross lens for all the chambers in the first model. But little loss in definition and the loss of only about 15% to 20% of light is expected at the mirrors. Their stainless steel surfaces are to be coated with evaporated aluminum or rhodium at Cornell University. Mr. R. C. Williams of the Cornell Physics Department has developed a process of coating high chromium steel with aluminum which gives a surface so hard that it cannot be scratched with a wooden point and which retains about the same reflectivity as aluminum on glass.

The nine separate images on the film will be transformed to a single composite photograph in a two lens transformer. The film will be placed in a carrier which has provision for centering and measuring the shrinkage of the film from a single eye piece magnifying ten diameters. The film carrier is placed on a turn table from which each wing image is projected to its position on the composite photograph held on another revolving table below the lens. The two revolving tables are geared together to keep them in step but accurate registering with the component setting is to be secured by means of dowels. Masks are placed over the part of the composite which is not being projected. Provision is made for using either paper or film held flat on a vacuum back or glass plates for the composite. The film carrier is removed from its turn table when the printing of the wing chambers is completed and placed over another lens for the projection of the central chamber at one to one ratio. Practically every element of the transformer may readily be adjusted and clamped to allow for small errors of machine work. Provision is also made for changing the positions of the lenses and the turn table to compensate for variable film shrinkage.

The film for the camera will be 23 inches wide and about 200 feet long, providing for 100 exposures. It is expected that the camera will be daylight loading and a special spool with concave ends with opaque leaders and followers is being tried for this purpose. An automatic device for indenting the film between each exposure provides for cutting the film between exposures, if desired, prior to development. The film is to be held flat in the focal plane by a vacuum back with an electric pump of l/2 cubic foot capacity as a source of vacuum. Tests of a model vacuum back in the Bureau of Standards low pressure tank indicated satisfactory performance with such capacity at 20,000 feet altitude. The collimating marks are to be photographed on the film by a set of lamps and lenses at each corner. Images of levels, a watch, a data card and a counter will also be photographed at the same time. The image of the counter will be so placed that it will appear at the corner of the transformed photograph so that hand numbering of the photographs will not be necessary.

A telescopic sight will be mounted directly on the camera so that the camera will be automatically oriented when the images of the ground follow the drift lines in the sight. Travelling lines are provided in the sight which are driven in synchronism with the ground image by means of a variable speed mechanism which also automatically operates the shutter release to main-

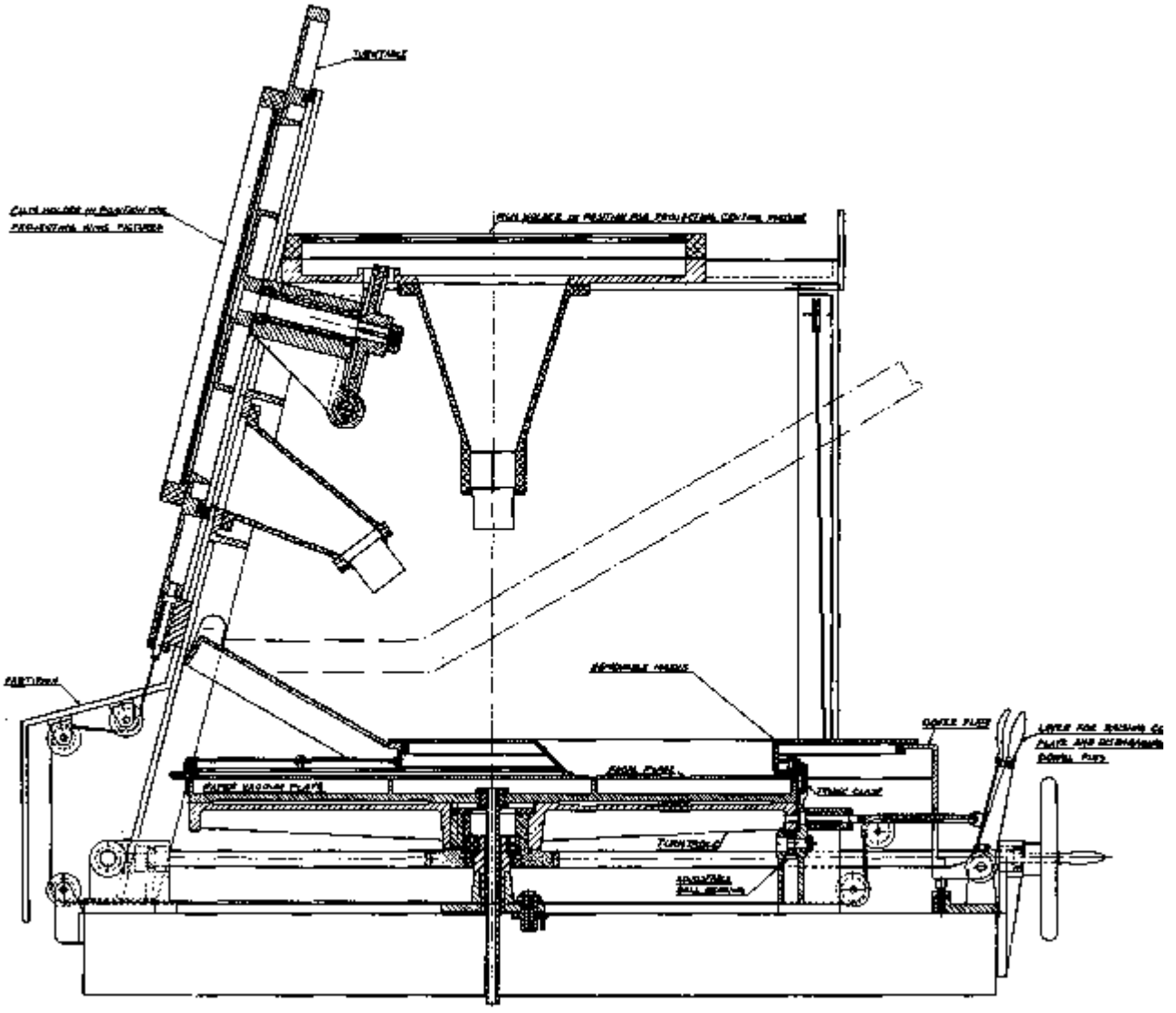


Figure 1

DIAGRAM OF TRANSFORMING PRINTER FOR NINE LENS CAMERA

tain the desired percentage of overlap of the photographs. In fact "all modern improvements" are to be included in the camera except a provision for photographing the horizon. A tilt of only one minute will cause a difference in correspondence of about 1/50 of an inch between two composite photographs which overlap 60%. On account of the large aperture necessary for a lens sufficiently fast to photograph the horizon through the red filters required, it would be impracticable to photograph the horizon on a scale large enough to determine the vertical within 4 to 5 minutes of arc. Since the difference in correspondence will give more accurate results with any ordinary amount of control, it was decided to omit the equipment for photographing the horizon from the camera.

The camera will be about 25 x 27 inches in size, about 31 inches high and will weigh about 300 pounds. It is to be handled and transported always on its own gimbals resting on a cart when not in the airplane. A special hoisting device will be used to raise the camera through a hatch cut into the bottom of the airplane. A Bellanca "Pacemaker" or Fairchild 1-A is the minimum size of airplane which can be used to carry the camera.

The design of the camera is based on data furnished by the National Bureau of Standards. The advice of the scientists in the Bureau of Standards, particularly of Dr. I. C. Gardner, Chief of the Optical Instrument Section, has been sought on practically all questions. The mirror and lens specifications were written after tests conducted there, and the finished parts will be tested in the laboratories of the Bureau before they are accepted for use in the camera.

The camera is being built by the Fairchild Aerial Camera Corporation, which assumes full responsibility for its mechanical operation. The Coast and Geodetic Survey will make the optical adjustment. The Fairchild Corporation has done an excellent job in designing to meet the exacting and rather complicated specifications and we all hope that we shall have a successful camera. The contract price for the first model is $24,350 which will be paid in a lump sum, if and when the camera makes 500 satisfactory exposures. It is expected that the camera will be ready for trial late this fall

If the camera is a success, there is no question but that its advantages will be ample justification for the expenditure of time and effort. One fourth to one twentieth the number of photographs to plot and a stereoscopic parallax of two to four times that of other cameras are worth striving for. In order to do contouring, a rectifying camera to rectify the nine lens photographs and a projector will be necessary. Preliminary designs are being prepared for this equipment. No funds are at present available for construction of these, but if the camera is an unqualified success, the advantage of 2 to 4 times the stereoscopic parallax will doubtless lead to the construction of these additional devices.

It is not easy to visualize the effect of this camera, granted that it is a success, on surveying and mapping as we now know it. Imagine an entire quadrangle within the scope of one photograph on a scale of 1:27,000. Allowing 60% overlap, both along and between the strips, only six or seven photographs will be required per quadrangle at 1:24,000 scale. The need for adjusting radial line plots should largely be eliminated. On account of a stereoscopic parallax of two to four times that of present cameras, it should be practicable to extend the advantages of stereoscopic mapping to more level terrain as well as reducing the cost of topographic mapping considerably below that possible with present methods or equipment.

SOUNDING TO GRANITE

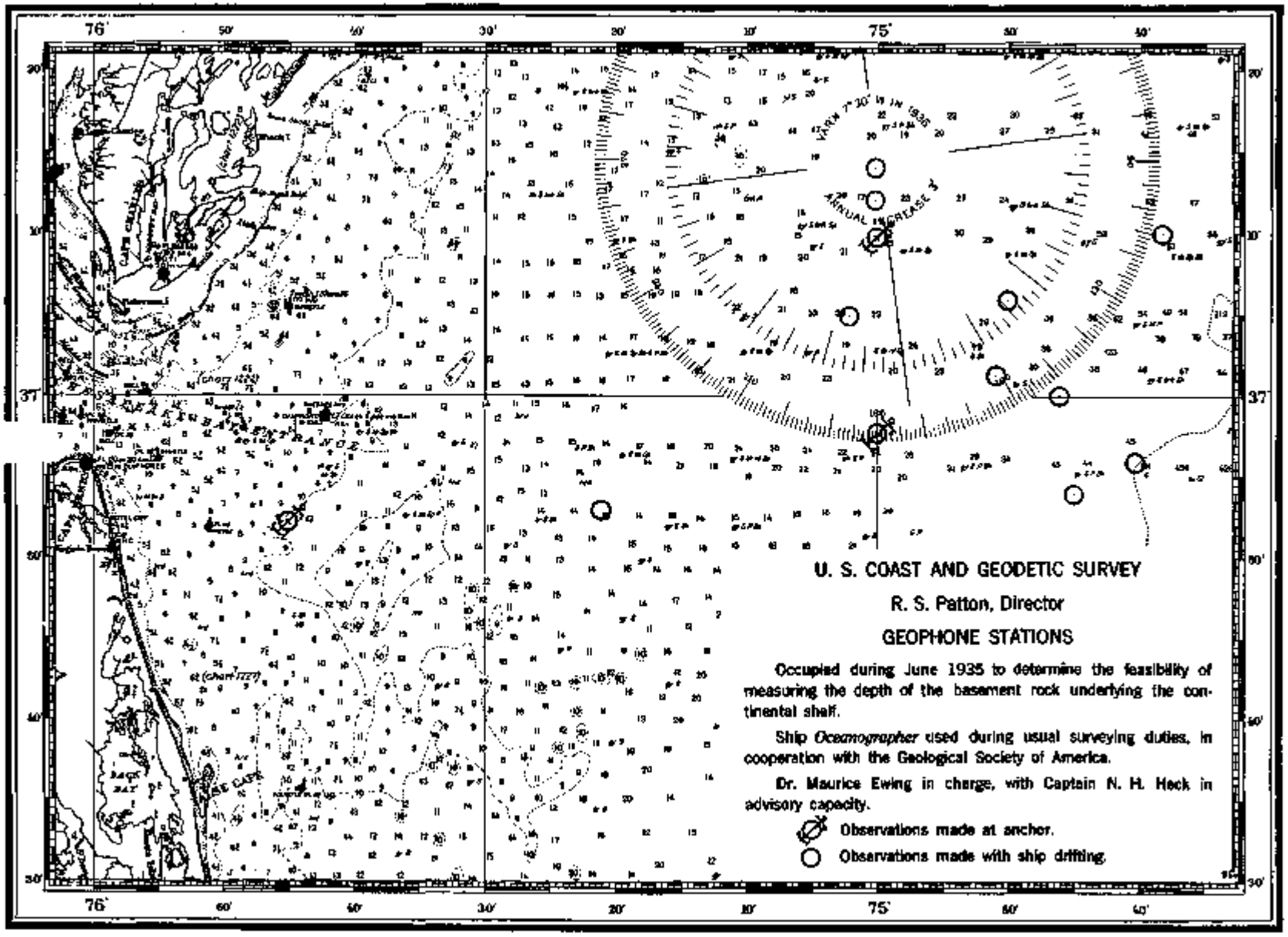
N. H. Heck, H. & G. Engineer
Chief, Division of Terrestrial Magnetism and Seismology
U. S. Coast and Geodetic Survey

Some time last winter Doctors Richard M. Field and Benjamin L. Miller approached the Director, U. S. Coast and Geodetic Survey, with regard to the use of one of the Bureau's vessels to find out whether it would be possible to measure the depth of the basement rock underlying the continental shelf off our Atlantic Coast.

It was agreed by the Director that this might be done provided no expense to the government was involved and that the necessary funds would be provided by the Geological Society of America. Funds to the extent of $2000 were granted to Dr. Ewing of Lehigh University during May. Since the project involved seismic information of great interest, I was assigned to keep in touch with the plan and to aid in putting it into execution at the proper time. The OCEANOGRAPHER was selected because of the locality of her work. On June 14th, I left Washington and Dr. Ewing arrived on June l6th. The death of Lt. Brown and injury to Captain Seran delayed sailing on the 17th and departure was made on Wednesday night. Little was accomplished during the first week except the all important work of installation and testing and study of needed new methods.

It was necessary for me to remain another week and this was authorized on my request. Air the close of the week, I returned to Washington via Wilmington, Delaware, for reasons which will be given later and returned to duty on July 1st. A brief explanation of the project will make my report clearer.

In geophysical prospecting, the method of refractions has been preferred for a number of years. It is closely analogous to RAR work except that the waves passing through the earth are more complex than those passing through the water. The problems are analogous to those of the nearby earthquakes, waves from which


U. S. COAST AND GEODETIC SURVEY
R. S. Patton, Director
GEOPHONE STATIONS
Occupied during June 1935 to determine the feasibility of measuring the depth of the basement rock underlying the continental shelf.
Ship *Oceanographer* used during usual surveying duties, in cooperation with the Geological Society of America.
Dr. Maurice Ewing in charge, with Captain N. H. Heck in advisory capacity.
Observations made at anchor.
Observations made with ship drifting.
76°
75°
37°

pass through the upper crustal layers. This method while it is possible at sea with two vessels could not be considered at this time.

Another method has recently come into favor though not fully approved by all geophysicists. This is the method of reflections. It resembles our acoustic sounding except that the explosion is on the bottom and the reflection is from some reflecting layer. In reflection records, many other waves are recorded but reflections can be readily identified. Horizontal waves arrive at recording instruments at different times, while vertical waves due to reflections, arrive at practically the same instant, if the instruments are not too far apart. The reflection method is the only one which can be used from a single vessel, and in the case of the OCEANOGRAPHER a spacing of 100 feet between instruments could be obtained.

The instruments used were geophones of the type developed by the Geophysical Research Corporation and they were loaned to Dr. Ewing for the work. In view of this loan it was of especial importance that none be lost. A brief description of the geophone is of interest. It consists of a cylinder of aluminum for the outside casing, perhaps 18 inches high, with a ring in the top and weighing about 18 pounds in the water. A single conductor enters through a hole and the connections are made inside and sealed by parafin. The steady mass is a magnet mounted on springs and its movement past fixed coils sets up currents which when amplified actuate the recording galvanometers. The recording is done on paper wider than motion picture film, but perforated in the same manner and all three geophones are recorded on the same record.

The firing of the bomb has to be taken care of so that one galvanometer first records the firing of the bomb and then immediately becomes available for taking the record of one of the geophones. In this way with three geophones there are parallel records which show the firing of the bomb, the arrival of the water wave, the wave passing along the surface of the earth and the refracted and reflected waves. Many waves which would be shown on an ordinary seismograph are eliminated on account of the short period of the geophones, which is .03 second and the instrument is therefore responsive only to waves of this general period. Since horizontal waves arrive at the geophones at different times on account of the different distances, they are not taken for reflections which, since they are practically vertical, reach all geophones at nearly the same instant. The line connecting the impulses is directly across the record. The time scale is large, a second being on the order of eight inches and hundredths of seconds are placed on the record by a tuning fork, thus making it possible to estimate thousandths of a second.

Dr. Ewing's eventual report will go into more detail, but what has been said will suffice in connection with my part in the project.

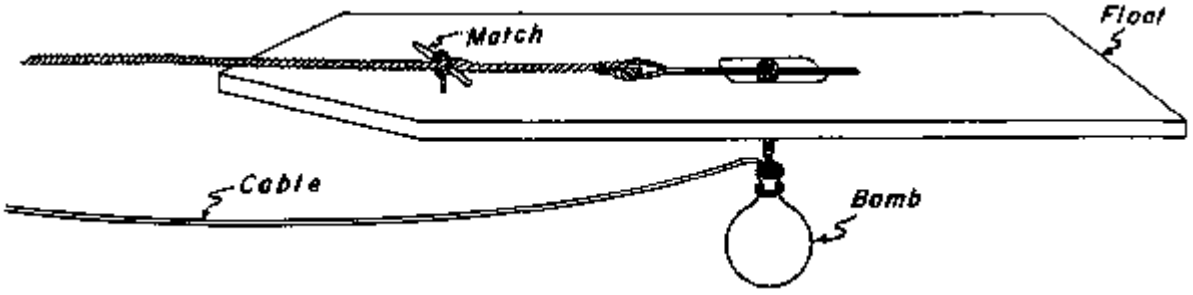
At an early state of discussion of this project, I suggested that the only way to get reflection was to lower geophones from three places on the vessels separated by not less than 100 feet and this was done. This required the mounting of four reels, one for each geophone and one for the firing circuit, since it was necessary that the bomb be on bottom at least three hundred and preferably five hundred to a thousand feet from the nearest geophone. Tests proved that this plan was perfectly feasible even with a rapidly drifting vessel, up to depths of fifty fathoms.

Installation of reels on the OCEANOGRAPHER was somewhat difficult on account of her fine teak rail. Dr. Ewing provided reels which could have been readily installed on vessels of the minesweeper type but not without great difficulty on the OCEANOGRAPHER. Accordingly hand reels were made by the ship's, force and were installed by lashing pipes to adjacent stanchions and letting the bases of the reels rest on the rail, in which case the worst that could happen would be scratching of the varnish which could be readily taken care of. In practice, the geophones were raised and lowered by hand and then the cable was wound on the reel. This was a somewhat awkward proceeding, reminding me of my first days in wire drag work, and made the operation a little harder for the crew. Small power reels would greatly facilitate the operation.

The reel for the cable to the explosive was more rigidly mounted and this could be used both for paying out and reeling in. It was found practical to use this method at the same time that water samples and temperatures were taken with practically no delay. A very important safeguard was that the ends of the wire on the reel were fitted so that the cables from the control panel could be plugged in at the proper time just before firing, and this applied both to explosion cir-

cuit and to geophones. The practice adopted was to have the bomb ready and the instant the telegraph from bridge to engineroom was heard, the bomb was put over. By the time the ship had come to a full stop the bomb was on the bottom at the desired distance. As soon as the geophones reached bottom extra slack cable was given, all were quickly plugged in and the bomb was fired. The instant the explosion was heard the plugs could be pulled out and reeling in started. In forty fathoms everything was aboard before the temperature observation was complete and in fifty it required only a few minutes more, though with power reals it would be less. There was no loss of time to the ship and the crew simply left their duties for a few minutes and returned to them.

Dr. Ewing had many problems into which I will not enter, except to say that his galvanometers had two different sensitivities so that he obtained two records. He had three stages of magnification and the bomb performance varied with depth and with amount of explosive. With all these variables it was hard to set the instruments so as to get good records, but Dr. Ewing was quite successful and while only a few records approach perfection each contains something of value. One record in particular was stated to give a better reflection than, according to his knowledge, had ever been obtained on land. However, it was soon seen that this method of attack is only suitable for reconnaissance. The next step was, as I suggested, to see if it were possible to make observations at night when the vessel was at anchor. This required the development of a method by which the bomb could be placed at desired distances from the ship. Obviously a float with a suitable detaching arrangement would make this possible. One was devised which did not prove satisfactory. Then it occurred to me that a board float with a suitable detaching device would do the work. The device consisted simply in a towing line passing through a screw-eye at the front of the board and attached to a rod or pin through an eye at its front end. The rod passes through two screw-eyes near the center of buoyancy of the board. Between them a transverse slot is cut in the board through which an eye in the line supporting the bomb is passed. With the pin in place the bomb is supported just below the board. A pull on the towing line pulls out the pin and the bomb drops to the bottom. In order to prevent the pin being pulled out prematurely the line is opened up enough to pass a match through it just back of the forward screw-eye. The match will hold for any ordinary pull but a sharp jerk on the towing line breaks it.



In this way a series of bombs of various sizes could be fired at the same spot and various adjustments could be made at the control panel so that chances of obtaining a satisfactory record were increased.

The first week there was no success in firing bombs. The office furnished a copy of the report of the successful use of bombs on the west coast and with modifications of bombs provided by Dr. Ewing along the lines suggested by Mr. Crary of Dr. Swing's party and the west coast experience, the problem was solved and there were no failures in depths up to 55 fathoms during the next week. An essential feature is coating the final taping where the detonator wire enters the bomb with collodion.

In deep water a small bomb on the bottom proved very effective. In one case scarcely a teaspoon of TNT in a small pipe bomb was used and this gave more intensity than needed. Such a bomb gave so slight an explosion that it could not be heard in the radio room and yet it gave a position with the station vessel 25 miles away. This suggested some possible means of supplementing present RAR bomb practice and experiments along this line are being considered. It is quite possible to fire bombs electrically at a considerable depth by the same method long used in tube sounding provided that there is a small power reel or sounding machine available to bring back the cable. Dr. Ewing provided for the geophones a cable about the size of a pencil with a single conductor and a sheathing of fine steel wire separated from each other by insulation so that the cable may be considered as two conductor.

Dr. Ewing occupied one of the unused staterooms forward and installed the apparatus in the room reserving only the upper berth for his personal use. This proved an effective arrangement. The cables were led through passageways without interference to anyone.

In the original discussion of the project it was feared that the water wave, the wave passing along the surface from explosion to geophone might blot out the rest of the record and so prevent obtaining the desired reflections. This proved not to be the case, though the water wave is so well recorded that it may be used to obtain distances from explosion to geophone. In practically every case the two waves mentioned are out of the way before the features in which we were interested arrived. I will not discuss records further than to say that it is now possible to draw certain inferences regarding depth of the bed rock, though additional work must be done before accurate depths can be assigned. Nearly every record contains a reflection of some kind. There are now on hand at least fifty records.

The enclosed section of the chart (1109) shows the remarkably wide range of results during a week of fine weather during which the work was carried on. It will be seen that from the view point of best attack on the problem, the observations are too scattered, however, a most excellent reconnaissance has been made. In order to make the work directly quantitative, it will be necessary to start at two wells which reach to bed rock, one at Fortress Monroe and the other in Mathews County, Virginia, and after firing both reflection and refraction shots at these, proceed to sea, anchoring every five miles for reflection work right out to the edge of the continental shelf and then firing refraction shots at 15 or 20 mile intervals.

The program was a very strenuous one and showed that the work must be systematized to a definite program.

At a conference at Wilmington, Delaware, held immediately after the completion of the work on the OCEANOGRAPHER and attended by Doctors Miller, Field, Ewing and the writer, a program was adopted which is expected to result in observations along at least one line across the continental shelf with needed observations on shore to make interpretation complete and satisfactory.

I feel that the project was carried out successfully in a very short time and in spite of many difficulties and that the way is thus laid for obtaining geological information of great importance. The Coast Survey will undoubtedly benefit from the information learned regarding bombs.

I wish to express my hearty appreciation of the fine cooperation of Lieutenant Graham, especially as he was handicapped by having to act both as commanding and executive officer during the period. The handicap to the work through the death of Lieutenant Brown should be mentioned. He had been assigned by Captain Seran to cooperate with Dr. Ewing and in the brief time their exchange of ideas had proved valuable. I also wish to state that Chief Engineer Sawyer was especially cooperative, aiding greatly by modifying the bombs as necessary and by personally aiding in the work. The officers and crew did all that could be expected of them. It will be understood that though Captain Seran had given the necessary orders, unfortunately he was not on hand to take any active part in the program due to his injuries.

MR. KING APPOINTED COMMISSIONER OF LIGHTHOUSES

(From "Lighthouse Service Bulletin" August 1, 1935.)

Mr. King's many friends in the Coast and Geodetic Survey will be pleased to read the following quotation. The editor wishes to take this opportunity to extend congratulations and best wishes to Mr. King on behalf of former associates in the Coast and Geodetic Survey.

On July 16, 1935, the President appointed Harold D. King, formerly Deputy Commissioner of Lighthouses, to be Commissioner of Lighthouses. Mr. King has had 24 years' experience in responsible work in the Lighthouse Service, and before that, approximately 9 years in the related work of the Coast and Geodetic Survey. He is a graduate of Dartmouth College, having specialized in science and engineering, and has also qualified as a master mariner; this combination of engineering and nautical training and experience is especially valuable in the operations of the Lighthouse Service.

In the Lighthouse Service, prior to his designation as Deputy Commissioner in 1930, Mr. King was superintendent in charge of three important lighthouse districts, including a long tour of duty in the Fifth District, the headquarters of which were then in Baltimore. By designation of the President, he represented the United States at a meeting of an international committee at Genoa, Italy, in 1929, for the consideration of a uniform system of buoyage and lighting of the coasts of the world. In the Coast and Geodetic Survey he served on the Atlantic coast, the Pacific coast, and in Alaska and the Philippine Islands, including duty on a number of surveying vessels, two of which he had command.

Mr. King took the oath of office as Commissioner on July 18, in the Commissioner's office in the Bureau; the Secretary of Commerce, Daniel C. Roper, Assistant Secretary, J. Monroe Johnson, and other important officials of the Department were present, together with the entire staff of the Bureau.

Secretary Roper made the following felicitous remarks:

"Captain King, I congratulate you on the opportunity for public service which you will have as Commissioner of the Bureau of Lighthouses. This agency of public service is both old and honorable. It dates back in our history to the establishment of our Federal Government, having been inaugurated in 1789. or during the first administration of George Washington. Furthermore, it has kept pace in its development with the expanded requirements of shipping and water travel, as wall as abreast with modem thought and invention in providing safety to property and to human lives.

It is an agency well balanced in its interest in property and in human beings. There is something inspiring to the thoughtful traveler when he looks upon one of these light guides at sea or elsewhere in water travel. They seem to say, 'Be of good cheer, all is well.' Yes, they seem to speak to us to the effect that someone is thinking of you and caring for you. It flashes a soul force which overrides selfishness with unselfishness, manifesting interest in and for others. The buoy that outlines the channel seems to say, 'Let me take your hand and guide you along this treacherous way to security and safety.' Those who have developed this great service have established a symbol not only for the far-reaching lighthouse system of the United States but also a beacon of comforting guidance to the traveler in all walks of life.

It has been my privilege to visit personally several of the lighthouse districts and to inspect in some detail lighthouse depots and equipment. I am thankful for the opportunity of surveying the lighthouse service from Florida to Maine and from the Pacific coast along the great Alaskan Peninsula to the Bering Sea. One cannot have had this intimate association with this sterling am of Federal service without appreciating fully the accomplishments which have written a history of unfailing service.

Bat, important as the past record is, I visualize a still greater future for the Lighthouse Service. New developments in lighting and marking methods will facilitate and improve the present basic service and prepare the way for amplifications and extensions of the present system. The record of the past, Captain King, which you and your aasociates, and those who have gone before you, have established, constitutes a great challenge for the future. I consider it a deep privilege, therefore, to extend to you and to your faithful assistants in and out of the Washington office my sincere greetings, my hearty congratulations, and my good wishes for continued service to humanity. Captain, turn on the lights."

UNIFORM METHOD OF MARKING INTRACOASTAL WATERWAY

(From "Lighthouse Service Bulletin" August 1, 1935.)

The intracoastal waterway, passing from north to south along the Atlantic coast and from east to west along the Gulf, traverses several lighthouse districts. Recent rapid progress in the completion of connecting links looking toward an ultimately continuous route makes it highly desirable that it be uniformly marked, which has not heretofore been the case due to the slightly varying practices in the different districts. The Lighthouse Service has therefore adopted a uniform method of marking for the intracoastal waterway to be generally applied south of Norfolk, both on the Atlantic and Gulf coasts. A drawing showing standard practice as to lighting, buoyage, beacons, daymarks, etc., has been prepared for the

guidance of each district, all types of aids being shown in their proper colors. To a considerable extent, standardization of structures will also be accomplished. These standards will apply to all aids established subsequent to the adoption of the uniform system and present aids will be changed over to conform to the new system as rapidly as practicable with a view to accomplishing complete uniformity in accordance with the adopted system.

It is anticipated that this complete uniformity in aids will be particularly helpful in eliminating any cause for misunderstanding by mariners, as well as simplifying maintenance and operation. Some favorable comment from navigators has already been received.

Some of the principal features applicable to the uniform system are as follows:

In proceeding in a southerly direction along the Atlantic coast and thence generally westerly along the Gulf coast the port hand is considered as on the left, starboard on the right, and aids colored and numbered accordingly.

Red lights are to be used throughout on the starboard side of the channel surmounting red superstructures with red triangular daymarks and having even numbers painted in white at the center of the daymark.

On the port side either white or green lights are used on black superstructures with black square daymarks bearing odd designating numbers in white.

For daymarks on unlighted beacons, black squares with odd numbers are used on the port side, and red triangles with even numbers for starboard side of channel, and numbered serially with the lighted structures in well defined geographical groups or channel divisions.

Single pile structures on which the triangular or square daymarks are not used will be fitted with a pointer board directed toward the channel. The top half of the starboard piles, including the pointer board, will be red with even white numbers, and the port piles and pointer board black with odd numbers in white.

A distinctive feature of the intracoastal waterway aids will be in the use of yellow borders on all daymarks and yellow tops or tips on the single pile beacon structures.

Where the intracoastal waterway traverses channels in rivers and inlets already marked as entered from seaward the numbering, coloring, etc. of aids in the latter remain unchanged. In such cases a yellow triangle or square is added to daymarks or to buoys to indicate the relation of the aid to the intracoastal waterway. By carefully observing the use of the triangle or square and the color yellow which is characteristic of aids marking any part of the intracoastal waterway, confusion may be avoided.

EXTRACT FROM "NAUTICAL MAGAZINE", JULY, 1935

In our issue of September, 1934, we drew attention to the Field Engineers' Bulletin" of the U.S.A. Coast and Geodetic Survey. The eighth number of this important publication is now issued and fully maintains the high standard of its predecessors. It is only occasionally that we seamen realize the tremendous amount of research and labour, often under extremely hazardous conditions, that are embodied in the charts and sailing directions on which we depend so largely. Publications of this nature, with which we may bracket the Hydrographic Review and our own Empire Survey Review, must fill us with a feeling of gratitude for the hard working and keen thinking personnel of the survey services. In the publication under review the editorial says, with a pride we have no hesitation in saying is perfectly justified, "Our good name has always stood for accuracy among the engineers of both the nation and the world." As honorable men they place on record their confession that "there has never been a case, when under some pressure we lowered our usual standard, that sooner or later we did not regret it."

Volume No. 8 has very interesting articles on "The Dorsey Fathometer," "The Foucault Pendulum Experiment," "The Coast Survey on the Pacific Coast," and "Submarine Valley off Chesapeake Bay Entrance." Nothing, perhaps, shows more clearly the supreme importance of the survey work than the sketch map

showing the changes in the shore line of the coast of Louisiana resulting from the hurricane of June 16, 1934, and two contrasting sketch maps showing the areas off Cape Alava, Washington, according to surveys of 1888 and 1931. A compliment to Great Britain, and therefore indirectly to the British Mercantile Marine, is shown by the inclusion of the Signal Reminder of the International Code published by Brown, Son & Ferguson, Ltd. A similar compliment is paid to our own Survey Service by the reproduction of a very humorous sketch by Lieutenant-Commander A. M. Hughes, R.N. of "Life in a Survey Ship," from the "Empire Survey Review".

We wish to acknowledge at this late date the Signal Reminder which was reproduced through the courtesy of Messrs. Brown, Son & Ferguson, Ltd., acknowledgement for which was inadvertently omitted from Bulletin No. 8.

Editor.

HURRICANE OF SEPTEMBER 2, 1935

(Extract from a letter to the Director from W. H. Bainbridge, H. & G. Engineer, U. S. C. & G. Survey).

During the hurricane which crossed the Florida Keys in the vicinity of Matecumbe, Lieutenant Bainbridge's party pressed all of their equipment into service for relief to the stricken area. The following extract mentions briefly the conditions during the storm.

"Your letter dated September 18, 1935, relative to the relief work in the area in the Florida Keys devastated by the recent hurricane was appreciated by the members of both parties.

In addition to the two launches, two flat bottomed barges, built by the party, and an outboard motor were furnished for the relief work. The barges and the motor are still being used at Lower Matecumbe.

The following may be of interest. The keeper on duty at the Alligator Reef Lighthouse recorded the following readings of a calibrated barometer on September 2, 1935.

12:00 Noon	29.85	inches
5:00 P.M.	29.20	"
6:00 P.M.	29.00	"
6:30 P.M.	27.84	"
8:00 P.M.	27.45	"
8:10 P.M.	27.35	"
9:00 P.M.	27.50	"
10:00 P.M.	28.40	"
12:00 P.M.	29.24	"

Mr. Kennedy of the local U. S. Weather Bureau Station stated that a wind of 200 miles per hour was conceivable with such a drop in the barometer between 6:00 and 6:30 P. M.

Alligator Reef Lighthouse was put out of commission by the hurricane. The only glass remaining was the pane parallel to the direction of the wind. The lens was completely demolished. The water tank and platform was carried away.

Three of four spongers and fishermen in the path of the hurricane reported barometer readings of 26.40 inches; one of the barometers giving this reading was checked; a correction of + 0.35 inches was obtained. With the correction, the reading was still fairly low!

One of the barometers showing the 26.40 inch reading was lost in the following manner. Two men had their boat in one of the small creeks about Matecumbe. During the lull, one turned the flashlight on the barometer, and apparently didn't believe what he saw because he took the light and barometer out to the other man standing in the cockpit, who took a look and heaved both overboard. When asked why he did that, he replied, "We won't need them where we are going". The boat was left high and dry in the mangroves when the water receded with no serious damage.

As you know two more hurricanes are playing around south of here. One originated in the same locality where the hurricane of 1909 originated, which hit Key West."

ADDITIONAL NOTES ON AIR PHOTO COMPILATION

Marshall H. Reese, Jr. H. & G. Engineer
Coast and Geodetic Survey

Indexing of Photographs.

As a rule when photographs are forwarded to compilation parties, the complete index maps have not been made. It is always desired that some form of an index map accompany the photos in order that the photo party can ascertain the approximate areas which the photographs cover.

After the photographs are received they should be accurately indexed on a standard chart of the Coast and Geodetic Survey, preferably on a scale of 1:80,000, as this scale is very convenient to work with. The main features of the 1:80,000 being that it covers a large area and at the same time there is sufficient detail to locate the photographs accurately. Every fourth photograph normal to the line of flight should be indexed, showing the "A", "B" and "C" prints. (See Figure 1.) The number of the photograph should be shown on one of the prints, and this should be followed through the particular flight. The letters of the respective prints should be shown in some conspicuous place, so as to identify readily the prints when viewing the index chart. Where there are overlapping flights, the various flights should be shown with different colors of ink.

All control data should be carefully spotted on the index charts. This may be done before the photographs are indexed, or afterwards, but it is much easier to spot the control on the index chart before the photographs are indexed, for when the photographs are plotted there are so many lines that it may be confusing in plotting the control stations. It is very important that the control stations be accurately spotted. If the stations are spotted accurately and the photographs are accurately indexed, they will assist considerably in recovering triangulation stations.

In beginning the search for a triangulation station, the first step is to determine the approximate position of the station on the photographs, then reading the description of the station and applying the data from the description to the detail shown in the photograph, it will be very easy to ascertain if the station can be reached better by truck or by boat. The photograph can be used as a detail map to guide the recovery party to the exact locality where the station is situated. This method has been very useful on this party, and considerable saving of time has been effected.

It is a good plan to make up at least three index charts of each section, one chart to remain in the office and the other two for use of the field inspection parties.

Sheet Layout.

It is very desirable to lay out the sheets so that the projection lines of the compilation will be parallel to the edge of the celluloid. By having projections made in this manner several advantages are derived. Projections of this type are much easier to make and, at the same time, are more accurate, for it is very easy to get a twist in a skew projection as it is not always possible to have sufficient lines for accurate construction. Another advantage is that it is easier to lay out sheets when a "north and south" or an "east and west" direction is predominant on a project. It also affords the Chief of Party the opportunity to adopt a uniform layout which can be made to conform to the 15-minute quadrangle layout of the United States topographic map. The sheets laid out 7½ minutes in longitude and 3 3/4 minutes in latitude can easily be applied to the quadrangle layout of the United States.

It is very hard, if not impossible, to follow this layout on a coast line project, due to the fact that there are numerous bays, lakes and rivers which are covered in a project of this kind, and also due to the fact that the coast line may be very irregular and does not follow any general direction, that is, "north and south" or "east and west", conducive to sheet layouts of this nature.

To obtain sheets which are always constructed either in a "north and south" or and "east and west" direction would increase materially the number of sheets on a large photo compilation project as is generally laid out at the present time

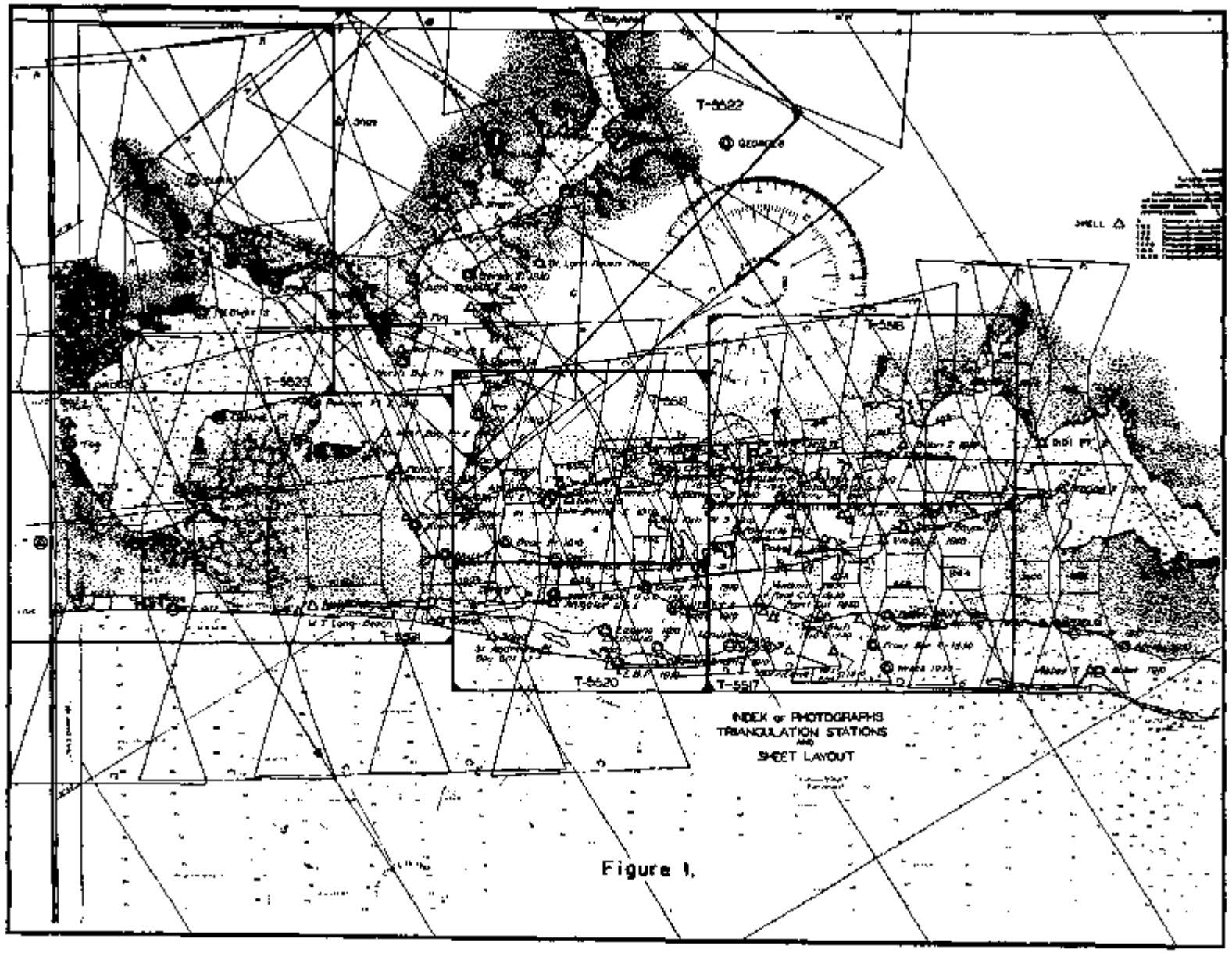

T-5522
GEORGE
SHELL
T-5523
T-5518
T-5520
T-5517
INDEX OF PHOTOGRAPHS
TRIANGULATION STATIONS
AND
SHEET LAYOUT

Figure 1.

along the coast lines. This feature of laying out sheets can be effected, but it will require a little change in the layout of flight lines of the photo project along the coast lines. At the present time all of the photographs are taken with the idea in mind to save as much photography as possible, which has to be considered from an economical standpoint; but if the policy to have all sheets made with their projection lines parallel to the edge of the celluloid is adopted, it will be essential that the flight lines of the photographs be so laid out that the sheets can be made to conform to this specification.

It is very desirable in making a compilation that the line of flight be somewhat parallel to the edge of the projection; therefore, if the flight lines were laid out somewhat in a "north and south" or an "east and west" direction, depending upon the locality and on the various other factors which have to be met, it would be much easier to have the sheets laid out in a uniform manner. It is believed that the additional amount of photography would be more than offset by the reduction in the number of sheets necessary to meet these specifications of having the projection lines parallel to the edge of the celluloid. (See Figure 1.)

As a rule the Chief of a compilation party lays out the sheets so as to cover the whole project in as few sheets as possible, as this is the only economical way to obtain the lowest unit cost per compilation. It takes almost as much time to make a small compilation as it does a full-size compilation, for it requires about the same time to make the projection, plot the control, make the radial line plot, etc. The tracing of the larger area is just one of the details in the compilation, for before the detail can be traced there are a number of steps which have to be accomplished. Small sheets also require about as much time and work to print them as large sheets. Therefore, from the economical standpoint it is not always desirable to follow the rule of laying out projections with the projection lines parallel to the sides of the celluloid on a large project where the coast line is very irregular and where the interior is broken by bays, lakes, etc. It is very easy to adopt this system where the photographs which are being compiled cover a large area and are flown with this thought in mind. A good example of this is the compilation of the photographs in Louisiana in the vicinity of the Mississippi River Delta.

An accurate sheet layout is very helpful in determining if there is sufficient control to control rigidly the radial line plot. From the sheet layout it can easily be determined where additional control is needed, and an idea can be obtained, depending upon the locality and conditions, as to the most economical manner in which the additional control can be established.

If the control is to be established after the photos are taken, a sheet layout or an index map is very helpful in properly distributing the control for radial line compilations. For as a rule the triangulation parties establish stations where they can be reached by truck with the least amount of trouble or cost. With an index map constructed and a sheet layout made, it is possible to distribute the control properly, and not normally increase the amount of triangulation stations which a control party ordinarily establishes when breaking down a first-order arc into a second-order coastal coordinating arc. This feature is obtained by placing the stations where they will serve the maximum advantage from a compilation standpoint and at the same time meet other needs, such as plane table and hydrographic surveys along the waterways. For example, a station that is placed near the junction of two sheets will serve to control those two sheets, whereas if the station were, say, a mile and a half or two miles from the junction it would be desirable to have another station nearer the junction of the two sheets. Of course, it is possible to extend a radial line plot some distance beyond the limits of the sheet, but at the same time a sufficient amount of control is necessary to plot the photographs rigidly.

Filing of Photographs.

The filing of photographs on a field project is subject to many considerations, the main ones being the office space, the particular layout of the offices, and the amount of equipment that is assigned to a field party. It is more or less impracticable to attempt to adopt a standard method of filing photographs, for on each project that I have worked we have had a different system, depending upon the prevailing conditions. In general, ideas used by this party will be explained.

It has been found satisfactory to make a filing cabinet, composed of a number of shelves, for unmounted photographs. The field prints and the office prints

are both filed on these shelves, in the boxes in which photographs are usually shipped to the field. A detailed list of the photographs contained in each box is pasted on the outside, the field prints being filed in separate boxes from the office prints, and this information shown on the poster. With this method of filing it is very easy to find the photographs desired.

The filing of mounted photographs was a bit more difficult, as they require considerable space. The large filing cabinet that is furnished to compilation parties is very efficient. If on a large party three or four of these were used they would take care of the filing of mounted photographs.

Control for Photographs.

Control points located by triangulation are the most satisfactory for use in controlling the aerial photographs; or by traverses run between triangulation stations when the positions of the points established are computed and the error of the traverse is determined and properly adjusted.

After the second order scheme of triangulation of an area has been established, it may be necessary to establish additional control for aerial photographs. The method in which this can be most economically done depends upon the topography of the surrounding country and the amount of control available. If it is in a section where there are roads, traverses would be the most satisfactory, as it has been my experience that traverses, when properly run and computed, are decidedly superior to any other type of supplemental control for the reason that an additional number of points are obtained and the location of these points can be located accurately on the photographs, such as road intersections and other natural features which can be picked directly on the photographs when the traverse is being run.

In areas where hydrography is desired, points can be located for the control of aerial photographs by use of aluminum mounted sheets. In this case, all the points which are located by intersections should be used. Points other than these which have sufficient cuts to prove that they are accurately located are subject to question, for it is very easy for the topographer to make a small error in reading the rod, and this error may compensate in a traverse. It is, therefore, recommended when additional control is to be located by topography that it be put in by intersection or else be included in a closed traverse, so that a check may be obtained on the points located. Extreme caution should be used by the topographer when side shots are taken for location of points to be used in air photo control. The rod readings should be checked, and if possible a direction should be taken to each of these points, and this will assist materially in determining if there is any error in the rod readings.

There is one serious disadvantage that is ordinarily found in sections where the hydrographic parties establish the second-order control, for, as a rule, they establish their control only along the shore line of the various waterways in which they are engaged in surveying. This serves the purpose for hydrographic and topographic surveys of the section, but for obtaining accurate locations of detail back from the shore line of waterways by the use of aerial photographs, it is absolutely essential that some control stations be established back from the shore line of these various water courses for the purpose of controlling the wing prints of five-lens photographs; and this same feature will exist if in the future we adopt a camera capable of producing large single-lens photographs.

In areas where this condition exists it would probably be more economical to run traverses to establish this additional control, for it would not be economical to locate these points by triangulation after the main scheme has been established. This factor should be given serious consideration when a triangulation party is establishing the control for areas along the coast line. It is not very easy to obtain these points back from the shore line of the various waterways unless steel towers are used, for, as a rule, the country is wooded, and to obtain these various points by the use of wooden towers would make the cost of the triangulation very expensive.

In establishing a coordinating scheme of second-order triangulation along the coast line, the chief of a triangulation party should have a comprehensive idea of the needs of a compilation party, for without the knowledge of the needs and various requirements of compiling photographs, the chief of a triangulation party is handicapped in establishing control for use in compiling photographs. One of the main deficiencies that is generally noted in the location of triangulation stations is that they are not established on the ground with a view to

tying them in on the photographs. If a station is established, and it is located in a section where, due to the topography and other natural features, it is impossible to locate it accurately on the photographs, this station becomes useless as far as air photo control is concerned. Serious consideration should be given to the sites selected for triangulation stations, with a view in mind that they will at some future time be used in compiling aerial photographs.

Radial Line Points.

Too much stress cannot be put on the picking of radial line points on the photographs. It has been my experience that the majority of bad intersections are traced directly to the points not being accurately picked on all photographs. In some areas it is impossible to pick radial points exactly the same on overlapping prints, especially if the photographs are the least bit hazy. This only applies, though, to areas which are heavily wooded and where no detail exists except trees, brush and other indefinite detail. In picking radial line points it is always desirable to have the points well distributed over the print. The number of points necessary depends entirely upon the detail to be traced along water courses. It is the practice of this party to pick radial line points at least every inch and a half if they can be selected. If this cannot be followed, additional points are sometimes added rather than points being left out, because in tracing the detail from the photographs the less adjusting that is done between radial line points, the more accurately the detail can be traced.

This party has designed a gadget ("radial liner") to hold one end of the straightedge when radial lines are being drawn on the mounted photographs or on celluloid. This gadget has proved very successful and the draftsmen on this party use it exclusively. The main advantage derived from it is that in drawing radial lines the end of the straightedge is anchored at the center of the photograph, and the draftsman does not have to give any attention to his straightedge when drawing a radial line either on the photographs or on the celluloid. It is estimated that this device reduces the time for drawing radial lines by at least thirty-five percent. By having one end of the straightedge anchored, the draftsman is also enabled to give more attention to the drawing of the radial lines. If the radial line should be drawn a little off the point that has been picked on the photograph, the draftsman can pick this up and when drawing the radial line on the celluloid he can draw his line directly through the point as picked on the photograph. (See Figure 2)

The machine nut shown in the accompanying diagram is screwed into the casting and is so designed that it is adjustable. It is made adjustable so that when the "radial liner" is used for tracing radial lines on celluloid it can be adjusted to hold the edge of the straightedge. This nut is screwed through a small hole in a piece of celluloid that has been fastened to the end of the straightedge by the means of tape. This hole is very small and the point fits against the straightedge, thereby eliminating any error that might occur by offsetting the straightedge from the exact center of the principal point. Some of the draftsmen prefer to use the "radial liner" without the celluloid on the end. They exert a pressure on the straightedge that will hold the straightedge against the point, as the weight of the "radial liner" (approximately ten pounds) will prevent the point from moving.

The "radial liners" that have been constructed for this party are made of iron. Brass would make the "radial liner" a little heavier and would give a neater appearance, but the cost would be about twice that of the ones cast of iron. The cost of the "radial liner" was $7.50 for the first one, but after the casting was made the price was $4.50 each, and it is considered that the money has been very well spent. The detailed drawing of the "radial liner" is shown in Figure 3.

Field Inspection.

In the compilation of photographs, the field inspection and locating of the control stations on the photographs is without question the most important step of a photo compilation, for all subsequent steps depend directly upon the data submitted by the field inspection party. Too much caution and stress cannot be placed upon the necessity of accuracy in tying in triangulation stations on the photographs. More trouble has been encountered on this party due to stations being incorrectly located on photographs than due to any other cause. There is also considerable other important information that has to be obtained by the field inspection party, and it is my candid opinion that the actual value of a compilation depends directly upon the information submitted by the field inspec-

tion party.

Contrary to the average opinion, it takes a man some time before he becomes a first-class field inspector, and in a number of cases some men never make good field inspection men for the reason that they are not careful and meticulous enough with the details of this work. I find that the most common mistake made by the average field inspection party is that the points picked on the photographs are not the points that they actually identify on the ground and make measurements to. This is especially true if there are only a very few natural features from which to locate a triangulation station. In the field grass spots, points of brush and other things which show up on the ground do not always show as prominently in the photographs, and this is where the majority of the mistakes are made. It is also desirable to have at least four or five ties to a station that is hard to locate on the photographs, so as to have a check on the plotting. This number of ties is not essential if there are natural features which can be accurately identified, and the points identified accurately picked on the photographs.

Some men do not have the facility of correctly orienting themselves on the ground and on the photographs. I have seen draftsmen who have had as much as six and eight months' experience on compilation work tie in triangulation stations which were a quarter of a mile in error, simply because they were not properly oriented, did not study the photographs carefully enough, and the points they selected were similar points a quarter of a mile away.

In locating a station on the photographs all the surrounding detail should be carefully studied, and, if necessary, measurements taken on the ground to iden-

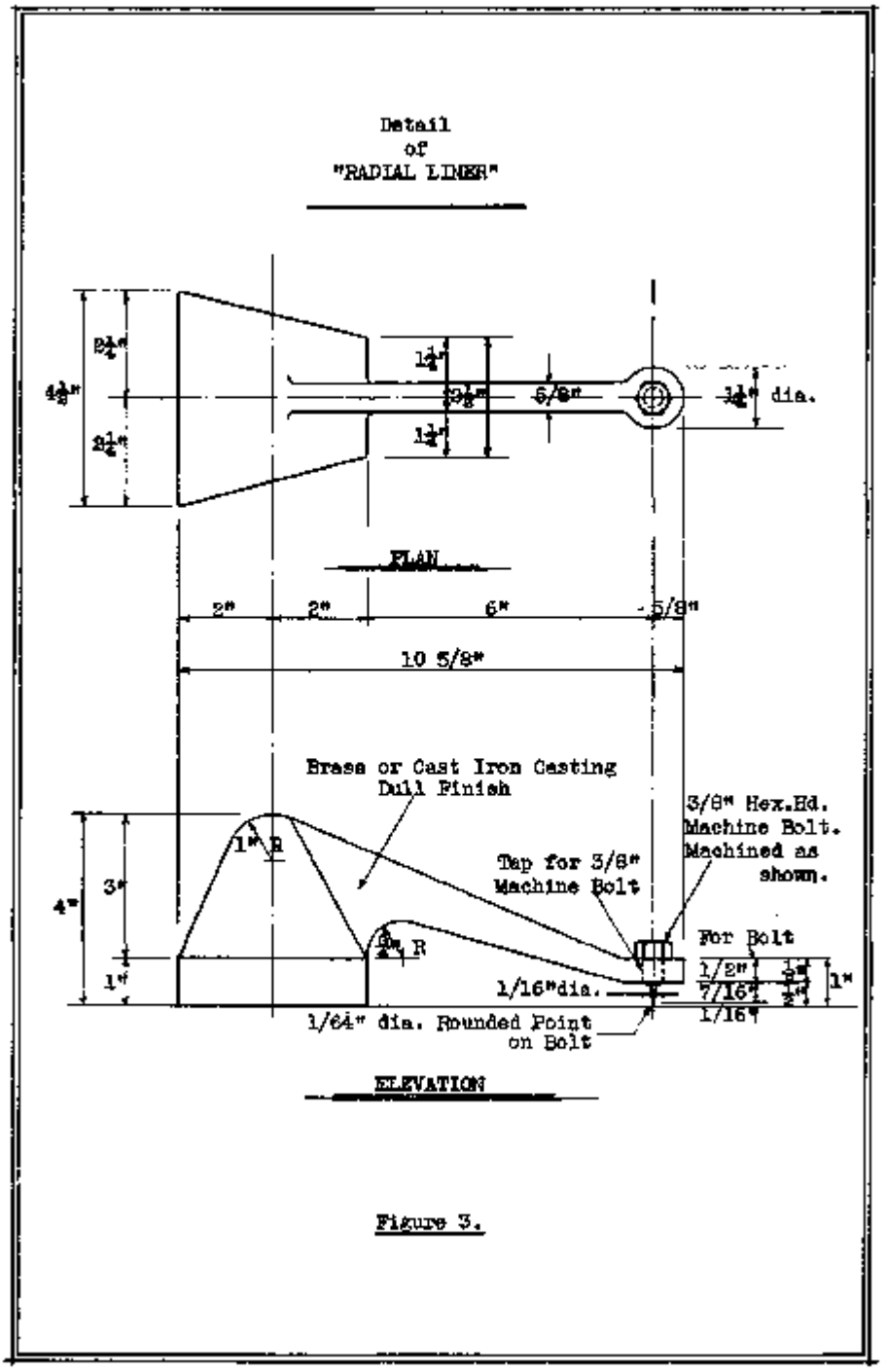
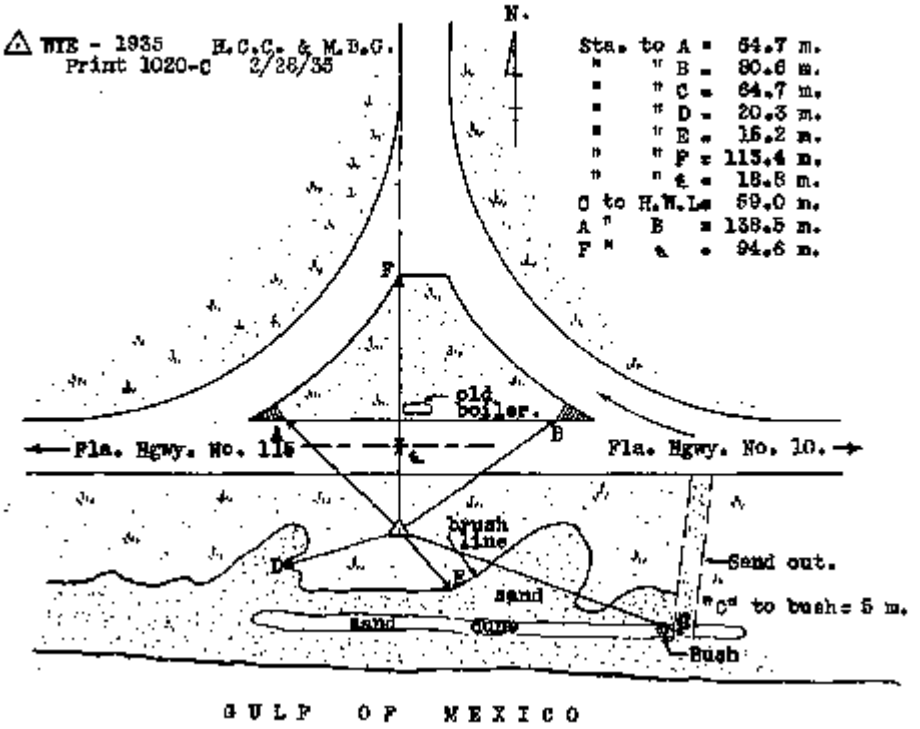


Figure 3.

tify the points before they are actually selected to tie in the station. A sketch used for locating a control station on the photographs should conform somewhat to the general topography of the locality, as this assists considerably when the control points are plotted on the office photographs. The points to which measurements are taken should be picked on the photographs by the man making the sketch, and these same points should be picked accurately on the office set of photographs. But, at the same time, the sketch as made by the field inspection party should be followed closely as it is very easy for a man to pick the wrong point in the field, and if the sketch is accurately made it will assist the office man in determining what point the actual measurements were made to. The name of the person or persons making the sketch, the date made, and the number of the photograph that was used should all appear on the finished sketch.

FIGURE 4.



In plotting the control points on the office photographs, extreme care and caution should be used in transferring the points packed on the field prints to the office prints. Unless a good intersection of the various arcs is obtained, an investigation should be made as to what might be the error. The sketch should be followed very closely to determine if the field party has picked the wrong points in the field or if the office man has not transferred points correctly to the office photographs. In some cases the field party may drop a tape length of thirty meters when the measurements are very long. When one arc fails to intersect the point that has been established, this may be the trouble, but in no case must it be accepted as a criterion for existing errors. In some instances it is necessary to show the plotting of the station as being questionable on the photograph and have a check made of the radial line.

When plotting control on the photographs the draftsman doing the plotting should determine to the best of his ability if the station is correctly plotted. If he has any doubt that the ties do not intersect at the proper point and that the station cannot be accurately plotted due to hazy detail or due to being located out in the extreme limits of the wing prints; he should make a note on the photograph that the plotting of the station is questionable and that it is to be used with extreme caution when making the radial line plot.

The draftsman making the radial line plot should follow this advice and if the station does not hold it should be checked against the sketch to see if it has been plotted incorrectly on the photograph. The draftsman plotting the station on the photograph should always initial the stations which he plots.

Aside from locating the stations on the photographs, the next most important step is obtaining data to trace the high-water line accurately from the photographs. It has been found that it is impossible to sketch accurately the high-water line on the photographs from inspection unless this is done soon after the photographs are taken, and even then it is very easy to make a mistake of five meters one way or the other. The sand beaches along the open ocean are very changeable, and if the photographs have been taken several months what appears to be the high-water line may not be the accurate high-water line at the time the field inspection party makes its visit. Therefore, to avoid this difficulty and to make more accurately the high-water line as obtained by the field inspection party, a method has been adopted on this party which has proved very

satisfactory.

When the field inspection party visits the area along the ocean front, instead of attempting to sketch in the high-water line they identify some point that is not changeable and that can be accurately identified on the ground and on the photographs. From this point a measurement is taken to the high-water line. These measurements along a straight, regular beach are taken at intervals of every mile, the field inspection party picking the point on the photographs and showing the measurements directly on the photographs.

When the draftsman in the office starts tracing the shore line along the beach he plots these points on the office set of photographs and sets off the measurements to the high-water line. These various points are connected on the office photographs and the high-water line traced from it. It is surprising how uniform these measurements are over a large stretch of sand beach. There might be a small error inbetween the points where measurements were taken but it is of no practicable significance.

It is thought that this is a very successful way of inspecting the high-water line. Of course there is always the error of misinterpretation by different people of what the high-water line should be on the wide sand beaches. I think that more error is made due to misinterpretation by different individuals than by actual error in the work.

If the field inspection party is making inspection of an area that is being surveyed by a hydrographic party, another method of accurately determining the high-water line has been adopted. — The field inspection party takes measurements from the topographic signals which have been located by the topographic party. It is not necessary to make a sketch for every topographic signal and plot it on the photograph, as the locations of the topographic signals can be transferred to the projection and measurements made to the high-water line from the points when transferred to the projection, thereby checking the shore line traced on the compilation. There should always be a sketch made for all marked topographic stations. These marked topographic stations are established to serve as additional control for future surveys, both hydrographic and topographic, and to insure that the located topographic station is properly located on the compilation it must be located on the photograph and treated in the same manner as any other control station.

In some cases errors have been found in these marked stations, and had they not been plotted on the photograph these errors would not have been discovered. Measurements to the high-water line are always taken from the marked stations, and at intervals of at least every half mile for other stations, and in this manner an accurate location of the shore line is obtained. This method has been followed for the last few months on this party and has proved very satisfactory in coordinating the work of the compilation party with that of the various combined parties working in the area covered by this compilation party.

After the field inspection party has completed a section, all the sketches are assembled and attached in a folder for the particular sheet on which they appear. This folder ordinarily is a piece of brown kraft paper with the sketches attached in the middle and both sides of the sketches being protected when the kraft paper is folded. An index of the stations in each folder is typewritten on a piece of paper which is pasted on the outside of the folder. This provides the draftsman a ready reference that enables him to look through the various folders and obtain the sketch that he is looking for without any loss of time, as the register number of each sheet is printed in large numerals on the outside of the folder. This folder also prevents sketches from becoming lost after they have been transmitted to the office, and this is an important feature on a large compilation party because a draftsman using the sketch may leave it lying on his table, and when it is necessary to refer to it again it has become lost. The method which has been followed on this party is that the folders are locked in a cabinet and are charged out to draftsmen using them. In this manner it is possible to ascertain readily who has the sketches and also who is responsible for their care.

The field inspection party has found that a piece of ply wood about sixteen and a half inches square is very useful as a small drafting board in the field for attaching the field prints to when a station is being located on the photograph. The photograph is attached to the board by ordinary paper clips. The advantage of having the field print attached to this board is that the points can be pricked more accurately. This is especially true if the wind is blowing, as it

is very inconvenient to attempt to prick points on the photographs with the wind whipping the print back and forth. This piece of ply wood is very light and it is very easy to attach four or five prints to it, saving the field inspector the trouble of having to carry with him the whole box of prints that he may have in the field. It is almost essential that a board of this type be used for the large single-lens photographs, for it is hard to handle them with any care along the beach with the wind blowing.

Mounting Prints.

It is very essential that the photographs be mounted in their proper relation to each other. It has been found that a small error in the mounting of one print will cause considerable difficulty in making the radial line plot. In a number of instances it has been possible to ascertain that one print was incorrectly mounted as all radial lines failed to intersect by a uniform amount, and after remounting the prints the proper intersections were obtained.

The method adopted on this party for mounting the photographs is by using the field prints to check the mounting. This is done by selecting common points on the uncut field wing prints near the line on which the prints have been trimmed. It is desirable to take about three sets of these points, one set of points near the center and one set near each edge of the "B" prints. In mounting the "D" and "E" prints it is necessary to use the untrimmed "B" prints. There is not very much detail shown on the untrinmed "B" print which appears on the "D" and "E" prints, but if care is taken sufficient points can be obtained. In mounting prints of wooded areas where there is no detail that can be accurately identified, this method has not proved entirely satisfactory, but it may be used to obtain an approximate check on the mounting.

This method requires a little more time to mount the photographs than by using the other method of matching the prints by inspection, but the additional time used in mounting pays for itself in that when the photographs are mounted it is known that they are all correctly mounted and form one composite photograph.

The tape used in mounting photographs will probably vary with the locality in which the compilation party is located. This party has run a number of tests on various mounting tapes and conclusions have been reached which have prompted us to discard the mounting of photographs with Scotch Cellulose Tape. Gummed paper tape was used by this party for mounting photographs with success. It has this disadvantage: it is not possible to mount the photographs as fast as with other types of tape. Contingent with our experiments, a tape has been found that has proved very satisfactory. It is known as Scotch Electrical Tape, and we have made extensive tests on this kind of tape and found that there is very little distortion due to atmospheric conditions, and that it has a marvelous adhesive quality. At the present time it is used exclusively on this party.

In mounting the photographs with this tape, or with any tape, it has been found that if the corners of the wing prints are left free there will be less chance of the prints buckling when atmospheric conditions cause the prints to expand or contract in either a transverse or longitudinal direction, as this method seems to allow the print to become somewhat adjusted to the mounting card; and if it does buckle it is very easy to release it by removing the small piece of tape at the collimating notch and reset this point.

Mounting Cards.

Considerable trouble has been encountered with the mounting cards, due to distortion caused by changes in atmospheric conditions. The cardboard mounting cards are very susceptible to changes in the moisture content of the air. I have experienced more trouble on the cards distorting on this project than on any other project, due to several distinct reasons: One of them being the type of office in which the party is located. The office is composed of a number of rooms, and when the weather was cold all windows were closed but as the change in temperature was so erratic that in a day or two the weather warmed up, all windows would be opened, thus allowing direct entrance of the damp air from Pensacola Bay. Also, if several days of rainy weather were experienced, everything became very damp, and as soon as the rain stopped the sun shone very brightly and everything dried out in a day or two, thus changing very materially the moisture content of the air. The cards on which the photographs were mounted under either of these conditions were subject to considerable distortion, which caused the photographs to either buckle or pull away from the mounting. There

was no way in which this could be prevented, and in a number of cases several photographs were remounted as much as three or four times during the course of a radial line plot. After experiencing so much trouble, the photographs were mounted only two or three days before the radial line plot was to be made, and in this manner some of the remounting was eliminated.

A scheme was adopted on this party that eliminated some of the distortion. This was accomplished by removing the mounting cards from the boxes and hanging them in a large open room, with practically the same conditions existing as would prevail after the photographs were mounted. This was done by taking an ordinary paper punch and punching two holes in one side and suspending the cards on two strands of wire by the use of paper clips. The cards would be taken out two or three weeks before they were needed, and seasoned cards were kept at hand. This seasoning of the cards eliminated quite a bit of the distortion, as the tests which we have made on this project indicate that the greatest amount of distortion takes place soon after the mounting cards are removed from the boxes in which they were shipped from the Washington Office.

The mounting cards seem to distort more when the "B" print was mounted with mounting tissue with the use of an electric iron, as the iron seemed to dry out the photographs and also the mounting cards, and as soon as rainy weather occurred these photographs buckled so much that it was necessary to remount all of them. Therefore, the method of mounting by the use of an iron in climates of this type is not at all feasible.

It is my recommendation that an investigation be made as to the advisability of having mounting cards made of a thin sheet of aluminum or some other material which has very little distortion. In litis manner we would eliminate a problem which causes considerable trouble to compilation parties located in wet climates. For a party of this size or any party which employs twenty or twenty-five draftsmen, two hundred metal mounting cards could be printed. These metal cards could be used over and over, for after a radial line plot and the drafting of photographs had been completed, the prints could be dismounted from the mounting plates, and the latter would be available for mounting other photographs. It would take a little time to dismount the prints from the mounting plates, but in the long run considerable time would be saved, as in the ordinary course of making a radial plot during the spring at least fifty percent of the photographs have been remounted on this project.

Aside from having to remount the photographs, the error which is introduced by the use of distorted mounting cards would be eliminated. The prints could be mounted by the use of Scotch Electrical Tape which can be removed without any legible trace remaining on the mounting plates or on the photographs. It is assumed that two hundred mounting plates for a large compilation party would be sufficient so that at no time would the compilation work be retarded on account of not having a sufficient number of plates. The average sheet requires about twenty photographs to each flight, therefore there would be enough plates to have ten sheets being worked on at the same time.

A series of tests have been performed by this party on two different types of cardboard used in mounting photographs, one being that which is furnished the parties by the Office, and the other being stiff, white cardboard (one eighth inch thick) which was obtained from the Army Air Corps at Maxwell Field. It was found that the thick cardboard distorted practically as much as the thin cardboard furnished by the Office.

Scale Factor.

It has been found that if a compilation party can have at hand all of the triangles which have been used in a triangulation scheme, distances can be obtained with very little work in determining the scale factors of the photographs. Aside from the time saved in having to compute distances between triangulation stations by squaring two sides and taking the sum of the two squares, the distance obtained being approximate, the accurate distance between two stations would be obtained when taken from the list of triangles. In view of the fact that only two lines are generally given on the Geographic Position form, it is necessary that these triangles be furnished from the Office, probably by photostating the original triangle computations. This method has been used exclusively on this project and has proved very satisfactory, as we obtained the triangle computations from the various triangulation parties operating within the territory.

It has been found that in determining the scale factor of one continuous flight, it is not necessary to make a rough radial line plot for each sheet of that particular flight unless the values obtained in the first radial line plot prove that the scale of the flight is either increasing or decreasing. From this information it is easy to determine, by inspection, the scale factors of adjoining sheets to a very satisfactory extent. Of course, this can only be done where good flying has been accomplished, and after working for some time with innumerable sheets the Chief of Party can tell if the flying of the whole project is more or less uniform. Otherwise, it is not possible to determine by inspection the scale factors of adjoining sheets, and rough radial line plots should be made. If the scale factor can be obtained by inspection, it should be done as it saves considerable time.

Making of Projections.

A template, drawn on celluloid and described in the accompanying sketch, is used in planning the arrangement of sheets. The template is made to the scale of the U. S. C. & G. Survey chart used as the sheet index chart. This template is used to determine the area covered by a 40" x 50" celluloid sheet and the maximum tracing limits for sheets on 1:10,000 and 1:20,000 scales as laid out on this index chart. It is also used in developing the projection diagram preparatory to constructing the projection, unless the scale factor is considerably smaller than a scale factor of 1.000, the amount of available overlap beyond the edge of the template can be disregarded or considered negligible in determining the most logical and proper arrangement of sheets. However, if the scale factor is appreciably less than 1.000, the extra amount of available overlap beyond the edge of the template can be quickly determined mentally in the following manner. Add a half minute of latitude and a half minute of longitude to the sheet of each .08 the scale factor is less than 1.000 (used with 1:10,000 scale) and for each .04 the scale factor is less than 1.000 (used with 1:20,000 scale).

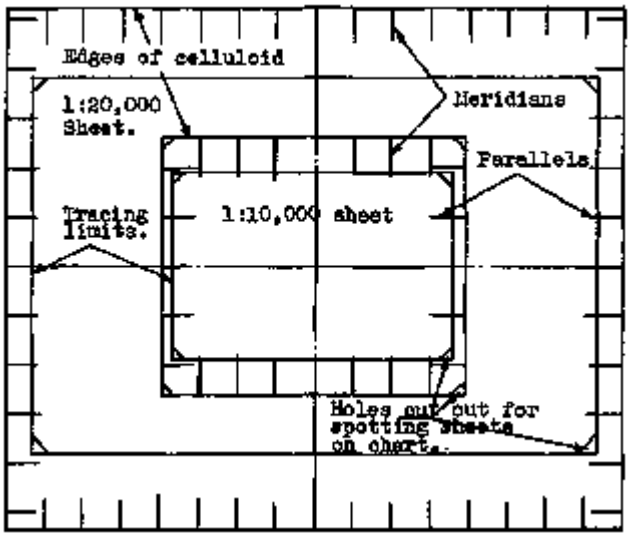


FIGURE 5.

SHEET LAYOUT TEMPLATE
FOR USE WITH 1:80,000 CHART

The projection is constructed on the reverse side of the celluloid and the checking is done from the surface that the detail is to be traced on. This method has been in use for some time on this party and has proved very satisfactory. It has one outstanding advantage and that is the projection lines are not disturbed by the draftsman in any manner during the process of compilation. Occasionally the ink on some of the projection lines becomes a little dim due to continued handling of the sheet, but it is very easy to "touch up" these small sections of the line. If the projection is constructed on the surface of the sheet that is to be traced, the lines become very dim in process of drafting the sheet, and it is necessary to practically re-draw the majority of

the lines after the drafting is completed, hence by having the projection on the back of the thin transparent celluloid this is avoided. It is seldom that projection lines can be retraced as accurately as the original drawing, and due to this same fact projection lines should always be drawn in with ink when the projection is constructed.

Plotting of Control on Celluloid Sheets.

A very efficient way of plotting control stations on the celluloid projections, by placing a dot of blue ink in the approximate location of the station, has been followed on this party for some time. The approximate position of the dot of blue ink is obtained by setting off the shortest DM and DP. The dot is generally made about an eighth of an inch square. The ink should not be applied too heavily in making the dot on the celluloid, but enough should be applied so as to form a uniform blue surface. The ink should be allowed to dry after it has been applied to the approximate position of the station on the celluloid.

The forward DM is set on a beam compass, or a bow-spring divider may be used, depending on the scale of the projection. Using this measurement, very fine scratches are made on the longitude line, the scratches being made very lightly on the celluloid so as to cause no detriment to the projection. From the two points which have been established on the projection line swing arcs, using the DP's (both forward and back). The center of the arc being the point established on the projection line, and inscribing the scratch through the dot of blue ink. Only pressure enough to remove the blue ink from the celluloid should be applied to the beam compass. The forward and back DM's and DP's are plotted in the same manner, and if the projection is correct the two scratches will form a single line.

The next step is to set off on the parallel of latitude, by the use of either the forward or back DP, a scratch the same as was made on the meridian of longitude. Using these points as centers, swing arcs of the DM's through the blue dot of ink, using the same care in scratching the celluloid as mentioned above. After plotting the forward and back DM's there should be the right angle intersection inscribed in the blue ink, the intersection of the two lines being the location of the triangulation station. This point is pricked and a small dot of black ink placed in it.

This method proves very efficient in plotting control on celluloid projections, as it is possible to plot it very accurately when all four measurements are used in plotting the station. It is also an excellent check on the projection, for unless a single line is obtained from the forward and backward DM and DP, a square would form instead of a right angle intersection.

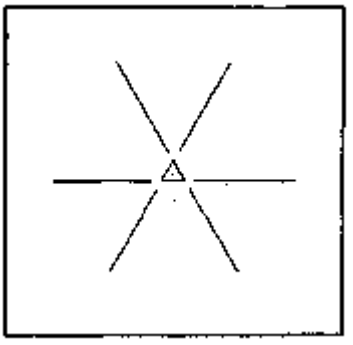
The scratches in the blue ink should only be deep enough to remove the ink from the celluloid, for to cut deeper into the celluloid will cause the black ink to run when the dot of ink is placed in the pricked point.

The stations are always originally plotted by using all four measurements, but when they are checked the shortest measurements are employed, and if a draftsman doing the checking finds any disagreement he replots the station, using the four measurements.

A template for drawing triangulation symbols has been found very helpful on this party. It enables the draftsman to draw the triangle symmetrical with very little effort and considerable time is saved compared to former methods.

The template is constructed by drawing an equilateral triangle on a small piece of celluloid. The triangle is constructed so that the distance from the apex to the base is 3.0 mm. The sides of the triangle are extended about 2½ inches to assist in the proper orientation of the straightedge when the symbol is being traced on the celluloid sheet.

The template is placed underneath the celluloid, and after it has been correctly oriented, the three sides of the triangle are traced according to the size of the template. The size of the template will depend upon the scale factor of the sheet. In actual work the template is constructed to the standard size, and the amount the scale factor differs from 1.00 is applied mentally as the symbol is being traced. The following sketch shows the details of the template.



Use of Shoreline Projector.

The shoreline projector has proved to be a most useful instrument. It is now possible to transfer shoreline from an aluminum topographic sheet to the reverse side of a compilation, which shoreline is traced on the compilation in blue ink. The manner in which this is accomplished is by taking a piece of celluloid and making a tracing of the aluminum sheet on the celluloid in black ink. The shoreline is then projected on the reverse side of the compilation. The topographic signals established by the topographic party are also transferred to the compilation at the same time the shoreline is transferred. A black dot is placed on the celluloid at the location of the topographic signal and circled by a 2.5 mm. circle. This method saves considerable time, and the most important feature of it is that the information transferred is very accurate.

A little caution must be used when projecting shoreline with the shoreline projector. The full amount projected upon the sheet should not be traced as there is considerable distortion of the lens in the comers of the square. The amount of distortion, of course, depends on the lens. The projector that we have on this party has considerable distortion in the outer edges of the lighted area.

The shoreline projector eliminates considerable work when transferring shoreline from the compilation to boat and smooth hydrographic sheets, the shoreline being transferred in one operation whereas in all former methods two or three different steps were necessary to transfer shoreline to boat and smooth hydrographic sheets, and even then it was not possible to transfer accurately when tracing from photostats or when using tracing paper, as there was always some error introduced which could not be avoided without using extreme caution and spending more time than was warranted.

The shoreline projector serves as an aid in matching the detail of adjoining compilations which are of a different scale. This can be accomplished in two ways: (1) by checking the common radial line points before the tracing is made; (2) after detail of one compilation has been traced it can be projected on the other to determine whether the junctions are the same. The former method is recommended, for when the radial points of a sheet are projected to the adjoining sheet it is possible to determine whether the radial line points are in common agreement before any of the tracing of the detail is accomplished.

Review of Compilations.

The review of a compilation is a very important step, because from my experience I have noted that it is practically impossible to get draftsmen to do their work in such a manner that all details have been fully taken care of.

If possible, the final review of a compilation should be made by the man who made the field inspection of the area which the sheet covers. In this manner the field inspection man would notice errors more readily than anyone else making the review. On a large project it may not be possible to follow out this plan, but an attempt should be made to do so for the results of the final compilation would be much more accurate.

Comment by B. G. Jones

The method of transferring topographic stations from planetable surveys to the air photo compilations by means of the projector as discussed in the preceding paper has been found satisfactory in this office provided the transfer of such stations is carefully checked.

The plotting and checking of topographic stations transferred from the planetable surveys to the air photo compilations should be entered and initialed on the data sheet for the air photo compilation descriptive report. This is being done by some parties at present.

Verification of the compilations and planetable surveys has amply demonstrated that positions scaled and entered on Form 524 or transferred from one sheet to another are not dependable unless checked.

In some of the compilation parties it has been practicable to have the draftsman who compiles a sheet assist the man in charge of the field inspection while the inspection is being made. This practice has been found to improve the quality of the compilations and should be adopted wherever practicable.

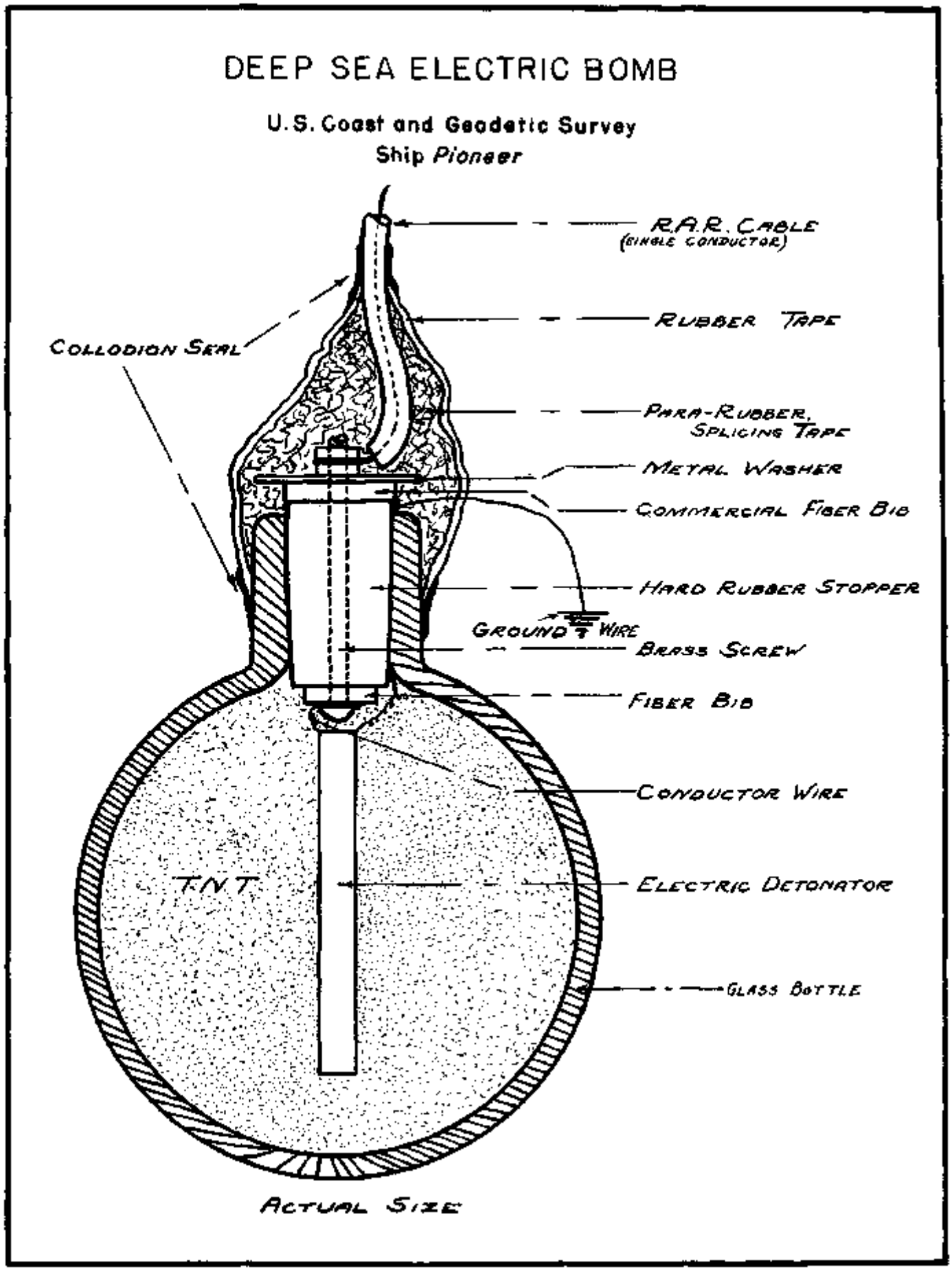
DEEP SEA ELECTRIC BOMBS

J. M. Smook, Hydrographic and Geodetic Engineer, U. S. C. & G. S.

In order to carry out the experiments between the ships PIONEER and GUIDE to determine the velocity and ray paths of sound waves in deep sea water, it was necessary to perfect a bomb that would withstand the enormous pressure encountered at a depth of 1000 fathoms, as the original intention was to fire bombs at varying depths, with 1000 fathoms as the maximum. There was no available literature on the subject, and inquiries of the powder manufacturers showed that so far as they knew, the field was a new one. They were very much interested, however, to see how the standard detonators would work at such depths, for at 1000 fathoms the pressure is approximately 2700 pounds per square inch.

The first consideration was to get a container that would withstand the pressure, and still be economical. A glass bottle was finally decided on, after having given considerable thought to having a special bomb made up according to specifications of our cast iron bombs. The bottle was spherical in shape and the walls were about 1/4 inch thick. (See figure). The bottle was then tested for its strength. This was done by stopping it up with a rubber stopper and lowering it to the desired depth. Practically all of the first attempts were failures, as the pressure forced the stopper into the neck of the bottle, and the latter came up full of water. Best results were obtained by using a washer over the top of the stopper, so that the pressure would be distributed to the neck of the bottle instead of directly on the rubber. That difficulty overcome, the next step was to make the bottle watertight to protect the T.N.T. and the detonator. This was done by drilling a hole through the stopper to take a No. 8 x 32 screw. A fiber washer was used at each end of the rubber. By tightening up on the nut, the rubber stopper expanded enough to completely fill the neck of the bottle.

The bottle was completely filled with T.N.T., and then a stick, slightly smaller in diameter than the detonator was forced into it, to make room for the cap. Before inserting the detonator, the conductor wire was secured to the screw, between the inside washer and the head of the screw and the ground wire was led along the stopper, in a slit made with a knife. The stopper was then placed in the bottle, fitting the detonator into the hole for same and slightly tamping the T.N.T. so that it was well packed around the cap. The nut was then tightened up as much as possible with a socket wrench. This left the ground wire free, outside of the bottle. (The sea water was used as the return.) The bomb was now ready to be secured to the conductor cable. The usual single oonductor rubber covered airplane wire (used for R.A.R. work) was used for this purpose. Two or three strands of the wire were secured to the screw just outside of the tightening nut, and another nut was then put on to hold it. Some para rubber splicing tape was wrapped around the neck of the bottle and up to a point above where the conductor cable joined the bomb. The para rubber was then covered with rubber tape. (As an added precaution, a coat of collodion was applied to the rubber tape, but this probably was not necessary.)


DEEP SEA ELECTRIC BOMB
U.S. Coast and Geodetic Survey
Ship Pioneer
R.A.R. CABLE
(SINGLE CONDUCTOR)
RUBBER TAPE
COLLODION SEAL
PARA-RUBBER,
SPLICING TAPE
METAL WASHER
COMMERCIAL FIBER BIB
HARD RUBBER STOPPER
GROUND WIRE
BRASS SCREW
FIBER BIB
CONDUCTOR WIRE
T.N.T.
ELECTRIC DETONATOR
GLASS BOTTLE
ACTUAL SIZE

In order to make the bomb sink fast and to keep the wire straight up and down, scrap railroad iron weighing about 60 pounds was used. It was secured by a piece of 6 thread line about four feet above the bomb and extended about one foot below same. (The ground wire was made fast to this weight.) The 6 thread line was made fast around the neck of the bomb by a piece of rope yam, so that when the explosion occurred the line would part and the weight would be detached.

The following precautions were taken to prevent a premature explosion of the bomb. The hook-up was so arranged that the firing switch was in the radio shack, for by throwing the switch an initial was sent out to the chronograph. The bomb would not explode, however, unless a lamp was firmly screwed into its socket and another switch was closed. The latter two were located on deck, near the dynamiter, and on prearranged signals from the radio shack the lamp was screwed in place and the switch closed. The lighting of the lamp indicated that the circuit was completed in the radio shack.

The bombs, when prepared as above mentioned, worked very satisfactorily and there were no failures up to a depth of 700 fathoms which was the deepest depth tried. One bomb failed to explode due to a leaking conductor cable and another failed when a bottle with a broken neck was sent down, causing the powder to get wet. Several empty bottles, fitted up with the stoppers, were sent down to 1000 fathoms and they came back perfectly dry, indicating that they would have made successful bombs at that depth. This brings up the possibility of using such bombs in our work. It was noted at a given position that a 4 ounce bomb fired electrically at a depth of thirty fathoms gave a full kick at a shore station, whereas a pint bomb thrown over the side at the same place, while the ship was underway, was barely heard. If the results of the experiments, conducted between the ships PIONEER and GUIDE, show that a sound wave will get through to a shore station better when at a considerable depth below the surface than at the surface, we can be prepared to fire the bombs at such depths. Also when engaged on R.A.R. work, whenever the ship stops for a vertical east, an electrically detonated bomb could be fired to obtain the position of the ship, and where a long distance from the stations, a larger bomb could be used by lowering it deeper in the water.

MAP EXHIBIT OF COAST AND GEODETIC SURVEY
INTERNATIONAL GEOGRAPHICAL CONGRESS, WARSAW.
(Letter received from National Research Council)

May 17, 1935

Captain R. S. Patton, Director,
U. S. Coast and Geodetic Survey,
Washington, D. C.

Dear Captain Patton:

As one of those whose institution contributed to the American section of the map exhibit at the International Geographical Congress at Warsaw in 1934 and who generously donated its contribution to the Congress, you will be interested to know of the excellent impression made by the American exhibit and the favorable comments it drew forth.

Professor Eugene Romer of Lwow, the chairman of the executive committee, conveyed his warm thanks for the American contribution in a letter sent out some time ago, of which you may have received a copy.

In addition he and a colleague have expressed themselves in print with regard to the American exhibit in general and your contribution in particular in the following passages quoted and in part translated from the publication indicated:

> "One section of the exhibit constituted a brilliant exception to a strict interpretation of the regulations. This was the splendid collection sent by the United States. This collection, prepared at some length beforehand, came to us as a surprise and we accepted it with gratitude. We are convinced that all who visited the exposition will share our feeling of gratitude. We sincerely hope that the map exhibit in Warsaw will exert an influence on future International Geographical Congresses.

It is not improbable that the initiative of the United States will point the way to follow for future exhibitions." (E. Romer, Catalogue de l'Exposition Internationale de la Cartographie Officielle, International Geographical Congress, Warsaw, 1934, P. ix).

"La collection d'une autre institution officielle américaine, le Coast and Geodetic Survey, était aussi des plus intéressantes. Elle comprenait divers types de cartes maritimes et aériennes, ainsi qu'une série rétrospective de la baie de San Francisco depuis 1889. La collection de cartes illustrent divers procédés d'exécution, expliqués dans leur plus grand détails, etait fort instructive." (J.Wasowicz in Polish cartographical Review, No. 48, Vol. 12, 1934, p. 222.)

The National Committee of the United States desires to take this means of expressing to you again its appreciation of your cooperation in making the American map exhibit a success.

NATIONAL COMMITTEE OF THE U. S.
INTERNATIONAL GEOGRAPHICAL UNION

Douglas Johnson, Chairman
Curtis F. Marbut, Vice Chairman
W. L. G. Joerg, Secretary.

The exhibit of the Coast and Geodetic Survey referred to in the second last paragraph of the above letter was prepared in the Division of Charts and consisted of three subjects: retrospective cartography; systematic cartography; and chart production methods.

In the first group, copies of Coast and Geodetic charts 5581 and 5532 were exhibited and legends attached explaining the development and changes in topographic and hydrographic detail from the earliest chart dated to the one of the current date.

In the systematic series eight charts were exhibited consisting of charts 9,000, 5,002, 5402, 5530, 5532, 5535, an aeronautical chart of San Francisco, and air photo compilation T-4670. The printed legends discussed the purpose of the systematic series of charts of a particular area. The same area was marked through the series from the larger scale harbor chart to the smallest scale general sailing chart. The type of information most essential to each chart of the series was noted. The aeronautical charts and the air photo compilations were exhibited with special legends explaining the particular purpose of these publications. The third series consisted of a group of five charts showing the various stages in the reproduction of the chart, beginning with the compilation made in the cartographic section and continuing the various steps through engraving and lithographic printing.

The exhibit was donated to the Polish Government for a permanent exhibit at the request of Professor Eugene Romer.

MINOR TRIANGULATION SYMBOLS

Extracts from Correspondence on this subject
Letter from G. C. Mattison, H. & G. Engineer

We have located a number of stations along the Connecticut coast by 3 point fixes wherever it was impracticable to cut in the particular stations from the occupied stations. Usually, one or more of the objects pointed on were intersection points, such as spires, tanks, etc. The stations located in this way are recoverable.

The method used in observing at these stations usually consists of two sets of directions with a seven inch repeating theodolite. In a few cases, where all objects pointed on had been located by 6 D and R, the 6 D and R method was used in the three point fix.

Information is requested as to the type symbol to be used on the smooth sheets, and on the progress sketch. I presume that a special symbol should be used on the progress sketch.

Extract from Director's Letter in Answer

Referring to your letter of October 29, the stations located by three point fixes on intersection stations should not be classed as triangulation stations nor should the records and computations be submitted as triangulation. They should be indicated on your photo compilation sheets by the standard topographic station symbol.

In cases where the three point fixes have been taken on stations located by "6 D and 6 R" and where the pointings constituting the three point fix have similar accuracy, the location work may be classed as triangulation provided there has been a check on each position such as would be obtained by a direction to a fourth station.

Any station meeting the above requirement that you decide to class as a triangulation station should be marked, described and shown on progress sketches and sheets as such. In other words the symbol used on a sheet as well as the manner in which records are submitted should depend on whether or not the station is classed as a triangulation station and the classification should depend on the accuracy with which it is located. In general, any station located with an accuracy lower than third order triangulation should be classed the same as stations located graphically.

It is impossible to draw hard and fast rules for distinguishing where third order classification ends and fourth order begins. The size of intersection angles and the definiteness of the pointings, of course, have a bearing on the accuracy. Also in some localities where the conditions are such that triangulation stations are necessarily widely distributed, it might be desirable to classify control work as triangulation even though somewhat lower than third order. However, in the locality such as the one in which you are working, where strong control is accessible and where a single weak point is apt to reflect on the quality of our control, it would seem that you could well afford to be conservative when in doubt as to how stations should be classified.

Stations classified as fourth order triangulation stations should be marked with topographic station discs. The descriptions of these stations on Form 524 should state how they were located. Any records submitted for these stations should be classed as topographic records rather than as triangulation records and the stations should not be shown on your triangulation sketches.

NEWSPAPER PUBLICITY

By Eugene T. Crowther, Clerk,
New Orleans Field Station.

Inasmuch as the public is taxed to support this service, it stands to reason that they should desire to know something about what is being done and the available results.

Basing my conclusions on seven years experience in the New Orleans Field Station, I believe that publicity is good policy. Persons have called who could not pronounce and define "Geodetic," and had only a vague idea about this service and how it could help them. They had stated their problems to someone who did know, and had been referred to this office for the information that suited their needs.

Several articles have appeared in local papers, resulting from interviews with our officers, and I have observed a salutary effect in the way of increased sales and calls for information, as well as favorable comment on the work.

Does a scientific or technical article interest the general reader? I have discussed that question with members of editorial staffs and they all agree that it does. The Managing Editor of the New Orleans Times-Picayune emphatically expressed his affirmation, and cited examples appearing in various publications intended for the general public. However, he concluded that such news should be written largely in non-technical language, contain human-interest and action, and be accompanied by photographs.

The Chief of Party and his men constitute the human-interest element. As for action, "They are the henchmen of progress; expansion; change. There is

little place for them in a static or contracting industrial and economic situation." (Director's address to the South Carolina Society of Engineers, Columbia, S. C., June 14, 1934.)

My experience has been that the cub reporter is not so eager for news unless it smacks of the sensational. I once tried, without success, to get one to interview an officer of this service. I later called on the City Editor, who promptly assigned a more seasoned reporter, which resulted in a prominently placed article.

Since the limited technical knowledge of the average reporter does not permit him to ask many pertinent questions, the Chief of Party may often find it necessary to take the initiative in preparing an article.

The average reader should be interested concerning the training, varied responsibilities and adventures of the officer on land and sea. The layman would think of him as an engineer only; then would learn that he is two kinds of an engineer — hydrographic and topographic or geodetic; a paymaster and supply officer; executive; captain of a ship. When it is considered that such officers, in the nature of things, are denied for long periods the comforts and satisfaction of a permanent home, doubtless the conclusion would be that all government jobs are not sinecures; that such self-sacrificing devotion to an essential public service, deserved wholehearted public support and cooperation.

The rural paper should not be neglected. It is the sole means of reaching a certain class. Its columns should be available more easily than those of the metropolitan daily. Things seldom happen in the small town, and local operations would be an outstanding event.

Certain situations create news value if utilized at the proper moment. Procrastination reduces such value in proportion to the time elapsed. Extracts from Special Publication No. 23 could be used to advantage.* My experience and observation convince me that there are very few organizations that can match the results of this service with the same investment of money and men; that these compilations are essential to the general welfare; that there is a vast amount of work to be done; that the extent of such endeavor depends on popular support (especially through Congress); that such aid requires public knowledge. Approved publicity efforts, in my opinion, constitute a duty owed to the service and to the country.

PLANE-TABLE NOTES

Compiled by Hugh H. Hartley, Librarian
U. S. Coast and Geodetic Survey

It is customary in the realm of the sciences to refer to the latest current development in any scientific field, as the best and most accurate, far surpassing all previous ones in performance. This applies particularly to surveying instruments. It is axiomatic that instruments in their present form, clothed with their increment of development, are considered ne plus ultra, by those who make use of them.

In this connection the following historical notes regarding the Plane-Table may serve as an illustrative example of comparative precision claimed at its various stages of development and employment.

This apparatus in its present form of perfection has been in practical use for such a period that its predecessors are either little known or not suspected. In fact, it is often supposed to be more or less of recent origin, following the thought that most everything we use today is of modem origin. The term modem for the most part being the word applied to things in current use. According to the requirements of the times and the progress of science toward exactness of methods, most instruments have been found not to be so much the immediate offspring of one mind, as the result of the gradual application of improvements upon older devices, the latter in their turn having held their places as improvements

* "The United States Coast and Geodetic Survey, its Work in Surveying and Charting the Waters of the United States and Possessions, Geodetic Control Surveys and Other Activities," reprinted from "The United States Department of Commerce", 1934, is the latest general compilation. (Editor)

upon some former and still more remote inventions. Figuratively we may glance down the ladder of time, pausing at some of its rungs to consider briefly statements regarding the plane-table in some of its stages of development.

Rung No. 1:

In U. S. Coast and Geodetic Survey Special Publication No. l44, Topographic Manual, Lieutenant Commander O. W. Swainson has written, "The plane-table is one of the best instruments for topographic surveying, as with it the map is actually drawn in the field where and while the feature can be seen and where the amount of detail to be mapped and the accuracy required can be changed to best advantage." (The type of plane-table described on pages 14 and 15 of this publication is considered to be one of the best in use today).

Rung No. 2:

The excerpt for this rung is from U. S. Coast and Geodetic Survey Special Publication No. 85, Plane Table Manual by Dallas Bache Wainwright. "The principle instrument in use by the Coast and Geodetic Survey for mapping details is the plane table. For this purpose it is a universal instrument. All of the necessary operations for producing a map are executed with it in the field directly from the country as a model. The invention of the plane-table is an interesting example of two well-known and exceedingly simple appliances being combined and adapted to a novel use and then as the wide scope of the combination was realized its gradual evolution from its simple form to a complex surveying instrument highly specialized in its mechanical details.

In its earliest form the plane-table consisted of nothing more elaborate than a sketching board with a sheet of drawing paper fastened on one face, and an ordinary wooden ruler with a needle at each end as a convenient means for sighting one edge of the ruler toward a distant object. In addition, on the upper face of the ruler there was drawn a scale of equal parts.

The novel use of this simple apparatus consisted in locating the salient features of an area by the graphic solution of the problem of a triangle with two known angles and one known side.

A base line was actually measured on the ground by means of wooden rods or a knotted rope. The subsequent operations were similar to those of cur modem graphic triangulation.

This elementary form is so useful and convenient for a rapid reconnaissance, securing in a limited time a map with details relatively well located, that it is still employed, particularly in connection with military operations.

A more elaborate design was invented in the latter part of the sixteenth century by Johann Praetorius and is described by his pupil, Daniel Schwenter, in a tract published in 1626. (The Coast and Geodetic Survey Library has a copy of the 1641 edition of this work containing some of the illustrations reproduced in Special Publication No. 85). The design included a box compass attached to the board, and the latter was mounted on a simple tripod. A device was provided for measuring heights.

In the succeeding century a tripod head with a crude ball and socket movement was mentioned, and it was proposed to replace the alidade sights with a telescope.

There was no general demand for the employment of the plane-table in topographic surveys until the beginning of the nineteenth century, and although the foregoing useful features had been proposed from time to time, they were not combined in an efficient design until the plane-table was adopted as a standard surveying instrument by the European Governments and in this country.

In the latter part of 1815 Ferdinand Hassler, who later became the first Superintendent of the Coast Survey, returned from London bringing with him, among other instruments, two plane-tables which he had constructed to serve as models for others to be made in this country for the survey of the coast which was then in prospect. They were not used until 1834, as Hassler's plans were interrupted by congressional action. At this date the systematic topographic surveys were commenced, and sheet No. 1 is a plane-table sheet which includes the north shore of Great South Bay, Long Island, from Patchogue to Babylon."

Rung No. 3:

In a Treatise on the plane-Teble and its use in Topographical Surveying, by E. Hergesheimer, Assistant, Coast Survey Annual Report 1880, Appendix No. 13, we find the following:

"The movements of the tables in use by the Coast and Geodetic Survey are of different construction, but all are of brass, and look to the same essentials, viz., sufficient strength for solidity, and horizontal revolving faces of large enough diameter and accurate fit to prevent vertical motion when clamped together, as well as sufficient room for lateral play of the axis of revolution of the upper plate, necessary in the different relations between the planes of the tripod head and the revolving faces of the movements, which latter are always required to be in a horizontal plane, and means for clamping the axis of revolution to the tripod head when the revolving faces have been made horizontal with the leveling screws; there being attached to the clamp of the revolving plate the usual tangent screw for fine motion.

The table-top or board should be made of well seasoned wood, panelled with the grain at right angles, to counteract as much as possible the tendency to warp; its upper surface finished as nearly as possible in a plane and attached to the projecting arms of the movements with firmness; great care being taken that its upper surface shall be parallel to the plane of revolution of the movements so that the two planes shall remain parallel in all positions of the board.

As much lightness as is consistent with requisite strength should be sought in the construction of all the parts."

Rung No. 4:

This excerpt is from Coast and Geodetic Survey Annual Report 1865, Appendix No. 22: On the plane-Table and Its Use in Topographical Surveying by Alexander Medina Harrison.

"The following description of the plane-table, in the shape in which it is at present employed upon the Coast Survey, and notes upon its use, are given as the results of a long experience of its good qualities on that work. Being the best instrument adapted for topographical purposes, it is desired to supply a want left by the very inadequate notices given of it in most American and English works, and to furnish topographical surveyors with a practical manual of its use. It may seem in some cases somewhat amplified, but those more familiar with it will overlook details intended for the benefit of beginners.

The invention of the plane-table is ascribed to Praetorius in 1537,* but the first published description appears to be that of Leonhard Zubler, in 1625, who ascribes the "beginning" of the instrument to one Eberhart, a stonemason. From this time forward it has received successive improvements, chiefly from the Germans and French, until it has reached its present form, which seems to be in keeping with the existing state of science." (The Coast and Geodetic Survey Library has the manuscript of Historical Account of the Plane-Table prepared for the Superintendent of the U. S. Coast and Geodetic Survey, by A. M. Harrison, April 20, 1875).

Rung No. 5:

This excerpt is from Philosophical Transactions of the Royal Society, London, Volume 41, 174l, "A new plotting table for making plans and maps in surveying: Invented in the year 1721 by Henry Beighton, F.R.S. (This new plotting table is nothing more than the old plane-table with some new contrivances or improvements, which are here described at great and unnecessary length, Reviewer). Mr, Beighton says, "one of the chief objections against the plane table was the difficulty in shifting papers, for you were almost necessitated, when you were at work on a sheet on the table, to put in all the work that is to be contained in it because

* (Some Notable Surveyors and Map Makers of the Sixteenth, Seventeenth and Eighteenth Centuries and their Work, by Sir Herbert George Fordham, Cambridge University Press mentions, "Waldseemüllers Polymetrum, from Reisohs' Margarita Philosophica Nova, of 1512, showing a combination of the theodolite and the plane-table, as now known to us." Encyclopaedia Britannica, under the title of Surveying, says, "The Romans certainly made use of an instrument not unlike the plane-table for determining the alignment of their roads." Editor.)

it is very impractical to put it on the table in the same precise position again, and this although it were with the utmost inconveniency in pursuing some grand station on circumscribing the whole. This is entirely obviated and I have remedied all the other objections against it in a very simple and easy manner, which I contrived in the year 1721 for making the correct map of the country of Warwick; by which, with good success and expedition I completed and published same in the year 1728 and called the instrument the plotting-table."

Rung No. 6:

In the year 1626 in which Schwenter's tract was published on the plane-table, in which tract he is highly effusive concerning the merits of this instrument, William Leybourn a famous English surgeon, mathematician, surveyor and teacher of mathematical surveying, was born. Among other items which are mentioned in a biographical note below, Leybourn published in 1650 the work which he called Planometria, which he later republished in 1653 as The Compleat Surveyor.

A fifth edition of the Compleat Surveyor by Leybourn edited and enlarged by Samuel Gunn, was printed for Samuel Ballard at the Blue Ball, and Aaron Ward at the King's Arms in Little Brittain, and Thomas Woodward at the Half-Moon against St. Dunstan's Church in Fleet street, London, 1722. The following is quoted from a copy of this edition belonging to the Library of Congress:

"The author of this treatise was frequently employed in surveying, measuring and mapping gentlemen's estates; as evidently appears from the several draughts by him drawn, and to be met with in almost every county in England.

These qualifications alone recommended the first edition; and the book itself made way for three more afterwards.

If to these be added, the great enquires made for this book (notwithstanding the many tracts on this subject,) and the many improvements herein contained, which were not in the former editions, and indeed most of them not before printed; they may be justly accounted sufficient reasons for publishing this fifth edition."

William Leybourn, born 1626; died about 1700, an English surgeon, mathematician, surveyor, teacher of mathematics and professional surveying, was joint author with Vincent Wing of the first treatise on astronomy written in English; URANIA PRACTICA, l648; and published the following Planometria in 1650, republished as the COMPLEAT SURVEYOR 1653; ARITHMETIC; Vulgar, Decimal, and Instrumental 1657; THE LINE OF PROPORTION or (of) NUMBERS, commonly called Gunther's line; made easie, 1667; CURSUS MATHEMATICUS, 1690; (Mathematical Sciences in nine volumes. This extensive work on the mathematical sciences contains 'A Triangular Canon Logarithmical' including the logarithms of all absolute numbers from a unit to 10000 and of artificial sines and tangents to every degree and minute of the Quadrant, with their complements, Arithmetical); and PANARITHMOLOGIA, 1693 (the earliest ready-reckoner known in English).

He appended after his name the title 'Philomath' which is compounded from two Greek words meaning, lover of learning. A few pages reproduced from "The Compleat Surveyor" follow:

THE COMPLEAT SURVEYOR,

Containing the whole ART of

Surveying of Land.

BY THE

Plaine Table, Theodolite, Circumferentor, Peractor,

and other Instruments.

After a more easie, exact and compendious manner, then hath been hitherto published by any: the *Plain Table* being so contrived, that it alone will conveniently perform whatsoever may be done by any of the fore-mentioned *Instruments*, or any other yet invented, with the same ease and exactness; and in many cases much better.

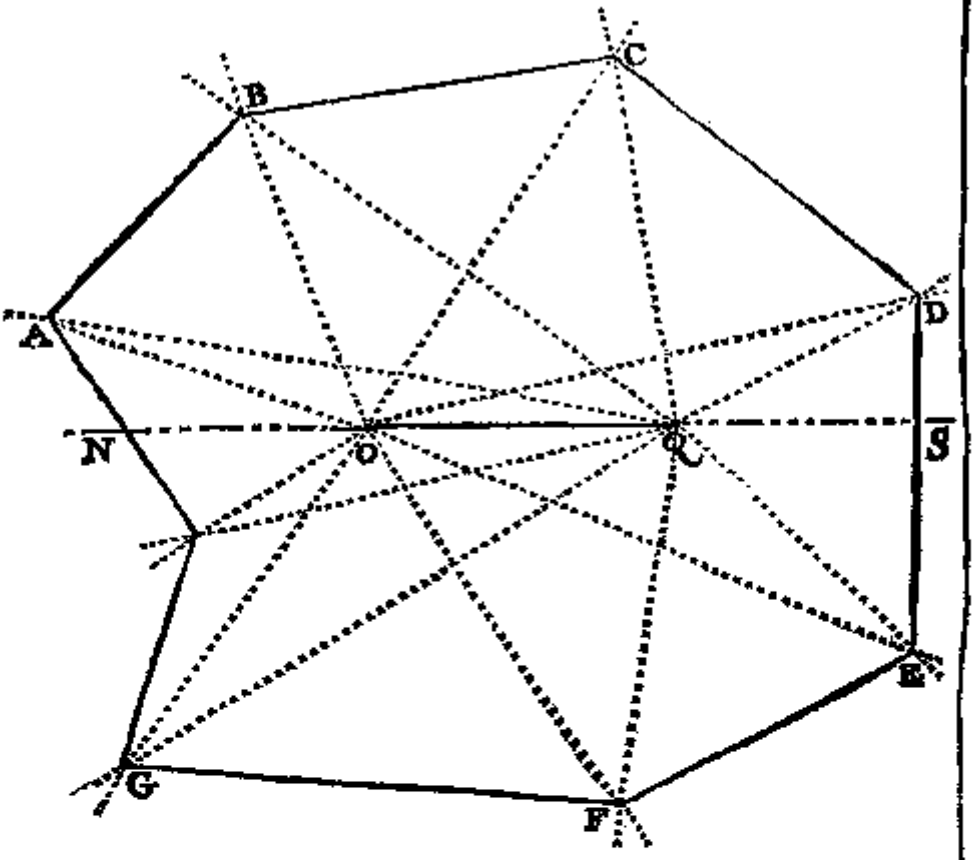
Together with the taking of all manner of Heights and Distances, either accessible or in-accessible, the Plotting and Protracting of all manner of Grounds, either small Inclosures, Champion Plains, Wood-lands, or any other Mountainous and un-even grounds. Also, how to take the Plot of a whole Manor, to cast up the content, and to make a perfect Chart or Map thereof. All which particulars are performed three several ways, and and by three several *Instruments*,

Hereunto is added a new way of *Surveying* of *Land*, by which a man may be satisfied whether his Plot will close before he begins to protract the same, with the manner how to order such Water Colours as are necessary for the beautifying of *Maps* and *Plats*; Also how to know whether *Water* may be conveyed from a Spring-head to any appointed place or not, and how to effect the same: With whatsoever else is necessary to the *Art* of *Surveying*.

The Second Edition, *with many* Additions.

By WILLIAM LEYBOURN.

LONDON,
Printed by *R.* and *W. Leybourn*, for *G. Sambridge*, at the signe of the Bible upon *Ludgate*-hill, *M. DC. LVII.*



CHAP. XXXI.

How to take the Plot of a Wood, Park, or other large Champion plain by the Plain Table, *by measuring round about the same, and making observation at every angle,*

Hitherto we have shewed how the plot of any plain and even ground, or any small enclosure may be taken severall wayes, as being the easiest for a practioner to try experience upon, I now come to shew how the plot of any large Champion plain, or over-grown wood may be measured, for in such kinde of grounds the former directions will be of little validity, for the largenesse of the Plain, or the thicknes of the wood may many times hinder both your sights and measuring; therefore the best way to measure these kinde of Lands is to go about them, and make observation at every angle.

Sup-

Suppose the following figure A B C D E F G to be a large Wood or other Champion plain, whose Plot you desire to take upon your Plain Table.

1 Place your Instrument at the Angle A, directing your sights to the next angle at B, and by the side thereof draw a line upon your Table, as the line A B, then measure by the hedge side from the angle A, to the angle B, which suppose 12 Chains 5 Links, then from your Scale take 12 Chains 5 Links, and set that distance upon your Table from A to F.

2 Remove your Instrument from A, and set up a mark where it last stood, and place your Instrument at the second angle at B, then laying the Index upon the line A B, turn the whole Instrument about till through the back-sights you see the mark which you set up at A, and there screw the Instrument: then laying the Index upon the point B, direct your sights to the third angle at C, and draw the line B C upon your Table, Then measuring the distance B C 4 Chains 45 Links, take that distance from your Scale and set it upon your Table from B to C.

3 Remove your Instrument from B, and set up a mark in the room thereof, and place your Instrument at C, laying the Index upon the line C B, and turn the whole instrument about till through the back-sights you espie your mark set up at B, and there fasten the Instrument: then laying the Index on the point C, direct the sights to D, and draw upon your Table the line C D then measure from C to D 8 Chains 85 Links, and set that distance upon your Table from C to D.

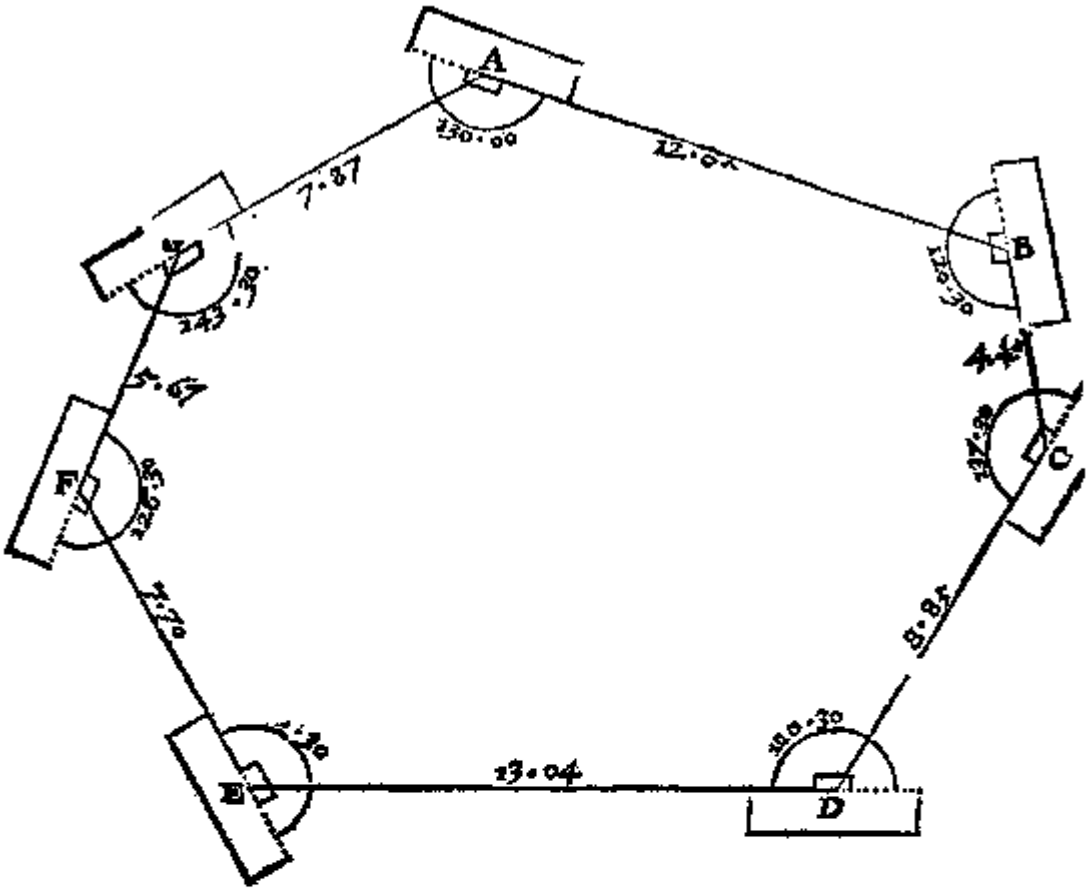
4 Remove your Instrument to D (placing a mark at C where it last stood) and lay the Index upon the line D C, turning the whole Instrument about till through the back-sights you espie the mark at C, and there fasten the Instrument: then lay the Index on the Point D, and direct the sights to E and draw the line D E then with your Chain measure the distance D E 13 Chains 4 Links, and see that distance upon your Table from the point D unto E.

5 Remove your Instrument to E (placing a mark at D where it last stood) and laying the Index upon the line D E turn the whole Instrument about till through the back-sights you see your mark at D, and there fasten the Instrument: then lay the Index on the point E, and direct the sights to F, and draw the line E F, then measure the distance E F 7 Chains 70 Links, which take from your Scale, and set it on your Table from E to F.

6 Remove your Instrument to F (placing a mark at E where it last stood) and lay the Index upon the line E F, turning the Instrument about, till through the back-sights you see your mark set up at E, and there fasten the Instrument: then laying the Index on the point F, direct the sights to G, and draw the line F G upon your Table, then measure the distance F G 5 Chains 67 Links, and set that off upon your Table from F to G.

7 Remove your Instrument to G (setting up a mark at F where it last stood) and lay the Index upon the line F G turning the whole

Instru-



Instrument about, till through the sights you see the mark at F, and there fasten the Instrument, then laying the Index upon the point G direct the sights to A (your first mark) and draw the line G A, which shall passe directly through the point A, where you first began, if you have truly wrought.

In this manner may you take the plot of any Champion plain be it never so large, and here note, that many times hedges are of such a thicknesse that you cannot come neere the sides or angles of the field, either to place your Instrument or measure your lines, therefore, in such cases, you must place your Instrument, and measure your lines parallel to the side thereof, and then your work will be the same as if you measured the hedge it selfe.

Note also, that in thus going about a field, you may much help your selfe by the Needle, for looke what degree of the Card the needle cuts at one station, if you remove your Instrument to the next station, and with your back-sights look to the mark where your Instrument last stood, you shall finde the Needle to cut the same degree again, which will give you no small satisfaction in the prosecution of your work.

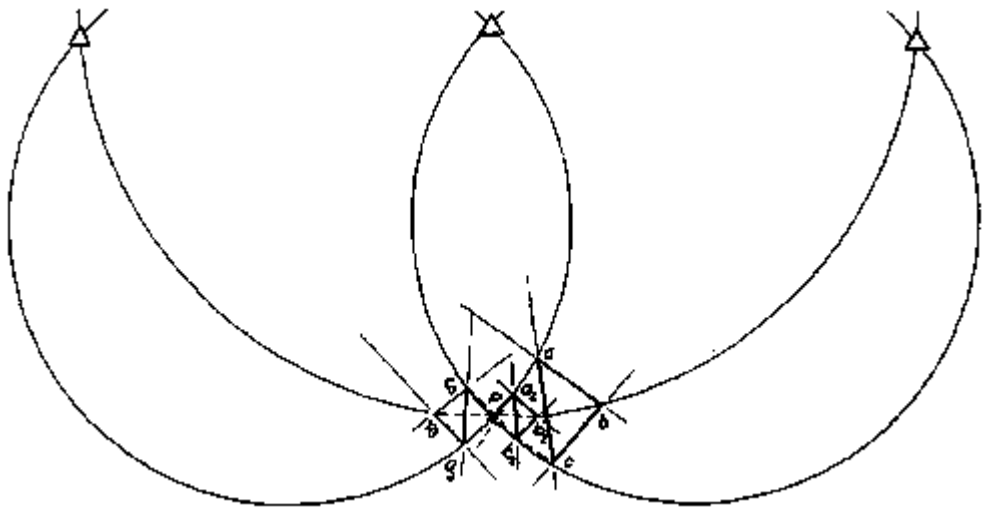
THREE POINT FIX: GRAPHICAL

Paul A. Smith, Jr. H. & G. Engineer,
U. S. Coast and Geodetic Survey.

Topographers have various methods of approximating the true position from the first attempt when a plane-table is set up for a three point position at an unknown point. A note in the Engineering News Record of January 10, 1935 by Professor J. Maughs Brown of the University of South Dakota mentions a method which has been in use by some field engineers of the Coast and Geodetic Survey for many years. Professor Brown attributes the origin of the method to Sergeant Cucunutti of the Mexican Army in the year 1592.

Briefly, the method is the determination of the true point by finding the intersection of the circles through the control stations and point sought. The table is oriented by magnetic needle, or by estimation, and the cuts are drawn from the control stations forming the usual "triangle of error", a, b, c. The table is then changed in orientation slightly and additional cuts are drawn from the control stations forming another triangle, a_2, b_2, c_2. If both triangles are on the same side of the point sought, "P", they will be similar, and if the second triangle is nearer to the point P, it will be smaller as indicated in the figure. If the similar vertices are connected as indicated by the dashed lines, the intersection of the lines will be a very close approximation to the point P. In case the change in orientation of the table is such that the triangle falls on the other side of the point P, as a_3, b_3, c_3, the triangle of error will be a reflection of the first, but as before, the similar vertices when connected will locate the position of the true point P. In the former case the determination by the intersection of the lines connecting the vertices will give a point outside the circles, while in the latter it will give a point inside, due to the position of the chords with relation to the arcs of the true loci. In actual practice the point determined by this method is usually so close to the true point P, that little or no difference can be detected, especially if the first orientation is close to the true, as is usually the case when a declinatoire is used to obtain approximate orientation. Many topographers use the method outlined in the Topographic Manual, p. 58, which is that the point sought is on the same side of all resection lines as the observer faces the station, and the distance of the point sought from the resection line is proportional to the distance of the point occupied from the control station through which the resection line was drawn.

Other topographers sketch short arcs of the three circles through the respective vertices of the triangle of error and thus arrive in a similar manner at the point sought. These three circles are shown in the figure below, and with a little practice it is easy to picture the approximate direction of the arcs from the first triangle of error accurately enough so that the second attempt usually gives correct orientation and position. Aluminum mounted sheets have eliminated the most serious trouble in taking three point fixes - distortion of the old linen mounted sheets.



ESTABLISHMENT OF RANGE BEACONS FOR MEASURED MILE SPEED COURSE

R. F. Luce, H. & G. Engineer, U. S. C. & G. Survey

A request from the Post Office Department, for a speed trial course over which vessels holding foreign mail contracts might be tested, led to the establishment of a one mile course in the Gulf of Mexico just east of Burrwood and the Southwest Pass of the Mississippi.

Field work on this project was accomplished by parties from the HYDROGRAPHER during the period June 6th to 25th, 1935. As shown on the accompanying sketch second order triangulation was extended off the adjusted triangulation line "S.W. PASS L.H. — SOUTH PASS L.H.". Since it was desirable to obtain an approximate mile somewhere along the jetty or its extension so that, from it, four triangulation stations could be established, two on opposite shores at right angles to the lower end of the mile and two others similarly located at the upper end, use was made of triangulation run by the U. S. Engineers. This organization had one station EAST JETTY on a line of prolongation of the east jetty, and a second station EAST JETTY 1 on the jetty somewhat over a mile from station EAST JETTY. By using the Engineers' distance between these two stations, a triangulation station was established approximately one mile from station EAST JETTY by measuring up the jetty toward this station from EAST JETTY 1 the amount by which the distance exceeded one mile.

Then an angle of 90° was laid off from the line between EAST JETTY and this new station NORTHEAST BASE at each station and four triangulation stations were established, two on the southeast shore named SW FRONT RANGE and NE FRONT RANGE ECCENTRIC and two on the northwest shore named SW REAR RANGE and NE REAR RANGE ECCENTRIC. The Engineers' figures were used only to obtain approximate locations, the plan being to have the final beacons erected on the lower range triangulation stations and to obtain offsets from the upper range stations by means of triangulation to the sites of the final beacons.

A line of the triangulation, "NE BASE - E. JETTY No. 3", approximately 2½ miles in length, was measured as a base following standard practices. This measured base length was used solely as a check on the same length as computed through the necessarily weak triangles of the triangulation scheme's first figure.

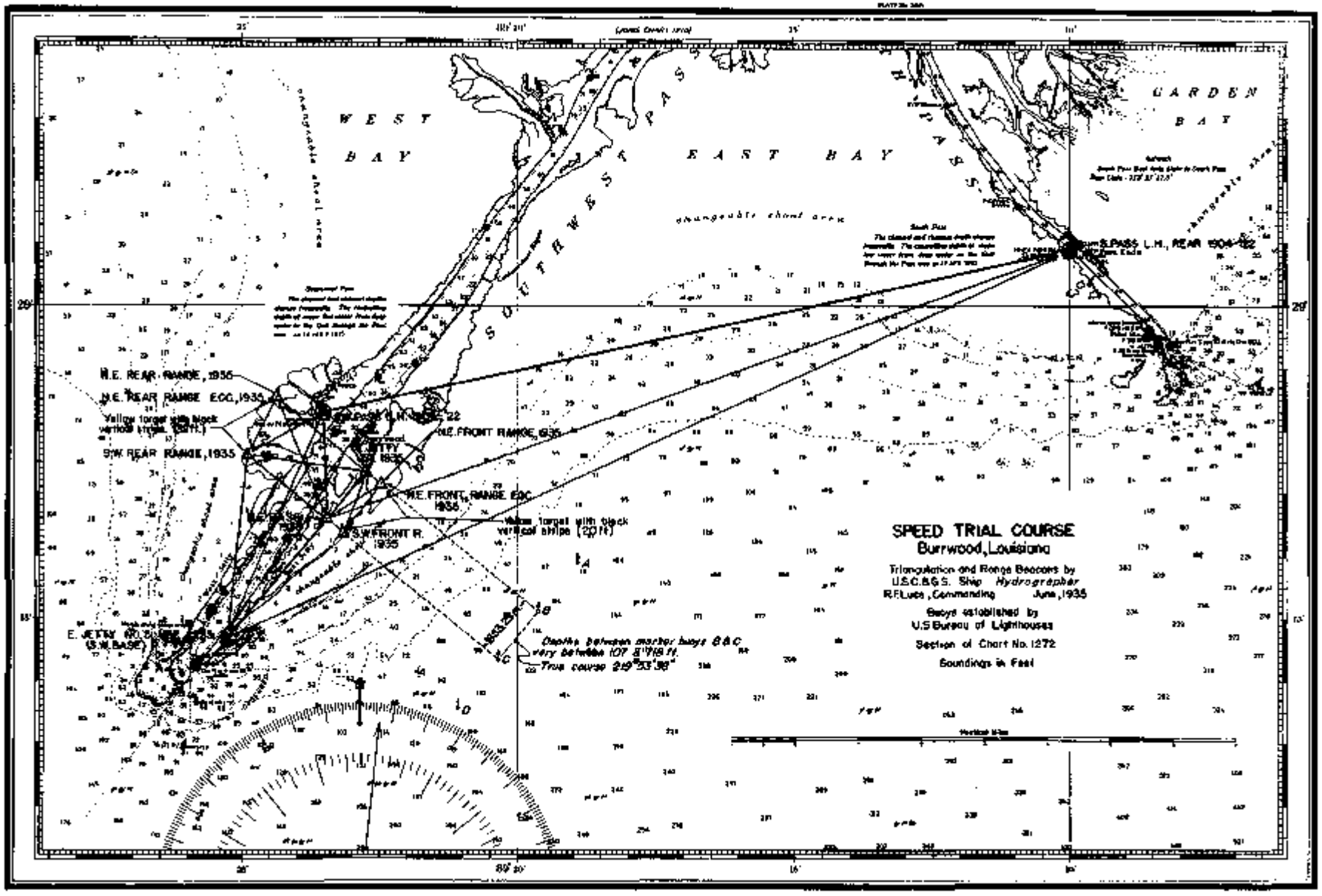
Especial efforts were made throughout the observations and computations to assure final parallelism of range lines at 1853.25 meters spacing.

The analysis of triangulation results filed with the computations show good values for the various accuracy criteria. There were no concluded triangles, the average closure being 1.7 seconds with a maximum of 3.6 seconds. Log side checks, averaging all common sides, yielded the excellent proportion of 1 : 5.1 (obtained : allowed difference). The measured base checked the triangulation length by 0.06 meters, a discrepancy of 1:77,000. The triangulation length was used to carry forward the computations.

With the triangulation computations completed, and planning to establish range beacons directly over the triangulation points "SW REAR RANGE" and "SW FRONT RANGE", the computed positions of the NE range points were obtained as follows: The azimuth of "SW FRONT RANGE-SW REAR RANGE" was obtained by inverse computation and checked by azimuth/angular computations from preceding triangulation lines.

Assuming 1853.25 meter lines normal to this range line the computation of right-angle triangles, formed by these normals with the triangulation lines "SW REAR RANGE - NE REAR RANGE (ecc)" and "SW FRONT RANGE - NE FRONT RANGE (ecc)", permitted the ready derivation of offset distances for the establishment of the NE range points along the prolongation of these lines. The geographic positions of the offset points, "NE REAR RANGE" and "NE FRONT RANGE", were each computed from a known geographic position, azimuth and length. The positions obtained were checked by eccentric triangle and geographic position computations.

An inverse computation of the NE range line,"NE FRONT RANGE - NE REAR RANGE" yielded azimuths differing by 14.7 and 19.9 seconds from the respective directions by inverse computation on the SW range line. As these geodetic azimuths in themselves did not prove parallelism of the range lines, points X and Y were computed on these lines at their intersections with the meridians through the respectively opposite front and rear range points. The agreement in latitude differences thus obtained proved satisfactory parallelism. Additional checks were also obtained through back azimuth computations and from right-angle

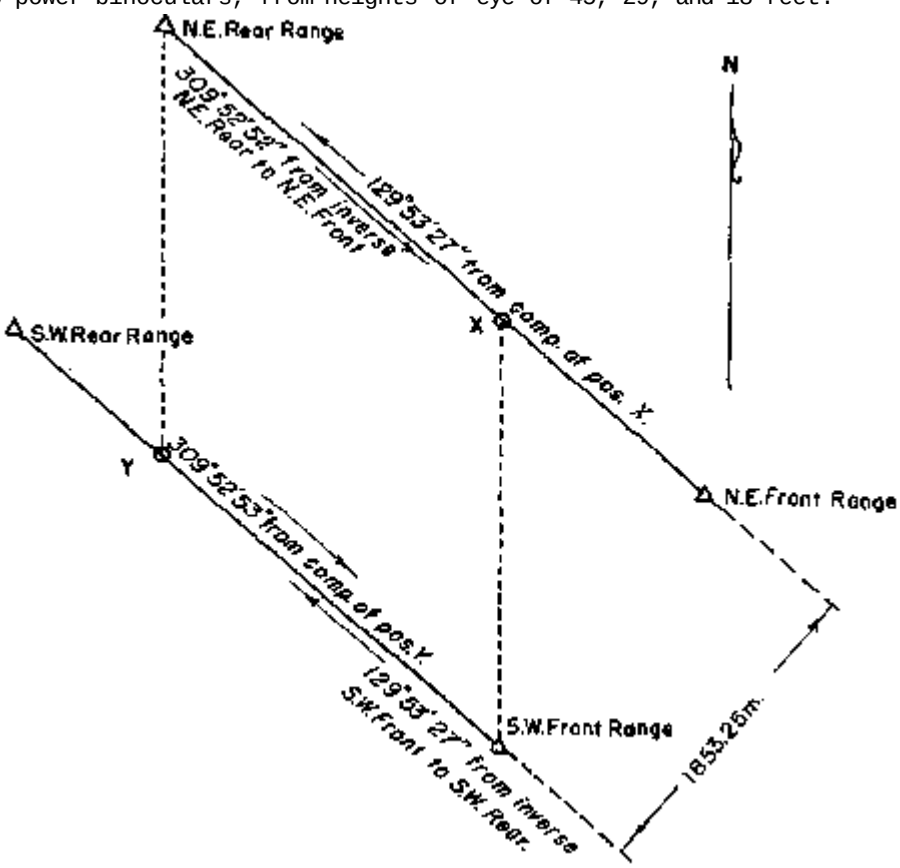

WEST BAY
EAST BAY
GARDEN BAY
SOUTHWEST PASS
S. PASS L.H., REAR 1904-22
N.E. REAR RANGE, 1935
N.E. REAR RANGE EOC, 1935
Yellow target with black vertical stripe (20 ft.)
S.W. REAR RANGE, 1935
N.E. FRONT RANGE, 1935
N.E. FRONT RANGE EOC 1935
S.W. FRONT R. 1935
Yellow target with black vertical stripe (20 ft.)
E. JETTY
(S.W. BASE)
Depths between marker buoys B & C very between 107' & 118 ft.
True course 219°33'30"
SPEED TRIAL COURSE
Burrwood, Louisiana
Triangulation and Range Beacons by
U.S.C.&G.S. Ship Hydrographer
R.F.Luce, Commanding June, 1935
Buoys established by
U.S. Bureau of Lighthouses
Section of Chart No. 1272
Soundings in Feet

triangle computations. The latter also proved perfect spacing of range lines at 1853.25 meters*

Four range beacons were erected) using sturdy construction, which, barring hurricanes or tornadoes, should stand for at least six months. Front beacons were 20 feet high to top of the 9' x 12' target; rear beacons 32 feet high to the top of the 12' x 19' targets. Targets are yellow, with black vertical center stripes (2 feet wide stripes for front and 3 feet far rear targets). These were symetrically constructed and accurately centered over and normal to the range lines so as to permit alignment of either black stripes or entire targets for marking the true range.

Marker buoys were so placed on the range lines that soundings taken between them varied from 107 to 118 feet. The Lighthouse Service placed buoys "B" at the Coast and Geodetic Survey marker buoy identifying the NE Range and buoy "C" at the marker buoy for the SW range. A sun azimuth observed from "B" to "C" yielded 221° 13', or l.4° off a course at right angles to the mean of the range azimuths. Approach buoys "A" and "D" were planted by the Lighthouse Service approximately one mile NE'ly and one mile SW'ly from "B" and "C" and on range with the same.

Six taut wire measurements over the range course yielded four values of 0.995, and one each of 0.996 and 0.997 on the taut wire counter. These were obtained in the late afternoon, with the sun behind the range beacons, thus necessitating observing on and aligning the entire target widths. While there was no trouble experienced in distinguishing the targets it is recommended that, to permit sighting on the vertical black stripes, speed trial runs be made before noon. The range beacons proved sensitive and were readily aligned at full speed using 6 power binoculars, from heights of eye of 45, 29, and 18 feet.



*The International Hydrographic Bureau, Monaco, has proposed that "the length represented by 1852 times that of the prototype of the metre shall be called the international nautical mile", but this proposal has not been accepted by all members of the Bureau, and the C S. Hydrographic Office and the Coast and Geodetic Survey use 1853.248 meters for the length of one nautical mile

(Editor)

See P. S. Coast and Geodetic Survey Special Publication No. 5, p. 4
Also, Appendix No. 12, Coast and Geodetic Survey Report for 1881, which contains a variety of values for length of a nautical mile according to definitions.

A UNIQUE BROKEN BASE METHOD

By O. S. Sutherland, Mathematician,
U. S. Coast and Geodetic Survey

In carrying forward a scheme of triangulation it is often desirable to introduce a base where, due to topographic characteristics of the country, no suitable site can be found. In such cases recourse may be had to a broken base measured in detached sections as shown in the accompanying figure.

In the example shown, AG is a line of the main scheme of the triangulation. The lines AB, BC, DE and FG were readily measurable but the topography prevented the measurement of the lines CD and EF. However, the base was measured and the different points connected by triangulation as shown. The least square adjustment of the base net insured the closing of the triangles and the accord of lengths when computed from the various measured sections. The line AG was then held as a base in the adjustment of the main scheme.

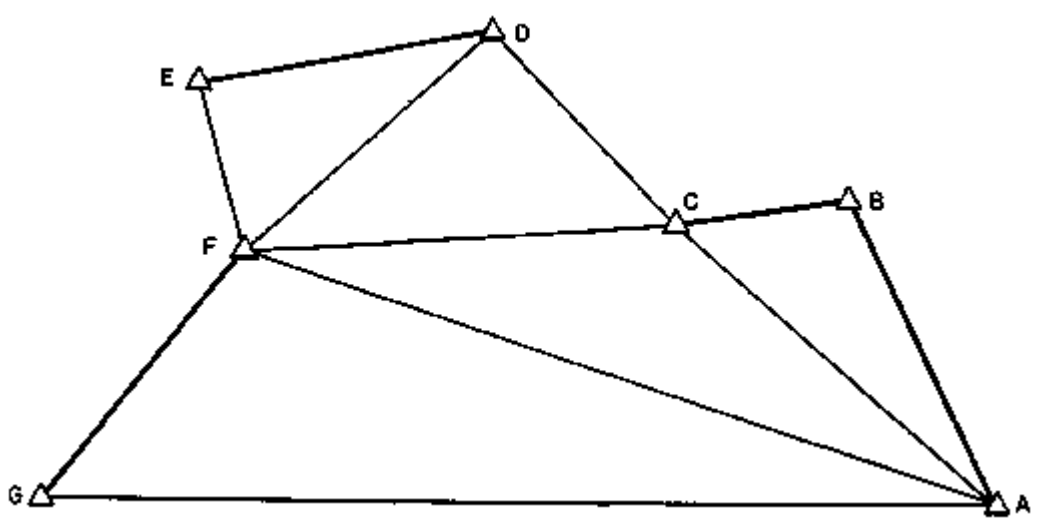
Such a type of base may well be used in several cases. Two such cases become at once apparent. First, where the triangulation is being extended up a river and has reached a point where the river is narrow and winding and figures necessarily have become weak. The chief of party feels the need of an adequate check on his length but finds no site where he can measure a full size continuous base. However, there may be numerous possibilities if he resorts to the method outlined above. He may find it possible to measure part on one side of the stream and part on the other. The second case is where the triangulation is advancing from island to island, as for example in some parts of Alaska. It may be possible to measure part of the base on one island and part on another.

In making use of this type of base the following precautions should be observed:

1. It should be used only as a last resort. If it is at all possible to measure the base in the orthodox manner, that should be done unless the time and expense factors render it prohibitive.

2. Care should be taken to secure expansion through good figures. Angles should be measured with extreme accuracy. The value of the measured base may be lost through weak expansion or poor observing.

3. The total length measured should at least be equal to the length of the expanded base. For example, in the figure, AB+BC+DE+FG should exceed AG in length.



APPRECIATION
(Copy of a letter received from the
United States Engineer Office, Jacksonville, Fla.)

April 20, 1935.

Subject: Assistance rendered by U. S. Coast and Geodetic Survey.

To: The Director, U. S. Coast and Geodetic Survey, Washington, D. C.

1. This office recently completed emergency work involving the execution of a precontract survey for certain dredging in the St. Johns River between this city and Green Cove Springs. The work performed involved the securing of information which can be used for inviting bids on the construction of a reach of a ship canal across the upper portion of the peninsula of Florida should this construction be authorized at a later date.

2. The assistant in immediate charge of the field work has submitted a report in connection therewith, paragraph 2 being quoted as follows:

"2. Too much cannot be said for the excellent control survey consisting of 2nd order triangulation which had previously been established throughout section of river covered by our survey, by the Coast Survey under the direction of Lieut. H. A. Paton, locally in charge. This work greatly facilitated our survey and resulted in the saving of considerable time and expense to this Department. It is estimated that approximately $15,000.00 was saved and the survey advanced at least one month. The time factor, however, would depend largely on size of force used. Triangulation stations had been established at convenient locations, several of which were provided with towers, some as high as 80 ft., making it unnecessary for us to establish any. Triangulation work had been completed, checked and adjusted, geographical coordinates computed and all of this data was cheerfully furnished us by Lieut. Paton. He is to be commended for the splendid spirit of cooperation."

3. The cooperation rendered by Lieut. Paton, in connection with the work recently accomplished, has been of great assistance to this office, and has resulted in a considerable saving in funds. This spirit of cooperation is appreciated and will be reciprocated whenever opportunity presents itself.

For and in the absence of the District Engineer:

(signed) P. A. Feringa..
1st Lt., Corps of Engineers,
Military Assistant.

AIR PHOTO COMPILATION IN COURT

An air photo compilation, T-5065, was forwarded to Mr. Halsey in response to his telegraphic request for a new chart of Gardner's Bay showing Robbin's Island. Although the telegram was received about 4:15 p.m. the shipment was made via air mail that night as requested.

Extract from the answering letter to the Director from Mr. Halsey:

"Dear Mr. Patton:

Your air sheet T-5065 showing Robbin's Island was received Friday night.

Saturday morning I attended court in New York. The opposing attorney tried to state that it was not certified etc., and any description or areas taken therefrom would be useless.

The Judge asked me if it was an official compilation of the U. S. Coast and Geodetic Survey. I stated: "Yes, from photos taken April 21st, 1933, and field surveys made by the Coast Survey, and so adjusted in Washington." He said: "Admitted, as they are the most accurate surveys obtainable."...

Respectfully yours,

(sgd.) Wallace H. Halsey"

February 12, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM No. 1 (1935)

DISCREPANCIES IN TOPOGRAPHIC SURVEYS

1. Comparison of air photographic compilations with contemporary plane table surveys shows unwarranted discrepancies as regards the number and the size of errors. The causes of the majority of the errors noted in both the compilations and the plane table surveys are listed herein for the information and guidance of field parties.

2. In general the most economical method of making the topographic surveys required by this Bureau, particularly on the Atlantic coast, requires the use of both the plane table and air photo compilations. Air photo compilations should be supplemented by the use of the plane table for location of detail not clear on the photographs, such as indefinite shore line, beacons, ranges, rocks, recoverable stations not located by triangulation, etc., as well as to provide additional control for photo plots.

3. A high order of accuracy must be maintained on the plane table surveys so that point locations of recoverable objects on those surveys can be used for controlling the photo plots and the detail can be transferred to supplement photo compilations without appreciable discrepancies. With the elimination of distortion by the use of aluminum-mounted sheets, the accuracy of plane table locations should be equally as strong as positions by photo compilation. This is indicated by the fact that most of the errors noted in the plane table work can be traced to the following:

(a) Errors in plotting control stations.
(b) Errors in projection.
(c) Excessively large holes pricked for control station points.
(d) Adjustment of large traverse errors rather than resurveying.
(e) Wide spacing of rodded points resulting in large errors in sketching. When plane table control surveys are made in an area for which the detailed topography is to be supplied by air photographs, the shore line or similar detail located by the plane table should be broken and a dot made at rodded points to indicate clearly the precise position as distinguished from sketching.
(f) Point locations accepted inside a triangle of error rather than by a precise intersection, or from an acute intersection.
(g) Insufficient basic control.

4. The larger sources of errors noted in the photo compilations are due to

(a) Insufficient control. In a number of cases additional control, available from the plane table surveys, has not been used, resulting in discrepancies between the compilation and the plane table surveys.
(b) Errors in Identification of points on the photographs.
(c) Heavy radial lines.
(d) Detail, not clear on the photographs, traced without adequate field inspection. This has caused large errors in delineation of the high-water line, particularly along sand beaches. In a number of cases certain detail, as the delineation of small islands, beacons, dolphins, rocks, etc., which was not defined clearly on the photographs, has been omitted.
(e) Errors in drawing projections and plotting control.

5. The descriptive reports of the air photo compilations indicate a tendency on the part of the compilers to accept the compilation as correct in cases of difference with the plane table without adequate inspection of all sources of error in the photo plot. The attitude should not be taken that the photo compilation is necessarily more accurate than the plane table. Both methods have limitations which must be recognized and both methods are capable of high accuracy within those limitations. In cases of discrepancies the photo compilation should not be accepted as correct without a careful check.

(M-143)

R S Patton
Director.

April 1, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 2 (1955)

LOCATION AND DRAFTING OF BUILDINGS ON AIR PHOTO COMPILATIONS.

Buildings on air photo compilation sheets shall be shown in accordance with the following instructions:

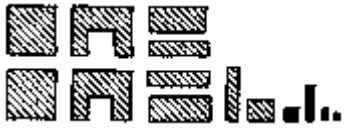
1. In urban districts where there is a well defined street system subdivided into sections approximately equal to city blocks:

(a) Immediately adjacent to shipping terminals and anchorages show all buildings except in oases where this tends to obscure more important detail.
(b) Back from the waterfront show only the outstanding buildings, and public buildings such as post offices, schools, courthouses and churches. Designate these where identifiable.

2. In rural districts, where the streets are not subdivided, as mentioned in paragraph 1, show all buildings appearing on the photographs.

3. Buildings shown on the compilations shall be located accurately and traced after a careful study under the stereoscope and field inspection, where necessary. Care shall be taken that the bases of the buildings are not confused with the shadows or with the perspective positions of the roofs. Bases should be drawn on the photographs under the stereoscope before transferring them to the celluloid. Location of buildings shall be controlled by frequent and well distributed intersection points, particularly where there are appreciable elevations. Incorrect location of buildings has been one of the most frequent errors made by inexperienced draftsmen.

4. Buildings shall be cross-hatched, or shown in black, according to size as indicated by the accompanying examples and shall be drawn with clean lines and square corners. Cross-hatching shall not be spaced closer than shown in the example. Trimming and erasing shall be avoided as much as possible and where necessary shall be done immediately after the ink is applied. Erasures of celluloid ink leave yellow stains on the celluloid and produce a ragged outline when photographed.



5. When making decisions regarding buildings to be traced, the Chief of Party should consider the purposes for which they are apt to be used in the future. In general these purposes are related to control, among them being: (1) The control of isolated photographs taken for revising the area; (2) location of new objects, such as airway beacons, landmarks, airports and new, prominent structures; (3) the control of, and coordination with, overlapping maps. Since these purposes are related directly to control, it is obvious that accurate tracing of buildings is of the utmost importance. (M-152)

R. S. Patton

Director.

April 22, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 3 (1935)

INSHORE HYDROGRAPHIC WORK

On the open coast, hydrographic development as close to the shore as is consistent with safety is desirable, but life or property should not be jeopardized to attain this objective. Sounding lines should be run as close to the beach as is considered safe by the officer in charge of the boat. The sounding record should show clearly that the inshore line is being run as close to shore as safety permits, and estimated distances to the breakers should be frequently noted in the record. From these data the line of breakers should be clearly sketched and shown on the boat sheet in ink, but in pencil on the smooth sheet.

It is to be understood, of course, that the chief of party will, in so far as practicable, plan his work so that the inshore sounding may be done during particularly smooth days and during periods of reasonably high tides.

It is realized that in regions of small tidal range, such as in the bays and sounds along the Gulf Coast, with only a depth of a few inches to a foot of water extending several hundred meters offshore, it may at times be difficult and uneconomical to develop closely this band of very shoal water, since the tidal range will not permit use of an outboard motor. Such areas should be fully described in the descriptive reports of hydrographic sheets and copious notes made in the sounding records when lines are run in close proximity to such areas, giving an estimate of the depth to shore, supplemented occasionally by a record of the actual depths by wading or pulling boat.

On rocky coasts where it is dangerous for the sounding boat to enter a certain rocky area, the fact should be stated in the sounding record and the outline of the area accurately drawn on the boat sheet. Where kelp is so thick that the boat can not penetrate it, this fact should be entered in the sounding record and an outline of such area carefully delineated on the boat sheet. If an important area, a flat bottom skiff should be used to investigate for danger.

M-154

R S Patton

Director.

April 22, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 4 (1935)

GEOGRAPHIC NAMES

The obtaining and verifying of geographic names by field parties should receive more attention. In a number of cases the field parties merely copy on their hydrographic and topographic survey sheets geographic names as taken from the current editions of the charts or other maps. Hydrographic, topographic, and air photo compilation surveys should be source material, and geographic names, obtained from sources other than field survey, should be verified by the field party if practicable.

Hydrographic sheets should be the authority for all geographic names outside of the high water line. They should include the geographic names of all water features, such as channels, sloughs, rivers, inlets, reefs, rocks, banks, shoals, etc. Topographic sheets and air photo compilations should be the authority for all geographic names inside the high water line, and these should include names of all land features and, in addition, names of lakes, small streams, rivers, and sloughs in which a hydrographic survey is not made.

It is almost impossible to have too many authentic geographic place names on an original survey sheet because it may be an authority for other purposes than charting.

Geographic names should not be inked on hydrographic or topographic survey sheets by the field party. They should be lettered in pencil and, after verification, will be inked in the Washington office. Neither should the geographic names be "struck up" on the air photo compilation by the field party. They should be placed at proper position on the overlay tracing which is submitted with the compilation.

It is desirable that the surveyor list all geographic names which appear on his survey sheet according to the source from which the information was obtained; that is, from our charts, from geological survey quadrangles, from local information, or from names assigned by the field party. Where names have been placed on the survey sheet from other maps or charts, this fact should be stated, the source should be named, and a statement should be made as to whether this information has been checked by the surveyor as being in general local usage.

The Division of Geographic Names of the Department of the Interior makes the final decision on disputed geographic names. In general, well accepted local usage of the name is the deciding factor. If geographic names appear on our charts or on other federal maps, and such a name is not found to be in the accepted local usage, a rather complete statement must be made by the chief of party as to how well established any other name which he recommends may be, the sources from which the name was obtained, and how well authenticated his information may be. In cases in which there has been no decision by the Division of Geographic Names or when the feature has not been named on any federal map, established local usage may be accepted by the field party. In all other cases, where established local usage differs from a rendered decision or from a name appearing on federal maps or charts, the matter must be referred to the Division of Geographic Names for a decision. The Division of Geographic Names opposes the naming of geographic features after any living person. The use of the possessive terminal "s" in geographic names is probably the most difficult case in which a correct decision can be reached. In general, the rule applied by the Division of Geographic Names is to omit this possessive terminal "s". This rule, however, is very often in direct opposition to local usage, and in many cases, the Division of Geographic Names has reversed its decision and replaced a possessive terminal "s" which had previously been removed. In many cases where a geographic feature has been named after a person, that person's name actually did have a terminal "s", and this "s", of course, in no way indicated a possessive. In other cases where tracts of land, islands, or points were at one time actually owned by a certain person, it seems quite proper to include the possessive terminal "s" when the feature has been named after the person formerly owning it. In contrast, however, the names of features such as rivers, inlets, and mountain ranges, should not be written in the possessive form.

There follow a few examples of the sort of information desired by this office when new geographic names are recommended. This information should be even more complete and specific when the recommended name differs from that now appearing on federal maps and charts.

"ARROWHEAD POINT derived its name from its resemblance to an arrowhead. This resemblance is more pronounced on the aerial photographs of this area. There is a signpost on this point labeled 'Arrowhead Point' so that all who play golf on the famous 'Pebble Beach Golf Course' come to know it by this name.

"STILLWATER COVE is the name given to the yacht harbor for the famous Del Monte Lodge at Pebble Beach. It derived its name because of its well protected nature. This cove seems to have had no name, at all until recent years, but according to local residents, it has become known locally as 'Stillwater Cove.'

"PEBBLE BEACH is the name given to the rocky beach between Stillwater Cove and Del Monte Lodge. The famous 'Pebble Beach Golf Course' adjacent to this beach derives its name from its close proximity to the beach at this point. This golf course became internationally known a few years ago when a major golf championship was held there, and Pebble Beach is synonomous with the golf course of the same name. For this reason the name Pebble Beach is unconditionally recommended for adoption.

"BIRD ROCK is the established local name of the large, high rock one (1) mile north of Cypress Point. According to U. S. Geological Survey quadrangle maps of this area, this rock and the smaller rocks one-fourth (1/4) mile to the southward are referred to in a group as Seal Rocks. In recent years only this smaller group to the southward has been called Seal Rocks, while the higher one to the northward is called Bird Rock because of the numerous birds that seem to always stand on, or around, it. These groups of rocks are posted in the above manner along the '17 Mile Drive.'" (M-155)

R S Patton

Director.

April 22, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 5 (1935)

HYDROGRAPHIC SURVEYS

In view of the fact that our force of field engineers has been supplemented by temporary personnel during the present period of expansion of activities, it is desirable to amplify and supplement the Hydrographic Manual in a few specific cases which have come to the attention of the office.

CHECKING PROTRACTORS

It is apparent from some of the discrepancies in field plotting that protractors are not being checked frequently. Steel protractors that are being used for smooth plotting should be checked with the aluminum sheet which is provided for that purpose. If such a sheet is not available the protractor should be checked by the method given on page 83, Hydrographic Manual. This method may be supplemented by the construction of 30°, 60°, 120°, and 150° lines geometrically, if found to be necessary, and the corrections for the protractor obtained.

DISCREPANCIES IN HYDROGRAPHIC SURVEYS

In verifying and inking sheets in the Washington office many errors have been noted which can be eliminated by more care in the field, in the execution of the surveys, recording of the data and plotting of the smooth sheet:

(1) As to the execution of the surveys, the faults consist generally of the following omissions:

(a) An insufficient number of positions to define accurately the courses followed by the sounding boat.

(b) Holidays left not filled in by hydrography.

(c) Adequate investigation and definite recommendation as to the disposition of such features as rocks and shoals shown on the charts or on prior surveys, but not found on the current survey.

(2) The records are deficient in the following respects:

(a) No notes as to course or change of course.

(b) No notes as to change of speed.

(c) No notes as to currents encountered.

(d) insufficient data as to distance from prominent objects when passed closely. Lack of evidence to indicate whether such distances are estimates or have been scaled.

(e) The use of the symbol "S" or "same" at the top of the record page instead of recording the signals at top of each page. In this connection, the plotter should check each time with the recorder the names of the signals as he plots the position.

(f) Plotting of positions on smooth sheets by angles other than those in the sounding book, but not indicating the change.

(g) Failure to record the fact that certain lines may have followed the shore-line rather than following a straight line between positions.

(h) Failure to note the character and permanency of a feature outside the high water line on which a signal is located, such as "iron stake," "wooden wreck, baring 5 feet H.W.," "temporary pole," etc. Such information is desired for all signals located outside the high water line.

In connection with the lack of sufficient notes in the sounding records, it is suggested that the chief of party detail the left angleman to see to it that proper and sufficient notes are made in the record.

(3) In the smooth plotting in the field the errors appear to be due to the following causes:

(a) Spacing of soundings by eye instead of with spacing dividers and the ignoring of time intervals.

(b) Ignoring of notes in the records.

(c) Plotting the soundings in a straight line between positions when they actually follow the shore-line.

(d) Making the position numbers too large (and in a few cases too small to be legible); also placing them too far away or too close to the positions.

(e) Placing junction notes on the sheet in ink. (These should be in pencil).

(f) Placing names on the sheet in ink which have not been investigated thoroughly.

(g) Failure to check conflicting or suspicious depths.

(h) Carelessly transferring the shore-line from topographic sheet.

(i) Failure to initial all operations performed by the field party on the proper stamp provided for that purpose.

(j) Using too hard a pencil.

(k) Failure to place a reference triangulation station on the sheet together with its datum.

(l) Incorrect plotting of +l/2-foot and -l/2-foot soundings.

(m) Failure to transfer notes made only on the boat sheet.

(n) Showing the low water line in ink. (This is contrary to paragraph l60(m), page 21, Hydrographic Manual).

(4) Transfer of shore-line from plane table or air photo compilations should be made in accordance with the following:

(a) Only the shore-line of water areas in which the hydrography has been done should be transferred to the smooth sheets.

(b) The transfer of shore-line to the hydrographic sheets should be checked in the field and so indicated. Any tracings used in making such transfers should be submitted with the hydrographic sheets.

(c) The shore-line should be shown in pencil only, unless it has been obtained from final printed compilations, compilations prepared in the office especially for the hydrographic survey, or reductions made by the new type of projector in the field.

(d) The shore-line should be shown in pencil only, in areas where the hydrographic survey definitely proves the shore-line to be in error.

(e) In all cases not covered by (c) and (d) the shore-line (high water) should be shown in ink.

DESCRIPTIVE REPORTS

Satisfactory descriptive reports of hydrographic sheets can not be written from memory after the survey is completed, nor by the individual who plots the smooth sheet if he were not in charge of the field work. It is suggested that the officer in charge of the hydrographic launch have at hand at all times in the field a notebook for each sheet for the recording of notes for the information and guidance of the chief of party in preparing descriptive reports. The notes regarding the various information called for in descriptive reports in the Hydrographic Manual would then be made from day to day by the officer in charge while the circumstances are fresh in his mind. The use of such a notebook must not in any case be allowed to take the place of notes properly belonging in the sounding record.

In some cases extenuating circumstances may make necessary the omission of some desired sounding lines, deviation from standard methods, an apparently incomplete development, etc. A complete record should be made of such circumstances in each case.

DAILY REVIEW OF FIELD WORK

The critical and thorough examination of the boat sheet, records and detailed notes of each sounding party at the close of each day actually proves to be a source of gratification to those chiefs of party who have followed this practice. In this manner a constant review of the survey during its progress is maintained by the chief of party. The daily review enables him to discuss the work with the hydrographer in charge, to direct additional or less development in the next day's work, to instruct in regard to errors or omissions in the records and notes on the boat sheet, and to improve constantly the work as it progresses. It is probable that only by current review of the daily work can improvement be made. It is obvious that it is practically useless so far as that survey is concerned to make criticism after the close of the field work and the transfer of the party to another location. When circumstances do not admit of a daily review, a most thorough one should certainly be made over the week end by the chief of party in consultation with the hydrographer.

R. S. Patton

Director.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 6 (1935)

AZIMUTHS AND AZIMUTH MARKS AT TRIANGULATION STATIONS

1. This Field Memorandum supplements and amends the circular of September 20, 1933, on this same subject.

2. The value to local engineers of azimuths at each triangulation station is being brought to the attention of this Office daily, sometimes by requests for azimuths and sometimes by reports from local engineers to the effect that they can not check the azimuths at certain stations as published by this Office. Every effort must be made to eliminate such discrepancies.

3. A regular standard disc azimuth mark shall be set at all stations (about 1/4 mile away). In addition, any natural objects visible from the ground and suitable for azimuth marks shall be observed on, even though their positions can not be determined. The standard azimuth mark and the natural-object azimuth marks shall be observed upon from 4 positions of the circle instead of 2 as required at present. The azimuth of such marks must be accurate within 5 seconds of arc, and to obtain this accuracy, great care must be exercised in centering the theodolite and target, if one is used, and in pointing. In the case of the standard azimuth mark, the building party shall erect a small bench, accurately centered over the mark, upon which one of the small signal lamps can be set. A small signal light with the reflector removed makes an excellent object upon which to point. The initial used should always be a light or heliotrope at one of the main-scheme stations. Natural objects chosen for azimuth marks should have something definite upon which to point as, for instance, the finial of a church spire or water tank.

4. All azimuth marks shall be visible from the ground to provide for azimuth checks after the removal of towers. This fact must be considered when setting the standard also azimuth marks.

5. All natural-object azimuth marks shall be listed on the face of the description of station card under the heading "Objects visible from the ground." If there is not room on the face of the description card to describe adequately the natural object and the exact point sighted on, such data should be written up in the body of the description. A note shall also be made in the description of station as to which of the natural objects is most suited as an azimuth mark. If no objects are visible from the ground at the station, a note to that effect shall appear in the description of station as well as in the record book and list of directions.

6. The importance of usable azimuth marks at each triangulation station can not be over-stressed, and all chiefs of party shall make every effort to determine such azimuths accurately.

Acting Director.

October 31, 1935.

U. S. COAST AND GEODETIC SURVEY
FIELD MEMORANDUM NO. 7 (1935)

COAST PILOT INFORMATION

It is important that Coast Pilot information be obtained from our field parties as well as from the periodic inspections and from outside agencies. The compilation of such information in a form in which it can be readily used has been neglected to a considerable extent by some Chiefs of Party.

In many cases the descriptive reports and field sheets have had to be used as the principal source for Coast Pilot information. These records do not reach the Coast Pilot Section in the ordinary course of office routine and considerable search is generally required to unearth the Coast Pilot material in this form. Moreover, information lacking in the Coast Pilot reports as to description of the coast, landfalls, strength of currents, presence of tide rips, cross currents, etc., is generally not available in the descriptive reports. With respect to controlling depths, it has been necessary in many cases to consult the survey sheets when such information should have been included in a Coast Pilot report by the Chief of Party.

It is most desirable that all information pertaining to the Coast Pilot be contained in Coast Pilot reports. This information can certainly be readily compiled by a Chief of Party while operating in a given locality. Information of vital importance to the navigator should be reported at once. General notes should be submitted in duplicate at the end of the field season.

It is essential that the form indicated on pages 156 and 157 of the Hydrographic Manual be followed in submitting Coast Pilot notes.

Landmarks for charts should be submitted in duplicate. The duplicate copy should be marked "Coast Pilot Section" and notations should be made on the form indicating how the landmarks may affect the Coast Pilot. This is important.

It should not be construed that only a revision of the published text of the Coast Pilot is required. An endeavor should be made to obtain additional information which would enhance the value of the Coast Pilot. This should be done not only in case of an area not previously surveyed, but the existing general presentation concerning a previously surveyed area should be closely examined for inadequacies. In cases where information in the Pilots is found accurate and adequate a statement to that effect should be included in the notes. Where there are few changes to the text it is only necessary to supply the new data and to indicate the page, paragraph and line affected, rather than recopy a considerable part of attendant unchanged text.

Vessels proceeding from port to port will endeavor to make a check of the Coast Pilot if this can be done without causing undue delay. Errors and deficiencies as may be noted should be reported.

The gathering of pertinent information from local sources in the area in which the party is working and in the locality conveniently adjacent thereto should not be neglected.

R. S. Patton

Director.

DISTRIBUTION AND STATISTICS OF FIELD PARTIES
U. S. COAST AND GEODETIC SURVEY - DIVISION OF HYDROGRAPHY AND TOPOGRAPHY
July 1, 1934 -June 30, 1935

Locality	Project H.T.No.	Ship or Party No.	Personnel*	Hydrography			Topography		Triangulation		
				Miles	Sq. Mi.	Sdgs.	Miles	Area	Miles	Area	Pos.
Me., Penobscot Bay	180	1	E. G. Crosby						150	3,500	400
Mass., Boston and vicinity	145	7	F. L. Peacock						50	300	386
Mass., Cape Cod	145	28	E. A. Daily	1,548	126	44,385	34	22	44	317	85
Mass., Buzzards Bay	179	5	W. D. Patterson G. E. Morris, Jr.	2,651	122	93,986	215	116	62	369	130
Conn., L. I. Sound	150	16	G. C. Mattison W. H. Martin	490	26	21,449	93*	77*	88	353	820
N. Y., Long Island Sound and New York Harbor	186	15	I. E. Rittenburg	1,918	70	59,653	197		14	12	47
N. Y., New York Lower Bay	178	2	M. O. Witherbee	1,838	89	78,110	34			9	8
N. Y., Hudson River	190	MI.	J. A. Bond[8]	746	55	25,359	90		52	52	346
N. Y., N. J., Vicinity of New York	121	12	R. C. Holstec				2,028*	614*	62	250	160
N. J., New York Lower Bay	174	14	E. R. McCarthy,	2,151	743	77,743	85	31	23	68	67
N. J., Southeast Coast	205	19	B. H. Rigg, E. B. Brown	890	25	40,428	52		58	220	47
N. J., Southeast Coast	205	2	J. C. Simmons	858	24	46,361	16	51	23	115	47
N. J., Southeast Coast	205	21	R. H. Kirsch				263*	90*			
N. J., Delaware River	202	8	H. B. Roberts C. N. Reed						14	9	130
Del., Md., East Coast	170	29	J. C. Tison, Jr.						14	30	27
Md., Baltimore Harbor	183	MI.	J. A. Bond[8]	3		169		6	20	40	50
Md., Chesapeake Bay	175	23	J. C. Partington J. C. Tison, Jr.				699*	363*	20	52	48
Va., Approaches, Chesapeake Bay	142 200	OC.	H. A. Seran[10]	9,067	8,339	75,497			6	16	10
Va., ditto	143 200	LY.	H. L. Schoppe[7]	4,758	750	81,998	10	4			
Va., ditto	144 200	OI.	H. Odessey[4]	703	71	16,948					
Va., Back River	173	OC.	H. A. Seran[10]						18	80	71
Va., Nansemond River	173	6	J. C. Bose R. H. Carstens	182	9	12,125	63	26			
Va., N. C., Currituck Sound	192	1	E. G. Crosby						150	900	160
N. C., North Landing River to Alligator River	189	NA.	J. C. Simmons R. P. Zymm[9]	3,243	190	102,950	196	50	66	216	142
N. C., Pamlico and Pungo Rivers	197	MI.	J. A. Bond[8]	2,941		97,630	372				132
N. C., Pamlico Sound		27	C. L. Anderson						10	100	13
N. C., Bay River and Hatteras Inlet	197	6	J. C. Bose, R. H. Carstens	311	15	18,119	116	58	27	70	67
N. C., Inland Waterway		18	E. H. Grenell				576*	214*			
N.C., S.C., Inland Waterways	154	19	B. H. Rigg, E. B. Brown	2,652	143	101,648	256		31	117	31
S. C., Georgetown north	198	2	J. C. Simmons	718	12	36,563	5		4	3	26
S. C., Winyah Bay		61.	H. Odessey[4]	822	36	31,974	15				

Locality	Project H.T.No.	Ship or Party No.	Personnel[1]	Hydrography Miles	Hydrography Sq. Mi.	Hydrography Soundings	Topography Miles	Topography Area	Triangulation Miles	Triangulation Area	Triangulation Pos.
S. C., Inland Waterways	162	21	H. H. Kirsch				1,887*	1,369*			
S. C., Ga. Inland Waterways	166	23	C. A. Egner, C. A. Burmister	1,762	122	50,393	25		70		54
S. C., St. Helena Sound	259	Ma.	J. C. Symons, R. P. Hyman[9]	465	14	16,432	4				
Ga., Inland Waterways	169	18	S. B. Grancell				1,953*	2,177*			
Ga., Fla., St. Johns River	168	26	H. A. Paton, O. W. Lovesee	6,150	242	284,442	649		62	92	246
Fla., St. Johns River	168A	20	T. M. Price		Field Inspection - new project						
Fla., St. Johns River	203	1	F. G. Crosby						125	550	214
Fla., Fort Everglades	181	22	W. H. Bainbridge	96	3	4,977	50	4			
Fla., Miami and Keys	158	3	H. A. Cotton, E. J. Seaborg	2,074	258	88,771	41 200*	6 40*	52	595	70
Fla., Miami and Keys	158	14	R. S. McCarthy, J.C. Mathieson, J.T. Jarman, E. J. Seaborg	7,296	565	258,211	160 27*	40 16*	72	430	192
Fla., Key West	191	22	W. H. Bainbridge	2,720	213	104,047	16	4	98	795	178
Fla., Apalachicola Bay and Tributaries	154	23	C. A. Egner, C. A. Burmister	4,134	255	111,446	80		56		70
Fla., St. Andrew Bay	195	5	W. D. Patterson, O. E. Morris, Jr.	2,523	86	96,913	264		49	96	87
Fla., Mobile Bay to Choctawhatchee Bay	196	15	I. E. Rittenburg	6,094	272	175,450	63				
Fla., Ala., Inland Waterways	185	24	M. E. Reese				1,928*	2,980*	141	669	264
Fla., Ala., Miss., Inland Waterways		27	G. L. Anderson						268	3,942	369
La., Miss. River delta		24	M. E. Reese				926*	541*	5	30	10
La., Atchafalya Bay and Intracoastal Canal	136	4	F. B. Reed, J. O. Tribble	8,400	891	220,731	775	320			6
La., Off Atchafalaya Bay	123	Ex.	R. F. Lane[6]	8,825	4,411	97,060	52	20	8	30	10
Tex., Inland Waterways	118	8	E. O. Seaton, E. B. Roberts, W. O. Russell, C. H. Reed	7,640	773	249,785	138	30	10	40	21
Tex., Inland Waterways	118A	20	T. M. Price				2,231*	1,205*			
Calif., Southern coast and Channel Islands	102 117	9	H. W. Knox, R. J. Sipe, J. C. Mathieson	4,362	281	86,950	209	32 188*	29	118	51
Calif., Southern coast	117	10	C. E. Green	398	30	7,172	23	7	5	10	6
Calif., Santa Barbara Islands	120 187	Pl.	O. W. Swainson[11]	9,783	2,549	147,247	98	60			
Calif., Point Sur Southward	184 206	Gu.	P. H. Hardy[5]	3,372	299	82,294	130	49	2	4	7
Calif., Sacramento River Delta	153 98	17	L. P. Raymer				36		13		971
Oreg., Columbia River	201	9	H. W. Knox, H. J. Sipe, J. C. Mathieson	716	42	25,558	150	32	50	226	127
Wash., Puget Sound	171	Ex.	J. Sanlor[2]	3,489	188	114,633	320	90	123	254	366
Alaska, Aleutian Islands	177	Di.	H. B. Campbell[3]	4,214	10,124	39,687	168	68	78	174	122
Alaska, Aleutian Islands	176	Sw.	A. M. Sobieralski[12]	6,378	1,966	59,461	240	126	235	1,170	141

Locality	Project H.T.No.	Ship or Party No.	Personnel*	Hydrography Miles	Hydrography Sq.Mi.	Hydrography Sdgs.	Topography Miles	Topography Area	Triangulation Miles	Triangulation Area	Triangulation Pos.
P. I., N. E. Luzon		Pa.	C. Shaw[3]	2,912	671	52,566	137	161	21	166	68
P. I., Manila Harbor		Pa.	C. Shaw[3]	338	6	13,521	4	1			
P. I., Balabac vicinity		Pa.	C. Shaw[3]	5,811	705	92,967	5	1			
			Totals....	138,382	35,770	3,523,749	20,350	11,089	2,574	16,409	7,080

Field Stations: Manila, E. R. Fagenhart, Director of Coast Surveys; Boston, F. L. Peacock; New York, G. D. Coyle; New Orleans, E. P. Growther, (Clerk in Charge); San Francisco, T. J. Mahony; Seattle, E. B. Derickson; Honolulu, J. R. Peters; San Juan, Porto Rico, E. H. Bernstein.

1. DISCOVERER: H. B. Campbell Com'd'g, R. R. Moore, J. M. Smook, W. M. Beaife, H. A. Kare, F. L. Bernstein, E. G. Forbin, E. C. Baum, E. B. Lewey, G. E. Morris, Jr., M. G. Ricketts, J. E. Jones, R. A. Gilmore, L. R. Robottom, R. A. Marshall, O. E. Hartzog, Jr., E. S. Olm, D. H. Konichek, H. J. Seaberg, K. E. Gile, F. J. Seule.

2. EXPLORER: J. Senior Com'd'g, L. C. Wilder, G. L. Bean, W. F. Malnate, E. B. Lewey, E. C. Baum, H. P. Garber, C. H. Jones, W. Weidlich.

3. PATHFINDER: C. Shaw and M. F. A. Stoddz Com'd'g, H. E. Finnegan, G. R. Shelton, G. C. Mast, G. S. Hutchison, E. B. Jeffers, D. H. Kruger, A. H. Hunyemtt.

4. GILBERT: H. Odessey Com'd'g, J. S. Morton, W. Deans.

5. GUIDE: F. H. Hardy Com'd'g, G. C. Jones, L. F. Raynor, R. F. A. Stoddz, L. T. Sanders, F. E. Quinn, W. J. Chowen, L. W. Swanson, G. C. Mast, I. R. Robottom.

6. HYDROGRAPHER: W. H. Parker, H. F. Lace and H. F. Hyman Com'd'g, A. F. Rattl, W. E. Greer, R. H. Woodworth, P. C. Dorm, G. R. Shelton, J. E. Jones, P. Taylor, O. E. Hartzog, Jr., E. L. Jones.

7. LINCOLN: E. L. Schoppe com'd'g, E. B. Roberts, C. A. George, C. H. Reed, D. H. Konichek, W. C. Russell, C. M. Conover, G. G. McIlwraith, E. B. Wright, F. E. Gleason, R. C. Overton.

8. MIRAGE: J. A. Bond Com'd'g, F. R. Goassett, C. F. Chenoweth, D. E. Sturner.

9. NATOMA: R. F. Hyman and J. C. Samsons Com'd'g, P. Taylor, J. C. Hall.

10. OCEANOGRAPHER: H. A. Saran Com'd'g, E. T. Graham, J. L. McIver, E. H. Sawyer, E. J. Brown, E. A. Daily, J. C. Boss, R. A. Earle, F. Natalis, J. S. Morton, R. A. Marshall, W. F. Deans, J. E. Waugh, E. H. Carstens.

11. PIONEER: O. W. Swinson Com'd'g, J. M. Smook, R. R. Moore, W. W. Beaife, H. J. Healy, G. M. Marchand, G. A. Nelson, M. E. Wennermark, C. G. McIlwraith, E. O. Zimmerman, H. L. Dagle, W. R. Scrogge.

12. SURVEYOR: A. M. Sobieralski Com'd'g, L. C. Wilder, G. L. Bean, R. C. Rouse, W. F. Malnate, I. T. Sanders, F. E. Quinn, G. A. Nelson, W. H. Gibbens, C. J. Wagner, A. H. Stewart, J. C. Ellerbe, H. C. Applequist, W. F. Deans, E. H. Sheridan, H. G. Connely, D. E. Sturner, H. W. Healy, W. J. Leary, G. E. Johanson.

PATHFINDER: [Laid up in Pasig River, Manila, P. I.]

Washington Office: Chief, Division of H. & T., G. T. Rude; Ass't Chief, R. H. Lukens; Chief, Section Vessels and Equipment, P. G. Engle; Chief, Coast Pilot, F. B. T. Siems; Chief, Section Field Work, F. S. Borden.

Other Officers attached to Division of H. & T. on duty in Washington Office during all or part of fiscal year: G. S. Reading, P. A. Smith, E. A. Daily, H. A. Cobton, F. A. Riddell.

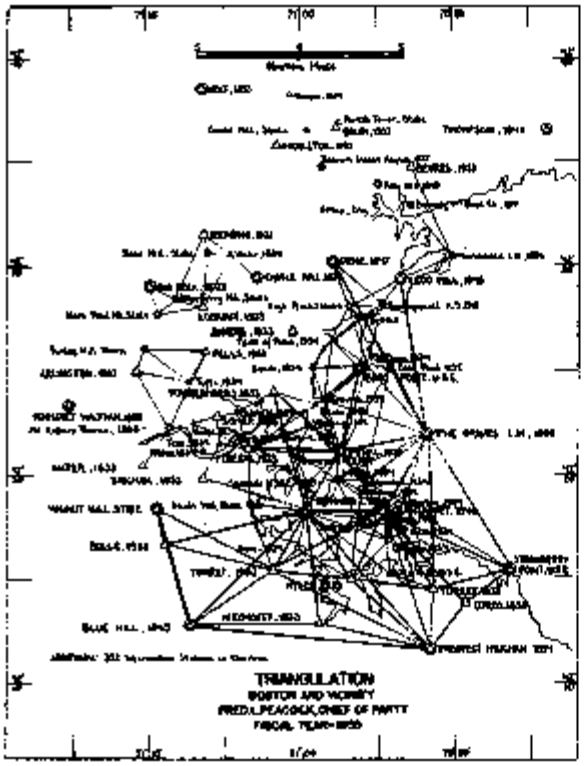
= Air Photo Topography.

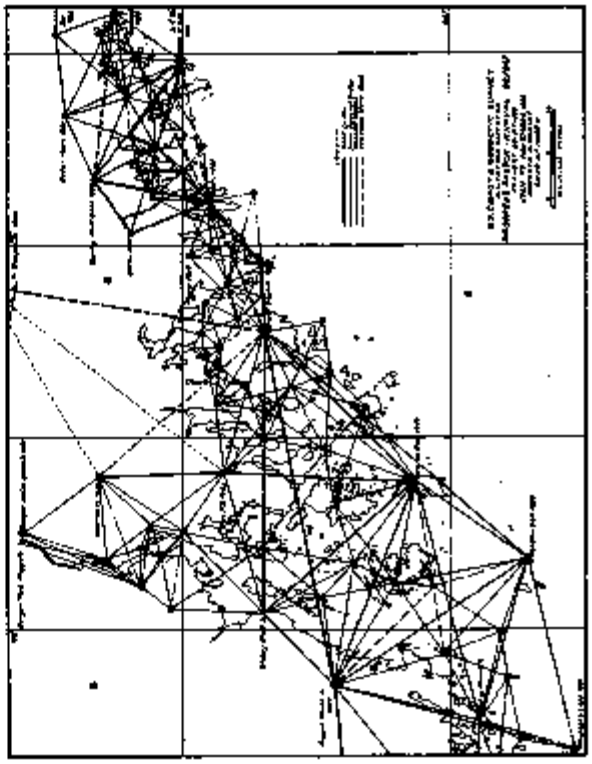
* Personnel conducting operations, including Commissioned Officers, Desk Officers, Chief Marine Engineers, Surgeons, Mates, Electrical Engineers.

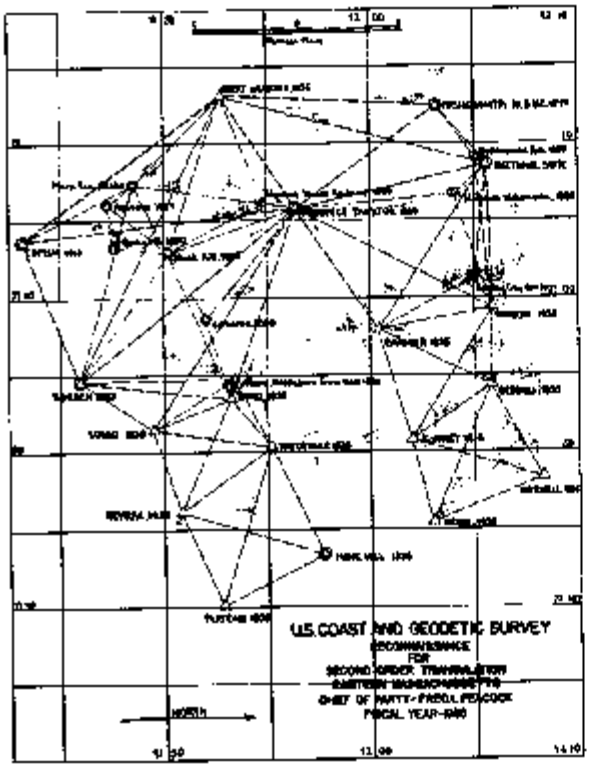
SUMMARY OF STATISTICS, DIVISION OF HYDROGRAPHY & TOPOGRAPHY - FISCAL YEARS 1929 to 1935 INCLUSIVE.

Year	Hydrography Miles	Hydrography Soundings	Topography Miles	Topography Area	Triangulation Miles	Triangulation Area	Triangulation Positions
1929	74,481	846,517	1,726	1,862	878	5,165	891
1930	71,433	780,049	2,275	1,915	863	5,651	1,164
1931	75,696	782,044	2,472	1,785	812	5,197	1,207
1932	72,185	767,322	1,969	1,051	303	3,330	1,523
1933	103,314	1,187,027	4,467	2,536	2,476	13,858	5,666
1934	110,615	2,520,126	14,577	7,725	1,969	14,352	3,375
1935	138,382	3,523,749	20,350	11,089	2,574	16,409	7,080

Regular appropriations supplemented by Emergency Construction and Public Works Funds during the years 1933, 1934 and 1935.


TRIANGULATION
BOSTON AND VICINITY
FRED'K PEACOCK, CHIEF OF PARTY
FISCAL YEAR-1850

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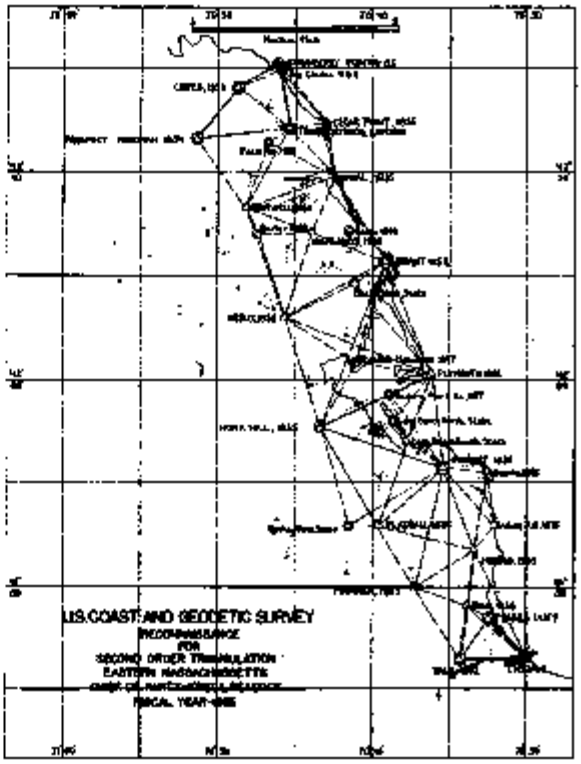
CHIEF OF PARTY-FRED'K PEACOCK
FISCAL YEAR-1880
NORTH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RECONNAISSANCE
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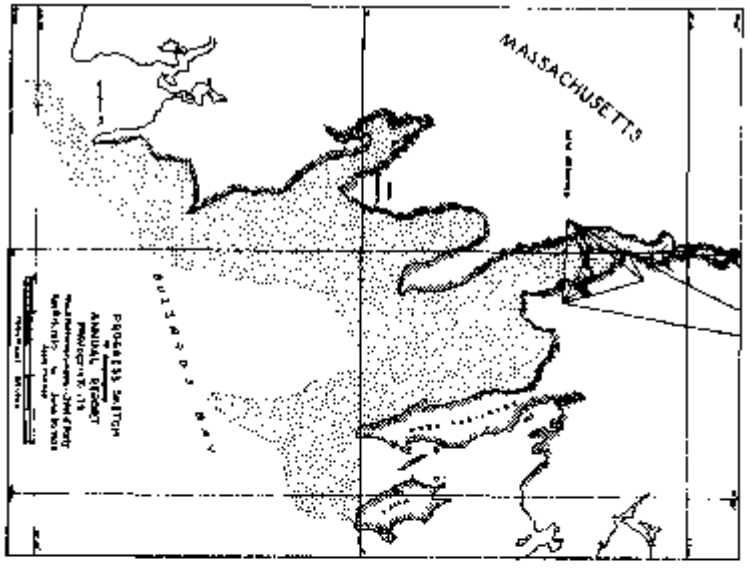
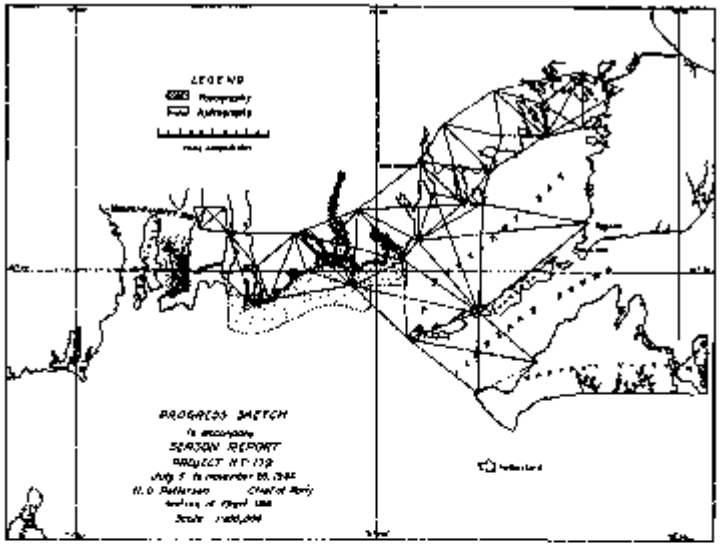
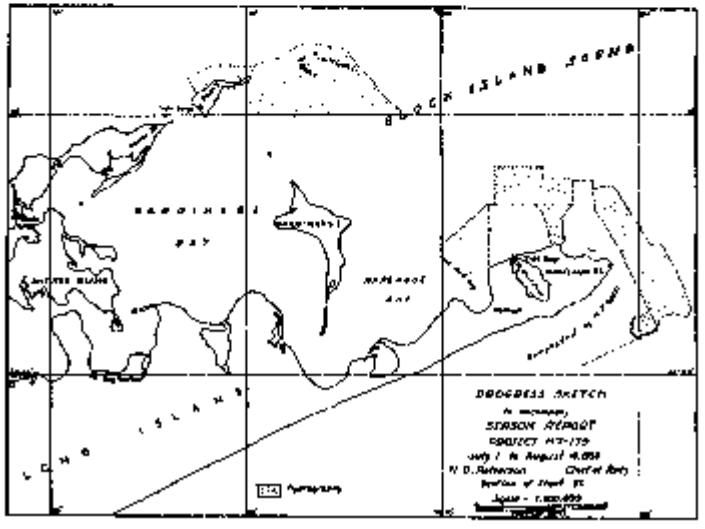
EASTERN MASSACHUSETTS


MASSACHUSETTS
BUZZARDS BAY
PROGRESS SKETCH
to accompany
ANNUAL REPORT


LEGEND
PROGRESS SKETCH
to accompany
SEASON REPORT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NARRAGANSETT BAY
LONG ISLAND
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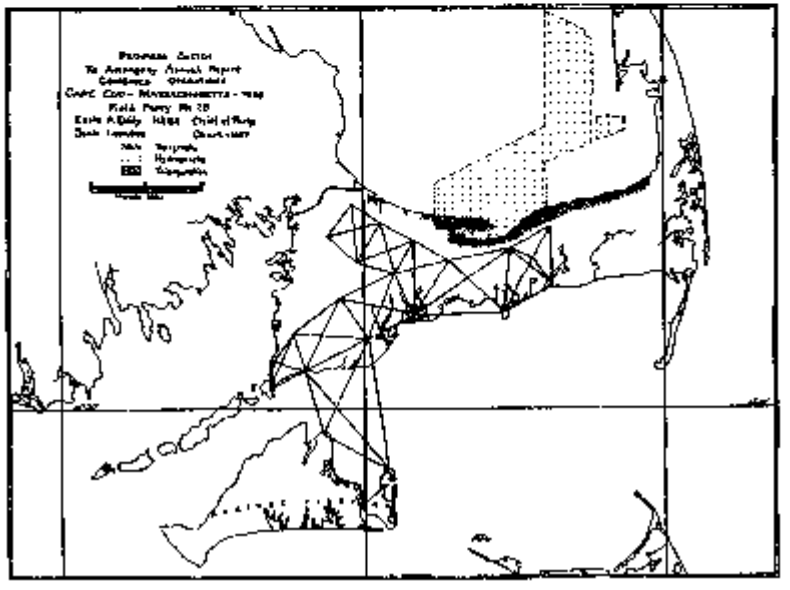
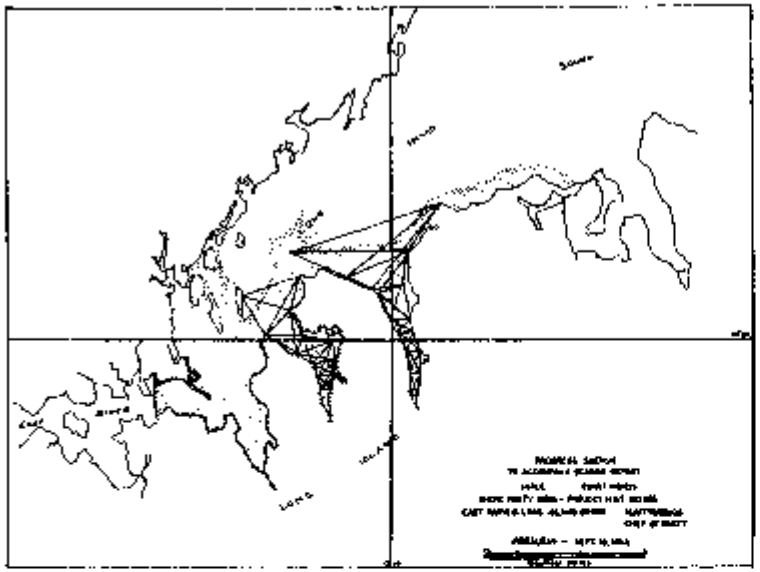
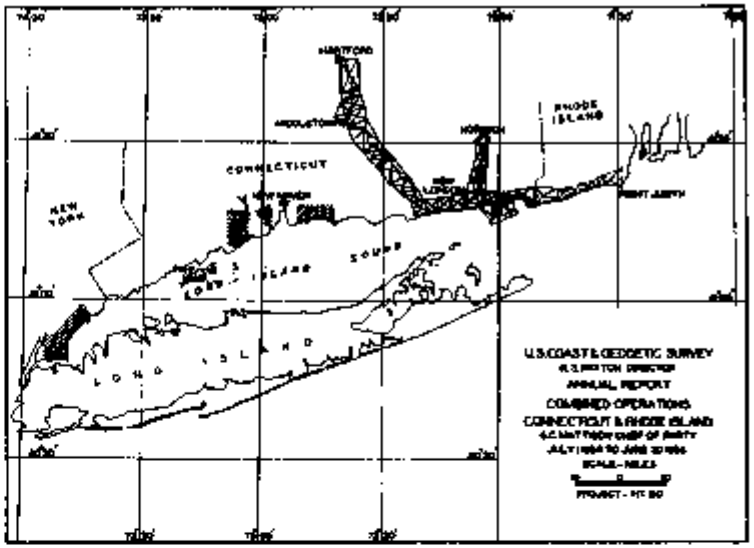
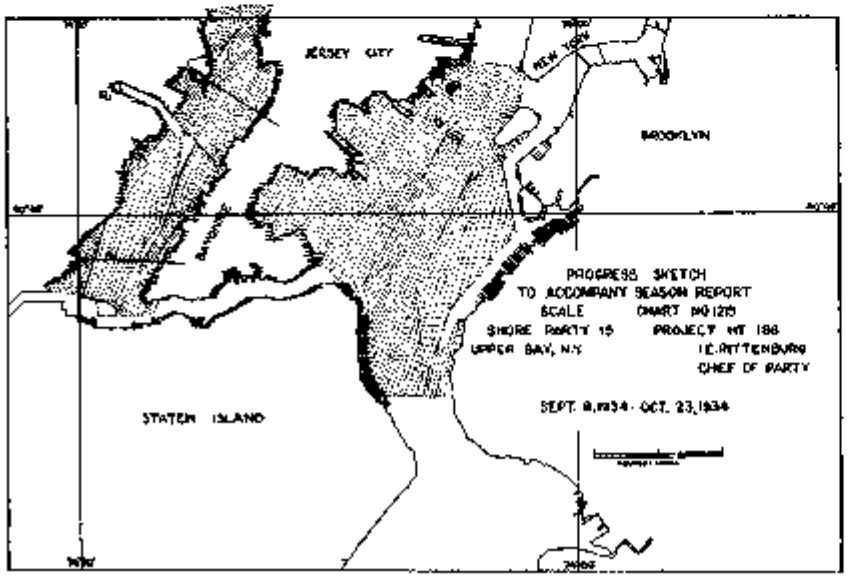
SEASON REPORT






HARTFORD
RHODE ISLAND
CONNECTICUT
NEW YORK
LONG ISLAND SOUND
LONG ISLAND
U.S. COAST & GEODETIC SURVEY
ANNUAL REPORT
COMBINED OPERATIONS
CONNECTICUT & RHODE ISLAND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NEW YORK
BROOKLYN
STATEN ISLAND
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TO ACCOMPANY SEASON REPORT
SCALE
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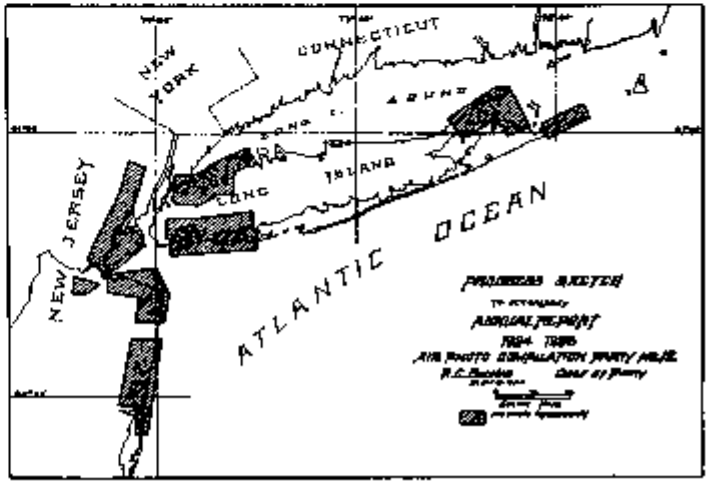
SHORE PARTY 15
PROJECT NT 188
UPPER BAY, N.Y.
CHIEF OF PARTY
SEPT. 8, 1934 - OCT. 23, 1934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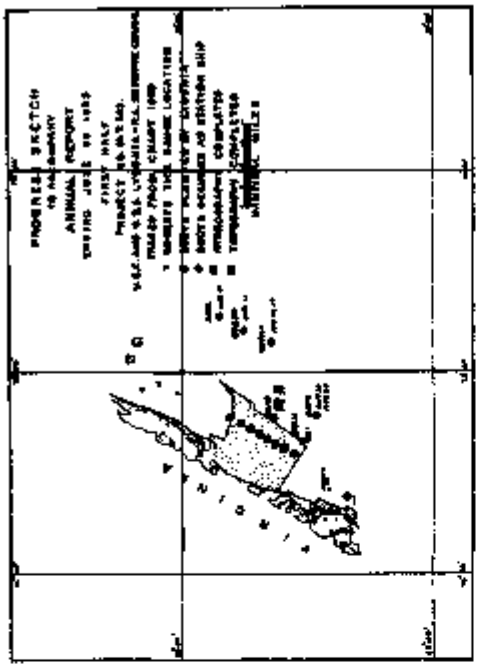
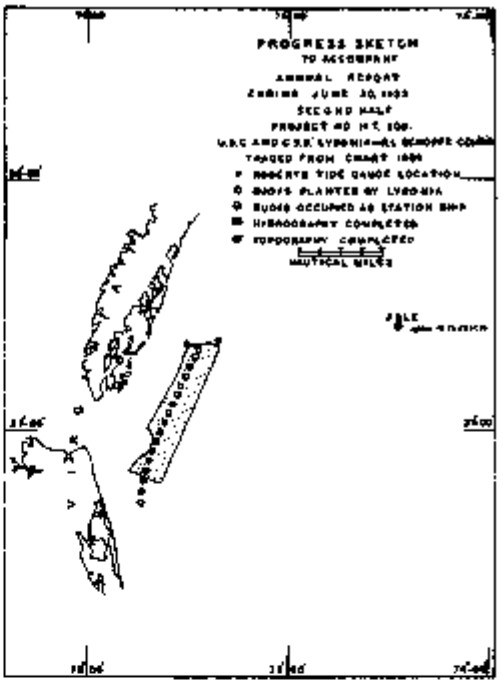
LONG ISLAND
ATLANTIC OCEAN
ANNUAL REPORT

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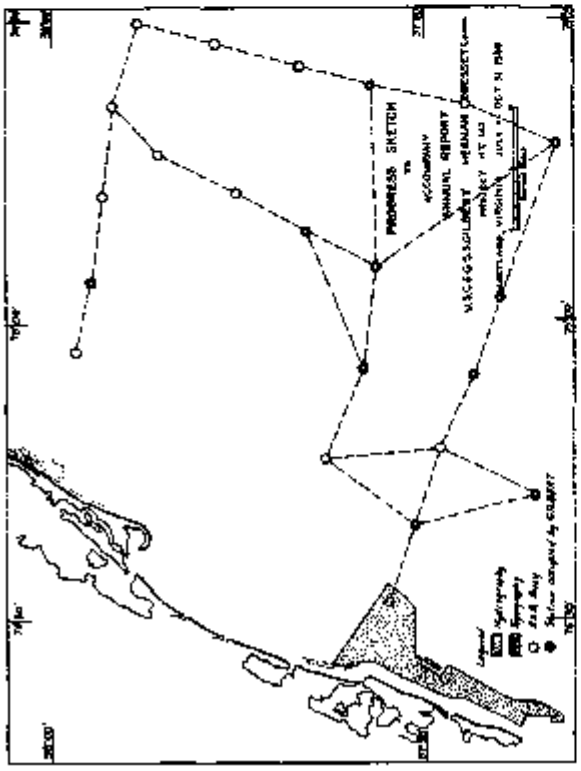

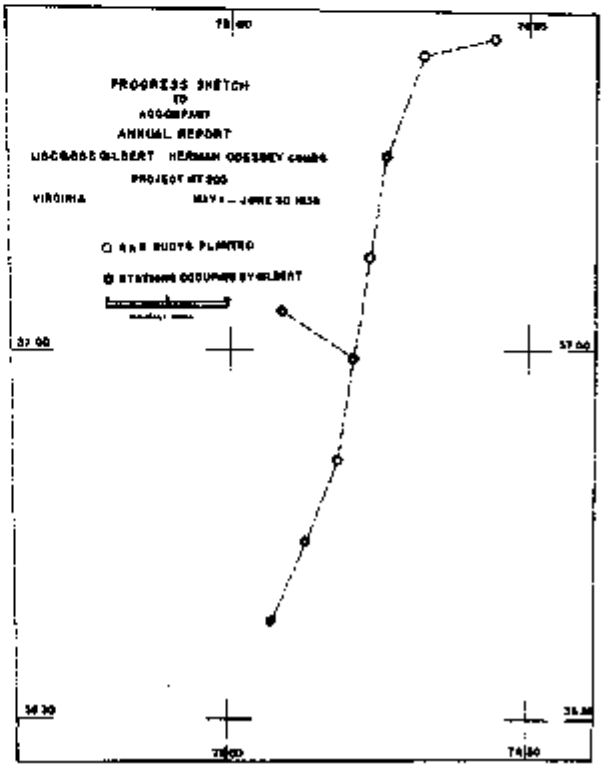
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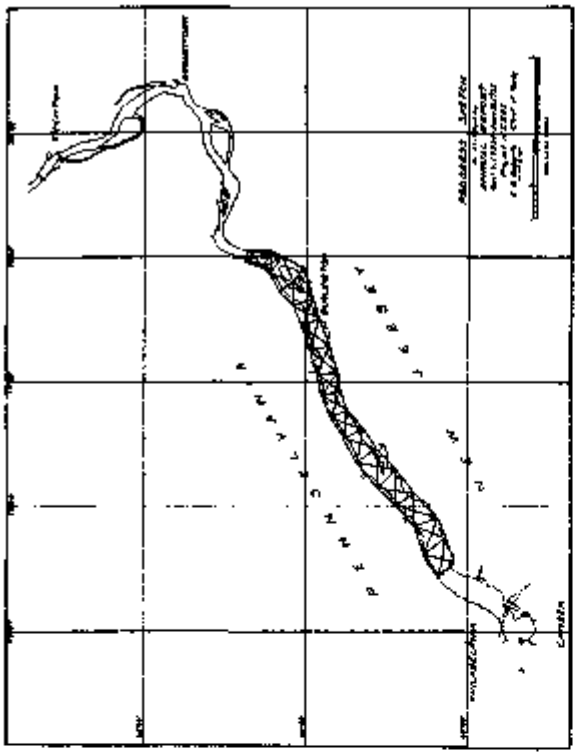
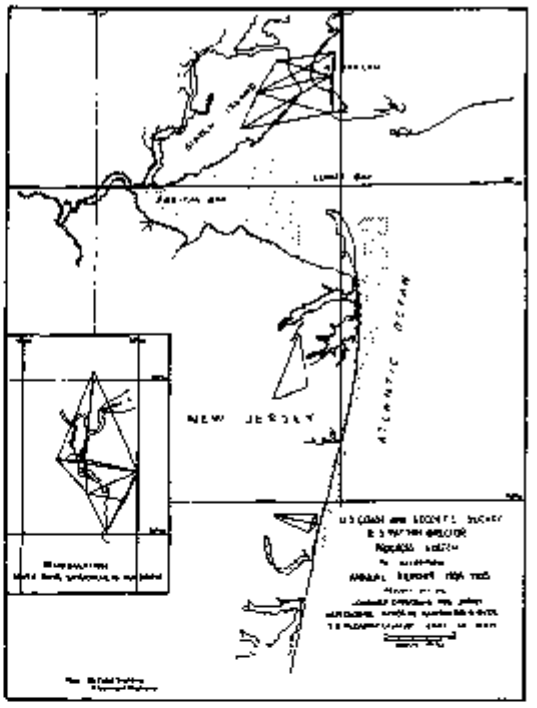
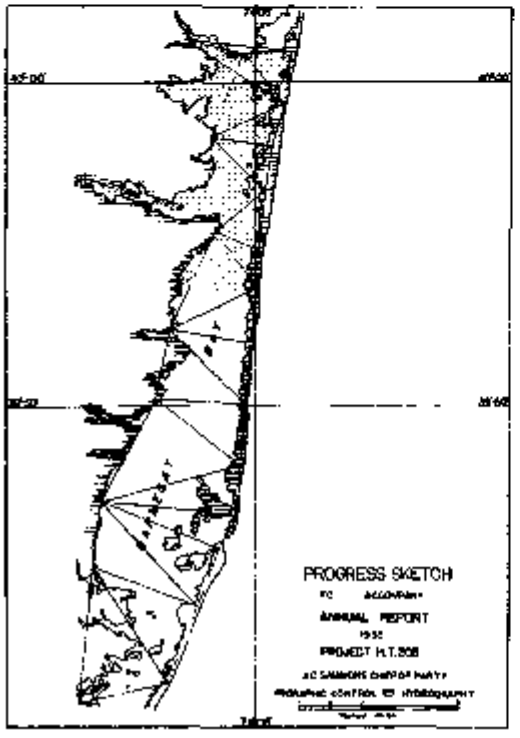
TO
ACCOMPANY
ANNUAL REPORT
VIRGINIA




NEW JERSEY
ATLANTIC OCEAN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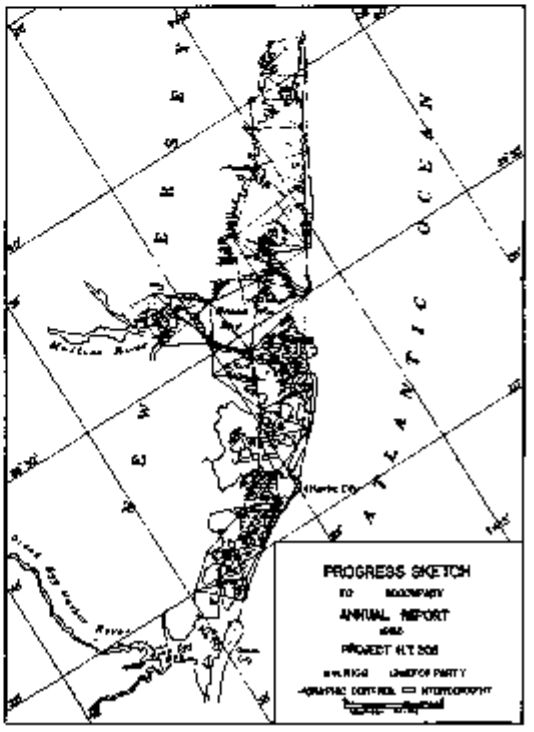
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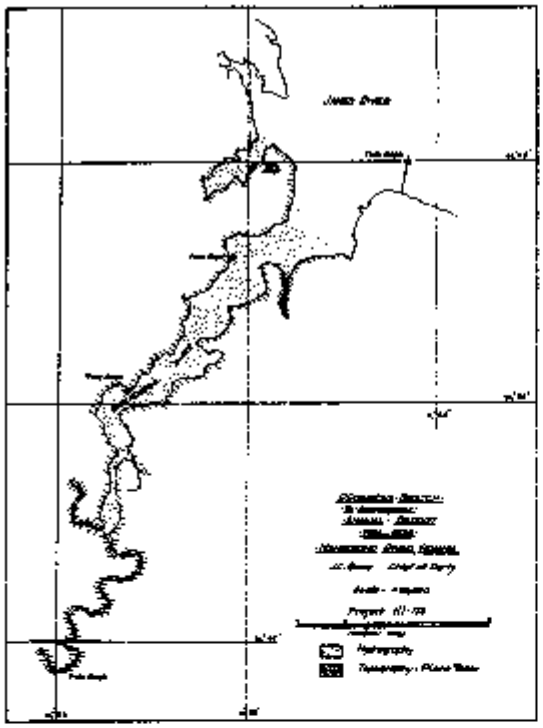

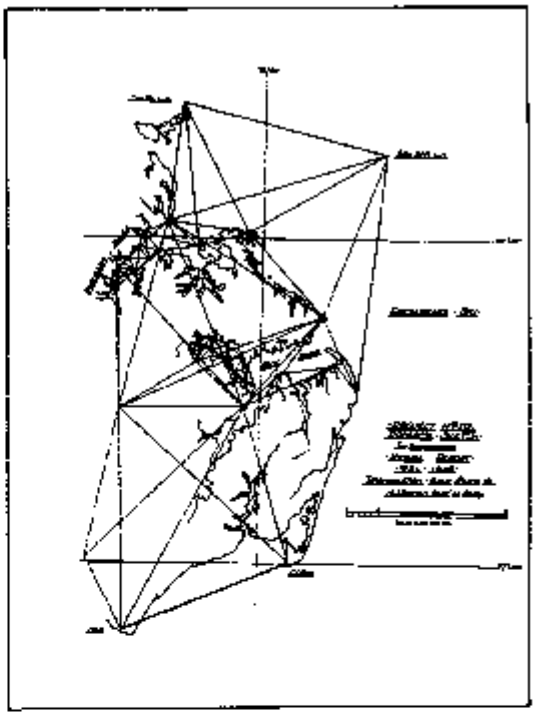

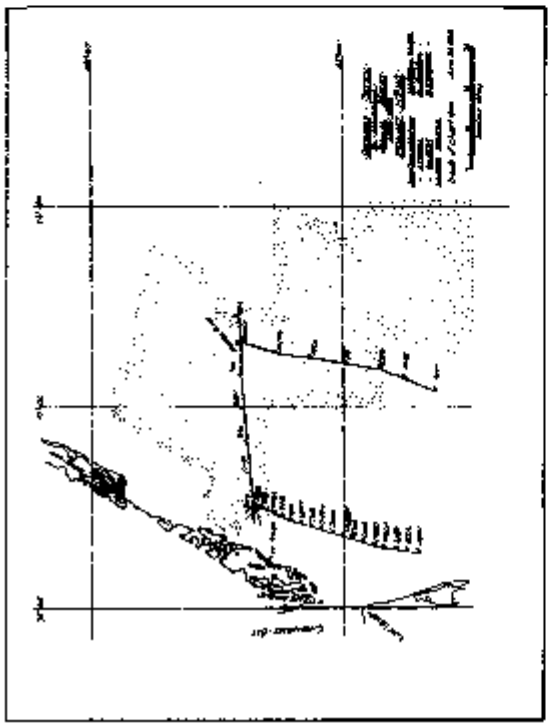

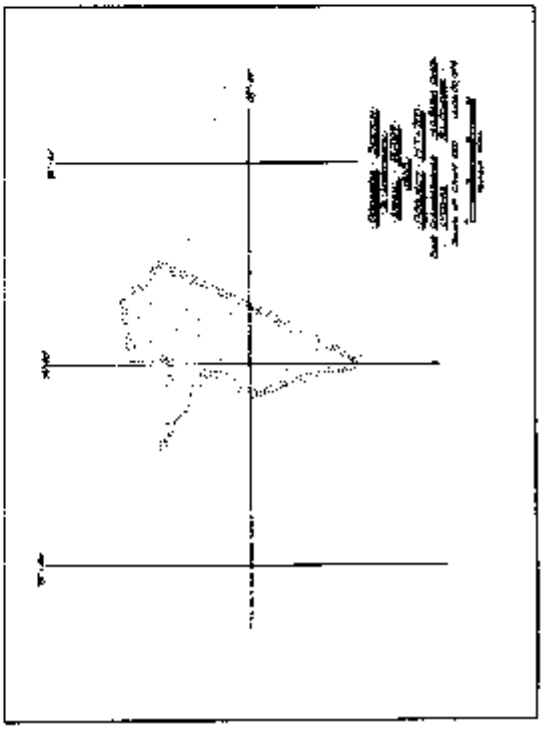

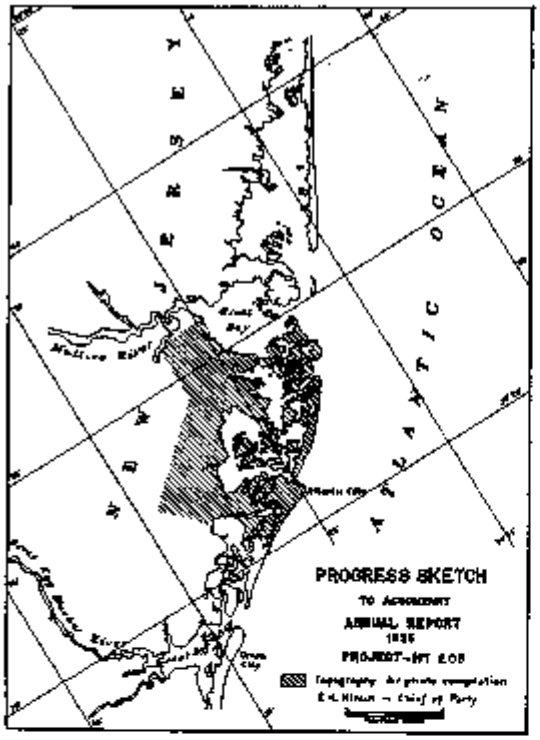
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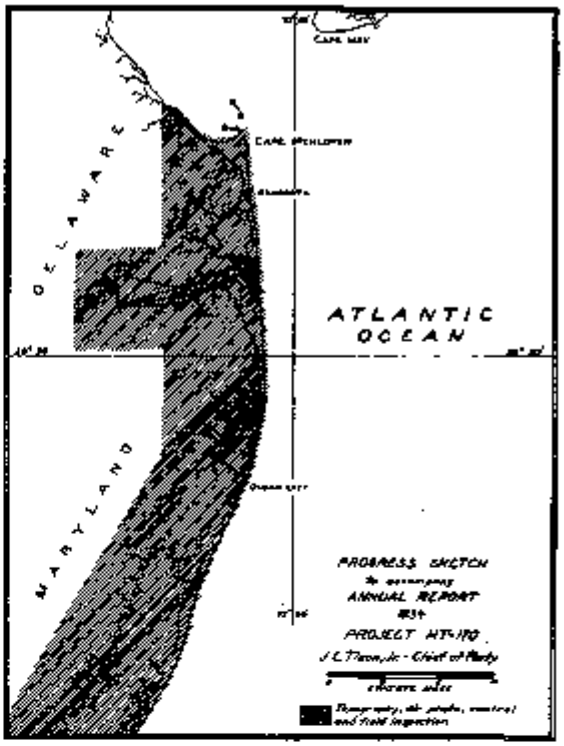
1936
PROJECT-HT 208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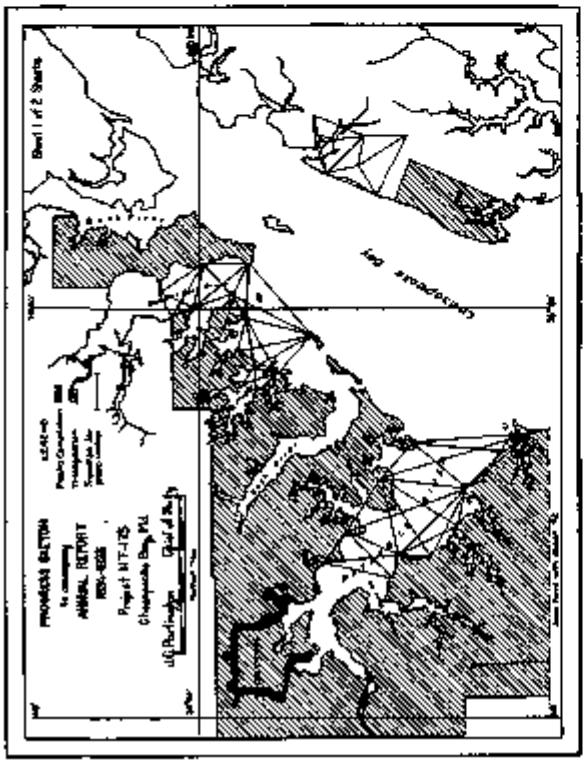
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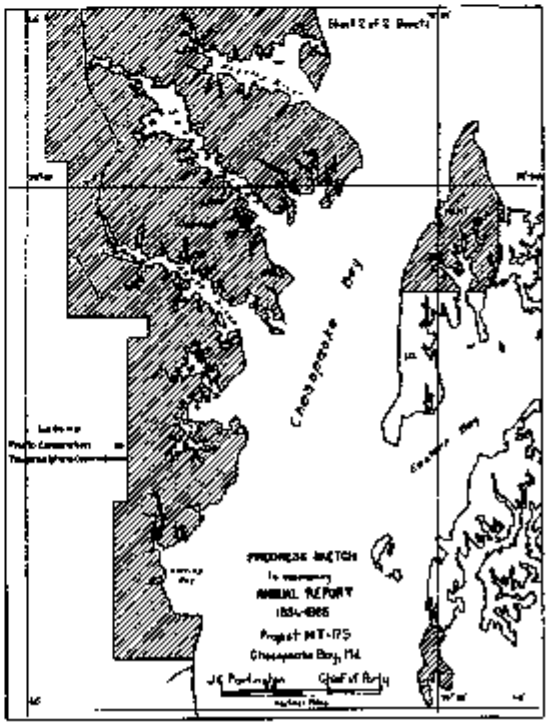
CHESAPEAKE BAY
PROGRESS SKETCH
ANNUAL REPORT
Project HT-175
Chesapeake Bay, Md.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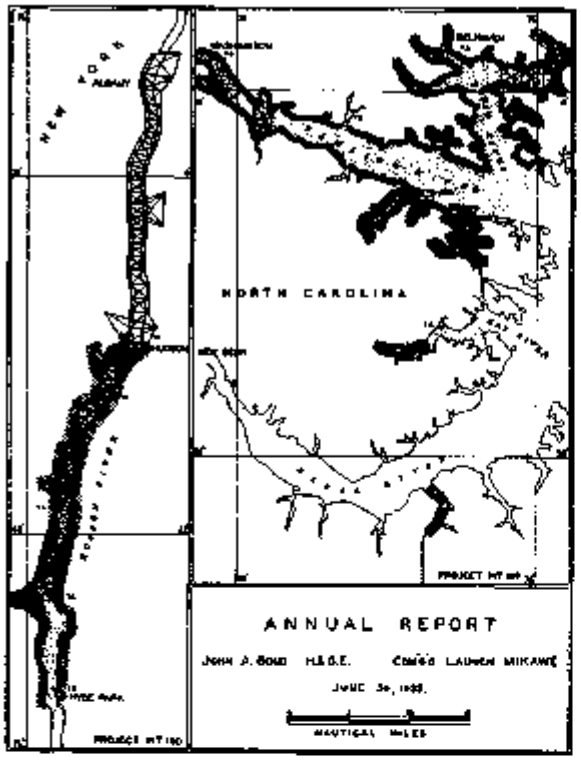
CHESAPEAKE BAY
PROGRESS SKETCH
ANNUAL REPORT
Project HT-175
Chesapeake Bay, Md.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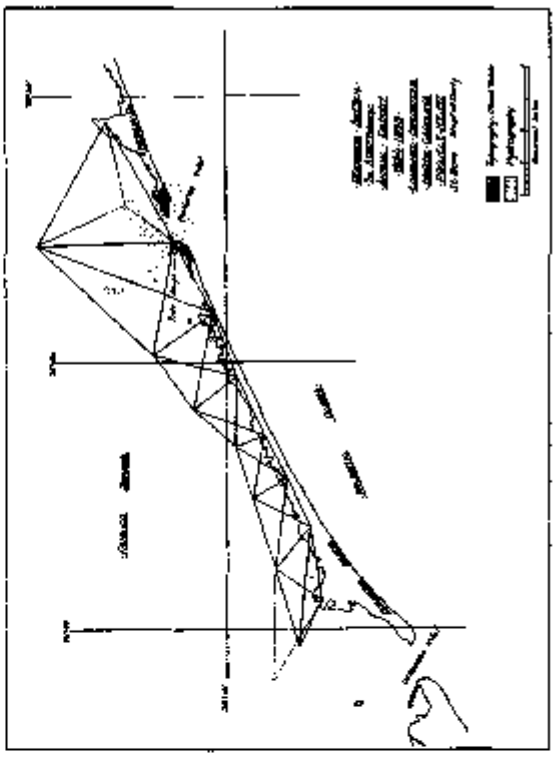
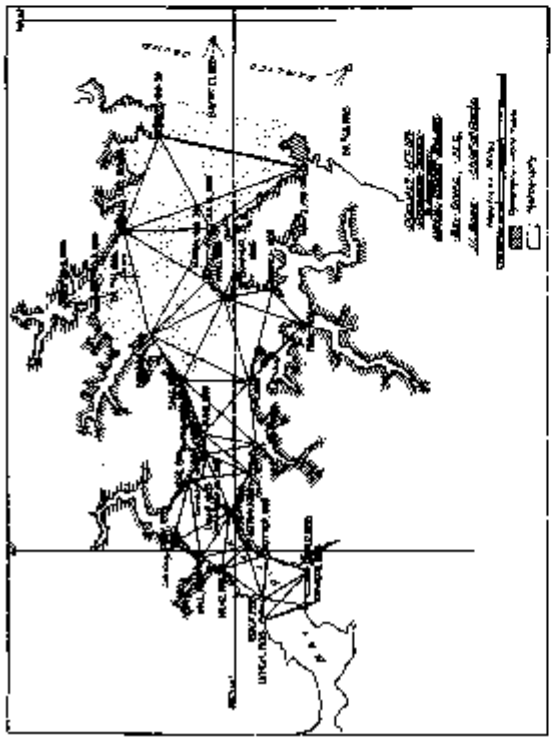
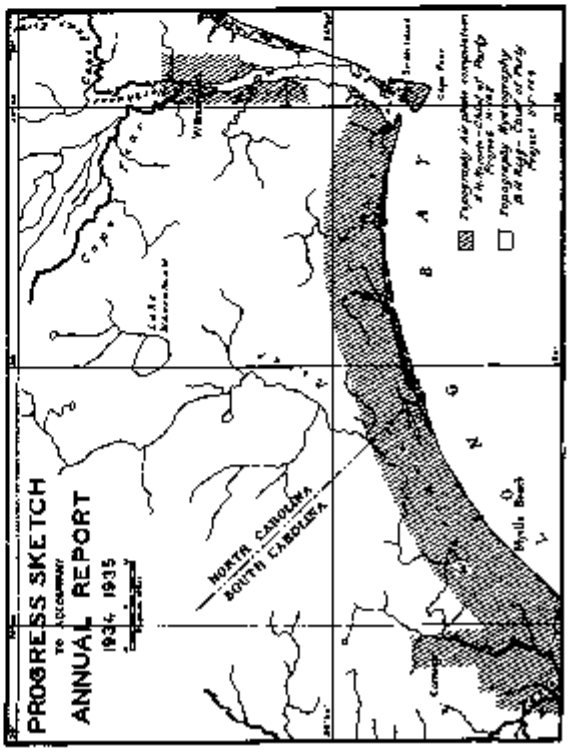
NORTH CAROLINA
ANNUAL REPORT
NAUTICAL MILES



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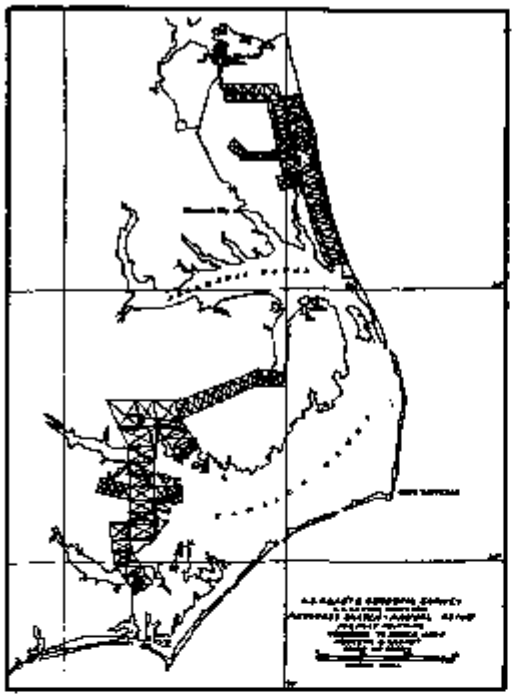
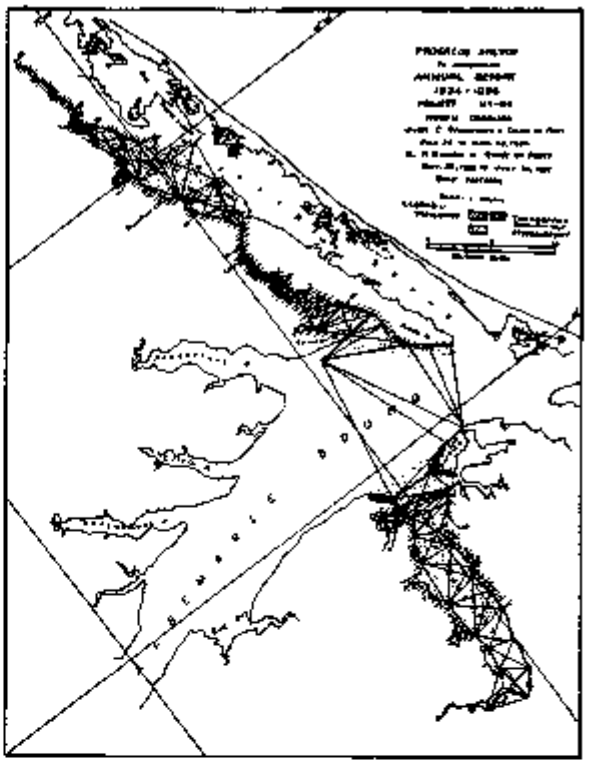
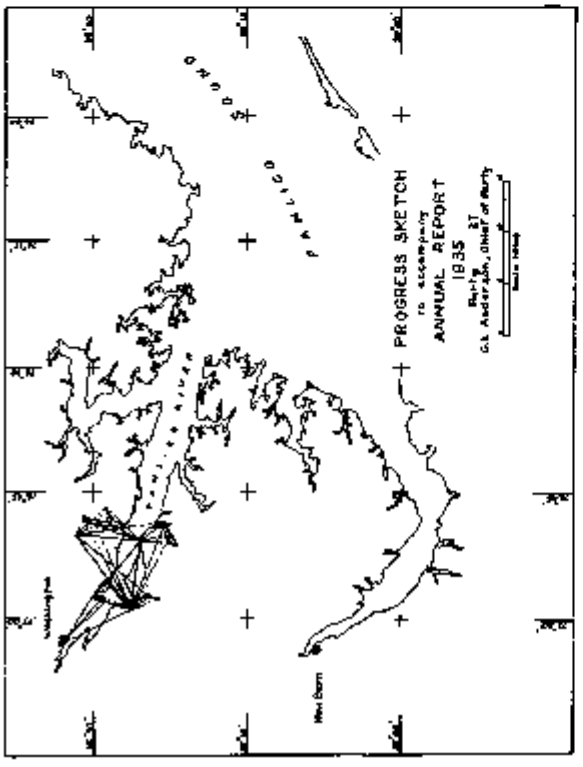
TO ACCOMPANY
ANNUAL REPORT
1934, 1935
NORTH CAROLINA
SOUTH CAROLINA
BAY



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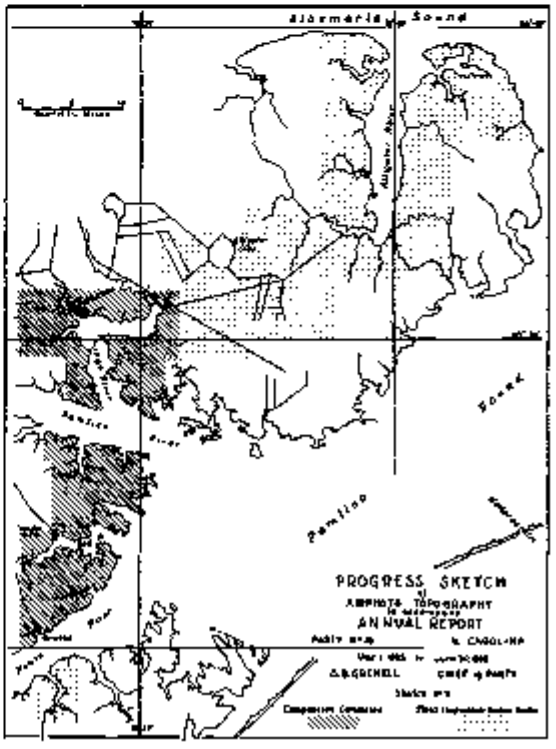
to accompany
ANNUAL REPORT
1835
By Lt.
G.S. Anderson, Chief of Party


Albemarle Sound
PROGRESS SKETCH
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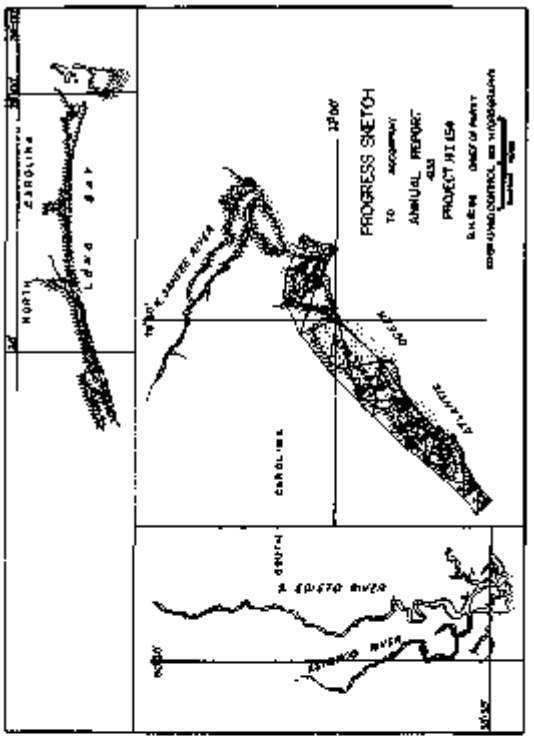
AIRPHOTO TOPOGRAPHY
to accompany
ANNUAL REPORT
N. CAROLINA
A.B. GRENELL
CHIEF of PARTY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TO ACCOMPANY
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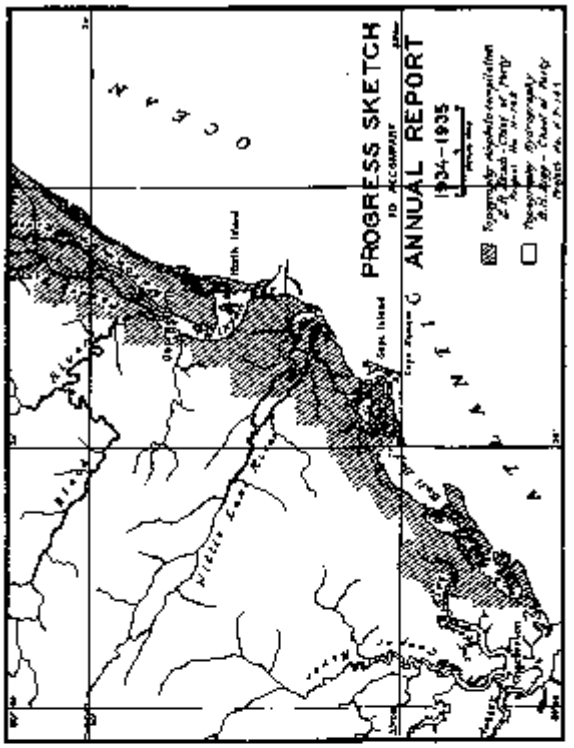
PROJECT H.T.S.
NORTH CAROLINA
SOUTH CAROLINA
ATLANTIC OCEAN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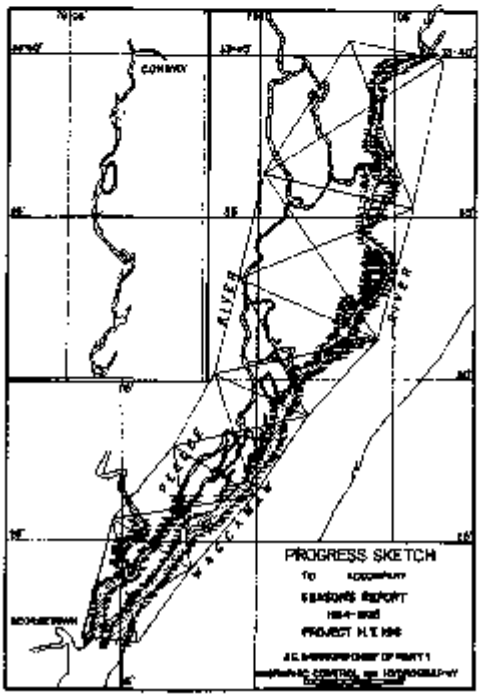
ANNUAL REPORT
1934-1935
North Island
Cape Romain
ATLANTIC OCEAN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MORRISTOWN
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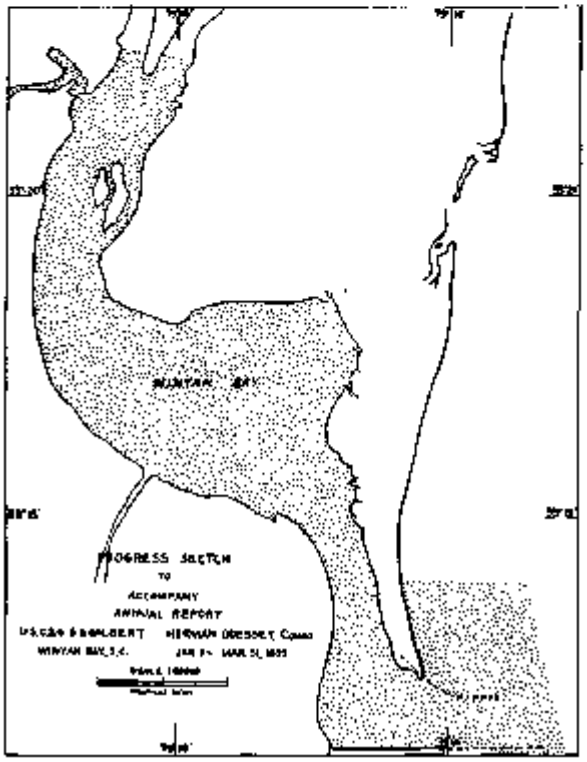
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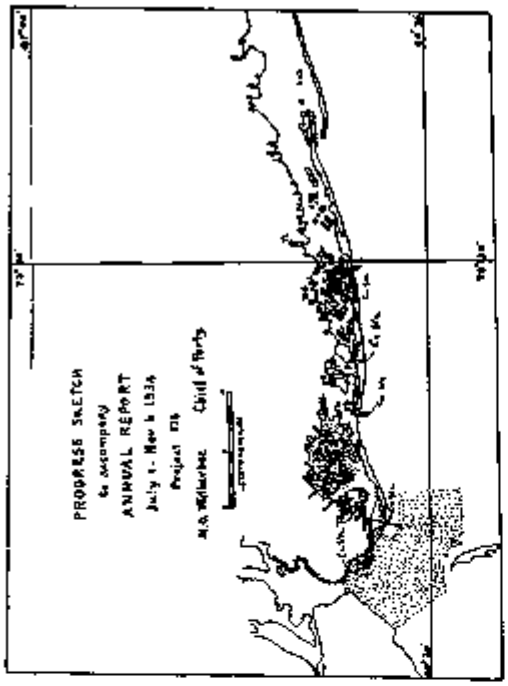
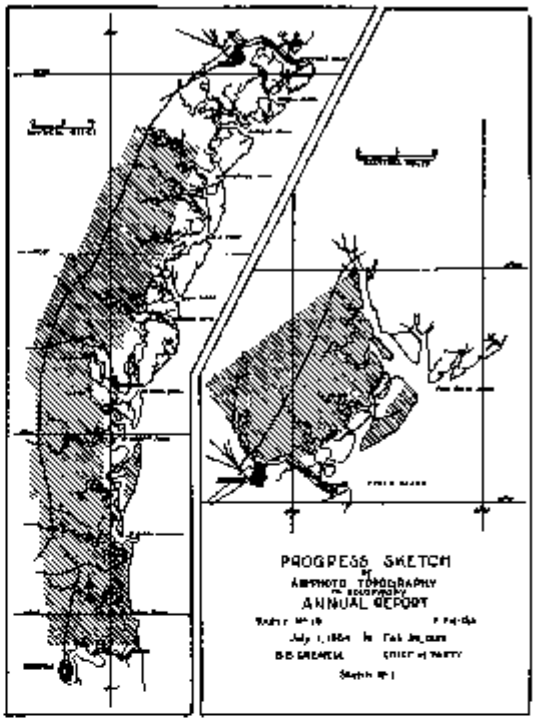
TO
ACCOMPANY
ANNUAL REPORT
WINYAH BAY


PROGRESS SKETCH
to accompany
ANNUAL REPORT


PROGRESS SKETCH
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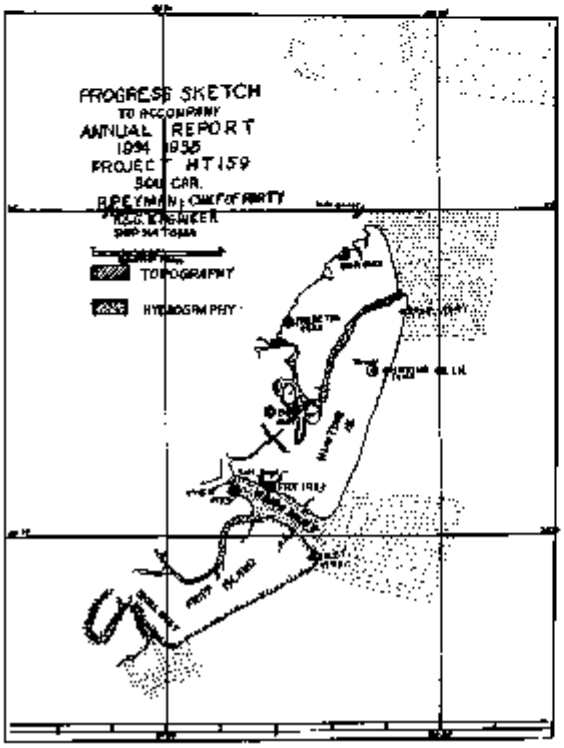
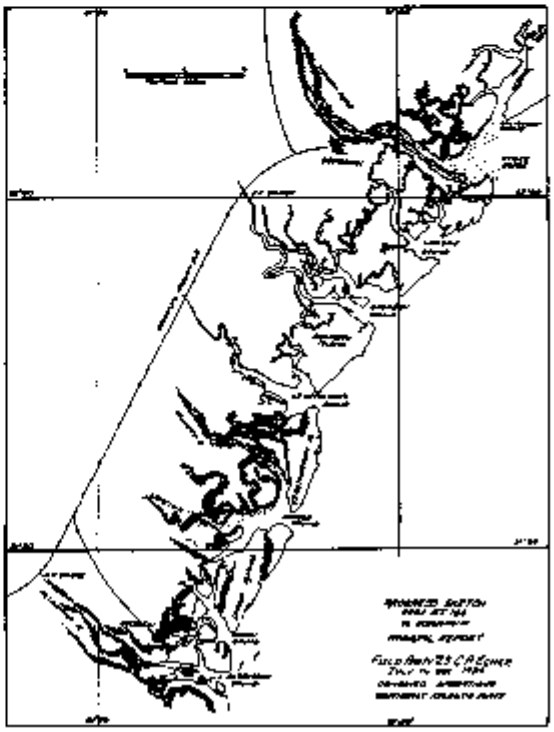
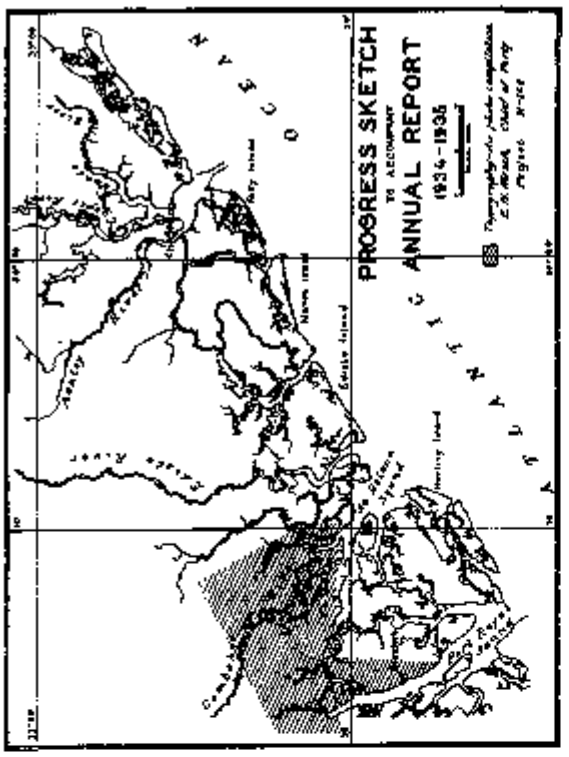

PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT
1934 1935
PROJECT HT159
TOPOGRAPHY
HYDROGRAPHY

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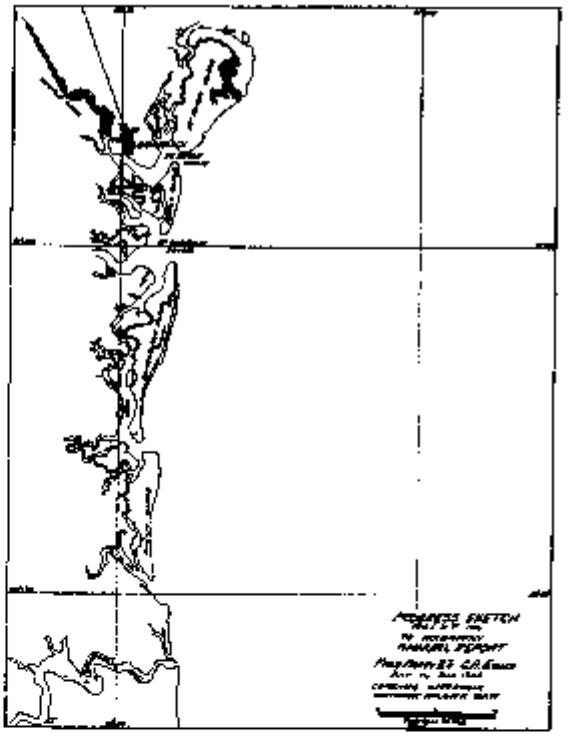
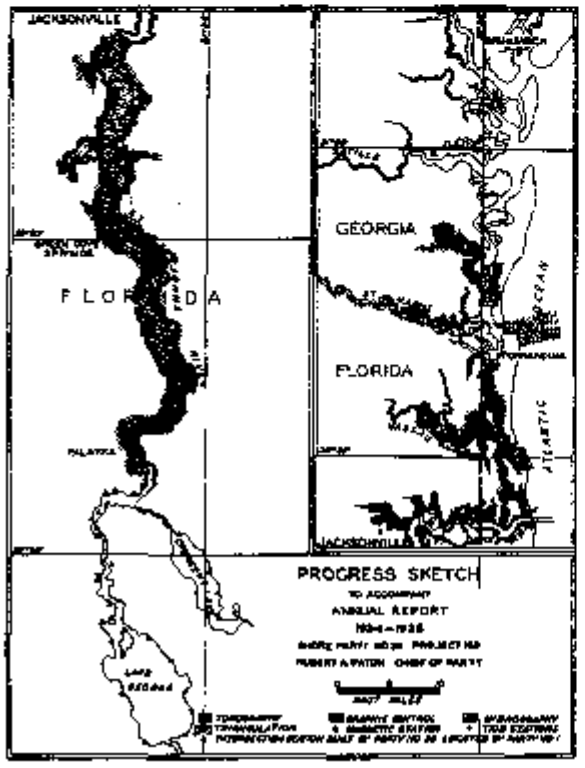
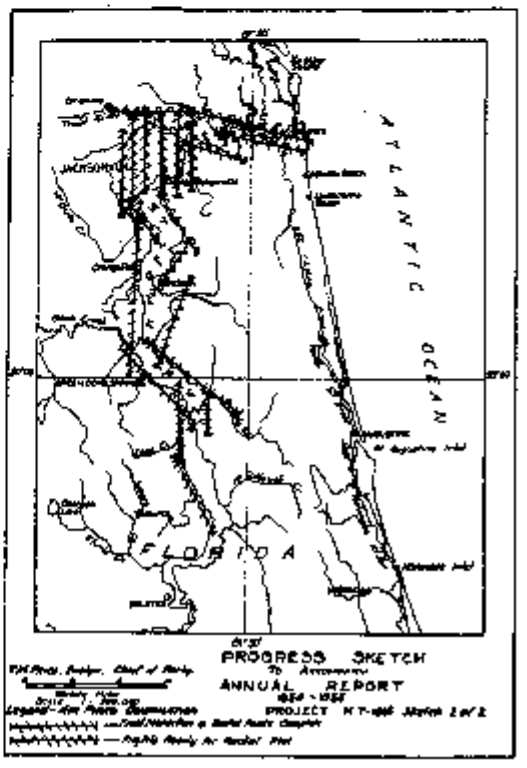
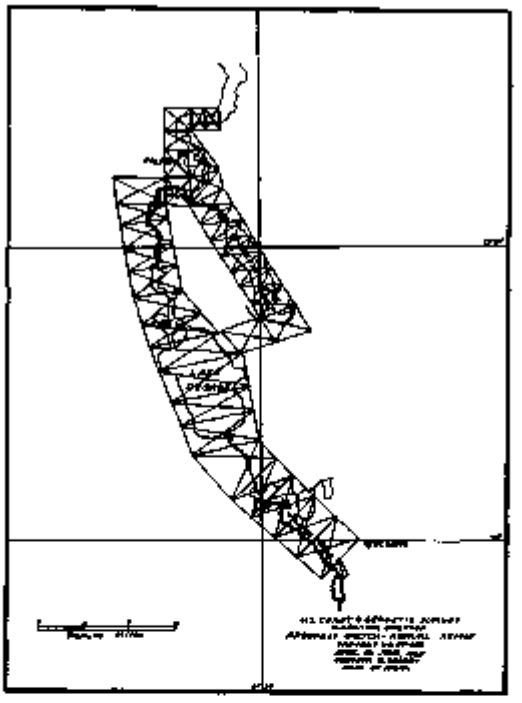
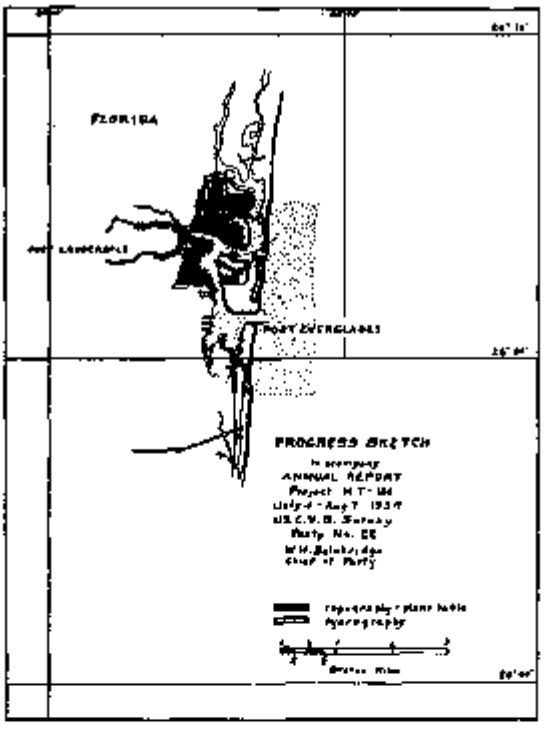
TO ACCOMPANY
ANNUAL REPORT
1934-1935




JACKSONVILLE
GEORGIA
FLORIDA
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT
1934-1935


ATLANTIC OCEAN
FLORIDA
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT

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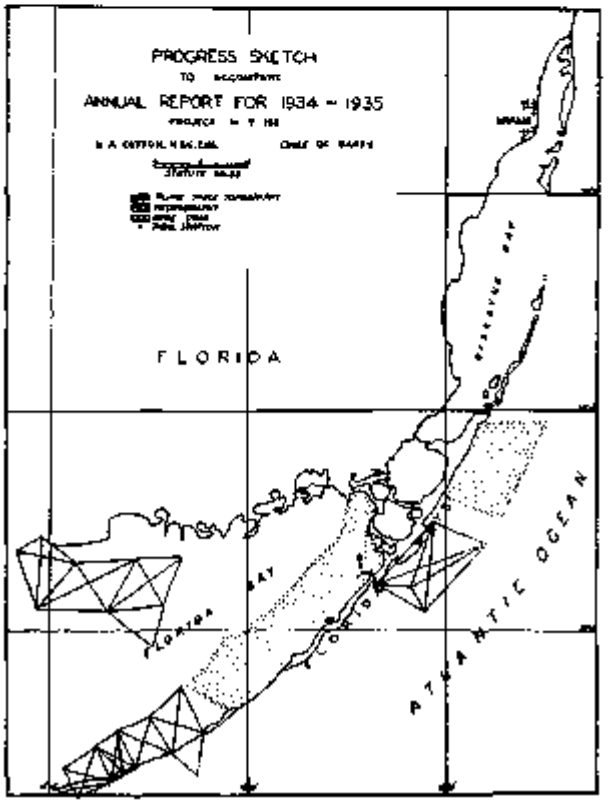
PROGRESS SKETCH
ANNUAL REPORT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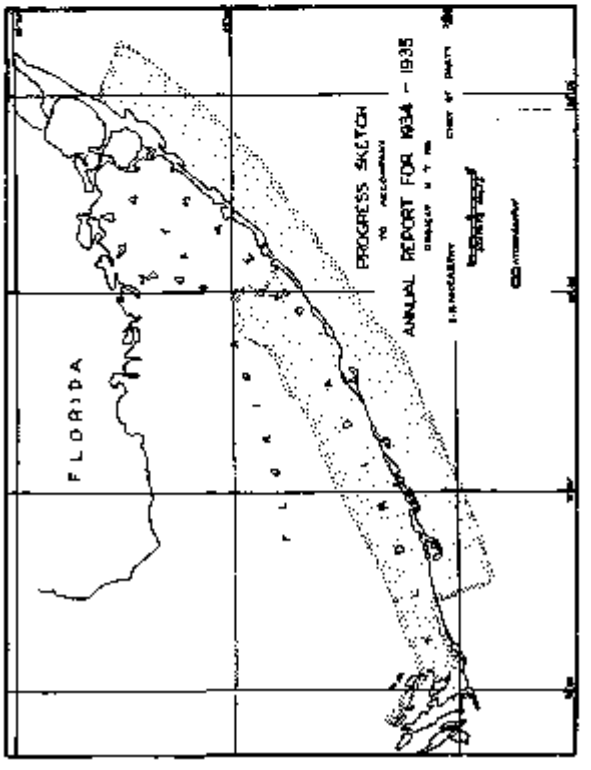
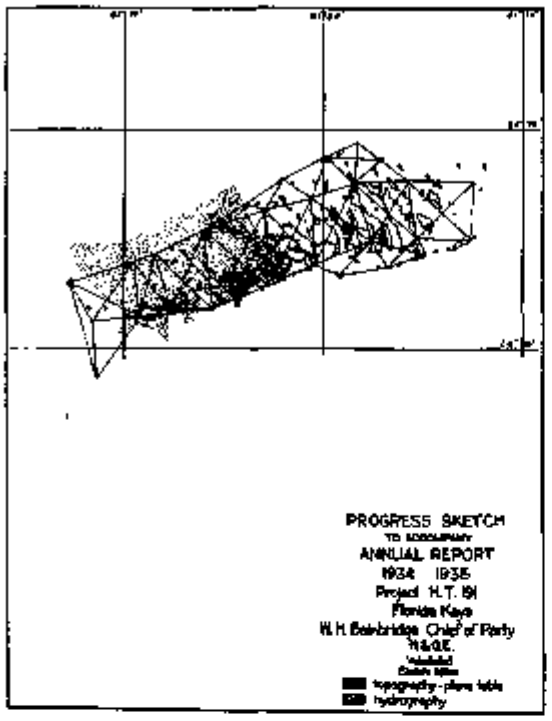
TO
ANNUAL REPORT FOR 1934 - 1935
FLORIDA
FLORIDA BAY
ATLANTIC OCEAN


PROGRESS SKETCH
TO
ANNUAL REPORT FOR 1934 - 1935
FLORIDA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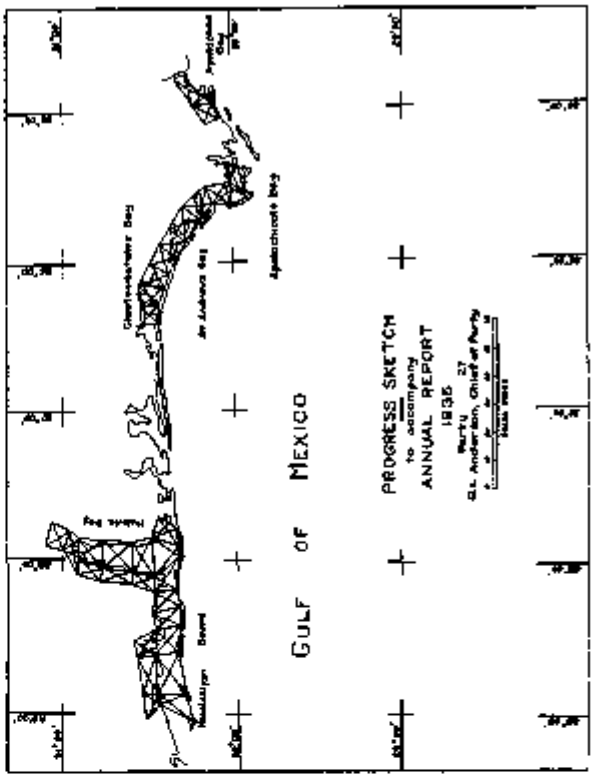
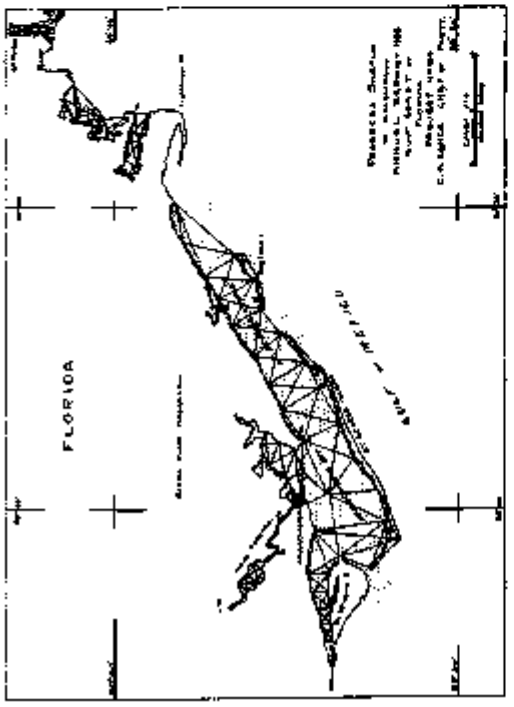
ANNUAL REPORT
1934 1935
Project H.T. 191
Florida Keys
W. H. Bainbridge Chief of Party
N.&O.E.
hydrography


GULF OF MEXICO
PROGRESS SKETCH
to accompany
ANNUAL REPORT
1935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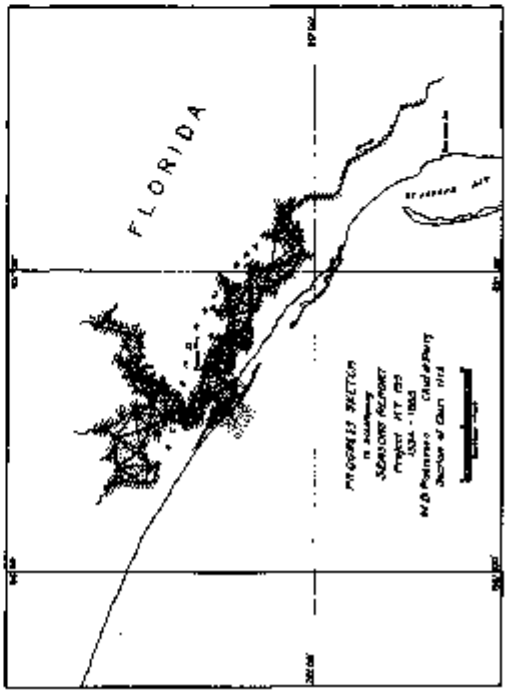
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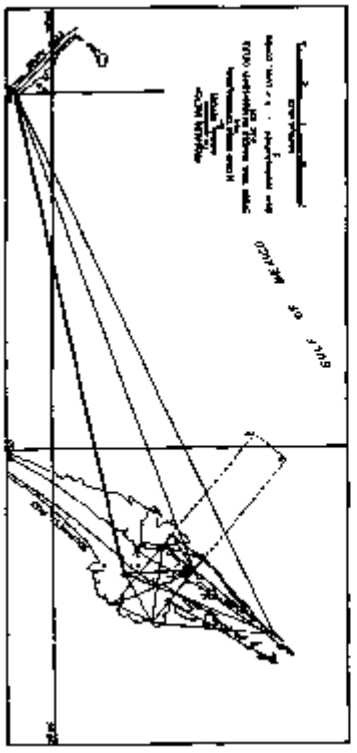

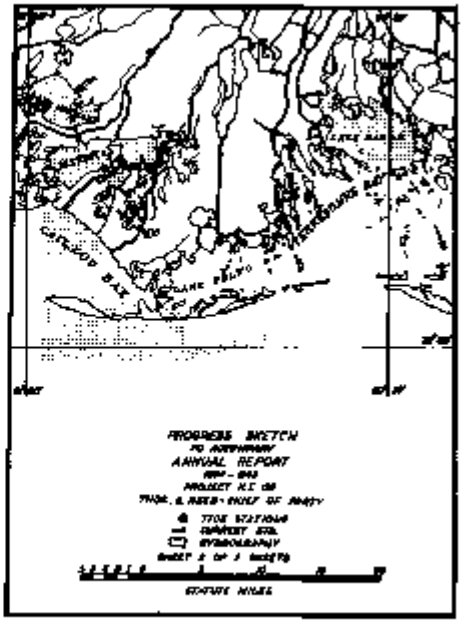
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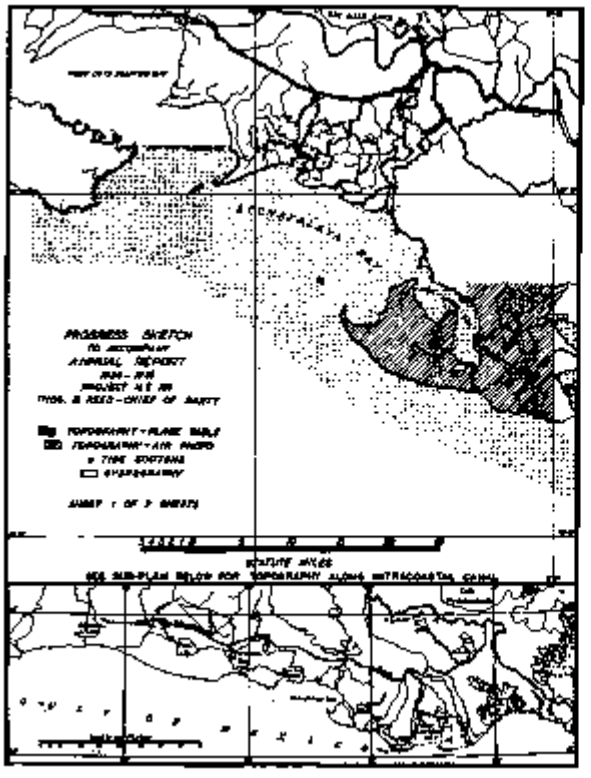
TO ACCOMPANY
ANNUAL REPORT
PROJECT H.E. 08
THOS. B. REES - CHIEF OF PARTY
TIDE STATIONS
TOPOGRAPHY
SHEET 2 OF 3 SHEETS
STATUTE MILES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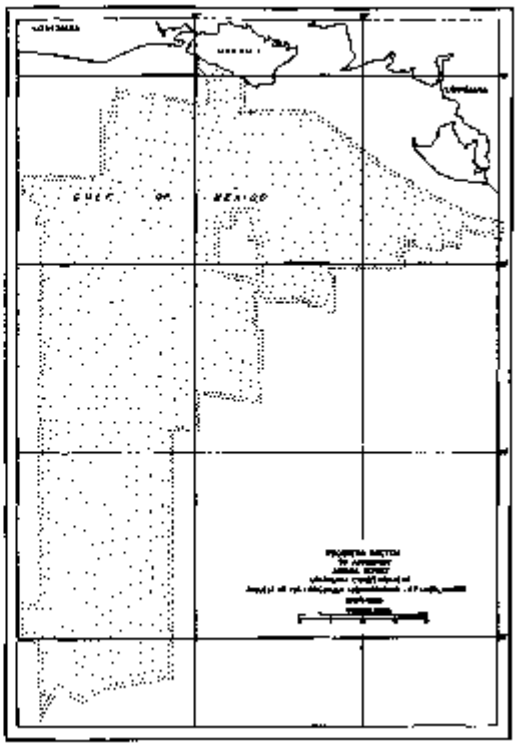
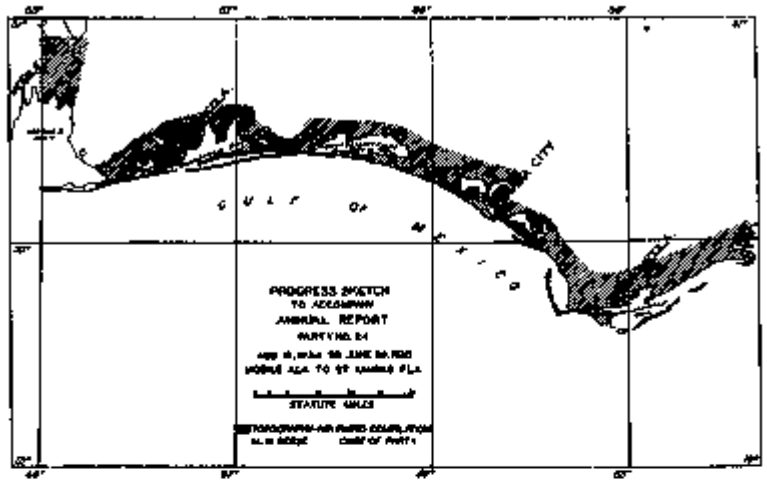
TO ACCOMPANY
ANNUAL REPORT
PROJECT H.E. 08
THOS. B. REES - CHIEF OF PARTY
TOPOGRAPHY - PLANE TABLE
TOPOGRAPHY - AIR PHOTO
TIDE STATIONS
TOPOGRAPHY
SHEET 1 OF 3 SHEETS
STATUTE MILES


GULF OF MEXICO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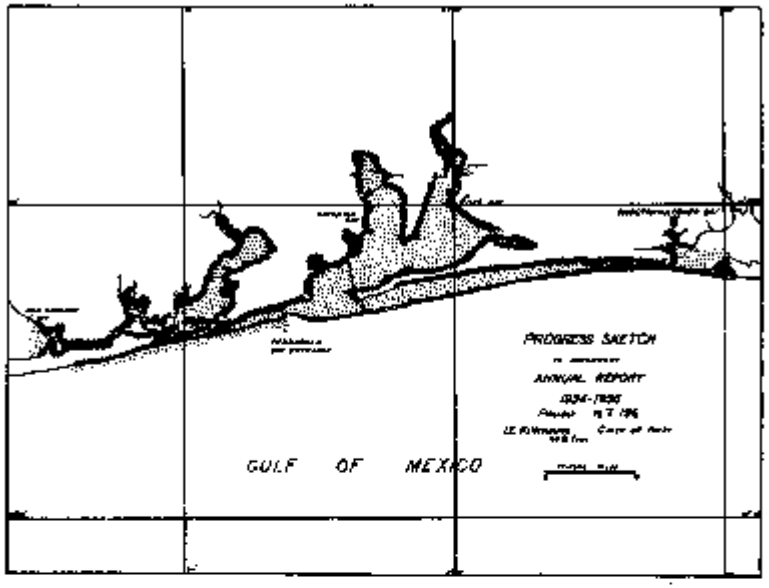
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT
STATUTE MILES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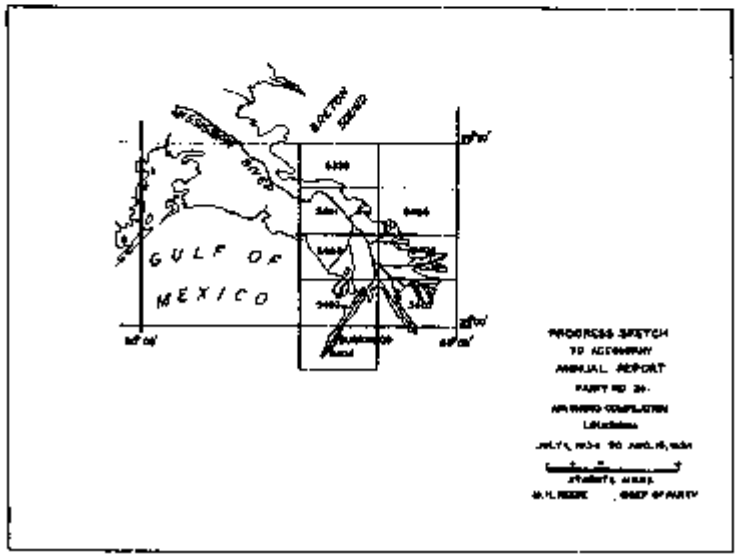
ANNUAL REPORT
GULF OF MEXICO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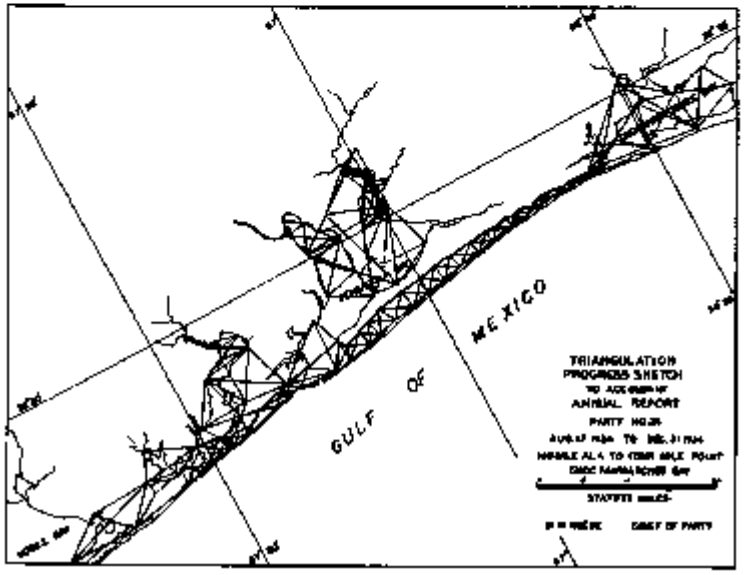
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT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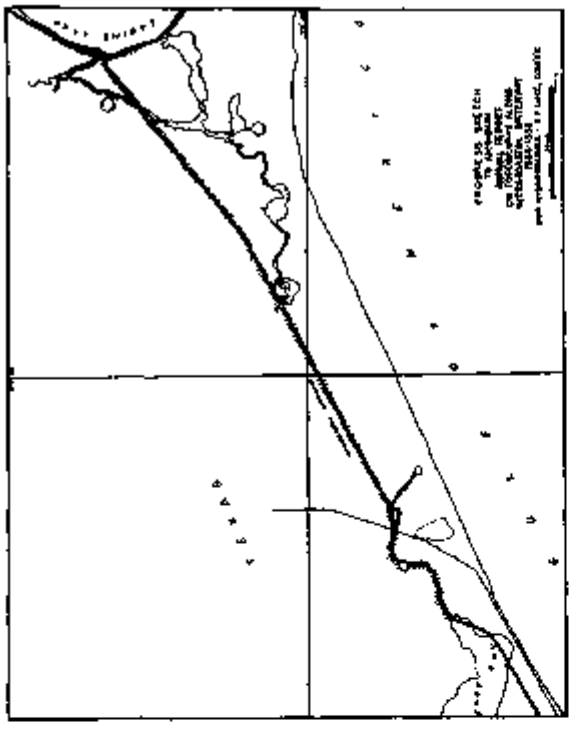
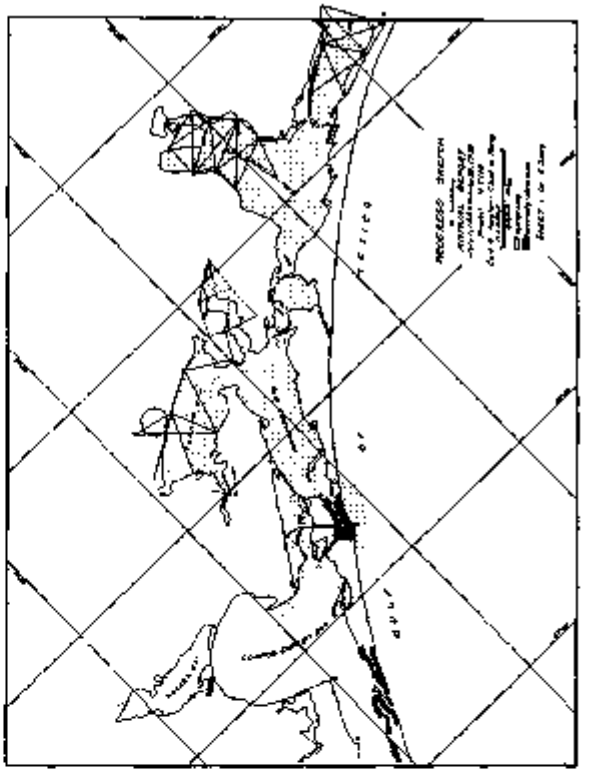
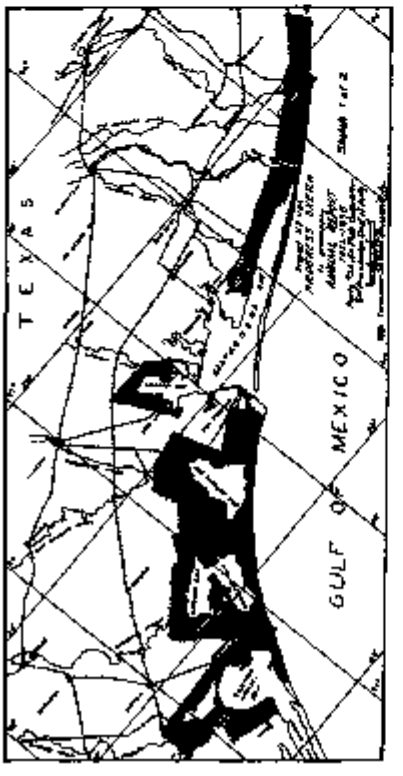
TRIANGULATION
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT
STATUTE MILES



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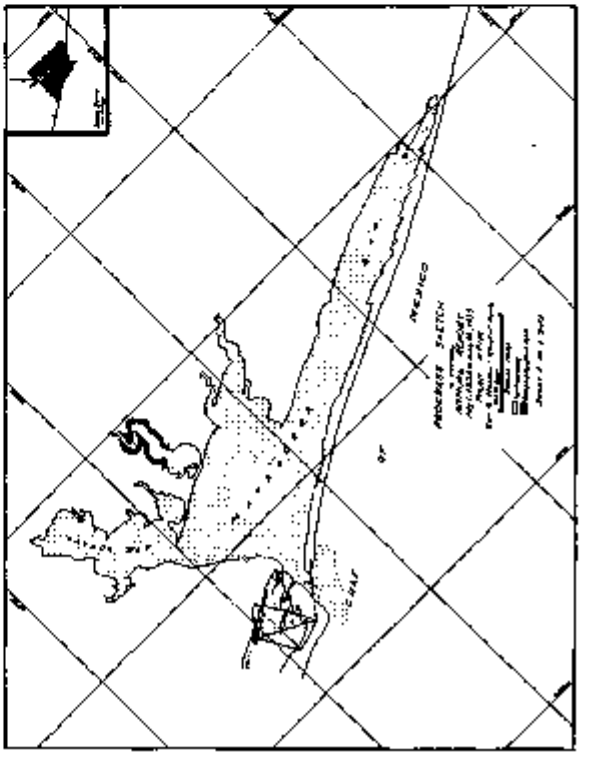
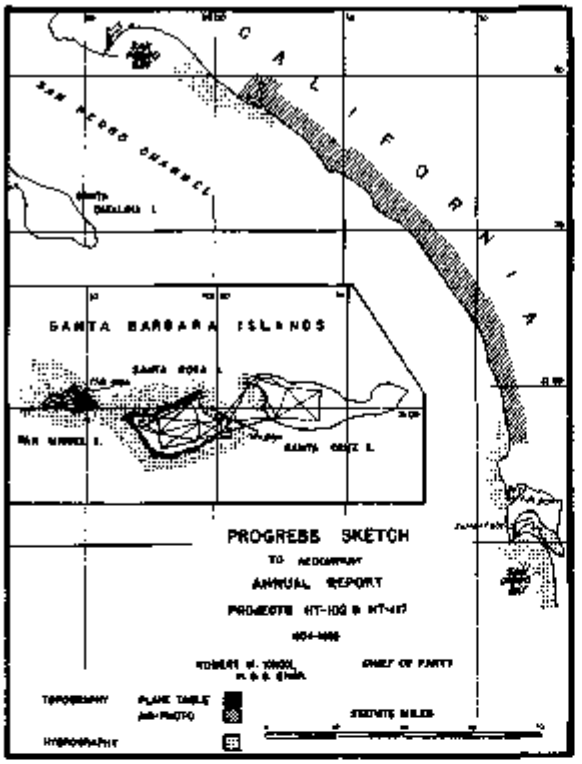
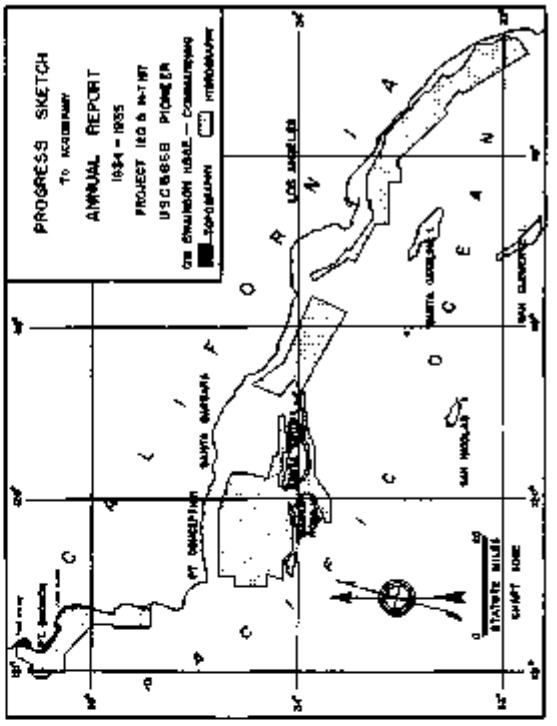
GULF OF MEXICO




CALIFORNIA
SAN PEDRO CHANNEL
SANTA BARBARA ISLANDS
SANTA ROSA I.
SAN MIGUEL I.
SANTA CRUZ I.
PROGRESS SKETCH
TO ACCOMPANY
ANNUAL REPORT
STATUTE MILES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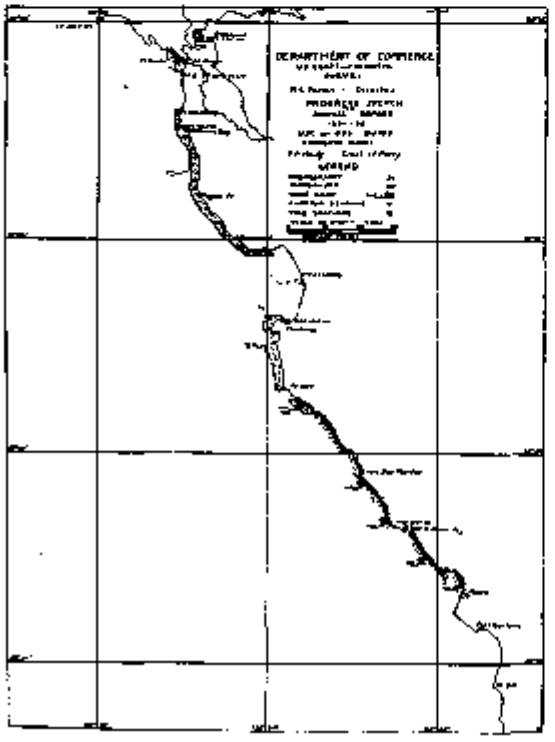
TO ACCOMPANY
ANNUAL REPORT
1934 - 1935
PROJECT 160 & H-1187
USC&GS PIONEER
CALIFORNIA
PACIFIC OCEAN
LOS ANGELES
SANTA BARBARA
SAN NICOLAS
STATUTE MILES
CHART DATE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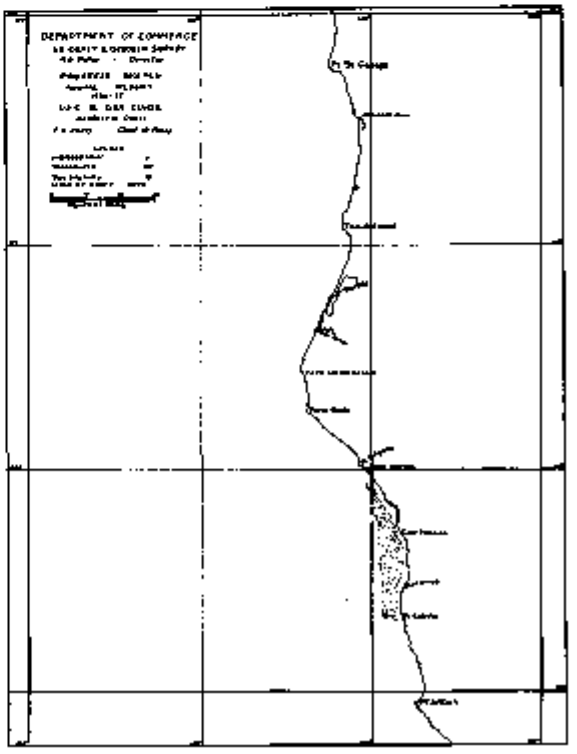
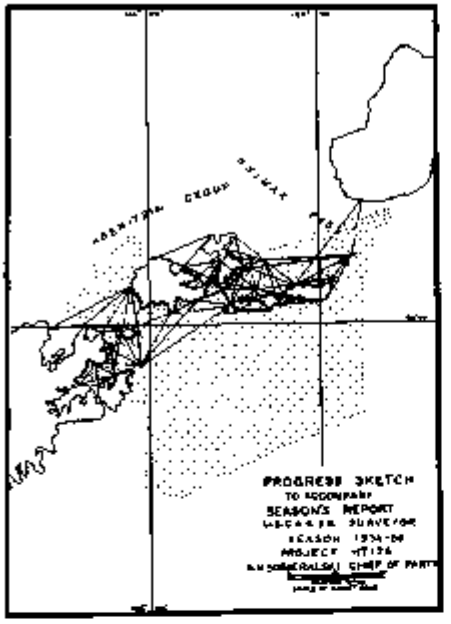
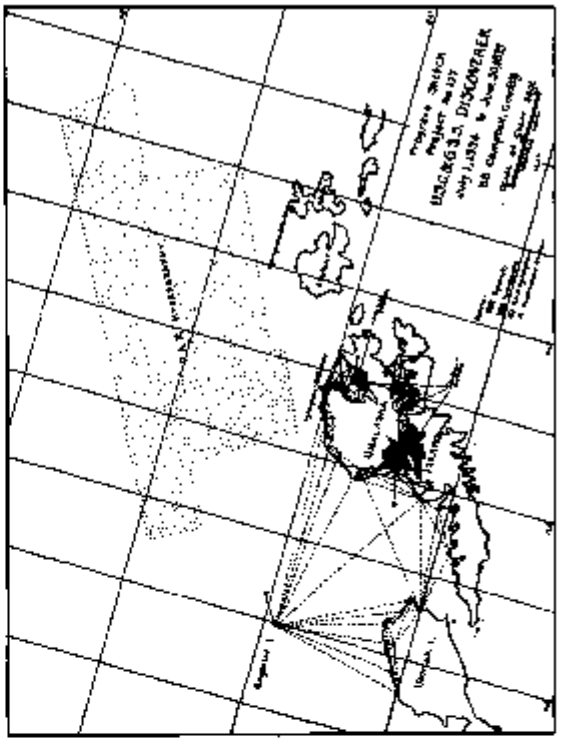
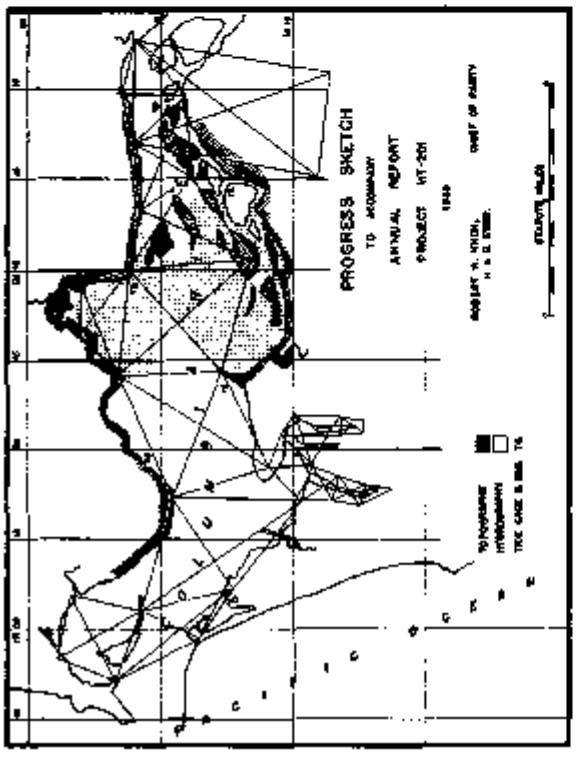

DEPARTMENT OF COMMERCE


PROGRESS SKETCH
TO ACCOMPANY
SEASON'S REPORT

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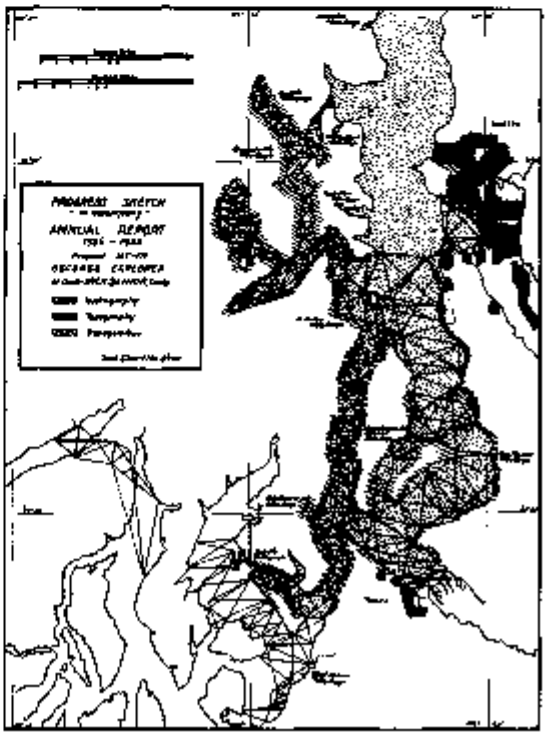
TO ACCOMPANY
ANNUAL REPORT
PROJECT HT-201


PROGRESS SKETCH
ANNUAL REPORT

DISTRIBUTION OF PARTIES AND STATISTICS

GEODESY - FISCAL YEAR 1955

Chief of Party	Locality	Star stations established	Length of scheme	Area
			Miles	Sq. mi.
	TRIANGULATION, FIRST ORDER			
C. F. Anderson	Leesfield to Alexandria, Minn.	95	150	3,900
	Aitkin to Roosevelt, Minn.	44	160	1,900
	Dayton, Kans., to Elmir, Nebr.	53	80	500
	Wellington to Beardsmore, Tex.	51	160	1,400
	Greenbrier to Brookbrillville, Tenn.	85	210	3,100
	Elmir, Nebr., to Ashing, Minn.	88	140	1,540
	Burlee, N.Dak., to Chamberlain, S.Dak.	101	255	6,600
	Ida, Okla., to Abilene, Kans.	84	220	3,200
	Abilene, Kans., to Delphina, Nebr.	35	160	1,400
	Colombus, Nebr., to Sioux Falls, S. Dak.	42	185	1,600
	Fairmont to Bowbey, N.Dak.	91	290	4,900
	Watrousa, Kans., to Cordell, Okla.	45	270	5,900
	Hobart, Okla., to Cisco, Tex.	43	135	1,600
	Cisco to Hamby, Tex.	52	260	2,600
	Hondo to Mission, Tex.	53	210	3,100
	Gotnesby, Okla., to Anthony, Tenn.	34	130	1,100
	Chamberlain, S.Dak., to Broken Bow, Nebr.	37	190	1,900
	Broken Bow, Nebr., to Kimmsey, Iowa.	30	140	1,400
	Alice to Encinal, Tex.	24	140	900
	Longmans to Lake Powell, Tex.	36	190	1,900
	Lubbock to Seymour, Tex.	40	135	1,300
John Towers, Jr.	Potomac River, Md. and Va.	20	60	600
	Chesapeake Bay, Md.	21	100	1,000
	Crisfield to Kilton, Md.	27	190	1,300
	New Freedom to Quarryville, Pa. (Susquehanna River)	28	180	2,400
	McGlamery, Fla., to Colquitt, Ga., and Bainbridge River spur	20	220	2,700
	Harrisburg, Pa., to Hershey, Pa.	05	05	800
	Tyrone, Pa., to Syracuse, N.Y.	28	85	800
	Lake City to Lake Shandra, Fla.	40	240	2,400
	Sebastian to Stuart, Fla.	28	130	1,300
	Miami to Key West, Fla.	29	140	1,000
	Appling, Ga., to Live Oak, Fla.	28	220	2,200
	Vicinity of Washington, D.C., Md. and Va.	10	15	160
	Blackshear to Ashburn, Ga.	47	290	3,200
	Newport to Frankfort, N.Y.	30	90	1,260
	Franklinville, N.Y., to Hornellsville, Pa.	48	190	1,450
H. A. Hecht	Hopkinsville, Ky., to Washington, Ind.	58	190	1,800
	Danville to Brookville, Ky.	41	55	900
	Amazon, Tenn., to Mitchell, Ia.	111	305	3,960
	Gulfport to Corinth, Miss.	45	290	3,840
	Jamestown, Tenn., to Albany, Ky.	18	85	700
	Greenville, Tenn., to Hoskins, Ky.	40	125	1,000
E. B. Latham	Helena to Missoula, Mont.	21	248	2,900
	White Sulphur Springs, Mont., to Belfield, N.Dak.	75	250	4,400
	King Hill to Kimama, Idaho	19	90	1,750
	Tuba to Sherwood Dam, Ariz.	61	125	2,500
	Phoenix to Chandlers, Ariz.	37	45	1,110
	Florence to Tucson, Ariz.	40	90	1,000
	Tucson to Nogales to Aja, Ariz.	30	130	1,960
	Boulder Dam, Nev. and Ariz.	9	15	150
Charles Fiorio	Johannesburg to Bridgeport, Calif. (Owens Valley)	84	80	1,000
	Austin, Nev., to Caldwell, Idaho	32	300	7,000
	Salina, Utah, to Grand Canyon, Ariz.	21	360	6,000
	Columbia River, Wash. and Oreg.	28	90	1,950
	Boulder Dam, Nev., to Grand Canyon, Ariz. (Colorado River)	20	180	3,400
	Henderson to Sulphur, Nev.	56	180	3,950
	El Centro to San Diego, Calif.	30	40	600
	Boulder Dam, Nev., to Yuma, Ariz. (Colorado River)	50	220	2,640
E. B. Perrez	Kenna, Kans., to Ogden, Iowa.	103	185	3,145
	White Water to Hardin, Mont.	50	280	3,900
	Minot, N.Dak., to Fresno, N.Dak.	95	300	3,800
	Cottonwood, N.Dak., to Bottineau, Nebr.	46	150	1,500
	Pineville, N.Mex., to Elston, Tex.	56	160	1,400
	Franklin to Pabin, Nebr.	30	150	1,500
	Rosenthal, Nebr., to Tyler, Calif.	60	400	2,000
	Sparta Springs, Kans., to Trickum, Tex.	84	140	1,400
	Belt, Okla., to Fort Sheridan, Tex.	118	260	3,900
C. A. Schenck	Berrien to Bellville, Ill.	27	58	500
	Hermon, Mo., to Kyneff, Minn.	115	390	4,960
	Alma to Mainstay, Wis.	71	250	4,640
	Hayward, Wis., to Princeton, Minn.	30	118	1,300
	St. Paul, Minn., to Ladysmith, Wis.	34	125	1,250
	Harwood, Ark., to Harrisonville, Mo.	91	325	4,400
	Havana, Ill., to White Creek, Mo.	91	325	2,316
	Chariton, Minn., to Kansas City, Mo.	99	315	3,100
	Mallester, Okla., to Palestine, Tex.	69	220	2,160
	Palestine to Bay City, Tex.	50	190	3,900
	Gagood to Sexton, Mo.	14	90	980
	Southport to Texarkana, Tex.	50	240	2,500
	Rockville, Tex., to Sandell, La.	42	92	900
	Sarepta to Winnville, Tex.	30	95	950
	Austin to Navasota, Tex.	35	100	1,300

Chief of Party	Locality	No. stations occupied	Length of season	Area
			Miles	Sq. mi.
	TRIANGULATION, SECOND ORDER			
John Davis, Jr.	Chappells to Charleston, S.C.	48	100	1,300
	Leesbrville, S.C., to Greenville, S.C.	55	110	1,100
	Catawba to Rockport, S.C.	55	120	1,140
J. H. Gilbert	Delaware River, N.J. and Del. Shoreline	9	10	30
M. A. Marsh	Smallhouse, Tenn., to Princeton, Ky.	37	130	1,350
	Paducah, Ky., to Martin, Tenn.	17	30	400
	Quincy, Fla., to Opelika, Ala.	35	130	1,300
	Lafayette, Ga., to Union Dist. Tenn.	58	200	2,400
	Greenville, Fla., to Statesville, Ga.	59	240	2,400
	Silver City, Ga., to Hardeeville, S.C.	94	200	2,000
	Huntington, W.Va., to Pennington Gap, Va.	37	140	1,350
	Hopkinsville, Ky., to Bowman, Va.	40	200	2,800
	Smithville to Hawks, Ga.	22	30	200
	Americus, Ga., to Montezuma, Fla.	38	130	1,800
	Alleghany, N.C., to Cohn, Ga.	32	90	900
E. S. Latham	Somerset, Ariz., to Pratt, N.Mex.	34	105	1,030
J. F. Hodgson	Superior National Forest, Minn.	20	104	1,020
Charles Pierce	Lincoln Valley to Washington, Calif.	41	120	1,260
	Rice to Kingsburg, Calif.	34	100	1,000
W. H. Porter	Chappallear, Tex., to Clayton, N.Mex.	105	350	3,600
	Tatums to Thornton, Tex.	107	400	4,000
G. A. Schanck	Reidell to Hawkinsville, Ga.	39	140	1,400
	TRAVERSE, FIRST ORDER			
H. W. Green	Miami to Naples, Fla.		71.8	
	TRACK LINES, FIRST ORDER			
H. E. Bruce	Milan, Mo.		6.2	
	Chandlerville, Ill.		6.7	
	Antigo, Wis.		6.0	
	Kaukauna, Wis.		4.6	
	Quincy, Mass.		3.2	
	Aberdeen, S.Dak.		7.3	
	Pingree, N.Dak.		8.3	
	Ruff, N.Dak.		5.6	
	Lenapah, Okla.		6.8	
	Avard, Okla.		4.8	
	Arkalis, N.Mex.		6.0	
	Brownsville, Tex.		4.2	
	Alexandria, La.		5.0	
	Lowell, Ariz.		9.5	
	Delmonte, S.C.		4.8	
	Derby, Fla.		4.3	
	Berwick, Pa.		5.8	
	Petty, Tex.		5.6	
	Lebanon, Mo.		4.4	
	Kendall, Okla.		7.6	
	Hoff, N.Dak. (reconnaissance)		3.3	
	Ingalls, Mont.		5.4	

Chief of Party	Locality	Length of season	Area
		Miles	Sq. mi.
	RECONNAISSANCE FOR FIRST-ORDER TRIANGULATION		
J. S. Hiby	Blackburn to Dunlap, Ga.	220	2,300
	Blackshear to Columbia, Ga.	240	1,400
	Lake City to Lake Stanton, Fla.	240	2,400
	Cleveland, Ohio, to Charleston, W.Va.	290	2,800
	Miami to Key West, Fla.	135	1,000
	Newcastle to Warren, Pa.	60	600
	New Freedom to Scranton, Pa.	130	1,950
	Washington, Pa., to Kingsville, W.Va.	150	1,200
	Winchester, Va., to Circleville, Ohio	235	2,520
F. H. Brugh	Sharon Springs, Kans., to Tucumcari, Tex.	160	1,600
	Scottsbluff, Nebr., to Hugo, Colo.	300	3,000
	Picacho, N.Mex., to Sheldon, Tex.	140	1,400
	Chain Butte to Missouri River, Mont.	104	1,900
	Mobridge, S.Dak., to Fredonia, N.Dak.	320	4,300
	Cottonwood, S.Dak., to Scottsbluff, Nebr.	150	3,000
	Fall, Okla., to Fort Sheridan, Tex.	320	6,000
	Franklin to Paris, Nebr.	150	1,500
	Hugo, Colo., to Longmont, Colo.	140	1,400
	Colorado Springs, Colo., to Allegro, N.Mex.	270	2,700
	Trinidad, N.Mex., to Raton Pass, Colo.	250	2,750
I. C. Johnson	White Sulphur Springs to Tagomar, Mont.	240	1,900
	Tuba to Florence, Ariz.	230	2,400
	Sierrawood to Stanislaus and Florence to Tucson, Ariz.	110	1,000
	Tucson to Nogales, Ariz.	60	900
	Ajo to Nogales, Ariz.	110	1,300
	Grand Canyon, Ariz., to Salina, Utah	68	1,250
	Columbia River, Oreg. and Wash.	58	1,200
	Stanley to King Hill, Idaho	90	1,800
	King Hill to Elmore, Idaho	70	1,700
	Warm Springs to Tuscarora, Nev.	210	2,000
E. B. Morris	Harrisburg, Pa., to Martinsburg, W.Va.	55	400
	Erie to Harrisburg, Pa.	180	1,600
	Towanda, Pa., to Syracuse, N.Y.	70	700
T. J. Mitchell	Newport to Plymouth, N.H.	80	1,240
	McGlamry, Fla., to Ocala, Ga., and Jekyll River	180	1,300
	Pittsfield to Belgrade, Maine, and Vanceboro to Jackson, Maine	230	2,500
	Appling, Ga., to Live Oak, Fla.	240	2,000
	Englewood, N.J., to Fort Hamilton, N.Y.	55	400
	Ogdensburg to Milford, N.Y., and Hoosicktown to Kingsbury, N.Y.	60	600
	New York City to Albany, N.Y. (Hudson River)	140	1,400
	Kingston, N.Y., to Providence, R.I.	140	1,400
	Boston, Mass., to Oneonta, N.Y.	140	1,400

Chief of Party	Locality	Length of scheme	Area
		Miles	Sq. mi.
	[illegible] FOR FIELD-CROP DEMONSTRATION (CONCLD.)		
William Meservier	Antigo, Wis., to Crivitz, Wis.	140	1,960
	Seymour, Wis., to Princeton, Wis.	115	1,990
	Lakefield to Eau Claire, Wis.	60	680
	Fredric Farm, Wis., to W. Pond, Minn.	50	100
	Dugout to Canton, Mo.	[illegible]	400
	Sherman, Minn., to Kansas City, Mo.	315	5,180
	Harrisonville, Mo., to Hartford, Ark.	[illegible]	3,400
	Hallsville, Okla., to Palestine, Tex.	210	2,100
	Palestine to Bay City, Tex.	160	1,900
	Hillsboro to Milliken, Tex.	65	600
	Smith to Brownsville, Tex.	140	1,100
	Ramsom to Arkansas Springs, Tex.	160	1,400
	Cochran, Miss., to Paragould, Ark.	185	1,350
	Paragould, Ark., to Dallas, Mo., and Bennett to Kennedy, Mo.	60	400
	Salt, Mo., to Hanna, Mont.	130	1,100
	Dallas to [illegible], Mo., and Steele, Mo., to Alto, Ill.	135	1,400
	Hampton to Le Mars, Iowa	180	1,700
	Dakota to Red Cloud, Nebr.	120	1,340
	Cambridge to Hampton, Iowa	90	900
	Long Prairie to Hoosick, and Thorsen to Hallock, Minn.	500	5,000
E. B. Foster	Elk City to Stanley, Idaho	150	2,000
	Ingomar, Mont., to Belfield, N.Dak.	170	2,800
	Arkansas, Colo., to Aztec, N.Mex.	100	1,000
	Engalan, Ariz., to Silver City, N.Mex.	200	2,040
	Silver City to Turley, N.Mex.	210	6,000
	Bartlesville, Okla., to Dismal, Okla.	140	2,980
D. S. Blewald	Grand Rapids to Ontonagon, Mich.	110	2,100
	Black Hills, S.Dak., to Columbus, Nebr.	100	2,000
	Columbus, Nebr., to Abilene, Kans.	180	1,400
	Abilene, Kans., to Ada, Okla.	230	2,800
	Parkersburg to Cameron, Tex.	140	1,600
	Cameron to Texarkana, Tex.	60	600
	Silver to Arkansas City, Ark.	140	1,640
	Beaufort to East Point, Miss.	120	1,100
	East Point, Miss., to Chillicothe, Ala.	120	1,440
	Earlham, Ark., to Claremore, Okla.	100	1,080
	Claremore to Marshall, Okla.	60	600
	Leesfield to Alexandria, Minn.	180	1,800
	Aitkin to Bemidji, Minn.	190	1,900
	Bolivar, Mo., to Chanute, Kans.	120	1,300
	Chanute to Niagara, Kans.	120	1,300
	Marville to Thermopolis, Wyo.	190	2,000
	Jerome, Mont., to Gateshead, Idaho	80	1,200

Chief of Party	Locality	Length of scheme	Area
		Miles	Sq. mi.
D. S. Blewald	Dalquest to Bentley, N.Dak.	200	4,320
G. A. Johnson	Weston, Conn., to Forest, Mass.	165	1,650
	Forest, Mass., to Bidwell, Ia.	180	1,800
	Demopolis to Hamilville, Ala.	130	1,300
	Demopolis to Mobile, Ala.	180	1,800
	Jackson, Ala., to Deerfield, Miss., and Spring Cottage to Hamilville, Miss.	140	1,260
	Kingston, N.Y., to Barnes, Pa.	300	4,000
	Glasgow Junction to Albany, Ky., and Milleratown to Hendersonville, Ky.	150	1,500
	Greenville, Tenn., to Bedford, Ky., and Tompkinsville, Tenn., to Albany, Ky.	190	2,380
	Danville to Lexington, Ky.	30	300
L. H. Shepard	Marion, N.Dak., to Fingalson, Minn.	900	9,000
	McPherson, Kans., to Frederick, Okla.	275	2,900
	Frederick, Okla., to Cisco, Tex.	120	1,300
	Cisco to Santa, Tex.	200	2,000
	Rogers to Mineola, Tex.	210	2,100
	Longview to East Tyler, Tex.	150	1,950
	Sioux City, Iowa, to Brooksburg, Nebr.	120	1,200
	Brooksburg, Nebr., to Bat Creek, Wyo.	210	2,100
	Cottonwood to Sheen, S.Dak.	350	3,570
	Groveton, Minn., to Tenmerwood, N.Dak.	190	1,900
	Cedar Lake, Minn., to Fritzgerson, S.Dak.	140	1,400
F. A. Baker	Jasper, Tex., to Cagdale, Ala.	90	900
	Harvard, Ill., to Skaite Creek, Wis.	256	2,560
	Elm City, Ill., to Kingsland, Wis.	150	1,500
	[illegible] FOR SECOND-ORDER DEMONSTRATION		
J. H. Riley	Longview, Ga., to Hamilton, Fla.	112	1,116
	Bainbridge to Bayne, Ga.	50	500
F. E. Brittain	Delaware River, N.J., and Delaware Boundary	10	50
F. W. Keogh	Clayton, N.Mex., to Campbellton, Tex.	380	3,600
	Cochran to Thurman, Tex.	400	4,000
	Kirkland to Crowright and Dodge to Nelson, Tex.	180	1,800
	Alexander to Jim, Tex.	800	8,300
L. C. Johnson	Sacramento, Ariz., to Red Bluff, N.Mex.	680	4,640
	Northam, Oregon	90	5,150
	Imperial Valley to Meadows, Calif.	130	1,000
	Rice to Kingston, Calif.	100	1,000
	Needles, Calif., to Tonopah, Ariz.	110	1,100
	Aguila to Peach Springs, Ariz.	100	1,400
J. A. Foster	Superior National Forest, Minn.	300	2,000
E. J. Maxwell	Silver City, Ga., to Rapidville, S.D.	200	2,000
	Lowdenville, S.C., to Gastonia, N.C.	130	1,100

Chief of Party	Locality	Length of schemes	Area
		Miles	Sq. mi.
	RECONNAISSANCE FOR SECOND ORDER TRIANGULATION (CONT'D.)		
T. J. Mitchell	Chappells to Charleston, S.C.	150	3,000
	Greenville, Miss., to Sarepta, Miss.	240	2,400
	Greenville to Hampton, S.C.	130	2,100
	Alexandria, La., to Ohio, La.	90	900
William Manning	Bellmeville to Tyrell, Tex.	90	700
	Denton to Ennis, Tex.	100	1,000
	Ennis to Kaufman, Tex.	140	1,400
	Weatherford to Dallas, Tex.	80	600
	Longview to Sequoia, Tex.	80	800
G. J. Stevens	Sheford to Sheyenne, Wyo.	180	1,800
L. O. Simmons	Alice to Kenedy, Tex.	100	400
	Gainesville to Bridgeville, Tex.	310	2,100
	Gallinger to Sherman, Tex.	140	1,400
	Lubbock to Spur, Tex.	235	1,300
	Sparta, Tenn., to Cookeville, Tenn.	130	1,000
	Wilmington, Ohio, to Washington, Tex.	130	1,300
	Jacksonville to Kenton, Tex.	130	1,300
	Vicinity of Montgomery, Tex.	30	600
	Jasper, Ark., to Arcadia, La.	140	1,400
F. L. Orton	Ada, Okla., to Tulsa, Okla.	100	1,000
	Dubuque to New Hamburg and Fort Madison to Keokuk, Iowa	140	1,400
	Quincy to Hanley, Mass.	140	1,400
	Troy to Tomball, Mass.	60	600

LEVELING

Chief of Party	No. of level instruments	No. of miles of 1st order	No. of miles of 2nd order	Total no. of miles of 1st and 2nd order
A. R. Fish	7	1,141	9,979	11,100
H. M. Gibson	8	1,366	13,167	15,633
John Lemkowski	4	496	4,408	4,904
Curtis L. Tower	4	580	4,668	5,248
G. T. Moore	4	128	7,408	7,536
E. J. Oliver	8	1,896	16,030	16,925
E. G. Hoskins	4	896	11,139	11,947
T. T. Sanders	2	600	4,128	4,608
A. J. Thorson	3	481	12,230	12,713
F. D. Trowbridge	4	1,328	10,484	11,800
F. R. Tuttle	3	899	13,594	14,493
A. L. Furbush	4	1,585	4,184	5,769

ASTRONOMICAL OBSERVATIONS

Chief of Party	State	Number of stations observed
A. J. Hoffmann	Florida	1
	Louisiana	3
	Virginia	2
H. H. Orbeck	Kentucky	1
	New York	1
	Pennsylvania	3
	Wisconsin	4
E. A. Shriver	Arkansas	1
	Florida	14
	Georgia	7

Chief of Party	State	Number of stations observed
G. A. Whiteus	Illinois	2
	Indiana	2
	Iowa	3
	Kentucky	1
	Maryland	1
	Minnesota	1
	Mississippi	5
	Missouri	1
	Nebraska	2
	Ohio	1
	Oklahoma	2
	Oregon	1
	Pennsylvania	1
	South Carolina	4
	Tennessee	2
	Washington	1
	GRAVITY OBSERVATIONS	
H. H. Bowman	Connecticut	20
	Illinois	1
	Maryland	1
	Massachusetts	13
	Montana	26
	New Hampshire	1
	Pennsylvania	7
	Wyoming	4
	Cuba	24
R. R. Rabid	Pennsylvania	15

SUMMARY OF OPERATIONS

CONSTRUCT - FISCAL YEAR 1930

TRIANGULATION

	New stations established	Length of schemes	Area
		Miles	Sq. mi.
First-order	4,956	34,218	104,000
Second-order	930	5,000	24,970

TRAVERSE, FIRST ORDER

Length of schemes in miles 56.0

BASE LINES, FIRST ORDER

Number of miles 320.1

RECONNAISSANCE

	Length of schemes	Area
	Miles	Sq. mi.
New first-order triangulation	34,076	102,000
New second-order triangulation	5,000	40,200

LEVELING

First-order, no. of miles	Second-order, no. of miles	Total no. of miles
10,918	139,385	150,303

ASTRONOMICAL OBSERVATIONS

Total number of stations observed 58

GRAVITY OBSERVATIONS

	United States	Cuba
Total number of stations observed	68	24

USE OF REPRODUCTIONS OF AIR PHOTO COMPILATIONS FOR PLANE TABLE RESURVEYS

At this time printing has been completed or is underway on 475 photo compilations covering large areas of the Atlantic, Gulf, and Pacific Coasts.

In addition there are some 100 photo compilations in the Washington office which will be reproduced as rapidly as practicable.

Upon completion of the verification and prior to the printing in this office, all recoverable detail located by the plane-table control surveys is transferred to the photo compilations which then comprise a complete record of all topographic data available at this office.

For purposes of resurveying this office can furnish a blueline print of the compilation or section of the compilation on the regular aluminum mounted plane-table sheet. The blueline print will show all detail of the compilation to precise scale on a non-distortion sheet. Revisions can be inked in black over the blue and so carried up to a proper junction with previous work.

The advantages of this method over the one of photostat or bromide copies, from which the old shoreline is transferred to the new plane-table sheet, are obvious.

Copies also can be printed in black where required.

Prints can be made on chart paper, boat sheet paper, or on smooth sheet paper and should be useful in many cases for inshore hydrographic surveys.

Indexes of all air photo compilations on hand have been made on letter size sheets and can be furnished as required by the field parties.

Film negatives can be used instead of photostats where it is necessary to forward precise copies of surveys other than air photo compilations from this office to the field. A film negative like a photostat shows the lines of the copy clear on a black background. The film will shrink or expand somewhat with changing weather conditions, but changes much more uniformly in all directions and consequently has less scale distortion than the photostat or bromide paper.

TIDAL CURRENTS BY SHAKESPEARE AND BACON

"Like to the Pontic sea,
Whose icy current and compulsive course
Ne'er feels retiring ebb, but keeps due on
To the Propontic and the Hellespont."

Othello, iii, 3.

The above quotation appeared for the first time in the 1623 folio edition of Shakespeare's plays, seven years after the reputed author's death. These lines are missing in the "Tragedy of Othello" as first printed in quarto form in 1622, Shakespeare having been in his grave six years.

Francis Bacon investigated the tides of the Mediterranean in or about 1616, and in his treatise on the subject entitled DE FLUXU ET REFLUXU MARIS, made especial reference of the phenomenon that through the Bosporus the tide never ebbs, i.e., the current flows continuously from east to west. He derived this fact from George Sandys' travels in the East, but had no knowledge, of course, of the undercurrent flowing the other way, nor of the extent of the evaporation from the surface of the Mediterranean, estimated at eight or ten feet per annum.

It is curious also that the two seas east and west of the Bosporus are used in a similar connection by both authors:

Pontus and Propontis	-	Bacon
Pontic and Propontic	-	Shakespeare

Charles H. Deetz