C. A. George

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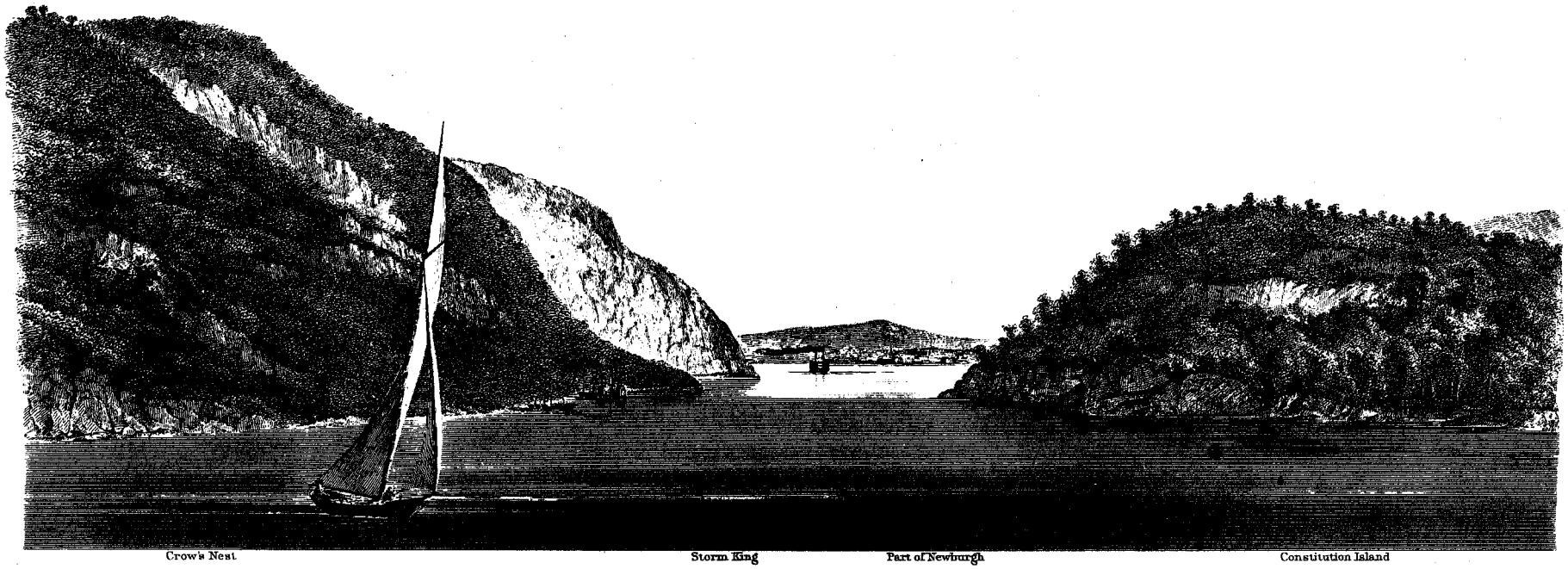

View of The Crow's Nest and Storm King, from West Point.

ETCHED IN THE DIVISION OF ENGRAVING U. S. COAST SURVEY 1876

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TAUT WIRE MEASURING APPARATUS

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

Just prior to the departure in March., 1933, of the OCEANOGRAPHER for the working grounds in the Gulf of Mexico, a "Taut Wire Measuring Apparatus" was received on board this vessel. This apparatus is the product of and apparently was developed by the Telegraph Construction and Maintenance Company, Limited, of East Greenwich, England.

The apparatus consists of a reel or drum, with a capacity of 140 nautical miles of piano wire, and with a double brake wheel, both mounted on a heavy standard; a portable davit and davit standard for handling the drum; and a measuring apparatus consisting of measuring or counter wheel, indicator, dynamometer wheel, two lead wheels and three sets of lead rollers. The measuring apparatus is mounted on a frame slightly more than eight feet by two feet.

The dimensions of the various parts of the gear are shown on the photostat of the arrangement.

Contrary to the reel on our deep sea sounding machines, the drum or reel of this apparatus does not revolve. The wire is unwound from the reel by a flyer which revolves around the drum.

The drum is secured to the drum standard bracket by a drum center consisting of a central ring and three arms. The central ring is held to the standard bracket by a heavy set screw and each arm carries two set screws on a pad at the end to engage a female pad on the drum.

The spindle through the center of the standard bracket carries the flyer on the drum end and a double brake wheel on the opposite end.

The dynamometer wheel has a lug on each side, through which a vertical guide rod passes. The wheel travels up and down the guide rods according to pressure exerted by the brake. The operator varies the brake pressure at will to keep an even tension on the wire.

The other parts need no description.

The manufacturer's instructions for the apparatus are as follows:

"PREPARATION OF GEAR FOR USE AND ATTENTION-REQUIRED WHILST RUNNING.- It is assumed that the drumstand and gear have been placed correctly in their respective positions on the ship according to the drawing, also that the wire drum which, when fully wound, contains 140 nautical miles of wire has been placed on the stand and the flyer connected to the brake spindle.

"NOTE.- The iron centre, with three arms, should be fitted in drum previous to lifting on the drumstand.

"TO PREPARE GEAR FOR USE.- The end of the wire is led over the flyer

wheel between the lead rollers over and three-quarters round the larve "v" counter wheel, up over the first lead wheel, under the dynamometer wheel, over the after lead wheel and between the stern rollers. The wire is then made fast to the end of the rope on one of the special fire-bar anchors, as pattern supplied. Heave any slack of the wire back until the rope is at the stern rollers, and put the brakes on by turning the fly nuts. The gear is now ready for use.

"NOTE: CARE SHOULD BE TAKEN - That, when reeving the wire, the vertical part between the measuring wheel and first lead wheel is lead on the port side of the horizontal lead on; otherwise ends of splices will foul and ruck up. That the wire, when being passed under the dynamometer wheel, is led above the pins connecting the two sides of the dynamometer. That, when reeving the wire, a slight friction is kept on the brakes, otherwise kinks are liable to be formed. That, when not running, the drum be always covered to prevent the wire rusting.

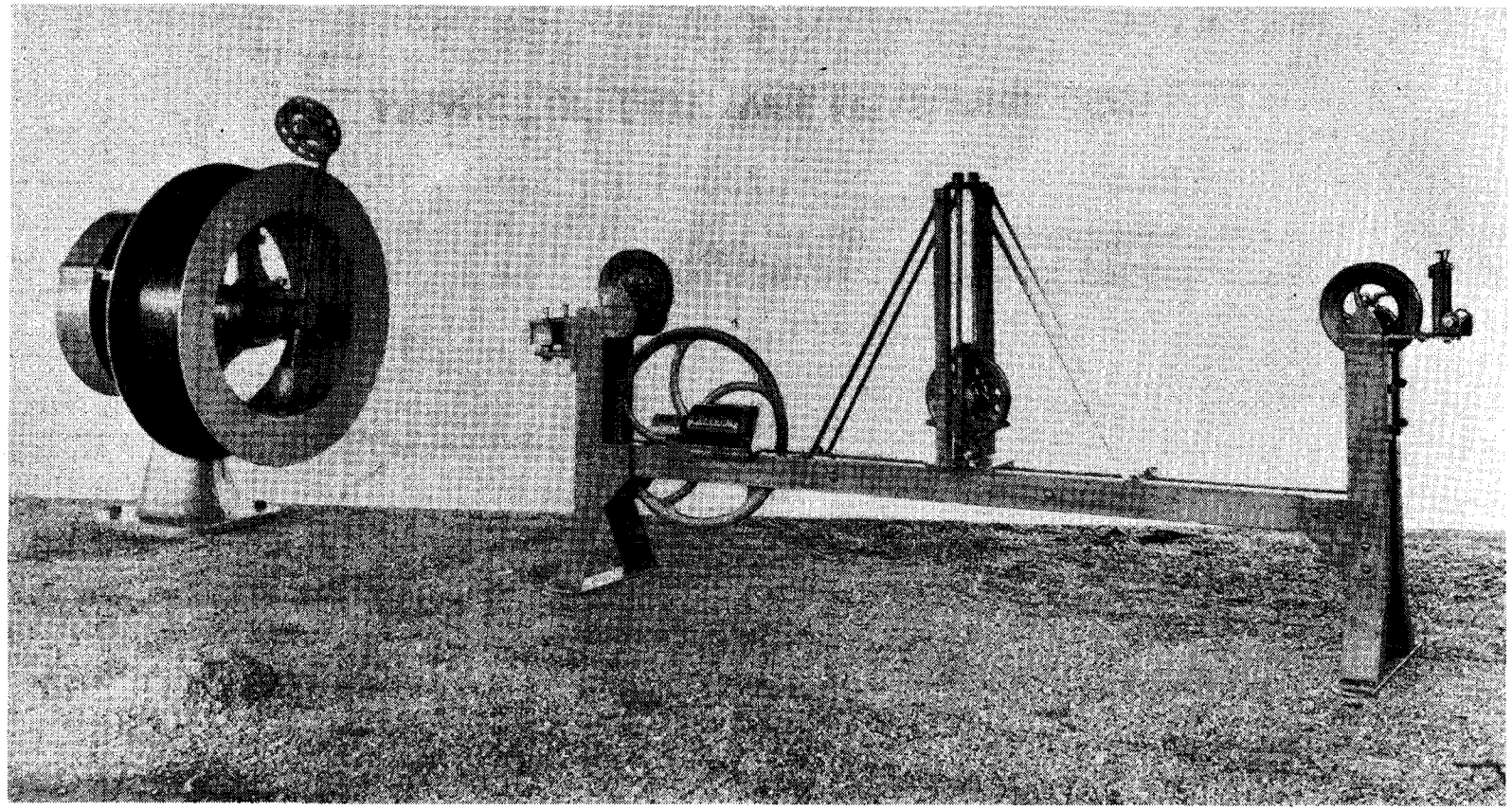
"TO START AND RUN GEAR.- Remove brass hexagon cap from flyer wheel spindle, screw on Stauffer lubricator provided for the purpose in place of cap, and fill boss of wheel with motor grease. When full unscrew lubricator and replace hexagon cap. The rest of the gear should be freely lubricated with the exception of brake straps. (These need only a drop or two of oil.) Start the gear about one mile before the position is reached from which a measurement is to be made. Lower the anchor by hand to a few feet from the water line, and if any sea be running the anchor should be kept clear of it. Release the brakes until the flyer revolves freely. Do not take the brakes right off, otherwise the flyer will overrun the wire and throw it off. Should this happen the wire must be cut and a fresh start made.

"NOTE.- The best way to cut the wire when running is to choose a straight portion of it, hold a piece of iron under, and tap the wire quickly with a cold chisel or other sharp instrument while the strain has been slightly increased. After a run of about one mile the strain should be increased to about 38 pounds. This should be sufficient for depths up to 1,000 fathoms. Should it be required to run the whole length of the wire off, the bottom end, where it is fixed to the drum with a wooden peg, should be examined previously to ensure that it has not jammed too tightly, otherwise the flyer might be bent. Always keep the brake cover on -- a heavy shower of rain on brakes and straps might cause the flyer to be released suddenly and throw the wire off.

"INDICATOR.- The indicator registers .001 nautical miles for each revolution of the measuring wheel."

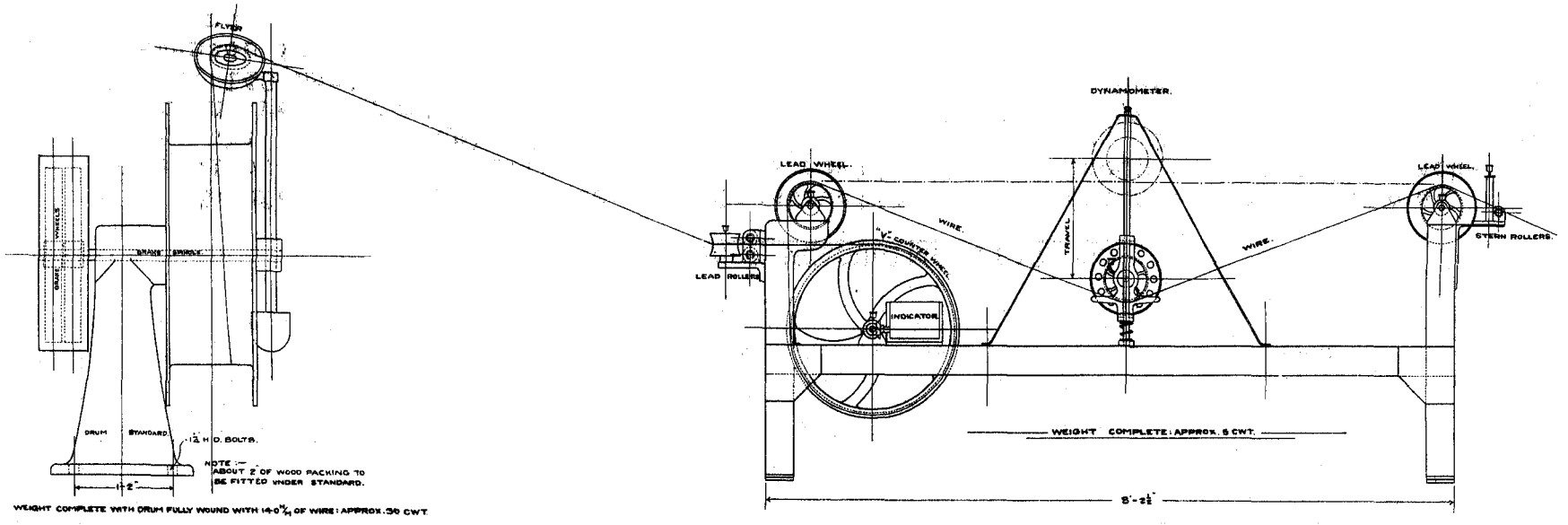
INSTALLATION ON BOARD:

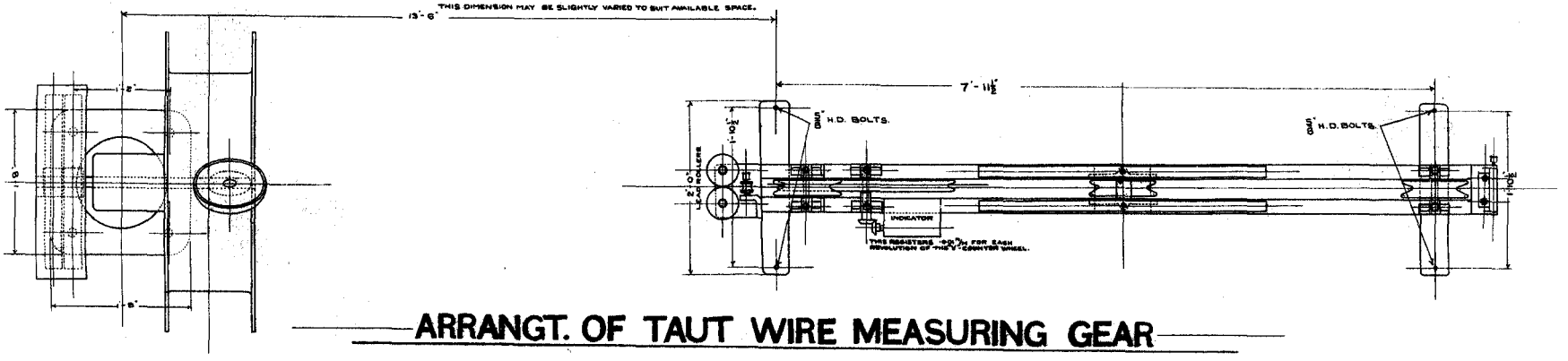
When this shipment was received we were all concerned as to how and where to install it. The individual parts are large, heavy and awkward to handle aboard ship. The reel loaded with wire weighs about 2400 pounds alone. We felt that we had a real white elephant on our hands and were skeptical as to its successful use aboard. The final installation



TAUT WIRE DISTANCE MEASURING APPARATUS

Manufactured by the Telegraph Construction and Maintenance company, East Greenwich, England. Differing from the reel or drum on deep sea sounding machines, the drum or reel of this apparatus does not revolve. The wire is unwound from the reel by a flyer which revolves around the drum. The drum has a capacity of 140 nautical miles of piano wire. On the OCEANOGRAPHER, when measuring distances in depths ranging from 10 to 25 fathoms, tension was maintained at 36 pounds and the wire was laid down at the rate of 9 to 10 knots.





ARRANGT. OF TAUT WIRE MEASURING GEAR

SCALE. 1 1/2" = 1'-0"

and remarkable success in operating it in our work are therefore all the more gratifying.

Before attempting to install this gear aboard ship, it was set up on the dock in Port Arthur to ascertain the space required and also to allow the personnel to become familiar with the assembly.

This preliminary set-up on the dock gave the information necessary for the installation aboard ship. The weight of the gear prevented its installation on the house top, which otherwise would have been an ideal location. The room required for the installation prevented installing it on the quarter deck, which left the alleyways the logical site. The apparatus was finally installed in the port alleyway with the reel abreast of the after end of the main deck house and the dynamometer-abreast of the after deck house.

Accompanying the gear and forming a part of it was a heavy davit and a standard to handle the reel. These parts were not used, the gear being installed in a location which permitted the use of the after launch davit to handle the reel.

The reel or drum standard was installed permanently with 1-1/4" holding-down bolts through the deck and underlying plate. The drum and brake wheels can be removed and stowed elsewhere if necessary or desirable. The dynamometer was installed semi-permanently only. It is comparatively light and can be moved with ease. It was mounted on athwartship skids which in turn are wedged and screwed to the deck. In mounting the dynamometer, care should be taken to have it as near as possible on an even keel, using wedges as necessary. Whenever the dynamometer is inclined, even when the ship is rolling, the lugs of the dynamometer wheel will bind against the guide rods, prevent any movement of the wheel and render it impossible to tell the strain carried on the wire.

OPERATION:

The operation of the gear is simple after the installation has been made. The flyer moves around the reel on the brake spindle as an axis and unwinds the wire. The rapidity of rotation of the flyer depends directly on the speed of the ship. Obviously the wire, if the gear is operating correctly, will be paid out at the same rate at which the ship is moving "over the ground". On the OCEANOGRAPHER we steam at 90 revolutions per minute when operating the gear. This gives us a speed of between nine and ten knots.

In winding the wire on the reel a heavy grease had been used by the manufacturer to prevent rusting of the wire. As the wire is unwound by the flyer, this grease is thrown badly in all directions and after our first test of the apparatus the deck, bulwarks, deckhouse sides, and awnings were covered with this grease. In subsequent operations we covered decks, etc., with canvas, but even with this protection some grease will find its way to unprotected parts. When it becomes necessary to refill the reel it is believed that powder can be used instead of grease and this feature will be eliminated.

It will be noted in the manufacturer's notes quoted previously that in running the wire a strain of about 38 pounds, as shown on the dynamometer scale, should be used. All our experience has been in depths of from 10 to 25 fathoms and in those depths we have found that a strain of about 36 pounds is the best. To obtain a greater strain than that requires the brake bands to be set up against the brake wheel so tightly that the wheels soon run too hot.

We found it necessary to install new springs on the brake bands; the ones furnished with the machine were too long and the bands could not be set up sufficiently with them.

CAUTION:

The wire splices on our original are very poorly made and are liable to jam in the lead rollers when using the gear. If this occurs the wire will part, as happened once on the OCEANOGRAPHER, and the flyer might be bent. There apparently is nothing that can be done about this condition on the original. Refills should be made with wire spliced according to standard Coast Survey methods or preferably with one continuous length.

CIRCUMFERENCE OF MEASURING WHEEL:

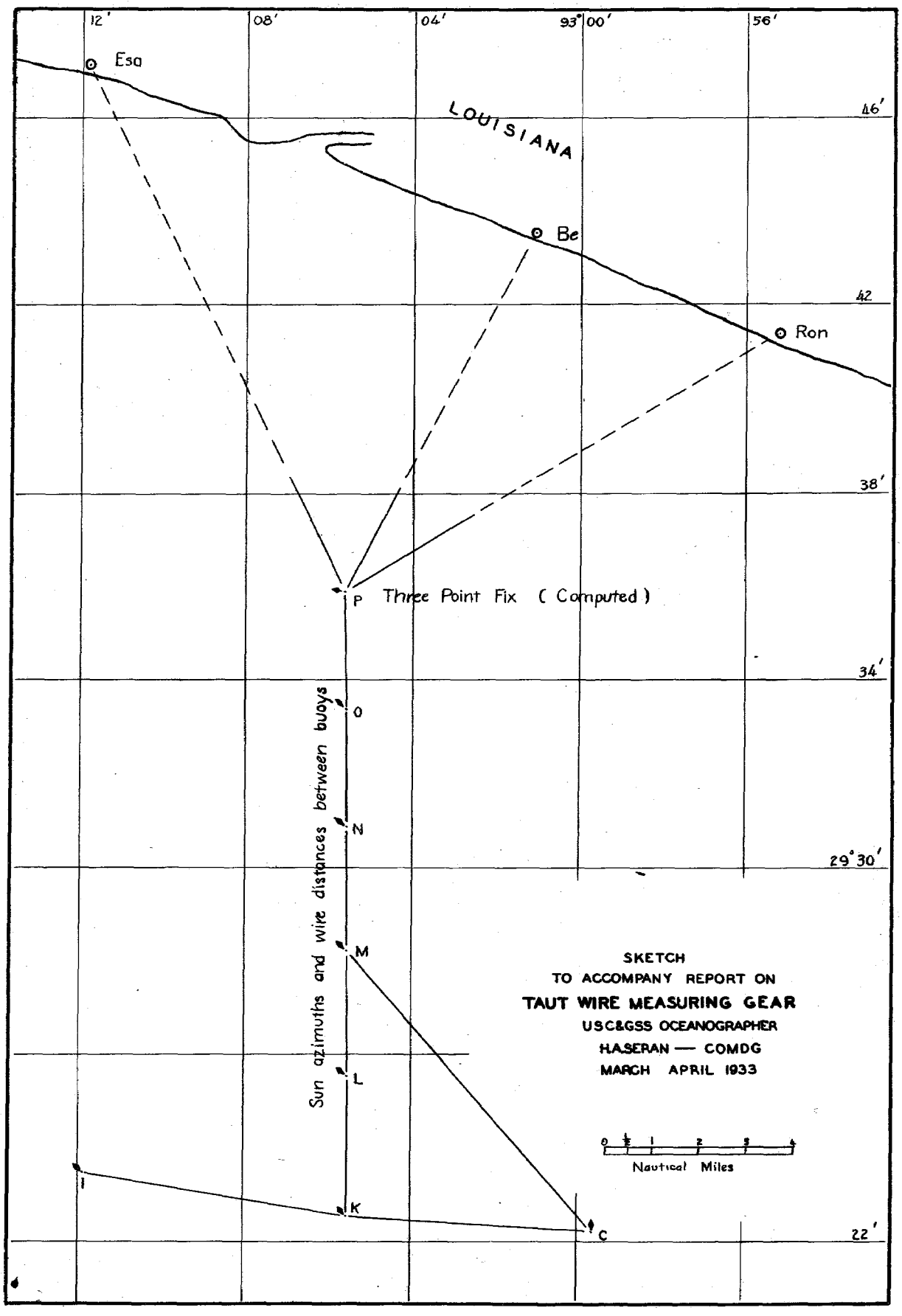
The manufacturer states "the indicator registers .001 nautical miles for each revolution of the registering wheel." This was not accepted as final and careful measurement gave a circumference of 1.86035 meters, which distance is used on all our work with the gear.

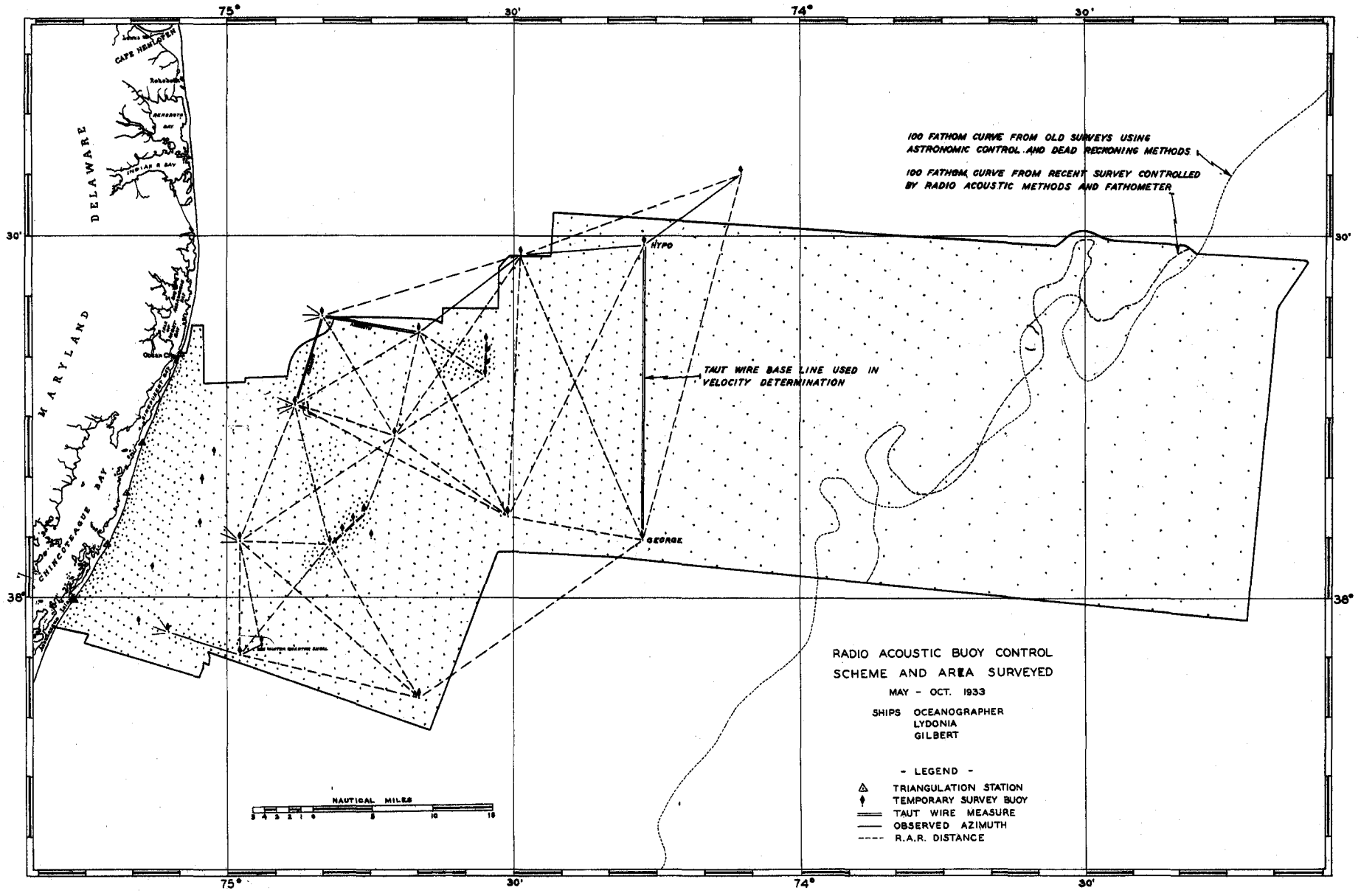
RESULTS:

On Project HT 124 seven buoys were located by distances measured with the gear and sun azimuths. The inshore buoy "P" was located by a three-point fix from shore signals. Buoys O, N, M, L, and K were practically in line and extended offshore from P. The distance between buoys was about 2-3/4 miles. The distances in the line of buoys P to K were measured by steaming along the line of buoys and reading the indicator when each buoy was abeam the dynamometer. The distances between buoys K and I, K and C, and C and M were determined by separate runs at different times.

Buoy I was the offshore buoy of the first line of buoys set out near the western limits of the project. The other buoys in that string were located by full-speed, double-runs of the ship and sun azimuths. There was some discrepancy in the position of I as determined by the full-speed, double-run method and as determined by the taut wire from K. As the atter determination was regarded as the stronger, in plotting the smooth sheet the taut wire determination of I will be held fixed and the intermediate buoys between I and E adjusted to the full-speed, double-run distances.

The position of buoy C was determined in two ways: First, by a taut wire measurement of the distance from K and the sun azimuth from K, and second, by the two taut wire measurements K to C and M to C.


12'
08'
04'
93° 00'
56'
46'
42
38'
34'
29° 30'
22'
Esa
LOUISIANA
Be
Ron
P Three Point Fix (Computed)
O
N
M
L
K
I
C
Sun azimuths and wire distances between buoys
SKETCH
TO ACCOMPANY REPORT ON
TAUT WIRE MEASURING GEAR
USC&GSS OCEANOGRAPHER
HASERAN — COMDG
MARCH APRIL 1933
0 ½ 1 2 3 4
Nautical Miles


75°
30'
74°
30'
38°
DELAWARE
MARYLAND
CAPE HENLOPEN
CHINCOTEAGUE BAY
HYPO
GEORGE
TAUT WIRE BASE LINE USED IN VELOCITY DETERMINATION
100 FATHOM CURVE FROM OLD SURVEYS USING ASTRONOMIC CONTROL AND DEAD RECKONING METHODS
100 FATHOM CURVE FROM RECENT SURVEY CONTROLLED BY RADIO ACOUSTIC METHODS AND FATHOMETER
NAUTICAL MILES
5 4 3 2 1 0 5 10 15
RADIO ACOUSTIC BUOY CONTROL
SCHEME AND AREA SURVEYED
MAY - OCT. 1933
SHIPS OCEANOGRAPHER
LYDONIA
GILBERT
- LEGEND -
TRIANGULATION STATION
TEMPORARY SURVEY BUOY
TAUT WIRE MEASURE
OBSERVED AZIMUTH
R.A.R. DISTANCE

Rigid computations of all the positions were made. (See accompanying sketch). The position of C as determined from K by taut wire distance and sun azimuth was:

Latitude 29°22' 14".4 Longitude 92° 59' 41".1

As determined from the triangle C,K,M with the three sides given and computing position from M:

Latitude 29°22' 13".4 Longitude 92°59' 41".2

a discrepancy of 1".0 in latitude and 0".1 in longitude, or about 30 meters. This is regarded as excellent for buoy work.

ADDITIONAL USES OF GEAR:

On project HT 142 the gear was used in connection with tests for the velocity of sound through sea water. The station ships were at buoys George and Hypo, about 23 miles apart. The OCEANOGRAPHER steamed along the line between the two buoys, kept course by the direction finder, and bombed at intervals of 1000 revolutions of the measuring wheel. R.A.R. distances from each ship were recorded at each bomb. It is believed this will give excellent information regarding the velocity.

Another use was in connection with the location of buoys for the control of an isolated shoal. One buoy was located by R.A.R., the other buoys necessary for the control were located by taut wire distances and azimuths from it.

VELOCITY OF SOUND IN SEA WATER

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

(Extract from a letter from the Commanding Officer, Ship HYDROGRAPHER related to the previous article)

The party on the OCEANOGRAPHER measured the distances between several buoys by means of the new British Taut Wire Machine and also located several buoys by means of the usual precise dead reckoning method. The party on the HYDROGRAPHER then measured these distances by R.A.R. method. In this way the velocity of the compression wave between the first set of buoys was determined and there was also obtained a comparison of the measured velocities with those given in the British Admiralty Tables for known values of temperature and salinity.

Between buoys M and K, a distance of 10,467 meters by wire, the velocity was 1519.7 maters, or 5.4 meters greater than the tabulated velocity for the observed mean temperature and salinity (the pressure effect was negligible). Between buoys N and K, 15,333 meters, the velocity was 1513.0 meters, in exact agreement with the theoretical velocity. Between buoys O and K, 19,933 meters, the velocity was 1510.3 meters, or 2.8 meters less than the theoretical. Between buoys K and C, 9540 meters, the velocity was 1519.6 meters, or 2.8 meters greater than the theoretical.

And between buoys K and I_2, 10,627 meters, the velocity was 1517.5 meters or 0.7 meters too great.

The average disagreement with the theoretical velocities was 2.3 meters or 0.15%. The greatest disagreement was 0.36%. These tests appear to confirm previous experiments where it was possible to get the true distance with reasonable accuracy and indicate that R.A.R. methods, using B. A. tabulated velocities for mean bottom temperature and salinity, will usually give results accurate to 1/3 of one per cent and, under favorable conditions, with an error of about 1/10 of one per cent, if the line is so long that errors in the corrections to reduce bomb and hydrophone to buoy anchors are inappreciable or if these corrections can be accurately determined.

COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL VELOCITIES

Buoys	Measured Dist. (meters)	Cor's. (m)	True Dist. (m)	Time (sec.)	Velocity (Experimental)	Velocity (Theoretical)*	Diff. Ex-Th	% Diff.
M		+ 9	10,476	6.90	1518.2	Mn. bot.		
to	10,467	+12	10,479	6.89	1520.9	Temp. 19.5°		
K		+ 7	10,474	6.88	1522.4	Sal. 32.2		
		+ 4	10,471	6.90	1517.5			
					1519.8	1514.3	+5.5	0.36
N		-11	15,322	10.14	1511.0	Mn. bot.		
to	15,533	-13	15,320	10.12	1513.8	Temp. 19.5°		
K		-18	15,315	10.12	1513.3	Sal. 31.1		
		-26	15,307	10.11	1514.0			
					1513.0	1513.0	0.0	0.00
0		-30	19,903	13.17	1511.3	Mn. bot.		
to	19,953	-36	19,897	13.17	1510.8	Temp. 19.5°		
K		-35	19,898	13.19	1508.5	Sal. 31.2		
					1510.2	1513.1	-2.9	0.19
K		-107	9,433	6.21	1519.0	Mn. bot.		
		-107	9,433	6.21	1519.0	Temp. 20.4°		
to	9,540	-107	9,433	6.19	1523.9	Sal. 32.3		
		-107	9,433	6.22	1516.6			
C		-107	9,433	6.21	1519.0			
					1519.5	1516.8	+2.7	0.18
K		+87	10,724	7.08	1514.7	Mn. bot.		
		+87	10,724	7.05	1521.1	Temp. 20.3°		
		+87	10,724	7.06	1519.0	Sal. 32.3		
to	10,637	+87	10,724	7.07	1516.8			
		+87	10,724	7.08	1514.7			
I_2		+87	10,724	7.06	1519.0			
					1517.6	1516.8	+0.8	0.05

* Theoretical Velocities derived from British Admiralty Tables H.D. 282

THE ROBERTS OFFSHORE TIDE GAGE

E.B. Roberts, H. & G. Engineer, U.S.C. & G. Survey

Need for Special Tide Gage

The extensive offshore hydrography performed during the past three years on Georges Bank has occasioned an urgent need for an instrument capable of recording tide levels in a shoal offshore area where means for the erection of conventional types of gages are lacking.

Natural limitations required the development of a completely automatic instrument in a pressure-tight container which could be lowered to the bottom and left there, undisturbed by waves or current. The logical principle to be employed was obviously that of pressure.

There is nothing new in this idea, but of the, many instruments available for recording pressure, none was found to be adapted for this particular use. The first attempt to meet the problem was by means of an apparatus developed in the Instrument Division of the Survey, employing a bellows diaphragm exposed to the water pressure, working a plunger against a helical spring, its movements being recorded by a stylus on a clock-driven drum similar to those used in the Rude tide gage. This apparatus failed because its parts, designed to work under initial great stress due to the pressure of the water in which it must be set, had not sufficient sensitivity of action accurately to record the relatively small tidal variations of pressure.

A later attempt was made, this time with a Bristol Liquid Leyel. Recorder, employing a Bourdon gage and delicate stylus arm, recording on a circular clock-driven chart. This apparatus was sent to the party of the HYDROGRAPHER, who installed it in the heavy casing supplied with the original pressure gage. The Bourdon gage operated under air pressure derived from a rubber element left outside the casing. The failure of this apparatus lay in the face that its range of operation must necessarily extend from atmospheric pressure through that represented by the depth at which it must be set. The tidal fluctuations, being a relatively small part of this range, covered so little area on the scale as to make a wholly inadequate record. While it is believed the instrument functioned correctly, the record could be read only approximately to the nearest foot, and the times of the tidal phases were uncertain in the extreme.

A successful tide gage for the purpose must be unique in two particulars especially: First, its recording element must be sensitive and accurate under the heavy pressures involved second, it must record the tidal fluctuations on a scale such that readings of the order of accuracy of one-tenth of a foot will be possible.

Inception of a Gage to Fill This Special Need.

During the early part of the winter of 1931-32 the writer conceived of a mechanism to achieve these results. Complete sensitivity and accu-

racy at all pressures were to be attained by adoption of a mercury-filled manometer tube as pressure measuring device, its indications being recorded by periodic photographs of the position of a light weight scale floating in one branch of the manometer and held upright with the least possible friction.

The scale value was automatically cared for by the fixed ratio between water and mercury level changes, depending on their relative specific gravities. This is seen to result in a scale value in the order of two and a half inches to the fathom of sea water, permitting readings of the required accuracy.

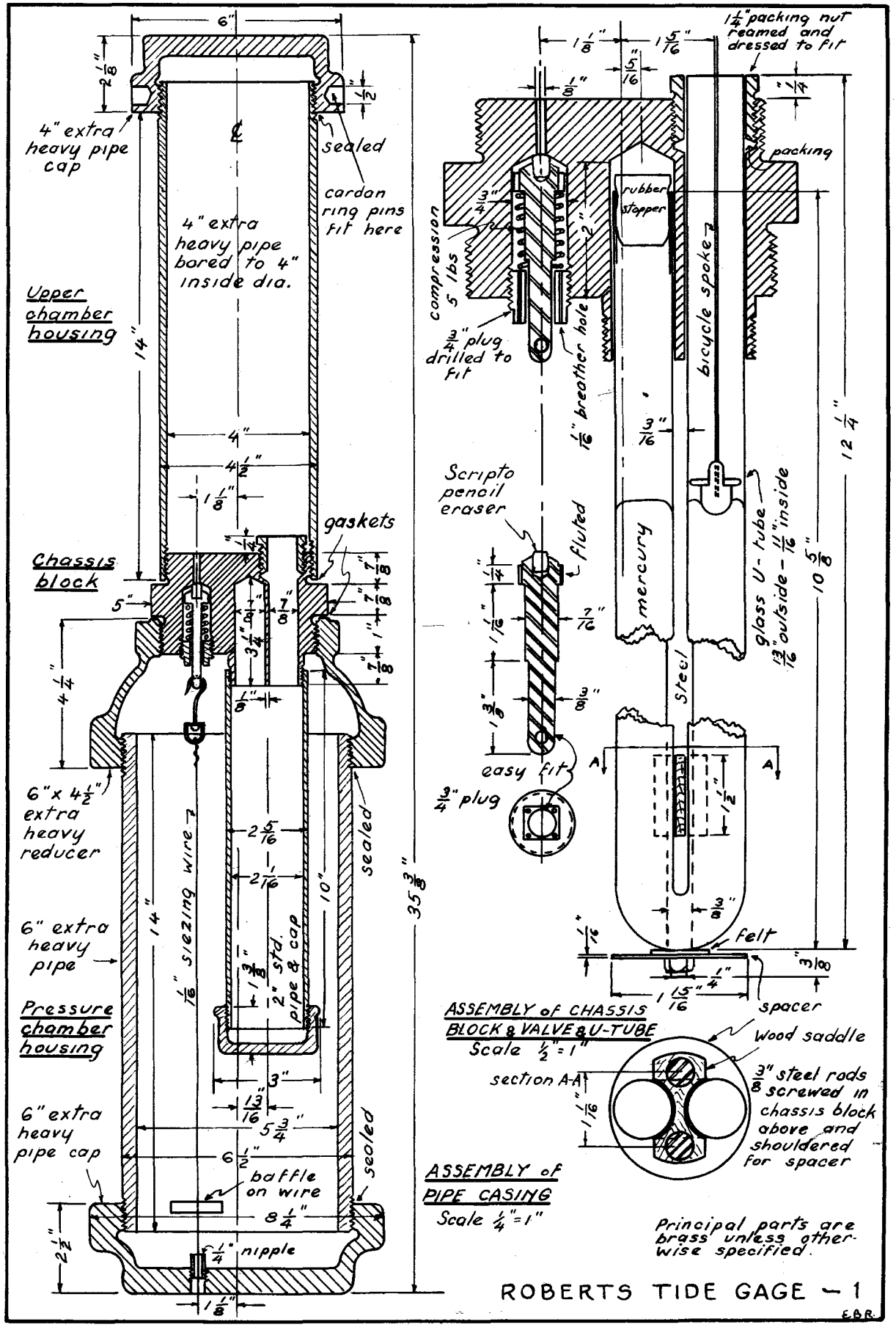
These ideas were communicated by the writer to his Commanding Officer, and through him to the office. The result was instruction to proceed with the construction of an experimental model. For this purpose the expenditure of one hundred dollars from the allotment of the Chief, Division of Tides and Currents, was authorized. The construction was to proceed aboard the HYDROGRAPHER under the supervision of the writer.

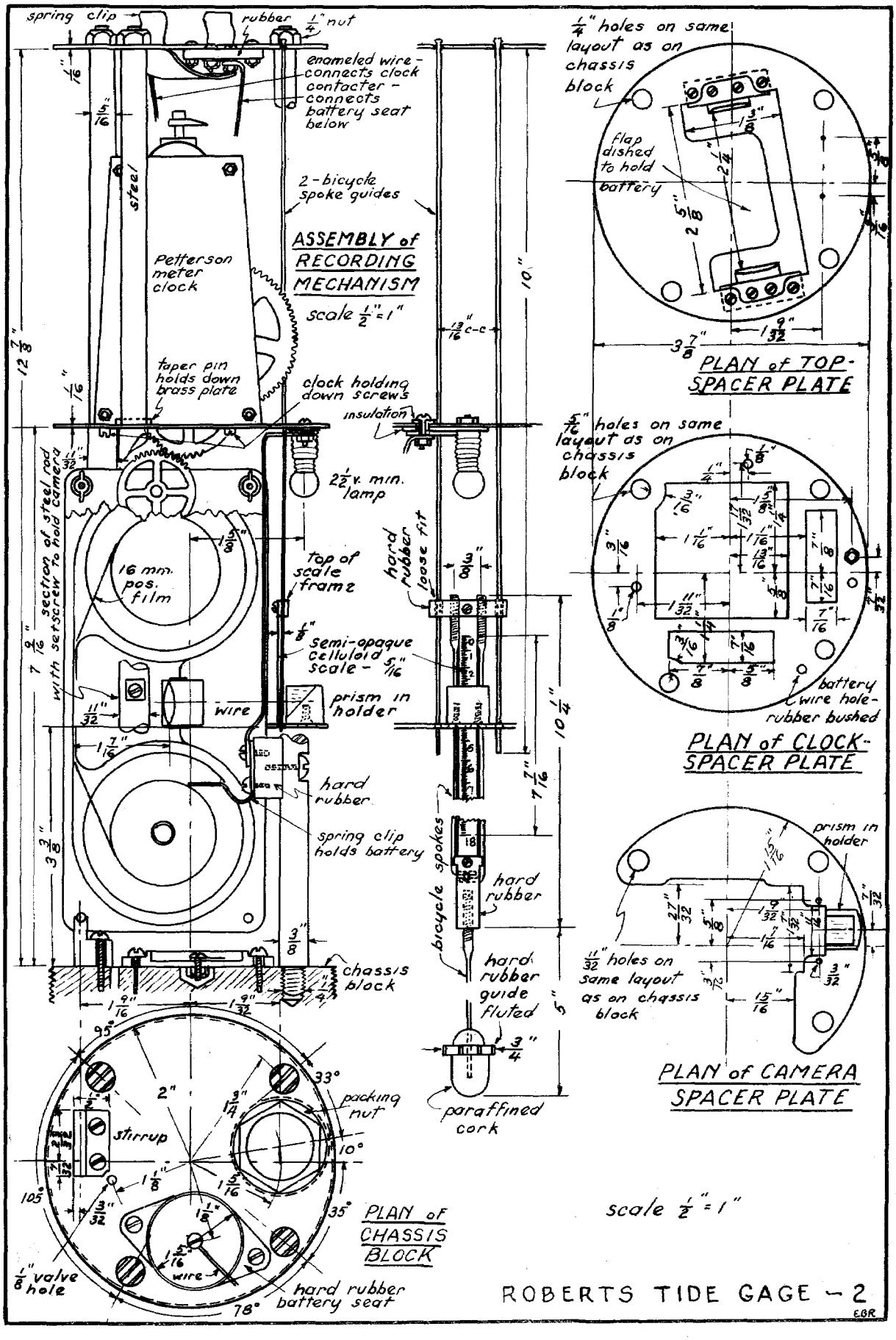
Design and Construction of the Gage.

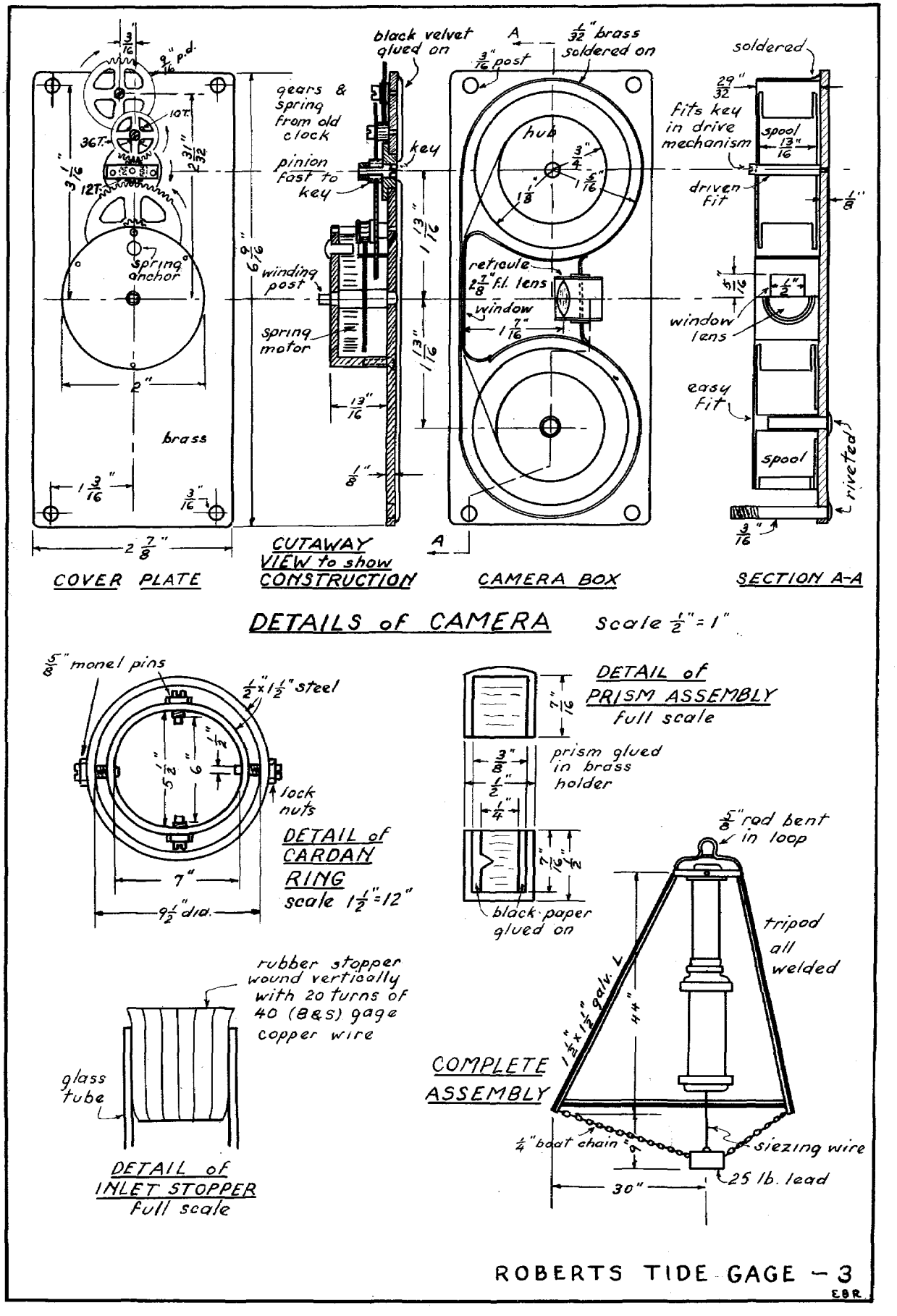
A problem to be met lay in the fact that the pressure resulting from ten fathoms of water, the depth at which it was thought the gage might be used, would demand a mercury tube long enough to accommodate more than fifty inches of mercury, corresponding to twenty-five inches of scale displacement. This was held to be impractical.

The expedient adopted involved the use of a case having two chambers, each connecting with one branch of the manometer. The lower chamber is a diving bell, always under full pressure, while the upper one is entirely sealed except that it communicates with the lower through the manometer, and by way of an equalizing valve, automatically held open during descent or ascent of the gage and closed during the observation period. The virtue of this arrangement is that the pressure in the two chambers, hence in the two branches of the manometer, is equalized during descent and no mercury level change occurs as a result of the initial depth of water over the gage. The valve closes, however, upon reaching bottom, and all subsequent pressure changes, those due to waves or tides, in fact, do actuate the manometer. The short-period changes are damped out in conventional fashion, and the resulting indications are those due to tides alone. The manometer tube can therefore be limited to an overall length of about a foot, and an extreme tidal range of eighteen feet (provided the gage be set at the time of mean tide level) can be accommodated.

Manometer: Several attempts were made unsuccessfully to blow a U-tube. Finally this unit was purchased from a scientific apparatus company. This tube, being glass, was mounted in a framework of steel rods. Wooden saddles and felt pads were placed where necessary to prevent danger of breakage. The long branch of the tube was passed through an opening in the chassis block, which is the partition between the two chambers of the gage. Sealing this passage was difficult and two tubes were broken before it was accomplished. A packing nut set down on cotton packing in white lead was successful, but care in setting up the nut was necessary.


4" extra heavy pipe cap
sealed
cardan ring pins fit here
4" extra heavy pipe bored to 4" inside dia.
Upper chamber housing
Chassis block
gaskets
6"x 4½" extra heavy reducer
sealed
6" extra heavy pipe
1/16" siezing wire
2" std. pipe & cap
Pressure chamber housing
6" extra heavy pipe cap
baffle on wire
sealed
¼" nipple
1¼" packing nut reamed and dressed to fit
packing
compression 5 lbs
rubber stopper
bicycle spoke
¾" plug drilled to fit
1/16" breather hole
Scripto pencil eraser
fluted
mercury
glass U-tube 13/16" outside - 11/16" inside
steel
easy fit
¾" plug
felt
spacer
ASSEMBLY of CHASSIS BLOCK & VALVE & U-TUBE
Scale ½" = 1"
Wood saddle
section A-A
3/8" steel rods screwed in chassis block above and shouldered for spacer
ASSEMBLY of PIPE CASING
Scale ¼" = 1"
Principal parts are brass unless otherwise specified.
ROBERTS TIDE GAGE — 1
E.B.R.


spring clip
rubber
1/4" nut
enameled wire - connects clock contacter - connects battery seat below
steel
2 - bicycle spoke guides
ASSEMBLY of RECORDING MECHANISM
scale 1/2" = 1"
Petterson meter clock
taper pin holds down brass plate
clock holding down screws
insulation
2 1/2 v. min. lamp
section of steel rod with set screw to hold camera
16 mm. pos. film
top of scale frame
hard rubber loose fit
semi-opaque celluloid scale - 5/16"
prism in holder
wire
hard rubber
spring clip holds battery
bicycle spokes
hard rubber
hard rubber guide fluted
paraffined cork
chassis block
1/4" holes on same layout as on chassis block
flap dished to hold battery
PLAN of TOP-SPACER PLATE
5/16" holes on same layout as on chassis block
battery wire hole - rubber bushed
PLAN of CLOCK-SPACER PLATE
prism in holder
11/32" holes on same layout as on chassis block
PLAN of CAMERA SPACER PLATE
stirrup
packing nut
1/8" valve hole
hard rubber battery seat
PLAN of CHASSIS BLOCK
scale 1/2" = 1"
ROBERTS TIDE GAGE - 2
EBR


COVER PLATE
CUTAWAY VIEW to show CONSTRUCTION
CAMERA BOX
SECTION A-A
DETAILS of CAMERA scale 1/2" = 1"
DETAIL of CARDAN RING scale 1 1/2" = 12"
DETAIL of PRISM ASSEMBLY full scale
DETAIL of INLET STOPPER full scale
COMPLETE ASSEMBLY
ROBERTS TIDE GAGE - 3
EBR

When finally assembled, the whole unit was protected by a pipe casing, so that nothing less than a very severe impact could possibly damage it.

Stopping down the pressure chamber end of the manometer required more experiment than any other part of the gage. A very small opening was needed if the reaction of the mercury column were to be delayed sufficiently to prevent objectionable errors due to wave action. It was considered necessary to hold the reaction within some amount in the order of a tenth of a foot of scale value during the period of passage of a long wave, while under a head of several feet of water. The opening to accomplish this was found to be almost microscopic, and it was thought that such an opening might easily become clogged. Small glass tubes were heated and drawn fine, approximating the desired result, but clogging occurred as feared. The final solution of this problem lay in the installation of a soft rubber stopper, wound vertically with a number of turns of very fine wire (40 gage, B. & S.). Many openings being thus provided, accidental clogging became unlikely, and the exact desired characteristic could easily be attained according to the number of turns. The mercury reaction, while thus well damped down, was found to be certain and positive, and the lag in indications was not great enough materially to affect the tide indications.

Scale: The scale was built up of a paraffined cork float, bicycle spokes, hard rubber blocks, and a semi-opaque celluloid strip upon which the scale was india-inked. The celluloid is that used for the plotting of air photography. The upper end block of the scale is a hard rubber yoke with two small drill holes fitting freely over a pair of bicycle spoke guide wires. The float was centered in its tube by a fluted hard rubber collar. At both of these contact points the friction is negligible. Recording being photographic, it is seen that no other mechanical load or contact is applied to the pressure indicating element, and the whole action is virtually frictionless. Repeated tests failed to disclose any observable lack of sensitivity in this indicating element.

Bicycle spokes were found most useful in the fabrication of such an apparatus. They were found to be stiff, straight, well polished, and rust resistant. The threaded ends were perfect for installing in the fittings.

The scale value was determined theoretically, then checked by laboratory test, and again by tide observation in comparative runs with a standard tide gage. Three factors determine the scale value. The specific gravity relationship of mercury and sea water predominates. The other factors are the slight change in pressure in the upper chamber due to rise or fall of the mercury column, and the change in effective water head due to the changing water level in the lower chamber. The latter are both variable with depth, so that any adopted scale value can be correct at only one depth. The scale was divided according to the theoretical considerations concerned for a depth of seven fathoms, and subsequent tests showed the adopted value to be correct within negligible limits. Theoretically the scale is not uniform throughout the scale length, but the distortion may safely be neglected. The correction to the scale readings for

depths other than seven fathoms has been computed, but not verified by test. This error amounts to one-tenth foot in ten feet range for each two fathoms difference in original depth of setting, the indicated tidal range being too great when the gage is set in the greater depths.

It is assumed the air temperature in the upper chamber remains constant at that of the surrounding water during the period of observation. If appreciable changes in water temperature occur, a sufficient number of temperature observations should be made to correct the record. It has been figured that a rise of one degree centigrade in the temperature of the gage will lower the scale reading about one-tenth foot.

It is not thought there are any other existing factors which can affect the accuracy of the indications given by the gage.

Clock: The construction of a clock motor to control the recording being impractical, recourse in this particular was had to a Petterson Meter Clock, a spare one being sent from the Instrument Division for this purpose. This was the only major part of the gage not constructed by the writer.

Camera: The camera was designed and built for the gage. No shutter was used, since the camera would be in darkness except at the moment of exposure, the length of which would be governed by controlling the length of flash. The camera was soldered together of sheet brass parts, a short-focus simple lens being installed in an adjustable holder. A black velvet pad glued on the cover plate insures a light-tight fit over the spool box. The cover plate carries a spring motor to wind the film and a train of gears so placed as to engage the spring barrel gear of the Petterson clock, which therefore acts as an escapement to control the rate of winding of the film. This mechanism was assembled from gears and parts found in a clockmaker's "odds-and-ends box." While entirely workable, this part of the mechanism is the least workmanlike of the entire gage.

Loading and unloading of the camera film, as well as development of the record, require a dark room, which may be illuminated by a common ruby safe-light. Eastman 16 mm. positive film, at 90 cents per hundred foot spool, makes a strong exposure with a one-second flash of the miniature bulb worked by two flashlight dry cells. The camera storage spool will hold about thirty feet of film, enough for about five days' record. The leading end of the film is attached to the hub of the winding spool by a small bit of adhesive tape. Development and fixing of the film are readily performed without special apparatus, using standard solutions available at all photo shops.

Casing: After the design proceeded far enough to indicate the necessary overall dimensions of all parts, a casing was specified, consisting of brass pipes and fittings. Through an error, extra heavy stock was purchased, an unnecessary extra expense. It was necessary, of course, to have perfect pressure-tightness, but the use of standard weight best quality red brass should be sufficient guaranty of this.

A small amount of machine work on the pipe was necessary, especially the cutting of true seats for the chassis block gaskets and the turning of machine threads for the working connections. The upper and bottom end caps, and the bottom reducer connection, were set permanently with red lead, leaving only two gasketed working connections. Experiment with different types of gaskets showed best results from thin wire-inserted rubber, smeared with white lead. The oil made it necessary to renew the rubber occasionally as it deteriorated rapidly, but the results justified this trouble. It is believed that a hand setting of these connections would have been perfectly air-tight, but to be safe stillson wrenches were always used.

The chassis block was machined from a short length of 5-inch rolled brass round bar. Extreme care was used to have the threads perfectly centered and aligned, as well as the foundation holes for the various parts fitted to this blocks. This was required to insure the necessary small clearances and the perfect fit required of the working parts.

The chassis block constitutes a partition between the upper and lower chambers. A valve permits air communication between these chambers, as shown by the drawing. The use of a rubber plunger in the valve resulted from repeated failures in the attempt to make a tight all-metal valve. The valve operated perfectly, tests showing no visible change in scale reading over periods of several days during which the valve held pressure in the upper chamber. The valve was designed to be held open during the lowering or raising of the gage by a lead weight hung by a wire from the valve stem. This weight was hung below the base level of the gage stand, so that contact with bottom would relieve the valve of this weight, permitting its spring to close it until the gage was lifted. Comment on the workability of this arrangement will be made later under "operation."

Frame for Working Parts: Assembly of the recording mechanism, comprising clock, camera, optical system, scale guide, batteries and wiring, was on a frame consisting of four steel rods screwed into the chassis block, holding three circular brass plates at different levels. The rods pass through the plates, being shouldered to hold them at the proper levels. The plates are 1/8" less in diameter than the inside clearance of the pipe casing; thus they act as spacers to guard the mechanism from contact with the casing.

Stand: The construction of the stand depended on the necessity of supporting the gage in an upright position. Cardan rings were built, carrying monel metal pins, the inner ring pins engaging two holes in the top cap of the casing. This gimbal arrangement functioned well. The tripod was all-welded of 1-1/2" galvanized steel angles. As built the whole assembly did not have sufficient weight to remain secure against overturning by the pull of a buoy, nor did the sharpness of the feet give assurance against settling in a soft bottom, so in practice various temporary arrangements of horizontal boards, bars, or other footing pieces, together with iron pigs for weight, were rigged. A lead weight of about twenty-five pounds was cast about the ends of three chains leading from the legs of the tripod, the slack in the chains permitting the weight to

hang about a foot below the plane of the tripod base. A ring in the lead weight permitted attachment to a wire from the stem of the equalizer valve, the connection being made short enough so the valve carried the full weight. The chains then acted as stays against swinging, thus preventing damage to the wire valve-pull, or the danger of the wire pulling the gage sidewise out of vertical.

Operation

The first working tests of the gage were in the water, but not under full working conditions. Suspended by wire rope from a dock, several perfect series of tide observations were obtained, two of which were checked, without consequential differences, against the record of a nearby standard tide gage.

On Georges Bank, for which use the gage had been built, occurred a series of mishaps which prevented the realization of any really complete records. These have been the subject of previous special reports in connection with the submission of the records, but the matter will briefly be recounted here for its experience value in handling the apparatus.

The first few attempts resulted in capsizing the gage, due to the difficulty of placing it on the crests of narrow ridges swept by powerful currents, and, in one case, insufficient precaution against the overturning effect of the buoy. The consequent spilling of the mercury lowered the available range of the gage so that in only two cases were even partial records obtained, and none in others, due to the record carrying beyond the end of the graduated scale. Extensive repair work was occasioned by these mishaps, including the necessity of dismantling and baking all brass parts to remove mercury amalgam.

In the first few attempts the speed of descent caused the water to exert sufficient lifting effect on the weight so it failed to hold the valve open. This caused unbalanced pressures which blew mercury out of the manometer, putting the gage out of operation. This was finally prevented by tying the valve open with sail twine, the tie being broken by a rip cord when the gage was seated on bottom. It was unfortunate that such complication was added to the handling of the gage; in fact, it was erroneously doubted beforehand whether such procedure could be carried out without fouling the necessary lines. In future designs this matter should be anticipated, the weight being so proportioned as to obviate trouble due to water lift.

Another unforeseen trouble which was not understood until late in the season was the wetting of the recording mechanism by water which entered the bottom inlet hole as a jet, carrying up and through the valve in the rush of air. This was corrected by placing a deflector plate or guard on the valve wire a short distance above the inlet hole, but not before the clock was so wetted that the mainspring corroded and eventually broke. Its replacement was difficult, but a new spring was eventually procured on special order from a spring manufacturer in Connecticut. By such time the season was so late that there was no further opportunity

to observe tides on Georges Bank. Two series, however, were taken in the vicinity of Nantucket Shoals, the first failing because of the high seas running at the time, insufficiently damped out of the record. This was before the development of the final method of damping the inlet branch of the manometer. The second of the two final attempts with the gage was a complete success, the first in the history of the instrument.

No additional troubles of great consequence were encountered, such minor difficulties as came about being concerned with poor adjustment or fit of the parts, these being corrected as noted. The final results indicated that all parts were in good and, it is hoped, permanent working order.

Conclusion

The gage described is admittedly a delicate piece of apparatus, requiring great care in its use to prevent the variety of possible troubles inherent in its design. Considerable skill and detailed knowledge of the present model are demanded by its construction imperfections, the necessity for which could undoubtedly be avoided in the case of a new model of more workmanlike character. An experienced instrument designer could undoubtedly improve the mechanism in many ways.

No thought is implied that this gage should supplant the present types of automatic gages, where such can be used; in fact, its use involves more care and greater chances for failure. This much may be said, however, that it can give results, and has done so, under working conditions which have proved themselves beyond anything else available for the work. In this particular it can be said to have proved itself uniquely successful.

Before ending this report, one suggestion is made regarding possible extension of the sphere of usefulness of the gage. It occurs to the writer that a gage employing the general principles described above, and especially the method developed in this gage for making the record, may be useful for tide observations on open beaches exposed to surf or elsewhere in places where it would be difficult to erect supporting structures to hold up the standard gages. The method of use contemplated would involve the setting up of the recording part of the gage on the beach or at any-convenient point away from the water, the pressure being brought to the gage by a flexible armored tube leading from a diaphragm or bladder which could be weighted and placed where desired in the Water.

* * * * * * * * * * *

OLD 79

The following is quoted from a letter of March 13, 1934, from J. S. Bilby, Chief Signalman, U.S. Coast and Geodetic Survey:

"Truck No. 79, Make, Chevrolet Sedan Delivery, Model 1929: passed the ONE-HUNDRED-THOUSAND-MILE-POST (100,000) 5:43 P.M., March 13, 1934, and going strong."

SOME NOTES ON TIDE OBSERVATIONS

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

Many of the field officers engaged in hydrography are inclined to look upon their tidal observations as secondary to the major operations of their party. Consequently, there is too infrequent inspection of the tide gages or too little time spent in their installation. This probably emanates from a belief that results thus secured will be of sufficient accuracy for the reduction of soundings. However, as stated in a previous article in Bulletin No. 6, page 10, the subject of tides is a far broader field than the reduction of soundings. The proper installation and running of a tide station is no inconsequential matter, but is of importance in the party management.

It will not be amiss, therefore, to quote from a report to the Superintendent of this Survey dated September 6, 1854, by Lieutenant W. P. Trowbridge, Corps of Engineers, assistant in the Coast Survey, while engaged on tidal surveys of the Pacific Coast:

> "It has been a source of much regret that I could not have devoted more time to preparations for my new duties before leaving Washington; for, as I anticipated, experience here is costly, both in time and money. It seems a very simple task to make correct tidal observations; but, in all my experience, I have found no observations which require such constant care and attention."

This statement is still true. Tide observations must be carried on in exposed localities where in most cases the weather conditions are severe for precise recording instruments. Records of precision under adverse conditions can be obtained only by the exercise of more than ordinary care.

Improvements have been made in gages since Lieutenant Trowbridge wrote his report, but they still have a tendency to go out of commission soon after a visit to the station by the wire breaking or the pencil screw sticking, et cetera. Extreme high or low waters are lost by the failure to keep the ends of the screw as clean as the middle, or by a speck of sand jamming the pencil screw at a critical time, thereby stopping all recording of the gage.

The portable gage with all its advantages over the tide staff and in certain localities over the standard gage must be frequently inspected. Its portability does not relieve a chief of party of frequent inspections to see whether a proper record is being made. Marigrams have come into the office where gages have been left unattended so long that the clocks had stopped, and it was impossible to accurately interpret the curve.

The float well in both types of gages frequently becomes clogged without this condition being noted by the observer and corrected.

Progressive smoothing of the curve is indicative of a clogged condition. To be certain that the hole is not becoming clogged, the well should be cleaned at least once a month, and oftener if the intake of the float well is close to a muddy bottom.

The time used in the observations should be clearly and accurately stated, and the chief of party should know definitely in the case of staff readings at a subordinate station that the observer is using the time meridian he says he is in the record. This is especially troublesome in localities where daylight saving time is used, while the party is being run on regular standard time. There is no way to check back on this and the time difference between a standard station and a subordinate staff station may be in error by one hour.

In the supervision of a tide station the adequacy of bench mark connections should not be overlooked. As it is only through the bench mark connections that the tide planes derived are preserved for future use, a sufficient number of bench marks should be established in carefully selected localities. Descriptions should be clear and complete as to number and location so that they can be found by others with a minimum of trouble. Level connections between bench marks and tide staff should be carefully made at such intervals as necessary to assure stability of staff. A perfectly operating gage will not serve its full purpose if the record cannot subsequently be accurately referred to bench marks.

With the increased number of tide records now being received in the office, it is of great importance that all records be marked so that the station and party can be identified. Especially in the case of the portable gage records, each sheet should be marked with the name of the station and party, as the individual sheets sometimes become detached and are difficult to identify. Tide records should also be accompanied by a complete report of tide station on Form 681. This form should be submitted for all stations whether standard or portable gage or plain staff readings.

There is no doubt that with all the difficulties encountered in tidal observations, a chief of party should realize, as Lieutenants Trowbridge found, that to obtain accurate observations, constant care and attention will be needed.

. . . . . .

A standard tide gage has recently been received from one of the field parties. Upon overhauling this gage, the Instrument Division found that the ball bearing of a pencil screw was jammed on account of using a lubricant that solidified into a hard soapy mass. No gage can be expected to properly record tides under such treatment. Vaseline only should be used as a lubricant for these bearings.

THE PREPARATION OF BENCHMARK DESCRIPTIONS

E. S. Rappleye, Mathematician, U.S.C. & G. Survey

After all of the field and office work of geodetic leveling has been completed, there are just two things that are of real use, aside from possible scientific by-products which need not be considered here.

1. The bench marks themselves.
2. The published descriptions and elevations which enable engineers and surveyors to find and use them.

All of the details of setting the marks, the observing, computation, adjustment, publication, etc., are merely a means to an end - the marks and their published descriptions and elevations. Obviously, no matter how permanent a bench mark may be, if it can not be found when it is needed it might as well never have been established.

At first thought it might seem to be a very simple task to so describe a given bench mark that a stranger might, when given the published description and elevation, find and make use of it. However, it has been the experience of the writer, in handling some thousands of benchmark descriptions, that description writing is not as simple a matter as it seems from a merely casual consideration of the subject.

In general, a good description should lead a person from some place with which he is familiar, or which he can locate without any aids other than those available to all, gradually and by properly ordered and easy stages to the immediate locality of the mark. Having been led to a point from which the mark, if still in place, is visible, he should then be told exactly what to look for, in order that the mark may be positively identified.

Practical considerations, in publishing descriptions of bench marks, which must be taken into account are as follows:

1. The description should be as brief as possible without sacrificing clearness or the possibility of recovering the mark.

2. Sketches can not be used except under the most unusual conditions.

3. For the sake of uniformity a more or less standard form must be followed.

4. The descriptions must be readable and not written "telegraph" style.

5. Only generally accepted abbreviations should be used.

6. The order in which the various items in the description are arranged should be such as to lead a person trying to recover the mark to the desired spot with as little lost motion as possible.

Accuracy and clearness in the original descriptions are the prime requisites. The office personnel can rearrange and edit a clear and accurate description with little trouble, but if inaccuracies or ambiguities are present in the original description the editor's lot "is not a happy one."

Description writing is not a hard-and-fast routine. The character of the description will vary greatly with the character of the mark, its location and the abundance or scarcity of natural or cultural objects to which it can be referenced. A description of a mark located in the Union Station at Washington, D. C., would be a very different affair from the description of a mark located in an outcrop of rock alongside the trail up Mt. Whitney. To describe a mark in a public park in a city requires a very different sort of treatment than is best for the description of a mark in a field beside a railroad many miles from the nearest station or town.

The use of Form 638 for the description of bench marks has greatly improved conditions by providing blanks to be filled in with certain types of information which are required for all descriptions. It is in the detailed description, which varies for each mark, that most of the difficulties arise. Some comments on the proper use of Form 628 will probably be useful in improving the quality of the bench mark descriptions prepared in the future.

On the first line of Form 638, after the words "Designation of bench mark," should be filled in the letter and number assigned to the mark in accordance with instructions contained in paragraph 31 of the General Instructions for First-order Leveling (p. 8, Sp. Pub. 140). In the case of monel-metal rivet bench marks, special instructions call for designating them RV 1, RV 2, RV 3, etc., in the order in which they are encountered along the line. They are numbered from 1 in each state as the work progresses. The number of the starting bench of each class in each state in which a party is to work is given in the instructions for the project. Bench marks of other organizations should be designated in accordance with the practice of the organization which established them and not be assigned designations in our series of numbers. The designation used on Form 638 should also be used in the records and computations to avoid confusion.

The entries giving the state and county on the first-line of Form 638 should be the state and county in which the bench mark is located.

On the second line the nearest town is entered and the county name on the second line should be the name of the county in which the town (not the bench mark) is located. In the rare cases where the bench mark is in a different state from the nearest town the name of the state should follow in () the name of the county in which the town is located.

After the words "Distance and direction from nearest town" should be entered the distance and direction from the town to the bench mark. Do not give the direction from the mark to the town. Inasmuch as a town

is usually of considerable size, the distance and direction can only be given approximately. Ordinarily no attempt should be made to give the distance from the town closer than the nearest tenth of a mile and the directions need only be given to the nearest half quadrant, i.e., N., N. E., E., S. E., etc. Where possible the route along which the distance is measured and the point of departure should be given in this item. The form of the note should be somewhat as follows:

"2.4 miles N. E. along U.S. Hy. 101 from courthouse" or "3.7 miles E. along B. & O. R. R. from railroad station," etc.

Under the heading "Detailed description of location" should be entered the details concerning the location of the marks which are not given in the blanks provided on the form.

Generally the tendency of a man in the field is to write the description "backwards." In other words, he is standing at the mark and the nearest reference objects are noticed first and the more distant ones later. He usually writes them down in this order. The person searching for the mark usually wants the longer distances first and the minute details later. Of course, the relative order of the items can be changed in the office but this requires an immense amount of extra work where thousands of descriptions are being edited for publication.

An example of an actual description as written in the field and as edited in the office may serve to illustrate this point. The card as it came in from the field was, as nearly as can be reproduced here, as follows:

Designation "N 5" State "Maine," County "Cumberland,"
Nearest town "Scarboro," County "Cumberland,"
Distance and direction from town "In town"
Detailed description of location

"Vertically 2 feet above ground in retaining wall, 3 rail lengths north of bridge 119 and just north of railroad station at Scarboro, and 7 feet east of east rail. Western Div. B. & M. R. R."

Character of mark "Tablet set in wall."
Established by what organization U. S. C. & G. S."
Chief of party_____, Year "1923."

An edited version of the above description arranged in form for publication would be substantially as follows:

"N 5.- At Scarboro, Cumberland County, Maine, on the right of way of the Western Division of the Boston & Maine Railroad, just north of the station, 3 rails north of bridge 119, 7 feet east of the east rail, in the face of a retaining wall, and 2 feet above the ground. A standard disk, stamped "N 5 1923" and set vertically. (_____meters or_____ feet.)

To go into detail regarding the above description, there are two points of uncertainty:

1. Is the mark set in the face or top of the wall? We lean toward the notion that the disk is set in a vertical position in the face of the wall because of the use of the word "vertically" and the absence of a statement that it is "in the top of the wall."

2. Was the disk actually stamped "N 5 1923?" We assume that it was since instructions call for stamping the designation and year of establishment on the disk. Sometimes, however, for one reason or another disks are left unstamped and unless the original description covers the point we may publish it as stamped when it is not.

Obviously the order in which the items are arranged is better in the edited version than in the original, at least from the viewpoint of a person trying to locate the mark from the published description.

Under the item "Character of mark" should have appeared, in the above example, the entry "Standard disk, stamped 'N 5 1923,'" if it was actually so stamped. All details as to <u>where</u> the mark is and the position in which it is set should appear in the paragraph of detailed description.

<u>What</u> the mark is and any identifying marks upon it should come under the heading "Character of mark." Had this been a standard disk of the U. S. Geological Survey the designation might have been "129 (U.S.G.S.)" and the character of the mark might have been "U. S. G.S. standard disk, stamped '129.'"

A few additional points, listed somewhat at random, may serve to stimulate thought on the details of description writing:

Long distances or distances from towns or other rather indefinite places should, in general, be given to the nearest tenth of a mile together with the route along which the distance was measured.

Short distance should be given in suitable units, such as poles, rails, yards, feet, etc.

Measured distances should be given to the nearest tenth of a foot if they are measured from some sharply defined object, such as a rail, the edge of a concrete pavement, the face of a building, etc. Distances measured from trees, poles, and other objects where no sharply defined point is available from which to measure should usually be given to feet only though 1/2 foot may be used to advantage at times. Paced distances should be given in yards and distances determined by counting poles or rails may be given in l/2s or l/4s, but a finer subdivision of the rail or pole unit is rather fictitious accuracy.

In giving distances which are measured to the nearest tenth of a foot, use feet and decimals. If distances are not measured closer than the nearest half or quarter of a foot use fraction instead of decimals.

The last decimal place or fraction in the recorded length should be a clue to the accuracy of the measurement itself.

The possibility that the mark may be covered over by a fill, overgrown by weeds or brush, or otherwise obscured, should be kept in mind in writing the description. Usually, where it is at all possible, at least two references should be included which are of such character as to permit of so nicely locating the mark that extensive digging or search through tall grass and weeds will not be necessary.

Care should be used in selecting reference objects, where more than enough are available, so as to use in the description those that are most permanent. Directions to reference objects from the bench mark should not be given. It is better to give the direction from the reference object to the mark itself since that is the information desired by the person searching for the mark.

Because of the fact that, after the mark is set, the disk is all that is visible to the person recovering the mark, it is better practice to refer to the mark as a standard disk. A disk set horizontally (shank vertical) is the normal position for a bench mark disk and unless otherwise noted in the description they will be considered as having been set so that a rod can be held on the top of the disk. A disk set vertically (shank horizontal) in a vertical wall should be noted as having been set vertically since it is the more unusual position.

Unusual marks are often tied in and for these extra care should be taken to so describe the mark that a person entirely unfamiliar with the mark may recognize it and be able to make a positive identification of the point on which the rod was held.

It is obvious that a description, to be useful, must be clearly and accurately written. The leveling is of no value if the marks can not be found. This thought should be kept in mind by all chiefs of leveling parties and be impressed thoroughly on the minds of all subordinates who have to do with preparing descriptions of bench marks.

* * * * * * * * * *

ANOTHER STRAW

In time not so long ago, one of our triangulation parties at work in a section of the western mountains had occasion to hire a new lightkeeper. After a careful and concentrated training in the matter of centering his light and the use of the signal code, this new lightkeeper was sent to a mountain station. His light appeared on schedule, and the observing party completed three other stations of the quadrilateral without failure on the part of the new lightkeeper. Arriving at this station, the chief of party congratulated the lightkeeper on his faithfulness, and proceeded to observe. On completion of observations, the triangles involving the station failed to close by a matter of minutes. After questioning as to how carefully he had centered his light, the cow-puncher lightkeeper said, "Say, I could see you fellers from my cabin over there, so I jest showed the light out of the window."

NOTES ON MARKING TRIANGULATION

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

The essential parts of the specification for stations and reference marks now in use are given in the "Manual of First-order Triangulation", Special Publication No. 120, pages 20 to 24. No concrete block or post should be less in depth or cross-section than that given in the specifications.

In general, when material can be transported directly to the station the concrete mark is made larger in diameter or cross section than that given in the specifications.

The procedure in making the concrete mark is as Follows: A hole is dug to a depth of 3-1/2 feet or more. It is 18 inches square to a depth of 2-1/2 feet, then 10 inches square for one foot in depth. Concrete, made of good cement, sand, gravel or broken rock, is placed in the lower part of the hold to a depth of 6 inches. The concrete is smoothed with a trowel and a tablet station mark is then set in the center, with the top of the tablet flush with the concrete. A board is then placed over the lower hole to prevent disturbing the underground mark when pouring the concrete for the surface mark. No dirt or sand is placed on the underground mark between the mark and the board covering the hole. This completes the underground mark. The upper hole is then enlarged about 2 inches on each side near the bottom in order that the lower end of the block of concrete for the surface mark will be mushroomed, and then the hole is filled with concrete to within 9 inches of the surface of the ground. Next a mold or frame, 12 inches on a side at the top, 16 inches at the bottom and 12 inches in depth is set in the hole on top of the concrete. The center of the frame or mold should be centered over the underground mark, dirt is then filled in around the outside of the frame and tamped to prevent any movement, the frame is then filled with concrete to one inch above the top of the frame. The top of the concrete block is smoothed with a trowel and the edges beveled. The top of the concrete block is about one inch higher at its center than it is at the sides. A standard tablet station mark is then set in the center of the concrete with the top of the tablet flush with the surface of the concrete, the tablet is carefully centered over the underground mark. When finishing the top of the concrete block with the trowel, if the mixture is too soft and water comes to the surface, sprinkle dry cement over the top of the concrete and smooth it with a trowel until the excess moisture has been absorbed. To avoid cracking of the concrete, due to too rapid drying, it should be covered with a paper or cloth cement bag and then with earth for a period of 48 hours.

The mold or frame for the surface mark may be either square or round. The molds can be made of galvanized sheet iron. Square frames can be made of 12-inch boards if preferred. No mold should be less in diameter or depth than that given above.

Each reference mark should be set under the same conditions as specified for the surface station mark, except the concrete block may be 2 inches

smaller in diameter and 6 inches shorter.

All tablet station and reference marks must be stamped with the name of the station and year established before they are set in the concrete blocks. At stations established in school lots, church lots or other places where the grass may be cut by machine the mark should be level with the surface of the ground. If the station mark, due to surface conditions, is entirely beneath the surface, small pieces of glass, crockery, tile, etc., should be mixed with the dirt covering the mark.

The bits of glass, china, crockery, etc., should be about 1/2 inch to 2 inches in diameter. A supply of old broken articles can be picked up near any city or town where the trash, garbage, etc., are dumped.

Due to the fact that local road rights of way are being made wider, corners at crossroads and intersections are rounded to do away with dangerous square corners and property lines are often changed. All this makes it difficult to establish reference marks that will not be destroyed in the near future. Therefore, in addition to the regular established reference marks, actual measurements should be made from land section lines, half section lines, center of county or state roads or permanent objects to the station. When such measurements are made over rough ground with up and down slopes, the measurement should be made from the object to the station with a 300-foot tape and no correction need be made for grade. Land section lines are by far the most permanent reference marks that can be established and it requires very little time to make such measurements though the distance may be half a mile or more. The points on section lines from which the measurements are made should be as nearly as possible 90° or at right angle from the station. If the measurements are made from objects other than section or half-section lines the magnetic bearing from the object to the station should be given.

Mr. Mussetter recommended iron pipes to be used for marking stations on the sand dunes in Michigan. I am in full accord with his recommendation and I recommend the iron pipe should be used on the sand deserts and at all stations in sand drifting regions. The iron pipe should be 4 inches in diameter, filled with concrete and the tablet station mark set in top of the pipe with the top of the tablet level with top of the pipe.

Where a station is established within reasonable distance from a concrete or brick paved highway, one or more tablet reference marks should be set in the pavement opposite the station. They should be about 12 inches back from the edge of the pavement, and the top of the tablet should be flush with the concrete or brick. A measurement should be made from the reference mark to the station and the direction observed. The angle from the tangency of the pavement to the station should be about 90°. If the reference mark can not be seen from the top of the tower the magnetic direction should be given. Such reference marks will remain until the pavement is worn out or torn up and from them the stations will be easily recovered.

RECOVERY NOTES FOR TRIANGULATION STATIONS

(Circular Letter to Chiefs of Parties dated June 5, 1933)

A number of recovery notes for triangulation stations recently received from the field are not complete. They state that the old station was recovered and remarked, also that additional reference marks were established, but no description is given of the new station or reference marks, which is absolutely essential if the station is to be of maximum use to the public. The recovery note should state definitely what old marks are recovered, how the station is remarked and what new marks are established. It is not sufficient to say "recovered as described" unless the station is of recent establishment and the description is correct. Many of our stations are old and the descriptions do not fit them. In such cases complete new descriptions should be written on the recovery note card. For the stations which have been recovered several times, a complete new description is necessary in order to combine the original description and the various recovery notes so as to give a true description of the present condition of the station sufficient for its recovery without any doubt.

It would seem that the best procedure would be to have a complete description made of each station visited just as if it were a new station. Then it would not be necessary to refer to original descriptions or former recovery notes and a considerable amount of effort at this office would be saved.

Sometimes the recovery note states "recovered as described by the reconnaissance party." The reconnaissance descriptions are written for the use of the observing party only and are rarely a proper description of the station and reference marks. Furthermore, it should not be necessary to go back to the reconnaissance descriptions in order to obtain a complete description of the station. In other words, the observing party should furnish a complete description of every station, new and old.

Stations established by other bureaus, such as the U. S. Geological Survey, U. S. Engineers, U. S. Lake Survey, General Land Office, etc., as well as state and county boundary monuments, to which connections are made, should be described as new stations and not as recovery notes. The initials of the bureau which established the station should be placed in parentheses after the name of the station (U.S.G.S.) (U.S.E.). The description should be complete for usually the descriptions by the other bureaus are not on file in this office. It should be clearly stated what old marks were found, whether the station was remarked and how, and what additional reference marks were established. The description should also state whether the old station was used as one of the stations in the new scheme or whether a new station was established nearby and connection made to the old station by measured distance and azimuth.

STATION MARKS

St. Petersburg, Florida,
February 26, 1934.

Memorandum for the Director,
U. S. Coast and Geodetic Survey.

If you will pardon me I would like to comment on the method used in marking your stations along the Indian River in accordance with NOTE 6a.*

My experience over the last three years with the monument markers placed according to this method leads me to believe that it is a mistake to place this type of a marker close enough to the shoreline where even the highest tides can reach them. The very setting of the tile seems to so loosen the soil as to enable the waves to take hold. If not replaced soon, practically all the markers placed by your department along the Indian River during 1930 will be destroyed, excepting those which I have already rebuilt.

Our Department is experiencing the same trouble with markers set after this method during years 1930-32 with the exception that we have two reference markers for all station markers which enables one to recover original.

(Sgd.) Alfred P. Lund,
Chief of Party,. U.S.E.D.

*Note 6 - A standard bronze tablet set in concrete at the center of the top of a tile (a) which is embedded in the ground. (Ed.)

Comment by Casper M. Durgin, H. & G. Engineer

Mr. Lund apparently believes that these markers were more subject to loss because they were set in tile, thus loosening the soil and allowing the waves to take hold. This may be true, but I do not believe that a marker of any type will last long in any soil subject to erosion from waves and current.

Investigation of the descriptions of stations showed that these tile were 4" in diameter (and probably 2 feet in length). I do not believe that any other type of mark of the same size would have lasted any longer under the same conditions.

I have set concrete filled 12" x 36" tile in marshy ground with 16-foot "two by fours" in the center of each mark. Tile were used primarily to keep dirty and muddy water from mixing with the freshly poured concrete and to serve as a form above the surface of the ground. Similar forms of sheet metal could be used.

TIDAL OR SEISMIC SEA WAVES

N. H. Heck, Chief, Division of Terrestrial Magnetism
and Seismology, Coast and Geodetic Survey.

A recent compilation of so-called tidal waves or seismic sea waves from the earliest records, to the present has been prepared by the writer. This was done in part to meet the needs of the naval and merchant navigator for more information on the subject and, in part, as a contribution from its American Committee, of which the writer is chairman, to the International Commission on Raz de Marees of the International Geodetic and Geophysical Union. The American Committee, on which is represented the Hydrographic Office of the Navy, the Weather Bureau, Johns Hopkins University as well as the Coast and Geodetic Survey, is organized to see that such information regarding present day occurrences is now collected and sent to the Commission.

The complete list will be published in the Annals of the Commission, but this will not interfere with giving pertinent facts to the field force of the Coast and Geodetic Survey.

Of a total of 224 such waves from 425 B. C. to 1934 A. D., 76 occurred in waters of the Americas, records concerning which did not begin until 1530. On the shores of the United States and regions under its jurisdiction, there are listed 4 in California (none apparently important), 5 in Alaska, 5 in the Philippine Islands, 1 in Panama (slight), and 2 in Puerto Rico and the Virgin Islands.

The greatest known height ever recorded was 135 feet in the case of the wave from the explosion in 1883 of Krakatoa on the adjacent Java shore. Buildings, 47 feet above sea level, were washed away. At another place the wave was 72 feet high and the Dutch man-of-war BEROUW was carried 1.8 miles up a valley and left 30 feet above sea level. Waves 100 feet high have been observed both in Japan and Chile.

In addition to the case mentioned, many kinds of vessels have been thrown ashore or jeopardized. The list has included Malay proas, Spanish galleons, Russian men-of-war, merchant vessels, and U. S. naval vessels. Three naval vessels have been involved in such occurrences. The U.S.S. DeSOTO lost her propellor at St. Thomas by striking against a wharf and the MONONGAHELA was driven ashore at St. Croix. In the same year, the U.S.S. WATEREE was driven far inshore along the northern coast of Chile.

Recent occurrences of interest have included a series of waves at intervals over a period of 27 days on the west coast of Mexico not far from Acapulco; a wave from the Grand Banks earthquake of 1929 which swept up narrow inlets in Newfoundland and destroyed several villages; and the great Japanese wave of 1933 on the northeast coast of Japan which rivaled any of the many similar occurrences in this oft-visited region.

A wave which caused damage in a region where a number of the vessels of the Survey have been at work was that accompanying the earthquake of 1918 which severely damaged Mayaguez, Puerto Rico.

In many cases our tide gage records, particularly those on the California coast and the Hawaiian Islands, have been an important source of information as to whether a given earthquake was accompanied by tidal waves, especially in such regions as the outlying portions of Oceania. Observation of the waves by persons competent to report them is often missing. As recently as 1926 a wave which severely damaged Palmerston Island did not become known for three months.

The records indicate that in the vast majority of cases there is a withdrawal of the water first, though the opposite has been observed. It must be remembered that observations are usually made under conditions of severe mental stress, and this must be taken into account in appraisal.

ANOTHER USE FOR GEORGES BANK SURVEY DATA

(Extract from a letter to the Director, U. S. Coast and Geodetic Survey, from the Western Union Telegraph Company, New York City)

The extensive sounding operations carried out by the Coast and Geodetic Survey on Georges Bank during the last three years have a special interest for us.

One of our submarine cables (the 1889 No. 1 Hammel-Canso) was laid on the continental slope on the southern border of Georges Bank; another cable (the 1869 Duxbury-Canso) lies along the northeastern border of the same bank. Both cables have been broken repeatedly in the past in these localities.

Assuming the cause to be in part the configuration of the bottom, we are interested in having all the information obtainable on the subject.

As far back as 1925 one of our cable ships undertook wire and sonic sounding operations in this locality, the results of which are shown on the attached blue-print of the diagrammatical sketch and which indicate that the southern slope of Georges Bank has the same broken configuration as the eastern slope.

We have a copy of U. S. Coast and Geodetic Survey Chart 1107, published in December, 1931, and U. S. Hydrographic Office Chart 941, 120th edition, September, 1932, and would appreciate it if you could supply us with any more details on soundings taken on the borders of Georges Bank in order to incorporate them on our working charts of the cables.

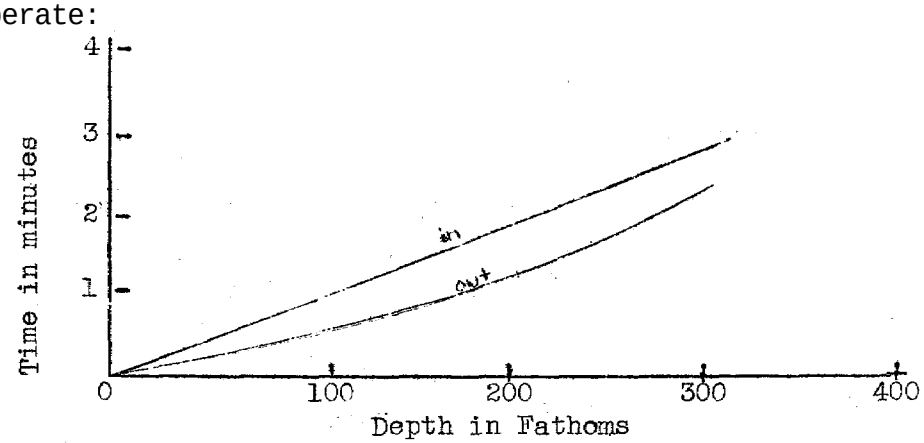
GASOLINE DRIVEN SOUNDING MACHINE

R. W. Knox, H. & G. Engineer, U.S.C. & G. Survey.

This party has made extensive use of a gasoline-driven sounding machine assembled by members of the party. The engine, a Novo Roller, Type KU, 1200 RPM, proved to be very satisfactory, much more so than the one furnished the previous year. The engine will throttle down to a very slow speed and still run without missing or coughing; it is powerful enough to heave-in a 36-pound lead at all depths encountered; it occupies very little deck space and is well adapted for connection to the type of sounding machine furnished; it is very nearly vibrationless and noiseless; it is economical in operation, using but 0.2 gallons of gasoline per hour; the cooling system is efficient, the amount of water necessary being approximately two gallons per day.

The engine and sounding machine were connected end to end, a platform being built so as to raise the latter to the height of the former, and such that the center of the shaft of the sounding machine was directly above the shaft of the engine. This arrangement made the assembly compact and reduced to a minimum the danger of catching fingers and clothing between the chain and gears. The largest gear ratio that could be used conveniently was 5 to 1; a 12-tooth gear was the smallest obtainable for the driving shaft, and a larger one than 60-tooth for the driven shaft would have made the assembled machine cumbersome. At this ratio the engine can be made to run slow enough so that the leadsman can properly control the lead near the surface of the water.

The following graph shows the speeds at which a 36-pound lead was founds to operate:



The brake and clutch of the sounding machine operate satisfactorily with the exception of the ratchet arrangement designed to set the brake. In this there is so little "give" to the parts, and although the grooves in the rack are close together, it was found that often the brake handle could not be pulled back far enough to set the brake securely. It is believed a hand wheel, with a knob on it, running on a threaded rod and the whole so arranged that the turning of the hand wheel would cause the brake shoe to come fast against the brake drum would be a satisfactory and simple way of securing the machine between soundings. This arrangement would in no way interfere with the present position or use of the handle.

With the sounding machine on the port side of the launch, and the leadsman facing forward, it was necessary to rebuild the counter sheave in order that it would run forward with the paying out of the wire. This was done by replacing the shaft of the counter with one long enough so that the pinion gear would engage the larger gear on the opposite side, thereby driving the counter in contrary motion. It is suggested that all counter sheaves be made with a longer shaft such that the pinion gear can be set to drive the counter either way; the sheave could then be used either on the starboard or port side, with the leadsman facing forward or aft.

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EXAMINATION OF CHARTED SHOAL AREAS

(Notes on examination of charted shoals prepared in connection with review of Hydrographic Sheet No. 5343 (Hudson River), reviewed by A. L. Shalowitz, Cartographic Engineer, U. S. C & G. Survey)

In connection with the additional work recommended on this survey, it is desired to emphasize the need for field parties making complete examinations of charted shoals when they fall within the limits of their work. The impression seems to prevail among some of the field officers that as long as the new survey verifies the existence of a charted shoal, although not necessarily the depth, it is a sufficient examination. This is hardly a justifiable conclusion. An attempt is being made to modernize our charts with good basic surveys. These charts of necessity contain information from a variety of sources, such as reports of vessels grounding, shoal depths obtained, reports of breakers, etc. Many of these may be of doubtful accuracy and reliability, but as a matter of policy they must be added to the charts.

And even in the case of our own old surveys, it should be borne in mind that many of these were made during a period of evolution of both field and office practices. Field methods were frequently below present standards and control was sometimes insufficient, making coordination with later well controlled surveys difficult. In the office, too, these old surveys did not receive the close examination and scrutiny that survey sheets of to-day receive, with the result that later investigations frequently disclose erroneous interpretations or application of the original data.

It is therefore imperative that all charted shoals, and particularly those of navigational importance, should be fully examined in the field with a view to verifying or disproving, as far as practicable, their location and depth.

The wire drag is of particular value in these examinations. It should be used for two purposes: First, to prove the existence of the shoal and determine the correct depth, and second, to sweep the shoal area with a clearance of not over two feet.

GASOLINE DRIVEN SOUNDING MACHINE
ANOTHER TYPE

From Special Report of G. C. Jones
H. and G. Engineer, U.S.C. & G. Survey

The principal features of the outfit are: Quietness of operation, low cost, and simplicity of installation. The quietness was obtained by using a triple V-belt drive. No muffler was needed for the exhaust except piping it to the rail. The belt showed no tendency to slip (as was feared might be the case when it became wet). Due to the triple feature, no idler pulley was needed. The total cost of the engine, special triple pulleys, V-belts, lumber and material for mounting with the sounding machine, one spare block for fairlead, and labor for mounting was $96.00. The installation on the launch was made by the party hands at a cost of about $2.00 for lumber, bolts and nails.

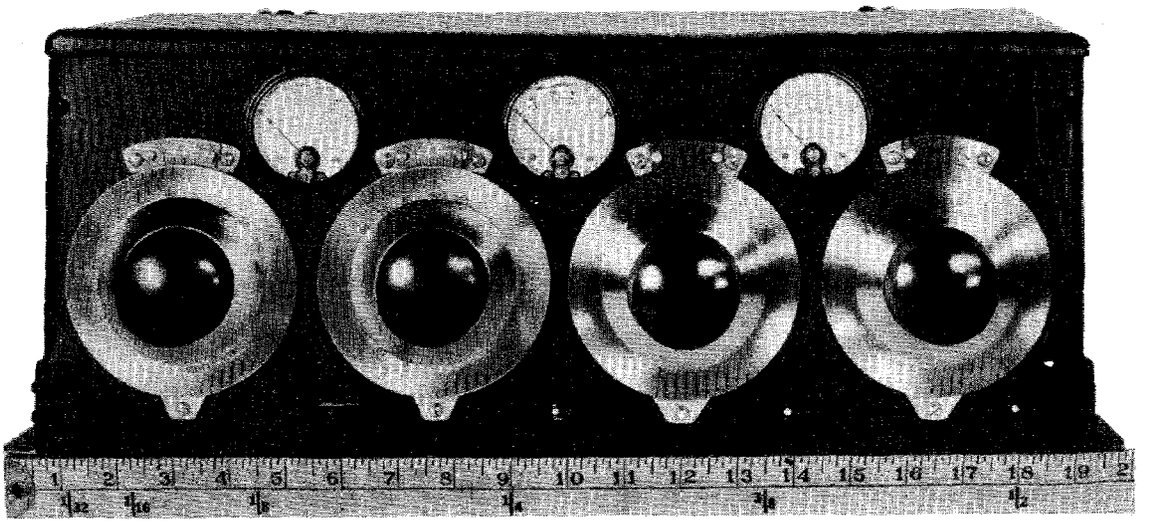
The drum of the sounding machine required two turns per fathom of sounding wire, and in order to haul in at 125 fathoms per minute, 250 r.p.m. on the sounding machine was required. On the 1-1/2 h.p. Fairbanks-Morse stationary engine used, the cam shaft can, if desired, be used for the drive. Its speed is 750 r.p.m. so that a 3 : 1 ratio of pulleys was required. The Fairbanks-Morse Company supplied the grooved triple pulleys and belts and fitted the pulley to the cam shaft. The machine shop, through which the purchase was made, fitted the pulley to the sounding machine and mounted both on a 3" x 12" x 3' 8" plank. The engine was mounted with slotted strap irons to permit tightening the belts. Approximate dimensions of the assembly as shown are: Height 19", width 12", length 3' 8". A simple frame for carrying fairlead and registering sheave and fastening to deck completes the installation.

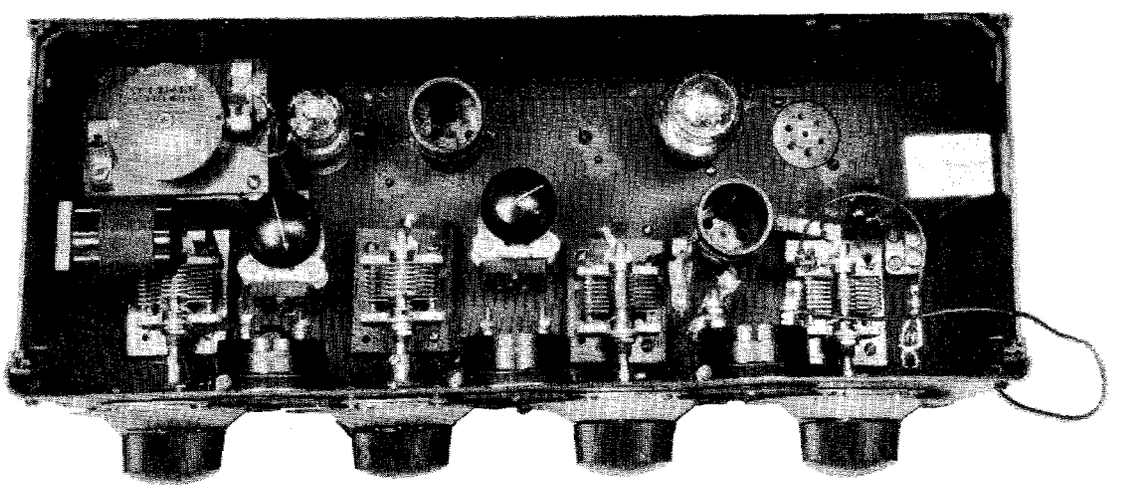
The 1-1/2 h.p. engine used is amply powerful at moderate depths. At 150 fathoms, using 30 pounds or heavier lead, and launch going full speed ahead, it becomes rather slow. The machine, as assembled on the 40-pound plank described, weighs 350 pounds, permitting handling by two men.

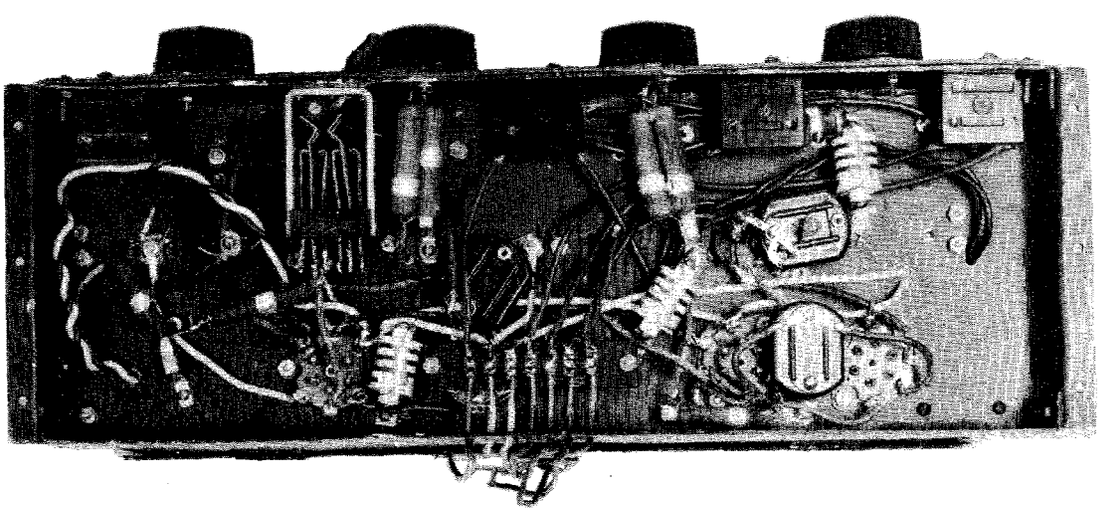
Material required:

1 power sounding machine as furnished by office.
1 Fairbanks-Morse 1-1/2 h.p. one cylinder stationary engine, style D.
2 cast iron triple groove pulleys, 2" wide; 1 - 3" diameter, 1 - 12" diameter.
3 V-belts, about 60" each
1 piece pine 3" x 12" x 3' 8"
2 pieces pine 2" x 12" x 3' 9"
4 pieces strap iron 1½" x ¼" x 16", 2 slotted
6 1" pipe washers
1 dozen 1/2" bolts, various lengths.

Total cost, including all material, machine work and assembling, but not including cost of sounding machine, $96.00.







PORTABLE R.A.R. TRANSMITTER WTFS

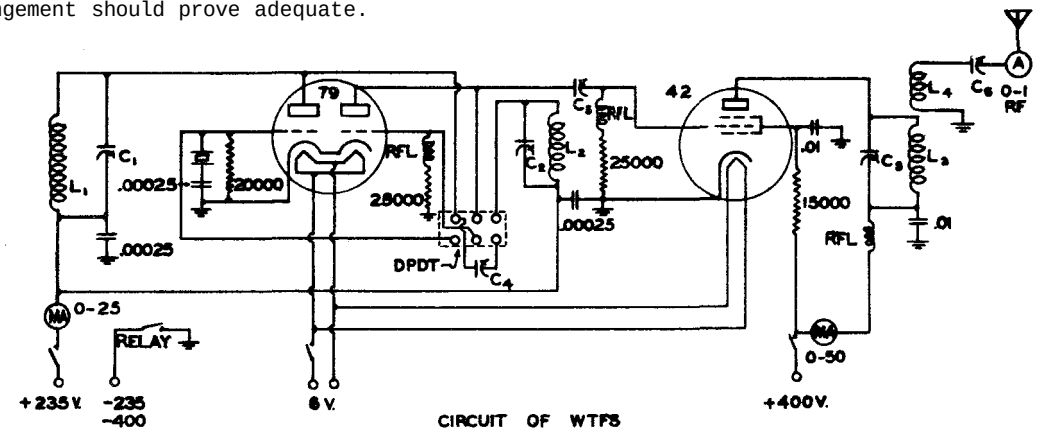
A PORTABLE RADIO TRANSMITTER OF UNIQUE DESIGN

Dr. Herbert Grove Dorsay
Principal Electrical Engineer, U.S.C. & G. Survey

The need for a compact portable radio transmitter with facilities for making a quick change from fundamental frequency to second, third, or fourth harmonics resulted in the circuit shown in the accompanying diagram.

The crystal oscillator is one half of a type 79 tube. The other half of the tube can be made to act as a doubler, trebler, or a multiple second tube on the fundamental frequency merely by changing the double-pole double-throw switch on the panel. There is no neutralization required in any of the stages. There are four toggle switches showing at the base of the panel. From left to right, they are:

1. Switch for auxiliary heater coil under the crystal mounting. This feature was provided to enable a small change in frequency to be made when both hydrographic stations are operating on the same frequency, and it is desired to make a slight change in frequency of either station for matching. It may be advisable to install a thermostatic control later, but the present arrangement should prove adequate.



CIRCUIT OF WTFS

Coil Data			
Freq. kcs.	4135	8270	16540
L_1 (turns)	26	26	26
L_2	10	6	4
L_3	30	10	4
L_4	15	6	4

All capacities shown in µfds.
All resistances shown in ohms.
C_1, C_2, C_3, C_4, C_5, C_6 all .00001 µfd.
All coils wound with No. 16 enameled, c.c. wire on 1-1/2" diameter forms, no spacing between turns.

2. Double-pole double-throw switch. With the handle to the right as in the photograph, the two halves of the type 79 tube are acting as oscillator and doubler. The coupling then between the plate of the first half and the grid of the second half is through a 100 µfd condenser, C_4, shown just below the switch in the diagram. When the switch handle is thrown to the left, the two plates and the two grids are in multiple and the tube simply acts as an oscillator. The grid resistor has a little lower resistance since they are then in multiple.
3. Tube filaments.
4. Plate supply for type 79 tube.
5. Plate and screen supply for type 42 tube.

The extra socket, shown to the right of the type 42 tube in the interior view, is wired in multiple to provide additional output if found desirable. A small telephone relay operates in the negative plate supply for both tubes. The coils for doubler and amplifier are conventional plug-in type, 1½-inch diameter, for quick change. In shifting the frequency from fundamental to second harmonic, only the last coil need be changed, and the double-pole double-throw switch thrown over. A little change in tuning may be necessary. All variable condensers are Hammarlund type MC-100 M (.00001 µfd.). All radio frequency chokes are Hammarlund Isolantite code CH-8. The antenna coil is wound on the same form with the plate coil of the type 42 tube, and one side grounded through the socket. The antenna is connected by a clip to the antenna coil. The case is aluminum, with hammered cover to protect the set from dripping water, and the entire set is to be mounted on a wood base with a rubber gasket between the case and the wood. All wires are connected to a terminal strip on the under side of the sub-panel, as shown in the photograph, and are colored to facilitate connecting. The plate supply is a 400 volt heavy duty "B" battery, and the heaters use a 6 volt storage battery.

During tests up to 2,000 mile distances, the set operated quite satisfactorily with oscillator plate 14 ma., 235 volts; amplifier plate 40 ma., 400 volts; and radiated approximately 0.35 ampere in a Marconi antenna. The addition of the second type 42 tube increases the antenna current about 0.2 ampere.

SCIENTIFIC WORK OF THE COAST AND GEODETIC SURVEY

R. S. Patton, Director, U. S. Coast and Geodetic Survey

In my annual report to the Secretary of Commerce for 1931, page 3, my conception of the relation of the Coast and Geodetic Survey to science is set forth. The contributions to science are of three kinds: The furnishing of basic data which can be used in scientific investigation; incidental by-products of the work done for utilitarian purposes, and contributions coming from the use of scientific methods in the work, whose development from time to time brings unexpected additions to scientific knowledge.

A contribution of fundamental importance has been the unceasing adherence for more than a century to high standards of precision. Repetition of work in the same region has not been due to lack of accuracy, but to changes in the underwater areas or shores, to greater demands of navigation due to increased draft of vessels, use of acoustic sounding methods in navigation and to many wants of an increasing population, and to continuing changes in the phenomenon observed, as, for example, terrestrial magnetism.

The area dealt with is no inconsiderable portion of the earth's surface and the application of scientific methods to so large an area is in itself a contribution to science, especially when it is considered that a very large part of the earth will probably never receive such detailed examination.

Geodetic Work

The place in science of geodetic work is evidenced by its intimate relation to the length of the meter and the shape of the earth. The utilitarian work of providing geographic positions, lengths and distances through triangulation and of elevations through leveling produces the necessary framework for accurate maps needed in many fields of scientific endeavor.

Field work that may be called truly scientific and that would not be done as part of the surveying and mapping of the country is the determination of gravity, observations for the variation of latitude, astronomical observations for the determination of deflections of the vertical and geodetic work to determine possible shifts of the earth's crust in regions of earthquake activity. Occasional work of this character includes participation in the world-wide longitude observations and measurement of bases used in the determination of the velocity of light.

In the office, computations are made for the triangulation and leveling of the fundamental nets, and although this work, as is the case with field work, may be classed as practical, the data are of decided scientific importance.

The work done at the office that is not of a decidedly utilitarian

character consists of studies to determine the shape and size of the earth and the form of the geoid or sea level surface and to discover the distribution of the densities in the outer portion of the earth's crust; reductions for topography and isostatic compensation of gravity and deflection of the vertical data; and studies leading to a better knowledge of the physics of the earth.

Hydrography and Topography

The area of the continental shelves and in the vicinity of submerged mountain chains is of peculiar importance from the viewpoints of biology, geology and oceanography. In these regions life is believed to have commenced and to have had important development; it is here that the principal stratification of rocks has occurred and these regions, though including a relatively small portion of the great ocean basins, present a relatively large share of oceanographic problems. Accordingly, facts about these regions are important in all these branches of science and especially the fundamental facts which are furnished by the Bureau in connection with its duty of meeting the needs of the mariner, in this its region of principal activity.

The delineation of the bottom and the existence of accurate charts which give the information in convenient form are of fundamental importance in all these fields, and without this information systematic studies can not be made. An excellent illustration is the use made by geologists of the accurate survey of Georges Bank, completed a year ago, in studying the origin of the great submarine gorges or valleys which indent the bank at intervals. Similar contributions are being made along all our coasts.

In connection with the surveys, samples of the bottom are obtained and these are an important aid to geological study. Temperature and salinity observations have been uniformly distributed on the continental shelves. Such observations are useful in connection with the weather, with fish culture, ocean circulation and in many other ways. The work that has been done since accurate methods became available reveals the inadequacy of the data on which geologists and oceanographers have heretofore based their studies.

Hydrographic surveys made of the same region at intervals make possible studies of changes, such as formation and removal of bars, shifting shoals and channels, and various forms of erosion and deposition along the shores. Specially valuable information has been obtained as to the deposit of silt at the mouths of rivers, notably at the mouth of the Mississippi River. Detailed surveys in glacial regions show the probable southern limits reached by the ice sheets and, where surveys have been repeated at suitable intervals, the rate at which glaciers are receding.

Correct delineation of the shores and elevations and contours of coastal mountains can scarcely be separated from the water surveys in usefulness since both must go together.

Surveys are now accomplished by acoustic methods which give both

depth and position. Science has made many contributions to carrying out this work. The advantages are greater speed of the surveying vessel with relatively less disturbing effect on accuracy of position from ocean currents, and operation at night and in a fog, thereby utilizing otherwise unfavorable weather conditions and enhancing both quality and quantity of work. The need for accuracy in shoal water sounding has had a direct effect in development of apparatus capable of accomplishing this — which has in turn conferred benefit on the mariner who can use the method in navigation. This in turn has required accurate charts to greater distances from the shore.

The delineation of path and velocity of sound in sea water is of general interest in the field of physics and important contributions have been made, though some of the problems are still unsolved. The Bureau was the first to issue a useful publication on the velocity of sound for deep soundings, as well as several accurate and approximate methods of arriving at a satisfactory velocity for any given sounding. Similar work has been done on horizontal transmission of sound.

Charts - In order that charts may meet the needs of the mariner, it is necessary to collect and compile much more material than can appear on the finished chart. There is a vast amount of detail useful for scientific purposes which can be obtained from photographic copies of the original sheets or otherwise. Studies have been made of corrections to apply to echo soundings taken on slopes in order to find how to determine the slope of the ocean bottom, a matter of peculiar difficulty since both position and depth enter. Theoretical studies have been made of sound transmission in order to develop theories which can be applied, so that greatest possible accuracy will be attained.

Studies of map projections have resulted not only in determining the value of various projections, but in the development of a new one.

Much study has been given to the scientific problems involved in actual chart production, with resultant effective methods of photolithography, copper plate engraving, paper treatment and many similar problems.

Tides and Currents.

The contributions to science on the part of the Division of Tides and Currents may be considered as of a two-fold nature, namely, the determination of basic data relative to tides and currents, and the interpretation and correlation of these data into the accepted body of science. A brief statement of each of these phases is given below:

Basic data - Under this head may be mentioned, first, the determination of the times, ranges and characteristics of the tide, and the times, velocities and characteristics of the currents along our coasts and in our inland bodies of tidal water. The Coast and Geodetic Survey is the only agency in our country engaged in a systematic determination of these data which are basic to the scientific study of tides and currents.

Another phase of this work relates to the, determination of datum

planes for reckoning heights on land and depths in the sea. These are determined by means of tide observations; bench marks are then established which permit elevations with respect to these datums to be determined accurately at hundreds of places along our coasts. In this field of work, likewise, the Survey is the principal agency in the United States.

In various fields of scientific research it is important to know in advance the times and heights of high and low water on given dates, or the days on which the lowest tide will occur. This basic information is furnished by the Coast and Geodetic Survey in the form of tide tables issued annually, in advance. Similar information with respect to currents is furnished by the annual current tables. In this field of work the Survey is the only agency in this country.

While the work described above is carried on for purposes of a practical character prescribed by law, scientific research is carried on in order that this practical work may be prosecuted effectively. The development of instruments and of methods for the analysis and reduction of the observations necessitates technical research of a scientific nature. As examples of such scientific work, we may mention the mechanical tide predictor designed and constructed in the Survey and the development of methods for the determination of mean values from short series of observations.

Correlation and Interpretation of Tide and Current Data - The scientific research mentioned in the previous paragraph, which is carried out in connection with the technical work on tides and currents is, in a sense, of a restricted character, devoted wholly to furthering the practical purposes which the tide and current observations are to serve. Scientific research of a wider character is prosecuted in connection with the correlation and interpretation of the tide and current observations.

Tides and currents are complex and highly involved phenomena which manifest themselves under a great diversity of forms. To correlate the observations made at different times and at different places, and to interpret the variations in time and in place, necessitates a scientific study of the whole subject. In the scientific development of this subject in this country the Survey has been virtually the only agency, and its staff from the time of Bache to the present day is recognized as a leading authority on tides and currents. The memoirs and studies published by members of the Division of Tides and Currents have been and continue to be recognized as authoritative in scientific circles.

In part, this latter phase of the work is carried on unofficially, in that the investigator devotes his private time to it. In this wise contributions have been made to the whole field of oceanography. The Gulf Stream, mean sea level, the relation of current to wind, types of tides and other special scientific studies have been prosecuted by members of the Division of Tides and Currents.

It should be added perhaps that the Division has furnished information to numerous investigations dealing with problems in which tides and currents enter as factors. Marine biologists, geographers and investigators

in other branches have been thus aided. As recent examples may be mentioned, studies of the variations in the tidal forces for use by physicists in the investigations on radio reception and on the velocity of light.

Terrestrial Magnetism and Seismology

The work in Terrestrial Magnetism and Seismology is a continuing contribution to the progress of science. It is part of an international effort to which many governments and other agencies contribute.

Terrestrial Magnetism - The contribution takes the form of closely spaced magnetic observations in the continental United States, Alaska, Hawaii, Philippine Islands, Canal Zone and Puerto Rico. These are brought up to any desired date by repeat observations at five or ten year intervals at selected places. Five magnetic observatories in Maryland, Arizona, Puerto Rico, Hawaii, and Sitka, Alaska, and during the past year the cooperative International Polar Year Observatory at College, Alaska, have made continuous records of the magnetic elements. Rigid standards of accuracy have enhanced the value of these records. Aside from utilitarian uses in controlling sea and air navigation and land surveys, the magnetic information is used in connection with geological studies by magnetic methods and for the study of radio transmission, especially short wave, which is closely related to the earth's magnetism. Considerable use has already been made in studies of the nature and laws governing the earth's magnetism and there is still much potential value in the records which has not as yet been utilized for lack of fully developed attack on the problem.

Seismology - The contribution to seismology is in the form of collection of earthquake information for the United States as a whole, and the regions under its jurisdiction except the Philippine Islands, and publication in convenient form; operation of seismographs at magnetic observatories and also cooperation at Columbia, South Carolina, Chicago, Illinois, Bozeman, Montana, and Ukiah, California, all places where there are no other agencies engaged in this work; immediate determination from the records of these and other stations of earthquake epicenters; operating, chiefly in California, strong motion seismographs developed cooperatively by the Coast and Geodetic Survey, Bureau of Standards, Massachusetts Institute of Technology and the University of Virginia. These last record the full strength of the earth motions in the central regions of strong earthquakes. They are of great practical use in the design of buildings and other structures and also provide the seismologist with information as to how earth movements develop and are transmitted in from the central regions.

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A recent report from the field explaining an inoperative tide gage states that the float was jammed by a small fish caught between the float and the pipe casing — another reason why tide gages should be carefully watched, even though they are designed for 8-day operation.

NOTE YOUR SURROUNDINGS

A number of requests for data which are valuable to the various scientific organizations of our country are received from time to time. Many of these requests are in the nature of questions regarding natural phenomena or geological action which might easily be observed by field parties, or anyone on these parties interested in the particular questions. For example, the recession or advance of glaciers, peculiar or remarkable forms of erosion and evidence of subsidence or rising of coasts, abnormal forms of coral growth, interesting submarine configurations, and almost any form of oceanographic or meteorological data. Nearly every one of our parties, either in the interior or along the coasts, will find something of interest, and in many cases the study of the particular phenomenon will give the observer an interesting hobby and a pleasing diversion. Our appropriations for research work are, for the most part, limited to development of methods and equipment pertaining directly to the advancement of accuracy and economy of surveys, but it is known that many officers have made observations and collected data on studies in which they are particularly interested during their spare time. Such data are always desired by the organizations studying that particular problem, and all field officers are urged to write articles on such subjects as they find at hand. These reports or articles can be preserved and made available by publication in our Bulletin or in other magazines devoted to the particular problem. As an example of these requests, there is quoted a paragraph of a recent letter from the Chairman, Committee on Glaciers of the American Geophysical Union:

> "I was very much interested to read in the Geographical Review, some time ago, an article by Mr. Paul C. Whitney, of your staff, describing the recession which the Mccarty Glacier on the East Arm of Nuka Bay, Alaska, has experienced during the last quarter century, as revealed by a comparison of the new surveys with those made by the Grant and Higgins expedition of 1 9 0 9 . . . . . .
>
> "Allow me to add that the Committee on Glaciers would appreciate very much being made acquainted with any other data on the advance or recession of Alaskan glaciers which may have been obtained by the surveying parties of the Coast and Geodetic Survey in the course of their recent work. Indeed, it would appreciate particularly if, with your approval, the Coast and Geodetic Survey parties in Alaskan waters could be advised of the objects of the Committee on Glaciers, and of the desirability of communicating to it any important changes in the positions of the glacier fronts which their surveys may disclose. Flotted positions on charts would of course be most definite, but photographs showing the glacier fronts with respect to identifiable landmarks would also be very acceptable."

EARTH'S ROTATIONAL FORCE AND NAVIGATION

Captain Gilbert T. Rude, U.S.C. & G. Survey
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(The January, 1933, issue of the Naval Institute Proceedings carried an article on the above subject dealing with types of current; with the deflective force of the earth's rotation as affecting currents; and with the effects of this deflective force, acting through wind-driven currents, on the dead reckoning position of a vessel.

Based on theory, on direct observations made by the Coast and Geodetic Survey on Light Vessels along our coasts, and on an investigation of the relation of surface currents to wind direction in the North Atlantic (The Marine Observer, IV, 153), certain assumptions were made and their application to dead reckoning suggested.

The following is a part of that article dealing with the effect of this deflective force on a vessel and is reprinted herein with the permission of the United States Naval Institute.) Ed.

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

It has been sufficiently well demonstrated that two per cent of the wind velocity approximates the drift of wind-driven currents along the coast; this velocity may be accepted without serious error for similar currents in the open ocean areas. The set of the coastal currents is shown to be about 20° to the right (Northern Hemisphere) of the wind direction; from theoretical considerations the deflection is 45° to the right in an open ocean area of infinite depth. Considering, therefore, only these data, it would appear logical to accept a mean of the two, or 30° to 35°, as the set of wind-driven currents in the open ocean, except that the investigations of such currents in the North Atlantic, to which reference has been made, indicate that the actual deflection approaches nearer the theoretical. It would appear, therefore, that a 40° deflection may be accepted without serious error for open ocean areas.

The preceding values, which for practical purposes can be accepted for use in open ocean areas with plenty of sea room, may be summarized as follows:

(1) The drift of wind-driven currents in the open ocean approximates in knots 2 per cent of the wind velocity in miles per hour.

(2) The set of wind-driven currents in open ocean areas is about 40° to the right of the wind direction in the Northern "Hemisphere and 40° to the left in the Southern Hemisphere.

Effects on a Vessel.- Accepting these assumptions, which are based on both theory and direct observations, the effects of wind-driven currents on the determination by the mariner of the dead-reckoning position of a vessel may be discussed in detail. Such a discussion may well be

demonstrated by examples, in which the wind directions are assumed to be from both the starboard and port hands, and from various directions relative to the fore-and-aft line of the vessel, since the deflection from a straight path taken by these wind-produced currents causes them to exercise different effects when put in motion by winds from different hands relative to the vessel. In these examples, it is to be understood that the different illustrative cases are assumed to be in the Northern Hemisphere and, therefore, that the deflections are to the right of the wind direction; in the Southern Hemisphere they would, of course, be to the left. Fully to demonstrate these different effects, eight cases have been taken, illustrated by Figs. 3 to 6, inclusive.

Figure 3A illustrates the current effect resulting from a wind 45° on the starboard bow. Assuming the wind velocity to be 55 miles an hour, the resulting current drift would be about 0.7 knot (2 per cent of the wind velocity), setting practically athwartship (40° to the right of the wind direction); and, unless taken into consideration by the mariner and an allowance made, the vessel's position at the end of a 24-hour period would be about 17 miles to port of the course laid down. In order to demonstrate the fact that a different effect accrues from a similar wind from the other hand, Fig. 3B illustrates the effect from a wind 45° on the port bow. Assuming the same wind velocity, the resulting current drift would be 0.7 knot, but setting practically aft and directly against the vessel's progress. In this case, outwardly similar to the last one, the vessel's position at the end of a 24-hour period, however, would be very nearly on the course laid down, but about 17 miles short of her logged distance.

A wind 45° on the starboard quarter produces a current setting practically fair with the vessel's progress through the water (Fig. 4A); the logged distance, therefore, will be less than the actual distance made good over the ground. Fig. 4B illustrates a wind 45° on the port quarter. The resulting current effect in this case, however, is practically athwartship. But for the deflective force due to the earth's rotation, the resulting current effect in these two cases, apparently quite similar otherwise, would have been identical.

Fig. 5A, illustrating a wind from dead ahead, demonstrates that the resulting current sets about 40° across the starboard bow, while in Fig. 5B, with the wind dead astern, the resulting current sets about 40° on the port quarter.

With the wind on the port beam (Fig. 6A), the resulting current sets 40° on the port bow, and, therefore, somewhat against the progress of the vessel over the ground. With the wind on the starboard beam (Fig. 6B), the resulting current sets 40° on the starboard quarter and, therefore, somewhat fair with the progress of the vessel over the ground.

It must be borne in mind that the effects of currents on the dead reckoning positions, illustrated in Figs. 1-6, are wholly external to the vessel; that is, the whole mass of water, bearing the vessel, shifts its position in the ocean. This mass movement can, of course, be taken

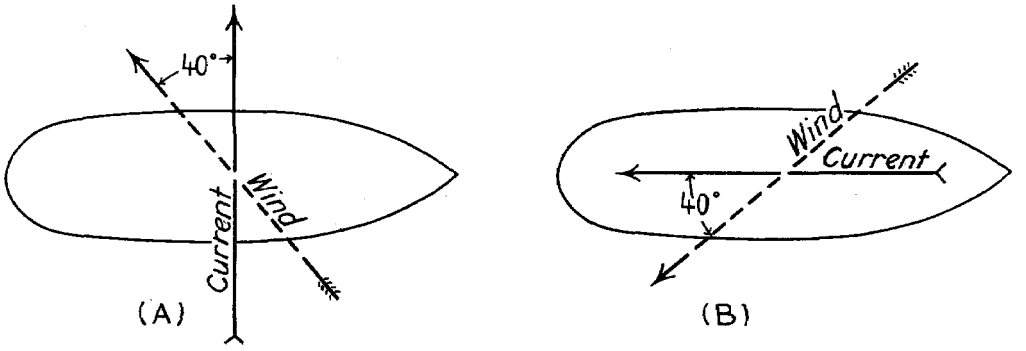

FIGURE 3

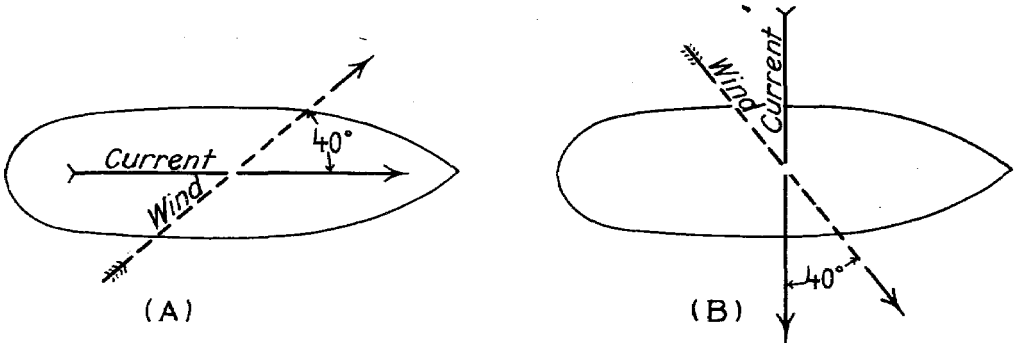

FIGURE 4

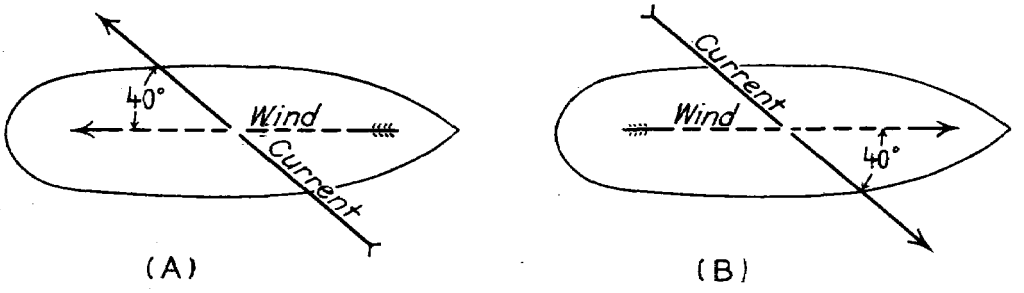

FIGURE 5

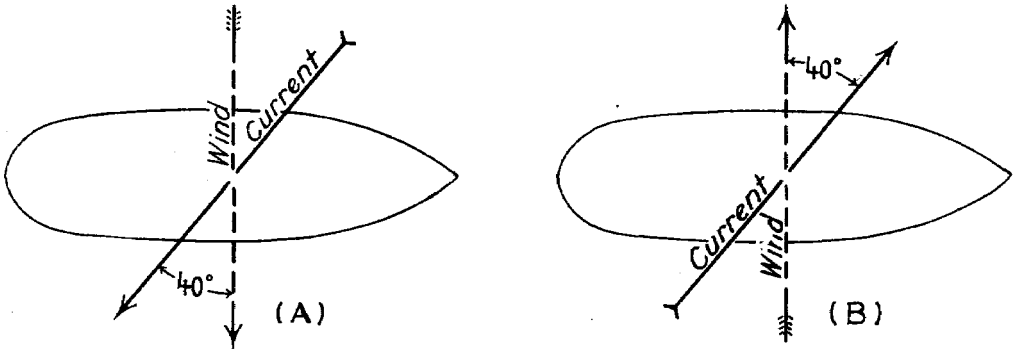

FIGURE 6

into account in the dead reckoning, either by regarding the current set and drift as a course and distance to be reckoned with, or, in order to follow more closely the track laid down, it can be allowed for by application of the graphic method of the "current rule" with which all mariners are familiar. In the two cases, however, illustrated by Figs. 4A and 4B, another problem arises due to the effects produced by action of the vessel itself. This additional source of error is brought about by the effect on the steering of the vessel, quite probable under the conditions illustrated by these two figures, with the wind on either quarter. This factor should be given consideration by the mariner, irrespective of the effects of the current as illustrated hereinbefore.

If the winds in these two cases are accompanied by a heavy quartering sea, the vessel tends to work to windward, especially to starboard, because of the effect on the steering brought about by the pounding of heavy seas on the quarter. A careful conning of the helmsman under these conditions generally will disclose that when off course, it is usually toward the side against which the following sea is directed. The resulting error is sometimes as much as two-to three-tenths of a mile an hour off the course laid down, depending upon the force of the sea and somewhat upon the vessel.

In making allowance for this correction to the course steered, consideration should be given to the difference in effects of the sea from the starboard quarter and from the port quarter. If the sea is from the starboard quarter, the vessel will work to windward (starboard) the maximum amount, since the current, due to the starboard quartering wind, sets fair with the vessel's course (Fig. 4A) and therefore has no compensating effect. On the other hand, the working to windward from a quartering port sea will quite probably be compensated entirely by the effect of the wind-produced current, since the current, due to a port quartering wind, sets practically athwartship (Fig. 4B), in a direction opposite to that of the error due to the vessel's working to windward to the port hand. In making steering allowance for the two conditions to make good the course laid down, it is obvious, of course, that the resultant of the two forces must be considered.

The mariner should not expect complete agreement always in the application of the theories and the assumptions set forth in this paper; many factors are involved not possible of evaluation in the present state of oceanography. The comments are offered him as an indication of the possibilities in the application of the known and proven factors and as a stimulus to further study on his part toward the possible evaluation of others yet unknown or unproven. The author will appreciate comments from the mariner, based on actual trial at sea, either in proof or disproof of the theories set forth herein.

At sea, especially in coastwise navigation, constant vigilance on the part of the navigator is the price of safety, for at tamon wind-driven currents of considerable velocity precede the wind which cause them. The writer has not observed this current condition preceding the wind by more than four to six hours. Attention should be called to the fact that these abnormal conditions are rarely encountered; they are mentioned in

order that the mariner may appreciate that remote unknown factors, not possible of evaluation, may at times affect his reckoning.

Extract from a letter to the Author from Edward B. Ellis,
Chief Officer, S.S. EXCALIBUR, American Export Lines

Having read your article in the January issue of "The Naval Institute Proceedings" I am taking advantage of your invitation to submit comment on "The Earth's Rotational Force and Navigation" and to ask you a question.

During the past two and more years I have been navigating this vessel across the North Atlantic, eastbound on 40 North and westbound on the regular tracks as laid down on the current Pilot Chart.

The current observed has nearly always coincided with the views stated in your article and ofttimes, to our consternation, very much against the vessel and the current arrows on the chart. Forty North eastbound should give us fair current a great distance over.

For the first four or five voyages we had, in general, fair currents eastbound, particularly in mid-ocean and in the vicinity of the Azores. Then our schedule was changed. Since this change we have not been able to get any favorable current to speak of, at best on one day's run only and that one from just north of Corvo Island for 400 miles eastward.

Do you think the loss of favorable set may be attributed to the following reason? Each round voyage from New York to the next sailing from that port consumes 56 days, placing the vessel in very closely the same positions each passage. Would that give us the same set for that particular place each lunar month and the same velocity? The phases of the moon are the same every voyage now.

From observation such seems to be the case, but I hesitate in blaming the moon for a noticeable loss of speed in this day of engineers! If we experience adverse current, eliminating the wind driving factor, in certain places and return in two lunar months, would the same current be expected?

We expect a certain decrease in average speed and increased slip each successive voyage since the last dry-docking, but almost a total loss of favorable current is inexplicable to us. If you could in any way enlighten me on this, I should be grateful.

Extract from Reply by the Author to Mr. Ellis' Letter

Referring to your question as to whether the absence of favorable sets and drifts recently may be attributed to the fact that your present schedule places your vessel each voyage very closely to the same geographic position every 56 days and, therefore, at very nearly the time of the same phase of the moon, the tidal current, that is, the current brought about by astronomical forces, in the open ocean areas of great depth is

of such small amount (probably less than a tenth of a knot) that it could have no appreciable effect on the speed of your vessel over the ground. In fact, even in the shoaler waters on the continental shelves the currents due to tidal forces are of small velocity generally only from one to four-tenths of a knot; and, too, this small tidal current is of a rotary character and, therefore, its effect is nullified during a tidal cycle of about 12 hours.

Of course, there are localities along the coasts where the strictly tidal current attains considerable velocity, such as over the shoaler areas of Georges Bank; and, too, the phases and declination of the moon have their effect on the Gulf Stream, accelerating or retarding the velocity of the stream as the case may be, but in the open ocean in great depths the mariner can safely leave tidal current out of consideration in reckoning his vessel's position.

Semi-permanent non-tidal currents in the open ocean, that is, those affecting the vessel's position, are due to prevailing winds, differences in barometric pressures and differences in densities of the sea water. The temporary currents which affect the vessel are due to local winds. These temporary wind-driven currents attain much greater velocity than do the semi-permanent currents and are, therefore, the ones with which the mariner is most concerned since the velocity they attain from the effect of high winds is sufficient to mask or entirely obliterate the semi-permanent currents.

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NEW INSECTICIDAL FUMIGANT

From "Journal of Washington Academy of Sciences," July 15, 1933.

In view of the high toxic hazard of hydrocyanic acid gas to personnel in connection with fumigation, the Bureau of Medicine and Surgery, Navy Department, has recently conducted a study of carboxide gas as an insecticidal fumigant for bedbugs and cockroaches for application aboard naval vessels. Carboxide gas is a mixture by weight of 9 parts of carbon dioxide and 1 part of ethylene oxide, the carbon dioxide removing the fire hazard and practically doubling the toxicity of the associated ethylene oxide. Carboxide gas was found to be effective in comparatively small dosages such as to render it economically practicable for conveniently short periods of exposure. With ordinary care a gas mask is not required for fumigation with carboxide and expert personnel is unnecessary.

A detailed report of this study will appear in the July, 1933, number of the United States Naval Medical Bulletin under the caption "Carboxide Gas: A New Insecticidal Fumigant for Bedbugs and Cockroaches," by Captain E. W. Brown, Medical Corps, United States Navy.

EXTRACTS FROM REPORT ON ATLANTIC COAST ARC, FIRST ORDER TRIANGULATION

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

The arc of first-order triangulation along the Atlantic Coast executed by this party extended from Providence, Rhode island, to Brunswick, Georgia.

Weather and Observing: A large range of possible weather conditions was encountered during the progress of the survey. In North Carolina and South Carolina hazy weather, caused principally by numerous forest and brush fires, continually delayed the observing party. It was found that during hazy atmospheric conditions, caused by smoke, that lights showed clearer before dark. It was also noted that with darkness the air became moist, causing fog which rose slowly. It is believed that the mixture of smoke and moist air combined to change the intensity and clearness of lights. Observations were consequently made on lights in the afternoon whenever possible.

Observations were carried on during rain with apparently excellent results. During cold weather it appeared that better observations could be made.

Several times observations were undertaken from steel towers while wind was blowing with an estimated velocity of as much as forty miles an hour. It was noted that when the bottom part of the tower was protected by trees there was very little vibration of the instrument. During moderately windy periods, when the apparent position of lights caused by the vibration of the instrument remained within the cross wires of the telescope, directions were recorded without waiting for lulls. However, when wind caused more apparent vibration of lights, directions were recorded only during calm periods. Apparently excellent results were obtained during windy weather.

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Signal Building: For signal building from Virginia to Georgia, twelve towers were available. Two ninety-foot towers were received in March, 1932, and used in Georgia and the northern states. Fourteen steel towers are needed for a scheme of triangulation such as the Atlantic Coast Arc. These towers should be high enough to be used for any station in the scheme.

At some stations it was necessary to place sand bags in holes to make a proper support for anchors. In one case, a 77-foot steel tower was built on bed rock. To anchor the supports for this tower, wooden cages were built around the anchor supports and filled with rock. When observing from this tower during windy weather, there was considerable vibration.

It is believed that shorter anchors, separate cages for the inner and outer tripod, and a cushion of sand on which to set the anchors would lessen the wind vibration to a large extent.

In one case a tower built on a marsh proved very shaky. Motion was apparently transmitted from the outer to the inner tower. To lessen this motion, three boards, 2" x 12" x 3', were set on the ground near the legs of the inner-tripod, four-by-four timbers were out so as to be just long enough to extend from the boards to the first horizontal angle irons of the tower at the connections with the legs of the inner tripod, then wedges were driven at the base of the four-by-four so as to shift part of the weight of the inner tower from the anchor-support to the ground support. The tower was then found to be much less subject to vibration.

For hoisting and lowering steel in building and dismantling towers, Plymouth, four strand, grade A, Manila rope was found to be the most satisfactory. Four strand rope is much more pliable than three strand rope. It is much easier to handle this rope. Accidents, due to kinking and tangling, are much less likely to occur. Plymouth rope proved to be more economical than other kinds of rope as it cost about the same as other rope and lasted much longer.

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Camping: During the survey the observing party lived in tents exclusively. The building party occasionally lived in houses during the winter. Free camp sites were available in Virginia, North Carolina, South Carolina, and Georgia. In Rhode Island, Connecticut, New York, New jersey, Delaware, and Maryland, free camp sites were often not available. Close to New York it was not practical to secure camp sites.

During a year of camping, weather conditions from below freezing to 100 in the shade were experienced. By the use of gasoline heaters, tents were made reasonably comfortable in cold weather. There was very little sickness when the weather was cold.

With the advent of very hot weather in New Jersey, mosquitoes were especially troublesome. In camp and on low stands along the coast, swarms of mosquitoes took most of the joy out of life. Mild and severe cases of diarrhea and dysentery in New Jersey and Delaware may be attributed to the weakening effect of mosquito bites, supplemented by hot weather and uncooked fruits and vegetables.

During hot weather, wooded camp sites were generally available. A wooded camp site in hot weather is essential for the observing parties. The members of these units must work late nights, especially in the summer. Part of the morning must be utilized for sleep. Money spent for shaded camp sites is amply repaid in the increased efficiency of the officers and hands.

A cook was hired by the building parties during this work. The observing parties hired a cook for part of the time. On other occasions the hands on the observing party alternated with the cooking besides performing their regular duties. In the majority of cases the results were very unsatisfactory. Satisfactory and dependable cooking would be best served by the addition of a cook for the observing parties.

TRIANGULATION. COASTAL COORDINATING SCHEME SAVANNAH, GEORGIA, TO JACKSONVILLE, FLORIDA

Casper M. Durgin, H. & G. Engineer, U.S.C. & G. Survey

Between 1850 and 1860 a complete coastal scheme of second and third-order triangulation was executed by various officers of the Coast and Geodetic Survey between Savannah, Georgia, and Jacksonville, Florida. As years passed, many of the original triangulation stations were lost, due partly to erosion of the coastline and partly to the lack of permanent marking. On account of the continual change of this section of the coast, especially in the vicinity of the entrances to the sounds, repeated topographic and hydrographic surveys were necessary to keep the charts up to date. Sufficient control was rarely available and, as a result, supplementary schemes had to be made beginning from whatever fragments of the original scheme remained near the localities where the work was to be done. This continued until 1932 when there remained only a few of the original stations and several fragmentary schemes, many of which had been begun from fragments of former fragmentary schemes originally tied to the basic control scheme.

In 1932 the Atlantic Coast Arc of first-order triangulation was executed by C. D. Meaney and H. C. Warwick, H. and G. Engineers. Between Savannah and Jacksonville, the scheme closely followed the coastal highway, which was from five to twenty miles inshore from the outside coast.

The purpose of the coastal coordinating triangulation scheme of 1932-1933 was to furnish a new basic coastal scheme closely tied to the Atlantic Coast Arc and to connect to it all existing fragments of former schemes of the Coast and Geodetic Survey and also the triangulation schemes of the U. S. Engineers. Furthermore, complete control was necessary for air-photo topography and a complete revision of the hydrography, both of which were to be undertaken on completion of the triangulation.

Character of Country.

Although the general nature of the topography along the inland waterways is the same between the Savannah River and the St. Johns River, it is appreciably different from that which adjoins it on the north and south. The coastal country within these limits, which are also the limits of the triangulation, is distinctive in that the outer coast consists of large wooded islands separated from each other by sounds, and from the mainland by open marsh through which runs the inside passage. The islands are from five to ten miles in length and are often almost as broad as they are long. The high land of the islands is covered with dense, semi-tropical foilage bordered by dunes near the coast and by low marsh land on the west. The narrow sounds form the outlet for the silt-bearing rivers that drain eastern Georgia. An intricate system of rivers, creeks, and sloughs extends between the sounds, in the marsh land behind the islands, and it is in this relatively open area, from two to five miles in width, and about the same distance from the outside coast, that most of the control was established.

The sounds become rough enough to require a stout launch for crossing, and at the same time it is necessary to have a shallow draft craft for the inland creeks. The tides which have an average six-foot range, are a very important factor in operating by boat, and the stage of tide materially affects the possibility of reaching stations and building signals. The area of the low land which is above water varies greatly between high and low tides, and the water line is indefinite in many places.

The marsh land is composed of the silt deposited by the rivers, and is usually a soft mud, offering little bearing. It is covered with grass or reeds usually about two feet high, but in the deltas that were cultivated, as at the Savannah and Altamaha Rivers, the reeds grow to a height of ten feet or more. Where, however, the mud has mixed with sand deposits, or shells, or at scattered hammocks, it is firm; and these places are much more desirable than the marsh for location of triangulation stations. The edges of the high land and marsh along the tree line on the east side of the mainland and the west side of the islands which can be approached easily by water or road were found to be the best for stations, both for permanency and ease of building and recovery, but the wooded hammocks which are scattered in the marsh, and the frequent difficulty of reaching the edge of the high land by boat or truck, sometimes made it impractical to do this.

The hammocks (or hummocks) vary in size from a mound with one or two trees to little islands, a mile square, with tall trees. These are scattered irregularly throughout the marshes, and much of the reconnaissance time was spent in getting lines that would clear these.

The marsh may be reached at varying intervals along the mainland by farm roads and trails from the paved Atlantic Coastal Highway which parallels the coast and is inshore from the inland waterway a distance of five to fifteen miles. Most of the large islands are developed as private estates and have roads; but causeways, over which automobiles can be driven from the mainland, connect only three between Tybee and the St. Johns River.

Much of the land along the coast is used for game preserves and turpentine woods. At present, a very small percentage of the ground is under cultivation or even cleared. The trees are mostly live oak, gum, cypress, pine and palmetto, the tallest of which are the pines which were found to exceed one hundred and twenty feet in height in some places, but, in general, no difficulty was experienced by using 103-foot towers, except when the trees were on elevated ground.

Party Organization

The party was divided into sub-parties, as follows:

1. Steel tower building party using truck.
2. Wooden signal building party using launch.
3. Wooden signal building party using truck.
4. Observing party using launch.

5. Observing party using truck.
6. Computations and drafting.

Recoveries

Many stations of former schemes were recovered and in almost every case remarked, at least by additional reference marks. In addition to 52 stations on the Atlantic Coast Arc, 56 previously established stations were tied into the present scheme. In all cases where stations were recovered, either the stations themselves or the other stations of the same scheme were tied into the present scheme. It was noted that the former stations when located on solid ground and especially on isolated hammocks are much more likely to be permanent, and that stations in marsh land are less likely to be recovered. Between the St. Marys and St. Johns Rivers, 15 of the 21 stations of the original basic scheme were recovered and of these at least 6 were stations with the original marking of 1860 and 1861. They had been marked with pine and cypress stakes and the preservation of the shakes was remarkable.

A great deal of time was spent in proving the existence or non-existence of old stations. Computations were used to aid the recovery of many previously established stations, since many of the original descriptions were hopelessly inadequate.

Marking of Stations

Many of the new stations are marked by concrete filled tile 12" x 36". About 200 tiles were used for station or reference marks. Special efforts have been made to put the stations on hummocks even though it meant packing across soft marsh about 150C pounds of material for each station in addition to the lumber for signals. This has meant a considerable amount of labor, but the marks will be as permanent as it is possible to make them.

In all cases where marks were placed in the marsh, 2 x 4's were pushed down in the marsh to hard ground, or a depth of at least 16 feet, in the center of each mark and cut off below the surface of the concrete. In cases where recovered stations originally marked in this manner were remarked, it was found that it was almost impossible to remove the 2 x 4 which had become firmly fastened in the ground, and it was necessary to knock the concrete off and use the same 2 x 4 in the new mark. It was noted that a 2 x 4 pushed down in very soft mud to a depth of about 12 to 16 feet will become relatively solid within a few hours.

Signals

Steel towers were erected at 42 stations to make connections to work of the Atlantic Coast Arc by C. D. Meaney and H. C. Warwick in 1932, and to aid in locating stations along tidal streams from the first-order scheme of the same officers. In nearly every case a 103-foot tower was used. There is no doubt but that the steel towers were of the greatest advantage and it is doubtful if the present coordinating scheme would have been tied into as many of the Atlantic Coast Arc stations if

steel towers had not been available.

At all stations where the line lay over marsh, it was found best to build 16-foot wooden tripods and scaffolds on account of visibility and accuracy of observations. Two attempts to cut down height of signals caused reobserving. All of the wooden signals remain over the stations and it is hoped that many of these will show up in aerial photographs. The scaffolds of the 16-foot signals are 8 feet square at the base.

Connections to Previous Work

The coordinating scheme connected to the following:

1. Eighteen lines of the Atlantic Coast First-Order Arc.
2. Seventeen lines and eleven single points of the original basic coastal scheme executed between 1850 and 1860.
3. A line of each fragmentary scheme executed between 1860 and 1932.
4. A line of each triangulation scheme of the U. S. Engineers.

Computations

Triangle and position computations closely followed the observing and a close examination was made of each quadrilateral to make sure that, in addition to proper triangle closures, the computed length of a side did not differ by more than four times the tabular difference corresponding to one second in the logarithm of the sine of the smallest angle entering into the computation of that triangle side. A few stations were reoccupied for this reason even though the triangle closures were within the allowable limits.

In several cases the side equation test was used to locate errors in observing and in every case this test indicated the point or points at which later reoccupations showed the errors to be. A very clear and detailed explanation of the workings of this test is given in an article by Paul A. Smith, Jr. H. and G. Engineer, on page 29 of the December, 1931, Bulletin of the Association of Field Engineers. It is believed that this test should be more universally used in the field and that it would be if it were fully understood and not believed to be a complex mathematical problem.

Accuracy

(1) Second-Order Triangulation. There are 115 second-Order triangles with an average closure of 2.53 seconds. There are three loop closures formed with the Atlantic Coast Arc with discrepancies in length of 1 part in 30,000, 55,000 and 400,000; and azimuth discrepancies of 0".5, 0".7 and 5".6.

(2) Third-Order Triangulation. There are 332 third-order triangles with an average closure of 3.70 seconds. There are eight loop closures formed by the third-order triangulation with the Atlantic Coast Arc, or

by a combination of second and third-order triangulation with the Atlantic Coast Arc. The maximum discrepancy in length was 1 part in 9,000, the minimum of l part in 35,000; and the average of about 1 part in 20,000. The average azimuth discrepancy is 3.8 seconds with a maximum of 6.3 seconds.

Progress Sketch

A progress sketch was submitted showing the following:

(1) Coastal coordinating scheme with connections to stations of other schemes.

(2) Stations of previous schemes recovered to which connections were not directly made.

(3) Tables listing the following:

(a) Connections to previous schemes

(b) Connections to U.S. Engineers' triangulation stations.

(c) All intersection stations.

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METHOD OF IMPROVING POOR QUALITY LEAD-LINE

(Extract from a letter from W. J. Chovan, Jr. H. & G. Engineer, U. S. C. & G. Survey)

I was in charge of a chartered launch hydrographic sub-party this season on the outside coast of California and considerable difficulty was experienced during the first part of the season with wire core sounding line, although the lead-line was prepared according to Hydrdgraphic Manual instructions.

The irregular shrinkage and protruding of wire core made the lead-line useless after about two days' usage. It was thought at first that this particular lead-line was just an inferior piece of cordage, so another line, called lead-line No. 2, was prepared and found to act in a similar manner, being unfit for further use after only two days of service.

The irregular shrinkage of the lead-line put doubt on the accuracy of the soundings and the protruding of the wire core raised havoc with the leadsmen's hands. In order to protect their hands, the leadsmen would snip the protruding wires, and at such spots the cordage would stretch enough to produce a gap of one full inch in the wire core. This is partly the cause of the irregular shrinkage.

I decided that if the cordage could be shrunk before being made into a lead-line it might hold its length. Accordingly, a line was boiled for about five hours, then laid loosely on deck until it was thoroughly dried. The line was then immersed in cold water for one hour and marked.

This line was called lead line No. 3. It was used steadily for over two months and finally discarded as worn out. During this period a morning, noon and evening test on each working day showed the line correct. During the balance of the season all lead-lines used were prepared as outlined above, and the results were uniform in each case, the lead-line retained its true length during its entire useful life.

GOOD WILL FOR THE SERVICES

(Extract from Editorial in the Army and Navy Register, July 8, 1933)

In most of the successful business organizations of the country there is maintained a "department of public relations," which has for its mission the development of a friendly attitude on the part of the public - "good will," it usually is termed for the want of better words.

Such a department can accomplish much in an organized way, but no up-and-going business establishment is content to believe that good public relations can be established and maintained by a small group of persons specifically assigned to the task. They know that no measure of professional effort designed to create good will can compensate for the acts of unfriendly and discourteous personnel who come directly in contact with the public and from mistaken or unwise policies, the enforement of which may affect them adversely.

To cite an example, if a company engaged in selling a public service should through their advertising attempt to create a friendly feeling the efforts might be entirely nullified by the discourteous action of a single employee; by a refusal to correct an obviously wrong charge or make amends for an error; or by indifference. All the advertising in the world would not change the opinion of the individuals personally affected by these things.

And so it is in the military and naval services with respect to educating the public up to a sympathetic attitude towards the uniformed services and the national defense in general. All the effort, all the work of we11-organized and efficiently operated intelligence and news services may be entirely offset as far as an individual is concerned by discourtesy on the part of someone wearing the uniform; by an attitude of pained superiority towards reasonable and proper requests; or by a failure to support some movement which may possess some merit.

There are those in the service who have the attitude that their efforts in behalf of the national defense are for the people of the nation and that they, the people, ought to appreciate it. Again there are those who are prone to calculate that the individual taxpayer contributes only a small mite to the national defense and that he is entitled to consideration only to the extent to which he pays. These are hackneyed ideas which have no place in the present-day trend of affairs. The services are on the spot these days, and it is up to every officer and enlisted man to assume the responsibilities that are his towards popularizing the services.

There are a thousand ways in which this may be done. To enumerate them would be to run the whole gamut of human endeavor. Officers and men should take advantage of the opportunities which present themselves from day to day. They should reach out and create opportunities for service to the people.

Apropos the Foregoing

The number of letters commending the field personnel which have been received recently by our office is most gratifying. Space does not permit reproduction of all these letters, but the paragraph below should inspire all with a desire to maintain our enjoyable relations with the people we meet in all the regions where we work.

A recent book, entitled "Seward's Ice Box," by Archie W. Shiels of the Pacific American Fisheries, contains several pages relative to the work of the Coast and Geodetic Survey in the development of Alaska. Mr. Shiels, who is well known to many of the field officers of the Bureau, pays the following tribute to the Survey officers with whom he has come in contact in Alaska:

"No article on this subject would be complete without a word of praise for the men actually in charge of the survey work and the amount of work they accomplish with the funds available. We know of no department that stretches its dollar quite so far to get 100 per cent value for it. It has been my privilege to know intimately most of the field officers detailed to Alaska work in the last twenty years or more. No finer or more efficient men ever trod a quarterdeck and no more courteous or accommodating gentlemen ever visited Alaska in any capacity — always ready to help and anxious to serve whenever and wherever they can. They are a credit to their chief who selects them and to the branch of the service in which they are employed."

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FROM TRIANGULATION TO OYSTERS

Extract from a report of the Commissioner of Fisheries on "Condition and Extent of the Natural Oyster Beds and Barren Bottoms of Mississippi East of Biloxi," by H. F. Moore, Assistant in Charge of Scientific Inquiry:

The triangulation on which the survey was based was furnished for the purpose by the United States Coast and Geodetic Survey, and is therefore accurate. All of the points established, excepting buildings and other structures of like character, are marked by substantial concrete monuments. Should Mississippi establish a system of leasing her barren bottoms for purposes of oyster culture, these stations will furnish an invaluable basis for the survey of the leaseholds. With the reference points which they furnish, it will be possible to measure the areas accurately and to locate the corners in a manner which will make impossible disputes between contiguous holders and between the lessess and the state. In all states in which oyster culture has been long established, the importance of being able to refer the water surveys to permanent and accurately determined points on shore is recognized as necessary to prevent litigation, fraud, and loss to the state, and in many cases the states have been impelled to establish such marks at much expense to themselves.

VARIATION IN SALINITY, COASTS OF LOUISIANA AND TEXAS

Extract from Monthly Progress Report of June 17, 1933
W. E. Parker, H. & G. Engineer, Commanding Ship HYDROGRAPHER.

As the work progresses offshore, the results with the R.A.R. equipment become more satisfactory. In depths between ten and fifteen fathoms, we have been able to carry sounding lines eighteen seconds from the station launches with detonators and have not yet had opportunity to test out the range of larger bombs in these depths.

The opportunity for increase in progress due to ease of bombing is somewhat offset by the increasing difficulty of keeping the light launches on station in the deeper water during rough weather.

Unlike the water on Georges Bank, the water of the Gulf varies greatly in salinity, and considerably more attention must be given to making salinity observations on this project than was necessary on last season's work. On Georges Bank one observed salinity a day was sufficient to insure a good velocity for the survey of a local area. Here it has been found that the salinity will vary by as much as eight parts per thousand in a distance of ten miles, that the salinity of bottom samples taken at the same location twelve hours apart will vary as much as five parts per thousand, and in depths of ten fathoms the difference in salinity of surface and bottom samples is sometimes as much as ten parts per thousand. Accordingly, numerous salinities are observed each day to obtain a satisfactory velocity of sound for the area being surveyed.

In this connection it should be noted that while there is but little difference between the bottom and the surface temperatures, or, in fact, between temperatures, either surface or bottom, ten or fifteen miles apart, there are wide differences in salinities. Bottom salinities have ranged from about 27 to 33 parts per thousand and surface salinities have been found as low as 24 parts per thousand. A difference of 5 or 6 parts per thousand has been found between surface and bottom where the depth was 6 to 8 fathoms. As yet no sound ranging between buoys has been carried farther seaward than about 8 fathoms.

(The Ship HYDROGRAPHER was operating at this time on the Louisiana and Texas coasts. (Ed.))

THE HURRICANE OF AUGUST 23, 1933
at Norfolk, Virginia

(Extracts from reports of H. A. Seran
Commanding Survey Ship OCEANOGRAPHER)

Report on the damage done by the recent hurricane has been delayed until information regarding the damage to the signals could be had.

The disturbance was of hurricane force and reached its maximum intensity at Norfolk about 9:30 a.m. The anemometer on the LYDONIA recorded gusts of 85 miles per hour and a steady wind of 75 miles per hour.

As reported in my radio of August 24, little material damage was sustained by the ship. On the OCEANOGRAPHER the forward awning ridgepole was broken and the port bow mooring chock pulled out. No damage otherwise. The naval authorities decided to move the LYDONIA during the lull as the center was passing. The tugs dented the plating on the LYDONIA in a couple of places, cracked the margin plank on the main deck and dished-in the bulwarks at the starboard gangway. The after half of the gangway door was torn loose. The GILBERT sustained no damage whatsoever. Each of the ships, of course, lost several mooring lines.

The OCEANOGRAPHER made a trip to the working grounds on August 25 and 26 to survey the situation. Several buoys, including those upon which our present work depends, remain afloat, although the superstructure on two of them was destroyed.

In the Hydrographic Bulletin of August 23 a number of our buoys have been reported adrift. However, several of those reports give positions corresponding to the original location of the buoys.

Ensign Konichek was sent to Ocean City on August 25 to survey the damage to the shore signals. As reported in radio of August 28, three of the tall hydrographic signals were down, two remain standing, although targets are gone, and some other work will be required on these structures. The center marks of all the signals were disturbed and are of no value as triangulation stations. He reports, however, that indications are the signals can be rebuilt within two feet of their original locations. The small signals are completely destroyed and the beach swept clean. The tide gage at Chincoteague was ruined and must be replaced.

As reported in radio of this date, Lieutenant Odessey accompanied by Lieutenant Brown, Lieutenant (j.g.) Bainbridge, Ensigns Waugh and Konichek, Deck Officer Carstens and 21 members of the crews, gathered from the various ships, left this morning for Ocean City to do the necessary repairing, rebuilding and reinstallation of the tide gage.

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It is with considerable pride the Commanding Officer reports that the radio plant on this ship was for a time during the height of the hurricane the only means of communication from Norfolk outside. The naval radio station was out of commission and all their traffic was handled on this ship until 8:00 p.m. when the U.S.S. OWL took over. Considerable traffic was handled for the commercial companies.

A telegram just received from the general manager, Southern Division, Postal Telegraph, at Atlanta, regarding the assistance rendered by this vessel, reads as follows:

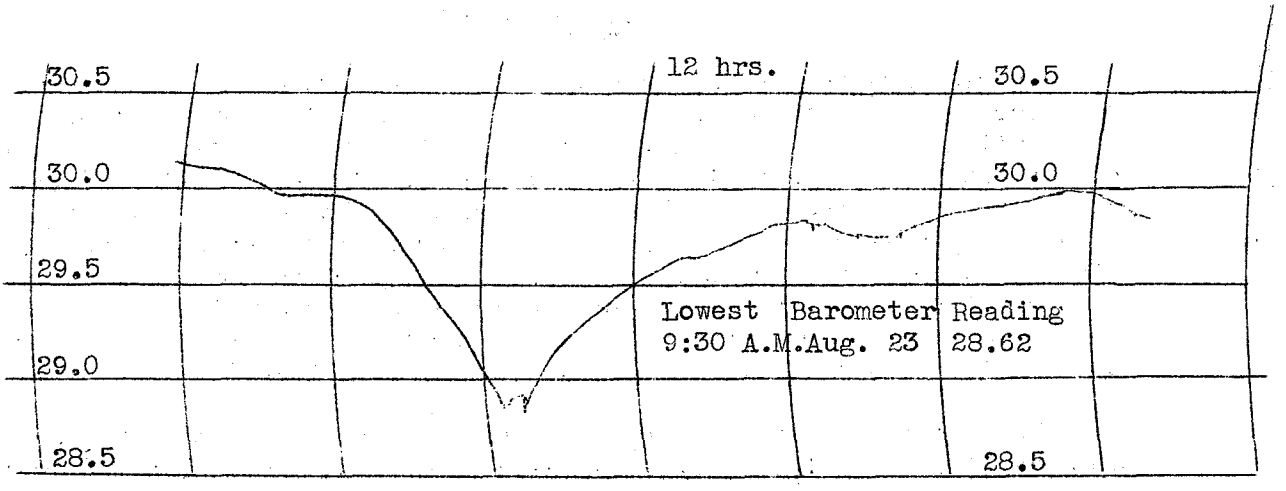
"We are deeply indebted to you for the fine cooperation and assistance rendered our Norfolk office in the movement of important traffic during the time our facilities were paralyzed as a result of the recent hurricane. For this we desire to express our grateful appreciation to you, also Lieutenant H.W. Hemple, Acting Chief Operator L. M. Rundlett, as well as any others who may have had a part in this heroic work."

Entire credit for this work is due the three radio operators aboard this ship, L. M. Rundlett, S. E. Lucia and E. F. Schwach, with particular credit to Rundlett.

As a matter of interest, the following note has been received from the Army Amateur Net Control station at Washington, I. C:

"Copied practically all your dope here at message center while you sent out traffic during the storm. Most stations reporting QRM on you, but our equipment here made it very feasible to read you 95 per cent solid. Hope WLM/W3CXL can arrange a schedule some time. Congratulations on your good work."

Copy of Barograph Record, U.S.C. & G.S.S. OCEANOGRAPHER



GEODESY EXPANDS

The annual appropriations, very small in size, made to the Bureau for its regular geodetic work prior to 1930 now amount to a million or more dollars. For the fiscal year of 1939 the geodetic appropriation for field expenses was $88,600. in addition to that, certain small sums were received from other agencies of the Government for cooperative work. In the office there were eighteen mathematicians, two field engineers and two clerks. For the present fiscal year, the regular appropriation is $127,000. But of the amounts of money allotted to this Bureau from the Public Works Administration, $2,600,000 are allotted to the Division of Geodesy. In 1929 on the regular work of the Survey there were very few parties in the field. Now there are fifty-four leveling instruments at work under eleven chiefs of parties and this number of instruments will be increased by ten or more within the next few weeks. There are now seven first-order triangulation parties in the field and as soon as instruments are available, there will be four observing units in each of the parties. Six large reconnaissance parties are now in the field while in 1929 there were only two, with no assistants to the chiefs.

The administration of all of these parties and the dissemination of information to the public from the office in Washington has been a heavy task, but by increasing the staff it has been possible to carry on the work with practically no lost motion.

The office force in Washington on the regular geodetic work is now composed of four commissioned officers, the original eighteen mathematicians and the two clerks and, in addition, seventy-five methematicians, computers and clerks paid from either the regular appropriation for geodetic work or from the Public Works funds.

In addition to this regular work of the Coast and Geodetic Survey, there is the Civil Works survey project which has necessitated a large increase in the administrative and technical staff in the Washington office.

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PLANE COORDINATES

In response to a persistent demand on the part of the engineers and surveyors throughout the country, the Division of Geodesy undertook the computation of plane coordinate systems for the various states. After a careful study, it was decided that some one of the conformal projections should be used because the resulting grid would be more readily applicable to engineering and surveying work. For similar reasons the projections used were limited to two kinds: The Lambert conformal conic projection with two standard parallels for states with greatest extent in an east and west direction and the transverse Mercator projection for states with greatest extent in a north and south direction.

Under the intensive CWA program, the work of computation was speeded up and all of the states, with the exception of California, now have the

tables for their respective grids in final form. All of this work was accomplished in the past three months with from 15 to 25 men working on the computations. Ten states were small enough to be included in a single system, hut in the other 37, two or more systems were needed to keep the variations of scale within such limits as to be of slight trouble in the applications. In Texas it was necessary to employ five systems on the Lambert projection.

It is the intention to compute the plane coordinates of all of the triangulation stations on the grids of the respective states. This will make immediately available the control survey data in any region on a plane system to which cadastral and public works surveys can be fitted by computations on the plane. It is believed that this will be a great aid to local and regional engineering and surveying projects.

This is the largest single undertaking in computation that has been planned and executed since the completion of the readjustment of the first-order triangulation of the country. By attacking the task in a vigorous manner and by concentration of effort, the project was brought to a finish in the remarkably short time of three months. An edition of three hundred copies of each of the tables was printed by photo-lithography so that an adequate supply is on hand for use in any region.

A publication illustrating the use of the coordinates for computations is in preparation and will be issued some time in the next few months.

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FAILURE OF STEEL TRIANGULATION TOWERS

The Bilby steel triangulation towers have been in use since 1927, during which time some fifteen or more of the towers have been blown down by various storms. The greatest loss from any one storm was caused by the West Indies hurricane of last September when nine towers, all that were standing in North Carolina, were all blown over. In one case the anchors came up apparently intact, while in others the towers collapsed at the top of the second frame.

It is important that we learn as much as possible regarding this subject, in order that we may build towers and so anchor them as to give every measure of protection to lives and property.

(Excerpt from letter of March 2, 1934, from the Vice-President, Aermotor Company, Chicago)

"We have your letter of the 28th, your reference No. 60-BJ, enclosing photographs of some wrecked Bilby towers, which we have examined with considerable interest.

"We believe the cause of the failure in each of these cases was the omission of the vertical girt stays which we furnish to give greater stiff-

ness and strength to the long girts in the bottom sections of the towers. We have examined all of the photographs very carefully and we do not find one of these vertical stays in any of the towers. We are afraid that the erectors, in their haste to assemble the towers, left off these important pieces.

"To make sure that you understand just what we mean, we enclose a section of blue-print with these vertical stays marked with pencil. The use of these stays not only greatly stiffens the girts against collapse in high winds, but prevents bending from the weight of the erectors in putting up and taking down the towers.

"We believe that if you will issue instructions to have these vertical stays used in all towers you will not find it necessary or desirable to strengthen the girts in any other way."

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DAMAGE CLAIMS

Importance of permission to enter upon property.

There has been a noticeable increase in the number of complaints from property owners, and damage claims submitted by them, due to the establishment of our survey stations on their property. In the great majority of these cases it is quite evident that the primary cause is due to our parties entering on private property without obtaining permission of the owner.

The claimant naturally, and justly, feels that his rights have been usurped and assumes a very antagonistic frame of mind towards this Bureau. In such cases a large amount of correspondence is required and it is very difficult for this office to arrive at a settlement with the claimant, as in these instances the damage, in the opinion of the land owner, is magnified because of his resentment occasioned by the fact that the Government trespassed on his property, cut trees, rutted his land, etc., without obtaining permission to do so. It is, therefore, imperative that every effort be made by our parties to keep these complaints to a minimum.

With our increased program, which we expect will be in effect until at least the end of the fiscal year 1935, a considerable amount of our work will be done in thickly populated area where the land values are correspondingly high, and unless the chiefs of parties instruct the men in charge of the various units under them to exercise caution and discretion in this matter, a considerable amount of unfavorable criticism will be directed towards this Bureau.

It is appreciated that in mountainous or isolated countries, considerable unnecessary delay would be occasioned were the party to attempt to locate all property owners, and, therefore, the chief of party must necessarily be governed by the locality in which the party is operating.

Every member of your party should have this important matter brought to his attention so that complaints of this nature may be kept to a minimum.

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CARE OF INSTRUMENTS

There are two lines of thought apparent in the designing of surveying instruments. One is that they shall be so made as to be delicate, requiring particular care on the part of the user, and that the various parts shall be put together with small screws, etc. The other line of thought is that the instrument shall be made with every degree of ruggedness possible, only reserving fine fits and small parts to such points as where they are unavoidable, and providing for reasonable ease of adjustment in the field rather than requiring that the instrument be returned to an instrument shop for adjustment.

The latter type of instrument is perhaps more like a machine than the popular interpretation of the word "instrument." However, it has been the policy to follow this latter line of thought in the design of the Coast Survey equipment in recent years.

No matter with what ruggedness surveying instruments may be designed, they are, nevertheless, of a precision character, and a certain respect must be accorded them in their care and handling. It is usually necessary to construct them of materials of a fairly soft character. It is also necessary to keep their weight down to a reasonable figure; consequently, they are to a certain extent structurally weak, or, better, not strong. This means that they must be protected against sudden and violent shocks.

In order to obtain the requisite accuracy, the bearing surfaces must fit very closely and they must be so smooth that they will not wear rapidly, if at all. In fitting such bearings, the instrument maker uses a lapping compound, which is essentially oil mixed with grit, the grit being a fine grade of emery, rouge or similar material. The user should consequently bear in mind that if he allows dust, especially mineral dust, to get on bearings when he is oiling his instrument, he is subjecting the instrument to the same process when he uses it that the maker has used in fitting the bearings, except that he is continuing to lap away the surface which has once been fitted, and it will accordingly become loose and useless.

Cleanliness in a precise instrument is perhaps as important as it is in the hospital. If bearing surfaces become dirty, or if the oil becomes at all gummy or thick, the quality of the bearing may be destroyed for the time being. Metal bearings really are not a metal to metal contact. When such contact obtains, friction results. Consequently a lubricant, such as oil, is introduced and the one part actually floats on a thin film of oil, which separates it from the other. If this oil film becomes thick or viscous, the bearing parts will be separated too far, the oil film will yield, allowing the bearing to cant and, in the case of theodo-

lites, will cause an irregular eccentricity. The oil used by the survey has been purchased with a view to an elimination of this trouble, as it is not supposed to become thickened with age. However, should difficulty be experienced in irregularity of observations, which can not readily be traced to any other source, it is recommended that the bearings be carefully cleaned with alcohol or benzine (alcohol preferred) and fresh oil be used. The oil should be applied with a lintless cloth, and only an absolute minimum applied where bearings must be a close fit. This has not infrequently been the principal source of trouble experienced in some work.

If the instrument has been wet with salt water, it should be disassembled, thoroughly cleaned with fresh water, dried preferably with alcohol, and oiled, to prevent corrosion.

It is recommended that graduated surfaces of precision instruments never be wiped. If dust accumulates on them, it should be carefully blown away or removed with a clean camel's hair brush. Graduations are usually on very soft silver, and grit will quickly imbed itself into this surface and cause scratches if any pressure is brought to bear upon it, such as would be the case in wiping. If a circle becomes tarnished, it is recommended that it be left alone until such time as the instrument can be returned to the instrument shop, where the tarnish can be removed by those thoroughly familiar with the process.

For those who have occasion to ship chronometers, special printed instructions have been prepared, showing how the corks should be applied underneath the balance wheel. Because of the fine pivot points and the heavy balance wheel used on such instruments, special precautions must be observed. The instructions can be obtained by writing to the Instrument Division. (See Association of Field Engineers' Bulletin No. 3, plate facing p. 97. Ed.)

In shipping tide gages, more care than might be apparent at first glance must be taken to carefully tie down all parts which may become loose or swing about, and this includes the tying of the lead screw on the standard gage in such a manner that it can not move end-ways. This instrument is somewhat awkward to remove from its packing case and there is a natural inclination to take hold of some of the bars, such as the striker bar or the lead screw, to lift it from the box. They should not be lifted in this manner, as damage may easily occur at these two critical points.

Precise level rods quite frequently are returned to the Instrument Division with every indication of having been transported by laying them on the bottom of the truck or elsewhere, where abrasion can occur and rub away the paint. So much trouble has been experienced that the entire design of the rod has been changed in recent years to protect the invar strip from this damage. Users should bear in mind that these rods are precision instruments, the overall error generally being not more than four or five one-thousandths of an inch. They are quite expensive to construct, costing in the neighborhood of $100 apiece, and should be treated accordingly.

In packing equipment for shipment, it should be remembered that the case may be inverted, and care should be taken that nothing can come loose and rattle about. This should be particularly observed where a number of items are packed in one box. There have been instances in which instruments of a fairly precise character were packed in a box which also contained a heavy weight which was not fastened down, with resultant detriment to everything except the weight.

Sawdust should never be used in packing instruments, as the extremely fine dust from it seems to be able almost to penetrate hermetically sealed joints. It has the disadvantage that it is a very ready absorbent of oil and if it gets on an oiled bearing the bearing promptly becomes dry and the instrument, in all likelihood, inoperative. Sawdust also readily holds moisture, and damage may occur through this cause. It is also advisable not to use excelsior, if it can be avoided, for the same reason. Shredded paper, of a good quality, is probably the best material.

The Instrument Division would greatly prefer that instruments not be painted in the field, especially as use is to-day being made largely of lacquers instead of lead paint or enamel. Such lacquers can readily be patched, where small scratches or abrasions have occurred, by use of a spray gun, but if any other material has been superimposed, it is usually necessary to clean the instrument clear down to the raw metal, involving considerable work and expense.

These suggestions have been made with a view to a better appreciation of the problems of handling equipment by the field parties with respect to their servicing in the Instrument Shop, and not in any spirit of criticism, as the difficulties under which the man in the field carries on are fully appreciated and it is realised that he does not have all the facilities which he could desire in either cleaning, repairing, or shipping these instruments.

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FIRST-ORDER THEODOLITES AND CIRCLES

In addition to the new first-order Parkhurst theodolites recently acquired by the Bureau, and which have already gone to the field, there are ten additional ones which should be available for field issue within a short time. These additional, instruments will be sufficient to adequately equip all of our triangulation parties with modern instruments and relieve the handicap occasioned by the use of cumbersome old instruments under which these parties have been working.

Good circles are hard to get and poor circles cause a great deal of annoyance. It is believed that some of our theodolites now in the field are equipped with imperfect circles, and it is hoped that this situation will soon be relieved. Decided steps have been made in this direction. The Bureau of Standards has already graduated and furnished this Bureau with five excellent circles and others are promised in the near future.

It is the ultimate plan to have all new and old instruments equipped with these "near perfection" circles. This, of course, will not be possible until sufficient instruments are on hand to enable the office to send out replacements for the theodolites now in use. In the meantime it would be a fine plan for each chief of party to send in a report on any theodolite which is equipped with a poor circle; this in addition to the information as to the number of the circle called for a short time ago by circular letter.

It would be extremely interesting if every person using one of our first-order theodolites could witness the operations of the various steps through which the circles go during the process of graduation. From the machining of the rough silver casting, through the electro plating of the section to be graduated, the marking of the large graduations, the polishing and construction of the "flat," the engraving of the small figures (done by hand with pantograph), and finally the intricate operation of graduating the 5-minute divisions. The precision and extreme precaution with which each of these operations is performed is astounding and is difficult to realize without witnessing. It is certain that one would respect his instrument a great deal more could he see this procedure.

When the circles are finally released by the Bureau of Standards, we put them through a rigid test at the shop. This is done by mounting them in a theodolite and measuring directions, the identical method to that used in the field, probably under more favorable conditions. Usually two sets of sixteen positions are observed.

For this purpose a room in the basement of the building in the Instrument Division is used. The instrument is set up on a rigid stand. The pointings are made on four or more collimators in sidereal focus, thereby obtaining the same effect as pointing on objects an infinite distance away. This is accomplished by using four or more old wye levels, mounted on brackets secured to the walls of the building at uniform height with that of the telescope of the theodolite to be tested. The cross hairs of one of these collimators or level telescopes, is put in sidereal focus by pointing and focusing on the sun. The theodolite to be tested is then pointed on this collimator and focused on the cross hairs of it. The remaining three or more collimators are then pointed and the cross hairs focused on the theodolite. With this accomplished the observing proceeds as in the field, except that two pointings are made on each object, thereby obtaining the same effect as two sets of sixteen positions.

The result of the observations obtained is put through a rather comprehensive analysis and the circle thoroughly studied.

It is planned to file this and other data pertaining to the circle, and by knowing which instrument each circle is installed in, a comprehensive history of this most intricate part of the theodolite will always be at hand.

GEODETIC SURVEYS AND MAPPING*

J. C. Carpenter, Member American Society of Civil Engineers

It would afford a great deal of satisfaction to those engineers and surveyors who are engaged in field work to know that the information they obtain will be incorporated in a permanent record to become a part of a comprehensive map of the whole country. Many surveys now made are based on assumed locations of starting points, both in a vertical and horizontal direction. If there were in existence a suitable number of monuments with known latitude, longitude, and elevation, all surveys could be tied into a permanent net work, and when completed could be checked and filed as permanent records, gradually extending our map information and providing starting points for other surveys and extensions. The very fact that his survey is to be a permanent record would encourage accuracy, thus raising the standard of all surveys, and all this can be brought about with little, if any, additional expense.

There is developing in this country a widespread interest in higher surveying and mapping and an appreciation of the value of this phase of engineering endeavor. It is truly remarkable that we, in this country, have been willing to go ahead with the development of our resources, expansion of industry and commerce, and other activities without having available an accurate knowledge of the terrain involved. A poor country could not have stood the waste involved.

The present moment is an ideal time to inaugurate a carefully planned program of higher surveying and mapping, and compilation of map data. There are two phases of the problem: First, the geodetic survey of the country must be completed to provide a satisfactory network of control surveys and to establish the location and elevation of readily accessible points for future surveys. The second phase involves the compilation and coordination of all survey and map data and establishment of a permanent file of all such information which will be available for use by the general public.

The Coast and Geodetic Survey is engaged in extending the Federal control surveys over the country, with the spacing of triangulation arcs at intervals of about 60 miles and leveling about 50 miles. No state is required to make any contribution toward the work, but, under the Temple Act, any state can secure priority in the completion of the control surveys by making a small contribution. One state, North Carolina, has taken advantage of this option, and it is expected that the triangulation and leveling will be completed during 1933, as far as Federal projects are concerned.

"Geodetic Control of North Carolina Highways" by George F. Syme, member A. S. C. E., Senior Highway Engineer, State Highway Commission, in "Civil Engineering" for March, 1932, describes the work under way in that

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* A paper recently delivered by Mr. J. C. Carpenter of the Texas State Highway Department at an engineering meeting in Little Rock, Arkansas.

state. In discussing the surveys for state highways which have been completed in North Carolina, Mr. Syme says: "Blue-prints and field notes of such surveys serve only for construction purposes and in a few years become almost entirely worthless. Imagine the tremendous economic loss of 10,000 miles of highway location costing a million or more dollars which, after construction, are utterly valueless for future accurate use. It is like casting priceless by-products of a great factory into the sea."

The North Carolina Society of Engineers, at a convention in January, 1930, started a movement which led to a cooperative agreement between the State Highway Commission and the U. S. Coast and Geodetic Survey by which the Survey agreed to complete the triangulation of the state with all possible speed. First-order triangulation arcs divide the state at intervals of about 100 miles, and these will be cut by second-order arcs so that there will be no point in the state more then 25 miles from one of the triangulation stations, with lines of levels similarly spaced. With future surveys subject to horizontal and vertical control and monumentation, each will become a part of the state system and can be easily and correctly reproduced.

The Board of Directon, A. S. C. E., on July 4, 1932, endorsed a resolution of the Surveying and Mapping Division supporting the program of the U. S. Coast and Geodetic Survey to establish and make available at the earliest practicable date controlling triangulation with the arcs spaced at intervals averaging not more than 25 miles. This resolution was referred to the American Engineering Council and was recommended by their Board of Control. The American Association of State Highway Officials passed a similar resolution at their meeting on November 14, 1932. On January 13, 1933, the American Engineering Council passed a resolution urging that Federal and state officials in charge of topographic surveys be encouraged to proceed, that Congress and the legislatures of the states be informed of the great economical and engineering value of the topographic surveys of the U. S. Coast and Geodetic Survey and be urged to make appropriations for the execution of these surveys, and that, in those states where mapping agencies do not exist or have adequate funds, the State Highway Commissions give consideration to the plan of their cooperating with the Federal mapping agencies on a 50-50 basis. The Council considers this subject of importance at all times, but especially now because of the disposition to reduce expenditures and also as a means of affording some employment for engineers. To be effective, resolutions of this nature should have the whole-hearted endorsement of State Engineering Societies and be backed with the active support of individual engineers.

The universal use of mapping data now being prepared is hampered by lack of coordination and the absence of any central agency where survey and map data can be assembled. To coordinate surveys and maps based upon assumed horizontal and vertical datum planes is a hopeless task, but with an accurate primary control established and all surveys tied in to this network, the compilation of topographic data would soon become almost routine procedure. There are many valuable maps in existence of which the public knows little or nothing. The state would perform a valuable

service to its citizens if it were to compile all available maps and survey data in order to avoid duplication of effort and also to assist its citizens in carrying out engineering and other projects. There are really two problems: First, to make the maps; and, second, to let the people know of their existence and how they can obtain copies of them.

The general mapping agency for any state will serve as a clearing house to write specifications for surveys and mapping; to collect and preserve all worthwhile surveys from all parties who use the system; to check all computations of such surveys for compliance with established standards; to coordinate surveys and post physical features and political boundaries; to formulate and put into practice policies for monumentation; to furnish the public with proper information as to data available for use; to keep an accurate up-to-date state map; and to perform other functions as they may appear desirable.

An example of an existing agency for collection of mapping data is the Board of Surveys and Maps of the Federal Government, which has issued a 54-page pamphlet listing "Map Collections in the District of Columbia." This list, with brief descriptions of the map collections in the District of Columbia, was compiled from a questionnaire sent out by the Board. There are 44 collections listed, nearly all of which are available for consultation in connection with research work and investigations. The descriptions give general information relative to the character of maps on file with each agency and indicate those which may be purchased. While this activity does not cover the ground that would be included in a general mapping agency for a state, it does provide a ready index of available information.

In preparing this discussion, information obtained from Mr. W. Bowie, Chief, Division of Geodesy, U. S. Coast and Geodetic Survey (also Chairman of the Surveying and Mapping Section A. S. C. E.), and Mr. George F. Syme, Senior Highway Engineer, North Carolina State Highway Department, has been freely used. These two engineers are pioneers in the movement and deserve credit for the active interest they have already created.

ADVANTAGES OF GEODETIC CONTROL FOR CADASTRAL SURVEYS

T. E. Ringwood

(Some months ago Mr. Oliver D. Keese, County Engineer, Los Angeles County, California, wrote to Captain William Bowie, Chief, Division of Geodesy of this Survey, and asked for information and opinions regarding the uses to which the results of geodetic surveys could be put. Captain Bowie wrote to Mr. Keese and gave him copies of some articles that had appeared in newspapers on geodetic surveys and their uses. In his letter he suggested that Mr. Keese communicate with Mr. T. E. Ringwood of Montauk, Long Island, N. Y., who had for many years been using the triangulation of the Coast and Geodetic Survey on Long Island in connection with the establishment of property lines and in subdividing areas for sale.

Mr. Ringwood responded to Mr. Reese's request and wrote him a letter, under date of March 27, 1933, which contained most valuable advice and information. A carbon of this letter was sent to Captain Bowie and he secured the permission of Mr. Ringwood to have the letter printed in this Bulletin. It is quoted below.) (Ed.)

With reference to your letter of March 20th, I would be glad to give you any information we have on the use of geodetic and plane coordinate control in cadastral surveys and our experience with it here.

We have used the system exactly as recommended by the U. S. Coast and Geodetic Survey exclusively since the inception of this project in 1925 and are of the opinion that it has resulted in the simplification of property surveys in addition to effecting substantial savings in engineering costs.

As an engineer on a development project of approximately 10,000 acres, I established it here and in subsequent private practice have extended the use of this system west from the easterly end of Long Island a distance of about 15 miles. Once established, the uses of the system are so many and varied that I, of course, could not give a complete description in a letter, but it will suffice to say that all sounding data and work done by Army Engineers in this area are tied into our control, as are also the Park Commission projects, New York State Highway projects, our own private road layouts, and all subdivisions are, of course, coordinated in the system.

The fact that the Coast and Geodetic Triangulation Stations form the skeleton of a vertical and horizontal control network, which, together with additional private triangulation and precise traverse nets, control location surveys of all facilities in an area of this size, results in advantages and savings which are obvious. Needless to say, it furnishes excellent control for topographic surveys which can be done in sections and assembled as they accumulate into a comprehensive topographic map over large areas with complete assurance as to the accuracy of both the horizontal and vertical control.

As to the use of coordinate control in the property and title surveys, we have sold nearly three million dollars worth of property here, a great deal of it by metes and bounds descriptions based on surveys tied directly to Coast and Geodetic control without reference to any other maps or points. One of these sales, involving some $60,000 worth of property, was challenged on the ground that the reference to Coast and Geodetic Survey exclusive of any other references rendered the description incapable of interpretation by laymen. The case was carried through the Supreme Court of the State of New York and the exclusive reference to the Coast and Geodetic Survey triangulation system was upheld as adequate for the purpose of conveying property in this state. This was in the nature of a test case, and since that time there has been no objection on the part of the title insurance companies, so we can assume, that it has been established.

Another phase of this same case brings out a point which is interesting, and that is the mere reference in a deed description to a survey system such as that of the Coast and Geodetic Survey, which, in effect, makes the published data on such a system executed by Federal, State or other public agencies legally a part of the deed description itself.

As a result of this, the Court inquired into geodetic methods and practice and with the excellent cooperation of the Director of the Coast and Geodetic Survey, our attorneys were able to submit a rather imposing exhibit of published data which apparently left the desired impression on both the court and the title companies' representatives.

So, from our experience with this phase of the work, I should say that the use of the geodetic system and the reference to it in deed descriptions automatically reinforces both the survey and the position of the surveyor with an excellent technical background and a sound foundation in the case of all surveys tied to it.

This point and the admitted prestige of the Coast and Geodetic Survey in that field become important where surveys involve litigation, or at least that has been my observation.

As to the cost of using the system and extending it, that, of course, would depend largely on the frequency of triangulation stations already established in your locality, and I should think the only initial cost would be that of tying the work already done in that locality into this system, the cost of which work, once it is done with the requisite accuracy, would be negligible compared to the savings in the cost of future work based on this system.

The source of this saving in engineering expense in our case has been mostly due to elimination of a great deal of traverse work and the proximity of reliable control to any anticipated project in the area covered by this system; also the facility with which accurate azimuth can be established at any point. I refer, of course, to the use of the geodetic control in conjunction with a plane coordinate system with the zero of coordinates approximately in the center of the area to be covered by each plane coordinate system.

I have in my files some cost data which I believe are conclusive proof of substantial savings in engineering expense effected by the use of this system in this particular locality. We do not have, of course, in this state the U. S. Land Survey control, and conditions vary so that it is possible that our data could not be applied to your problems in California; but as a general principle, it is my opinion that a standard control system (and the U. S. C. & G. system is unquestionably the best of these) is just as necessary for the improvement and conveyance of real property as is the standard system of weights and measures in any other line of business. This seems to be a generally recognized principle and it has been the subject of considerable discussion in the later texts on surveying. The most amazing phase of the situation is that so little public recognition seems to have been given the idea which, as you say, is probably due to lack of knowledge and information.

For specific reference, if you have not already seen it, I would refer you to a rather recent book entitled "The Legal Elements of Boundaries and Adjacent Properties" by Ray Hamilton Skelton, C.E., published by Bobbs Merrill Company, Indianapolis, Indiana. This book, in addition to recommending the use of the Coast and Geodetic control and outlining the advantages of such use, gives many horrible examples of misinterpretation of surveys which were due to the lack of such control.

I assume that the cadastral map which you propose will cover a rather large area and will form the basis for much of the mapped information in your county in the future, and for that reason I would think that the use of Coast and Geodetic Survey control as a basis and the use of a plane coordinate system, or as many as are needed to minimize the errors of convergence, would be almost imperative.

The City of New York effected some arrangement with the U. S. Coast and Geodetic Survey for the use of their trained staff and instruments for the execution of such additional triangulation as appeared necessary in the city. The cost of this work was surprisingly low, particularly in view of the accuracy maintained.

You might be interested in a recent article which appeared in the Military Engineer some months ago relative to triangulation control either established or in the process of being established in the City of Pittsburgh. Of course, the technical phases of the work are covered completely in information obtainable from the Washington office of the Coast and Geodetic Survey, and judging from the increasing number of articles which are appearing in the various engineering publications, I should say that the use of this control system is rapidly growing more common and that it will not be long before it will be accepted throughout the country as standard practice. This, of course, is an additional reason for the use of this control in the construction of any maps designed for use very far in the future.

A SURVEY FOR CORRECTING TAX DESCRIPTIONS

T. J. Mitchell

(Mr. T. E. Ringwood, in the previous article, has cited a case in which the Supreme. Court of the State of New York held that exclusive reference to the U. S. Coast and Geodetic Survey triangulation was adequate for the purpose of conveying property in that state. Mr. Mitchell, in the following article, presents a few of the difficulties found in attempting to follow old descriptions in an average community in the state of Michigan, and outlines the work of bringing the old surveys up to date and adds his request for more geodetic control to the rapidly increasing number reaching this Bureau.) (Ed.)

Previous to the present depression, the average free-holder considered taxes, like death, an inescapable penalty of existence. The depression, which made the tax load harder to carry, the attempts of legislative bodies to relieve the load and the new tax laws which were enacted all tended to make the average citizen tax conscious. While he was in this frame of mind, he made some interesting discoveries. He found that if his land description was not in legal form, his property could not be sold for delinquent taxes and that, therefore, he did not have to pay his taxes until the description was corrected. Also, in Michigan, a law was enacted cancelling unpaid taxes assessed prior to 1929. If his land description was incorrect, he had a chance to recover taxes paid previous to 1929. He also began to question whether all taxes had been equitably assessed and whether any parcels of land were omitted from the tax rolls. Taxes that could not be collected by tax sale, due to faulty descriptions, were charged to the county interested and had to be spread on the next tax roll. Last year $800,000 were thus charged to one county (Wayne). In consequence of the foregoing, there was a demand for surveys to correct these faulty descriptions. The writer had charge of such a survey in the city of Saline, Michigan.

Michigan is not considered an old state, yet some of its land titles date back to the days of the French occupation. Saline was settled soon after the War of 1812, and its first land patents were obtained during the presidency of John Quincy Adams. Its first plat was made and recorded in 1837 and attempted to show ownership conditions as they then existed. This plat was evidently never staked out; angles at street and property lines were indicated, but not measured, and linear distances along the main streets were probably obtained by assuming fencepost intervals as one rod. Other measurements were scaled from the drawing. Two additions were recorded in 1871. Since that date all descriptions were by metes and bounds. In 1914, a plat was surveyed but not recorded, and hence all descriptions depending upon it were illegal.

The recorded plats covered only a small part of the city. The main streets followed old Indian trails or military roads, so a very few descriptions were tied to section lines or government corners. No monuments were ever set on any of the plats. Property descriptions varied widely according to the ideas of the contracting parties. Perhaps the favorite type was the bounded one; that is, for example: William James conveys to

John Smith a parcel of land described as follows: "Bounded on the north by land now or formerly owned by John Doe, on the east by land owned by Richard Roe, on the south by land owned by John Jones, and on the west by Maple Street." Another type reads as follows: "The south one acre of the middle five acres of the Smith tract." Other descriptions started from natural objects, street corners or intersections, old sidewalks or other property boundaries. Due to these descriptions, private surveys were very expensive and seldom made. For similar reasons, litigation to determine boundaries was rarely employed. Two otherwise undesirable descriptions stand out as models of brevity: "Mr. W. J. deeded to Mr. J. C. a parcel of land in Saline township" and "Mr. E. F. owns one acre in the southwest quarter of Section 31."

Naturally, there was much confusion in the tax rolls. When metes and bounds descriptions are copied year after year from one roll to the next, the final result is apt to be a collection of errors. Many errors were found. Space will permit the mention of only a few. Three persons (two of them non-residents) were paying taxes on the same property. Others were assessed for property their neighbors owned. One citizen held a deed to an important street and, of course, many parcels were not on the tax rolls.

In order to make the needed corrections, a series of assessor's plats were made according to the Michigan laws. These necessitated considerable research. The recorded descriptions of all the property involved had to be obtained and when priorities were involved, as is frequently the case with metes and bounds descriptions, deeds running back for many years had to be copied. Records of all previous public and private surveys had to be collected.

The first part of the field work consisted of locating the government corners, rerunning the section lines and relocating lost and obliterated corners. This was the most time-consuming and expensive item of the project. Next the street lines were determined from a study of all available data, then the individual property lines were found, monuments were set where needed and the whole recorded on a plat. This procedure is not as simple as it sounds. The land surveyor is not a judicial officer and so can determine nothing in law. On the other hand, if his work is carefully done, it is quite uniformly accepted and the statute of limitations finally fixes the decisions he made. There is always the possibility of a judicial review of his actions, so he has to be reasonably careful that he has not overlooked any evidence that may later be presented in court, and also that his decisions are based on court decisions and on legal opinion when the precedent is doubtful.

The field work was planned so that all points of the survey could readily be connected with the U. S. Coast and Geodetic Survey control and the Michigan system of coordinates. Astronomical azimuths were used exclusively, a plane coordinate system for the whole city determined, and all monuments were located by coordinates. The U.S. Coast and Geodetic Survey second order traverse, a C.W.A. project, two lines of which when completed will pass through Saline, will make possible a quick and

economic connection of this whole survey with the North American Datum. Unfortunately, this control project was halted too soon. It is of the greatest importance that it should be completed at the earliest possible moment.

The plat law of the state of Michigan specifies in detail a reasonably permanent type of monument, but only a confirmed optimist would assume that any artificial monument would be permanent. City monuments, for obvious reasons, are particularly liable to obliteration. The only way to insure their continued usefulness is to connect them to the North American Datum. Then, if they disappear, they can be accurately and economically replaced. The added cost of this connection, when accurate control is available, is trivial compared with the cost of the original work and may be classed as insurance.

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TRIANGULAR HYDROGRAPHIC SIGNAL TOWERS

Letter from W. E. Parker, H. & G. Engineer, U.S.C. & G. Survey

This party has erected four hydrographic signal towers of the type described by Messrs. Paton and Deane in the Field Engineers' Bulletin for June, 1931. They were 100 feet tall, but otherwise in complete conformity with their specifications, except that twenty-four guys were used instead of twenty on three of them.

Two of these towers failed in a wind of no more than force 6, although one of them had previously withstood a wind of force 8, blowing for nearly two days. Failure was by breakage at or near the lower set of guys, about forty feet above the ground. In both cases the lower section remained standing, although this section of one of them was badly sprung. The two remaining towers were then examined. One of them, which had only sixteen guys and one set of targets, was found to be in good condition. The other was twisted and many of its diagonals and horizontals were loose or partly detached, the tails having sheared or drawn out. The damage was mostly on the long side, the hypotenuse of the triangle of cross section. This tower evidently would have failed soon.

There is no evidence that the failure of those towers was due to initial failure of guys. On the contrary, the guys appear to have held until the top section began to fall. Failure appears to have been due to loosening of braces, both diagonal and horizontal, and to rupture at splices and breakage of legs, probably in this order. Finally collapse resulted from buckling of the structure between guys. One of the towers that was still standing showed the first of these stages of failure.

It is our belief this type of tower lacks sufficient rigidity to withstand wind pressure, that its cross section is weak and that it buckles easily in the plane of the long side. It is more economical of labor and materials than is the four-sided tower, but we have lost in the two towers and failed all that could have been saved on about six of such towers.

Information is requested as to any comment on this tower by other field officers.

TRIBUTE TO THE SERVICE

(From Report of the Committee on Appropriations of the House of Representatives on the Appropriation Bill for Departments of State, Justice, Commerce, and Labor, for the fiscal year 1935.)

COAST AND GEODETIC SURVEY

The total of the estimates submitted by the Budget under the various appropriation headings for this Bureau amounts to $2,126,06l for the fiscal year 1935.

The work of this Bureau has to do with the publication of charts for the benefit of mariners; for control surveys in the interior which contribute to topographic mapping and varied engineering projects; prediction of tides and currents; studies in terrestial magnetism and earthquakes, and preparation of maps and charts for the guidance of aircraft and shipping.

An extensive hearing with the efficient director of this Bureau, which will be found reported in the hearings, has convinced the committee that further reductions in appropriations for the work being performed would be unwise. Lack of funds has forced serious curtailment of survey work on both the Atlantic and Pacific coasts. Many charts of harbors and coasts are antiquated and of little or no use to present-day navigation. To further reduce these appropriations would be to curtail services that are a proper function of the Government and which render a distinct service to navigation.

Comparative statement of the amounts appropriated for the fiscal year 1934, the Budget estimates for the fiscal year 1935, and the amount recommended in the accompanying bill for 1935

TITLE III—DEPARTMENT OF COMMERCE

Object	Appropriations, 1934	Estimates, 1935	Amount recommended in bill for 1935	Increase (+) or decrease (−), bill compared with 1934 appropriation
Coast and Geodetic Survey:				
Field expenses:				
Atlantic coast surveys	102, 000	105, 000	105, 000	+3, 000
Pacific coast surveys	141, 220	144, 520	144, 520	+3, 300
Tides, currents, etc	16, 820	13, 440	13, 440	−3, 380
Coast Pilot, compilation of	5, 200	5, 370	5, 370	+170
Magnetic work	37, 160	35, 079	35, 079	−2, 081
Federal, boundary, and State surveys; triangulation and leveling earthquake areas	150, 000	131, 970	131, 970	−18, 030
Special surveys and miscellaneous expenses	6, 735	3, 680	3, 680	−3, 055
Vessels, repairs of	63, 000	58, 200	58, 200	−4, 800
Pay, etc., men on vessels	533, 000	475, 011	475, 011	−57, 989
Pay and allowances, commissioned officers	633, 955	624, 991	624, 991	−8, 964
Office force, salaries	461, 000	478, 800	478, 800	+17, 800
General expenses, office	55, 000	50, 000	50, 000	−5, 000
Total, Coast and Geodetic Survey	2, 205, 090	2, 126, 061	2, 126, 061	−79, 029

N.I.R.A. ALLOTMENTS, 1933 - 1935

Project No.	State	Description	Allotment
FP 1	California	Surveys to modernize charts	$110,080
FP 2	Connecticut	"	38,410
FP 3	Florida	"	60,600
FP 4	Georgia	"	164,580
FP 5	Louisiana	"	152,220
FP 6	Maine	"	40,500
FP 7	Maryland	"	119,330
FP 8	Massachusetts	"	45,540
FP 9	Mississippi	"	15,010
FP 10	New Jersey	"	93,490
FP 11	New York	"	73,540
FP 12	North Carolina	"	49,800
FP 13	South Carolina	"	148,790
FP 14	Texas	"	58,640
FP 15	Virginia	"	80,470
FP 16	Washington	"	50,000
Sub	Total		$1,301,000
FP 17	Alabama	Triangulation, levels, etc.	18,525
FP 18	Arizona	"	39,100
FP 19	Arkansas	"	13,720
FP 20	California	"	30,750
FP 21	Colorado	"	37,050
FP 22	Florida	"	28,960
FP 23	Georgia	"	42,830
FP 24	Idaho	"	29,540
FP 25	Illinois	"	21,200
FP 26	Indiana	"	10,490
FP 27	Iowa	"	26,025
FP 28	Kansas	"	43,115
FP 29	Kentucky	"	13,525
FP 30	Louisiana	"	14,080
FP 31	Maine	"	10,650
FP 32	Maryland	"	4,560
FP 33	Michigan	"	12,100
FP 34	Minnesota	"	24,540
FP 35	Mississippi	"	23,120
FP 36	Missouri	"	24,550
FP 37	Montana	"	51,100
FP 38	Nebraska	"	33,225
FP 39	Nevada	"	41,200
FP 40	New Hampshire	"	3,120
FP 41	New Jersey	"	1,950
FP 42	New Mexico	"	37,920
FP 43	New York	"	10,225
FP 44	North Carolina	"	7,115
FP 45	North Dakota	"	34,100
FP 46	Ohio	"	14,550
FP 47	Oklahoma	"	38,600
FP 48	Oregon	"	19,100
FP 49	Pennsylvania	"	8,250
FP 50	South Carolina	"	14,625
FP 51	South Dakota	"	34,605
FP 52	Tennessee	"	11,400
FP 53	Texas	"	71,750
FP 54	Utah	"	29,115
FP 55	Virginia	"	14,090
FP 56	Washington	"	20,445
FP 57	West Virginia	"	18,240
FP 58	Wisconsin	"	25,190
FP 59	Wyoming	"	41,655
Sub	Total		$1,050,000
FP 60	California	Tides and Currents	500
FP 61	Florida	"	8,620
FP 62	Georgia	"	300
FP 63	Oregon	"	1,080
FP 64	Washington	"	500
Sub	Total		$11,000
FP 65	Alaska	Magnetism and seismology	1,440
FP 66	Arizona	"	1,534
FP 67	California	"	5,342
FP 68	District of Columbia	"	1,534
FP 69	Illinois	"	330
FP 70	Montana	"	330
FP 71	Nevada	"	1,000
FP 72	Oregon	"	1,000
FP 73	South Carolina	"	330
FP 74	Washington	"	1,000
Sub	Total		$13,840
FP 75	District of Columbia	Office computation, drafting, printing, etc.	224,160
FP 76	Various	Field surveys to modernize charts	811,920
FP 77	"	Field surveys, triangulation, leveling, etc.	1,469,120
FP 78	"	Field surveys, tides and currents	24,000
FP 79	"	Field surveys, earthquake, and magnetic	45,070
FP 80	District of Columbia	Procurement of boats, trucks and other equipment, instruments, supplies, and travel	441,292
FP 81	"	Office administration, computation, drafting, printing, etc. (Incl. Printing at G.P.O.)	309,698
FP 82	Various	Reconditioning of surveying ships	184,200
FP 83	"	Reconditioning of observatories	14,700
FP 84	"	Control surveys in various states in cooperation with Relief Administration.	563,120
		Total	$6,463,120

SUMMARY OF ALLOTMENTS.

1933 - 1935

Director (CWA and Office Personnel)	$660,779
Hydrography and Topography	2,569,982
Geodesy	2,780,276
Tides and Currents	60,088
Terrestrial Magnetism and Seismology	117,551
Charts	199,035
Instruments	54,262
Accounts	21,147
Total	$6,463,120

STATEMENT OF CAPTAIN R. S. PATTON, DIRECTOR U. S. COAST AND GEODETIC SURVEY

(Extracts from Hearing before the Subcommittee of the House Committee on Appropriations)

WORK OF THE BUREAU DURING THE PAST YEAR

Mr. OLIVER. We will take up this morning the appropriations for the Coast and Geodetic Survey. We have with us the Director of the Bureau, Captain Patton.

Captain PATTON. I would like to have you make such general statement at this time in connection with this service as you may think would be informing to the Committee. I will here state that in reference to recent allocations made to you by the P.W.A. and C.W.A., you may omit any reference to those in your opening statement because later we will probably recall you for a definite statement in reference to all appropriations made to you outside of the regular appropriation bill.

Captain PATTON. Mr. Chairman, the opening statement that I will make will be very brief because you know our work so well.

During the past year we have been engaged as you know along two parallel lines of work. They are closely related and yet there is a distinct line of demarcation between them.

The first consists of our regular work. We have certain projects, long-range programs of work that we carry on at a moderate continuing rate from year to year. Those programs produced-

(1) The Nautical Chart and the other publications for the benefit of mariners, such as the Coast Pilots.

(2) The control surveys in the interior which are the foundation on which is built the topographic map of the country and which contribute to the efficient and economical execution of a great variety of engineering projects, is another part of our program.

(3) We have our work in tides and currents from which we predict the tides and currents for the mariners, and which contribute engineering data for projects along the coast.

(4) We have our work in terrestrial magnetism and in earthquakes. The first gives to the mariner information he must have regarding the direction in which his compass needle points from time to time and from place to place. As you know, that direction changes both going from one place to another and with the lapse of time. Our work gives the same information to the land surveyor who uses a magnetic compass in his work or who uses other instruments to retrace lines run years ago with a magnetic compass.

Our work in earthquakes is a small study designed primarily to increase the safety of life and property, at places where earthquakes occur.

(5) Finally we have the project of producing maps of the country for the guidance of aircraft.

As I say, those are all long-range projects carried on at a moderate rate from year to year, the rate determined, of course, by the amount of the annual appropriation. At present we are carrying on that work at a rate about 35 percent below normal as determined by the appropriation for 1932. That means, of course, that we have some surveying ships laid up. In fact, each project has been curtailed its proportionate amount in the general reduction.

SURVEY OF WATERS ALONG ATLANTIC COAST FROM ALLOTTED P.W.A. FUNDS

That brings me to the emergency work which I will only mention briefly in order to give you a complete picture. We have certain allotments of Public Works money with which we are carrying on two kinds of work which are of such a character that they can make a large contribution to the relief of unemployment and also result in products of public value.

In the first place, about half of the emergency money allotted to us is being spent in surveys of waters along the Atlantic coast tributary to the ocean; the harbors and what we call the intracoastal waterway which extends all the way from Cape Cod down to the Mexican border.

As to the relief of unemployment derived from tnat work, I will just say briefly that about 70 percent of the money is paid out directly as salaries and wages to engineers and others whom we have taken on for that work. We are not employing them as engineers solely, but as rodmen and in all of the subprofessional capacities that go to make up a surveying party.

As to the intrinsic value of the work, there are two points concerned. In the first place, how efficiently can an expansion of this sort be carried on? In the second place, what is the public value of the work that is done?

I am glad to be able to say that in all this emergency work we are getting substantially the same results, the same unit costs that we get in our regular work. I have studied that with respect to the largest project on which we are engaged. That is the control surveys in the interior, the triangulation and leveling.

We find as to distribution of costs that a little better than 71 percent has gone to labor; that in the triangulation, the unit costs are 4.1 percent higher than the unit cost on the regular work supported by the regular appropriation. In the leveling, the unit costs are actually 10.8 percent less than on the regular work.

That was as a result of a study covering a dozen projects of each kind. I did not have time to have it include all of our work, but it is indicative.

Mr. OLIVER. How do you explain that?

Captain PATTON. In the triangulation, it takes some time to train a party that erects these steel towers, 100 to 150 feet high, by which we see over the surrounding trees, and overcome the curvature of the earth. A trained party will erect one of those towers in half a day and the progress of the party is determined by the speed at which the towers can be erected.

During a training period for the work, they did not go that fast. It would take perhaps 2 days to get a tower ready for use, so the whole project was slowed up a little bit at the first. The net results for the year, as I say, is an increase of 4.1 percent in the unit cost.

In the leveling there are two factors which made the emergency work actually cost less. As I said a moment ago, we wanted to devote a maximum of our expenditures to direct payment of salaries, and to do that we tried to keep down capital expenditures in every possible way. We borrowed instruments from the universities and technical schools of the country and even from the Canadian Government. We found in the Post Office Department a fleet of 49 old motor trucks that they had condemned. Congress had given them an appropriation to buy new ones. They very generously put those trucks in shape to use for another year or so and turned them over to us.

In such ways as that we kept down these capital expenditures and devoted the money to the employment of labor. In that way the unit cost on that work was less than normal.

PUBLIC VALUE OF SURVEYS OF TRIBUTORY WATERS ALONG THE COAST

As to the public value of the work: I will go back to these surveys of the tributary waters along the coast. The present charts of those waters are based very largely on surveys made in the seventies or earlier. As you gentlemen know, there have been extensive natural changes. Those changes are going on all the time. Beyond that, man himself has made very extensive changes in those waters. Every port along the coast is constantly at work improving its facilities. The Federal Government itself is spending something like $52,000,000 in projects for the improvement of this intracoastal waterway. All those improvements have to be shown on the chart before the mariner gets the benefit from them, and while we have excellent cooperation

with the Army engineers, their work is done for a different purpose and only to a limited extent results in data that are needed for the correction of the charts.

The result is that there is urgent need, and has been for some time, for a complete revision of our charts for those waters. Mr. Bacon knows the situation probably on Long Island. That is perhaps a little better than a typical case, but the local people there on Long Island have completely changed the physical character of those waters. They have dredged channels. The dredged material has been deposited in the marshes to make upland on which improvements of all sorts are made. Up to a year or so ago our charts were still showing the old preimproved condition and the people up there just could not use them. I am glad to say that that particular situation is pretty well cured now through the use of some of this emergency money.

Mr. McMILLAN. The same condition applies in my section, around Charleston.

Captain PATTON. Of course, it does. Let me give you an instance of that down there. You have a lighthouse inspecton down there in Charleston, Captain Beck. Captain Beck installed a complete system of new aids to navigation through your section of that inland waterway. He wrote in to his chief and said that he could not show those aids on the charts because the charts were so antiquated that they just did not fit and would the Coast and Geodetic Survey please be asked to make new surveys and revise their charts. We could not do it because we did not have the money. We know the need.

You will remember, Mr. Chairman, I presented the picture to you last year, and you made it possible for us to make a small start on the work out of the regular appropriation. You will recall that you put into the appropriation bill an item which authorized us to use an airplane for photographing the land adjacent to the waters and an appropriation of $25,000 for supplies and materials, photographic instruments, for use in that connection. That was admittedly just a small start on the work, but it was getting the project recognized and getting us in a position where we could take it up as soon as the financial conditions of the Treasury permitted.

So we have devoted about half of this emergency money to that project. The other half of the money has gone to what we call the control surveys in the interior.

CONTROL SURVEYS IN THE INTERIOR

Those control surveys consist of triangulation and leveling, the networks of which are being spread all over the whole United States.

A chart or a map is a definite, tangible product. You can pick it up and look at it and appraise it and appreciate its value. These control surveys are intangible in the value of their results. That is, it is hard to visualize them, and particularly hard for the man who is not an engineer. But the control surveys are to mapping, to highway construction, to railroad building, to power and pipe-line extension, to irrigation projects, to flood control, in fact to every engineering operation that requires accurate knowledge of the surface of an extensive area—the control surveys are to those projects what the steel framework is to a building. They give form and strength and rigidity to the whole thing. They are concealed inside the finished product. The public never sees them. Yet they are there serving that essential purpose.

If you will permit me, I would like to give you just 2 or 3 instances of the value of that work as more indicative of what it means than trying to explain it in abstract terms.

Mr. Oliver, 2 or 3 years ago the State of North Carolina voluntarily made an allotment to us of 25 percent of the cost of finishing the survey in that State. The work was a Federal project. They were under no obligation to do it, but because they wanted the results earlier than we could otherwise give them, they made that 25 percent contribution, in order to get priority for the work.

I want to read to you just a couple of paragraphs, if I may, of what the chief highway engineer of North Carolina has to say about the work in a paper that he gave to the American Society of Civil Engineers. It is brief. He says:

> In building our State highway system it was necessary to carry on the work in short disconnected sections, or projects, of from about 5 to 12 miles in length scattered throughout the State so that all communities could profit alike from the road program. The system consists of nearly 10,000 miles of roads, which have required 11 or 12 years to construct. Based on an average length of projects of 8 miles, about 1,250 separate final location surveys had to be made, not to mention numerous preliminaries, revisions, abandoned locations, hundreds of surveys for bridge sites, and about 1,250 sets of detailed plans, each consisting of from 10 to 100 standard-sized sheets.
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> Blueprints and field notes of such surveys serve only for construction purposes and in a few years become almost entirely worthless. Imagine the tremendous economic loss of 10,000 miles of highway location, costing a million or more dollars, which after construction are utterly valueless for future accurate use. It is like casting priceless byproducts of a great factory into the sea.
>
> When our future surveys have been subjected to horizontal and vertical control and monumentation, each will become a part of the State system. Each can be easily and correctly reproduced at any future date and from it other surveys may spring and become a part of the common system. Thus in a short while these surveys will form a composite structure, each in its true position with reference to the others, with the result that maps of our highway system will gain a new value.

The reason for such requests is that these controls not only reduce the first cost and insure the accuracy of engineering work based on them, but they, and they alone, make it possible to coordinate the results of one project with others executed surrounding it, whether executed at the same time or at any other time. If each is controlled, the accuracy of each project is sustained clear out to its periphery. If it is not controlled, you start with an assumed point, we will say, in the center of your project and you work out from that in all directions. You accumulate errors. There is no way of measuring those errors or even knowing to what extent they exist. The result is that your work is of an unknown accuracy as you recede from the center and when you bring two projects together, they do not fit. The data overlaps or there are gaps in between them. Your roads do not come together, your streams butt into the land, and all that kind of condition exists.

I wish I could make you see this picture as I see it; the tremendous possibility in coordinating work. Here under this administration we are planning a new era. We see visions of what we call the " new deal ", which among other things, means coordinated large-scale advance planning. One little detail of all this activity in which the Government is engaged is a tremendous increase in the demand for surveys, for maps. All these agencies—the Tennessee Valley Authority, the Agricultural Adjustment Administration and all these other agencies that are dealing with economic problems—are demanding maps on which to visualize their problems and to lay down the details for their solution.

APPROPRIATIONS MADE FOR CONTROL SURVEYS UNDER TEMPLE ACT

Mr. BACON. How much of the United States is accurately mapped now?

Captain PATTON. Mr. Bacon, about 45 percent of the United States is covered by topographic maps of some kind. About half of those maps were admittedly of a reconnaissance character, made in the early days, or are in such need of revision that they are of little value at present.

Mr. BACON. So only a little over 20 percent of the United States is accurately mapped?

Captain PATTON. Only a little over 20 percent is accurately mapped at the present time; yes, sir.

Mr. BACON. How long would it take to complete the mapping of all of the United States?

Captain PATTON. At the present rate of progress or at the rate of progress of the past half century, it will take 75 to 100 years.

In 1925 Congress recognized the situation and passed what is known as the "Temple Act", the act of February 27, 1925, which contemplated that the control surveys would be finished in about 12 years and the topographic map in about 20 years. But, for some reason, very little practical effect has ever been given to that act in the form of increased appropriations. So that the situation now is, except for what we have accomplished in the control surveys through the emergency allotment, that we have just about what it would have been if the Temple Act had not been passed.

ATLANTIC COAST SURVEYS AND RESURVEYS

Mr. OLIVER. The first item is for "Field expenses, Atlantic coast." You had appropriated in 1934 $102,000. How much of that will remain unexpended, do you estimate, as a result of the impounding of funds or other limitations that may have been placed on your expenditures?

Captain PATTON. $6,500.

Mr. OLIVER. And for 1935 the Budget has estimated $105,000 which includes one third restoration of the 15 percent cut in pay.

Captain PATTON. Yes, sir.

Mr. OLIVER. What does that one third amount to?

Captain PATTON. $3,000. I would like at this point, Mr. Oliver, to make a statement which applies to this and all other items of our appropriation. All of the different operations and purposes for which funds are allotted have essential parts in the process of constructing charts and maps. For example, 5 of the different appropriation items contribute to the expense of operating one of our survey ships while 4 additional items are involved in the preparation for use by the mariner of the results of the field work accomplished. On account of this close relation between the various appropriation items it is very important, in the interests of economic and efficient administration, that a proper balance be maintained between the amounts of the different items.

This year, as was the case last year, we have been allowed a certain sum as the total amount of our estimates. The amounts of the individual items in these estimates are the results of our efforts to distribute this sum to the best advantage based on our experience during the past 2 years in working under reduced appropriations. Small increases in a few items over the amounts appropriated for the present year are more than balanced by decreases elsewhere so that, after making the necessary allowances for different pay reduction percentages, the total of our estimates is $5,379 less than the total of our appropriation for 1934.

The Atlantic and Gulf coasts of the United States south of New York are subject to constant change due to the forces of nature. Changes also are constantly taking place along the entire seaboard through the works of man such as harbor improvements by the United States Engineers, construction or removal of waterfront features and landmarks, and so forth. In many regions the charts are based on surveys made during the days of sailing ships and other light-draft vessels and are inadequate to meet the present needs of navigation. Resurveys from time to time along the whole extent of both coasts, to maintain the accuracy of the charts and to modernize those which are based on older surveys, constitute a never-ending task.

Funds appropriated for "Party expenses, Atlantic coast, will be used chiefly to purchase supplies and equipment for survey vessels and shore parties, for pay of temporary personnel in shore parties, and for the incidental operating expenses of field stations at Boston, New York, and New Orleans.

It is planned to operate 1 ship on the Gulf coast, 1 small ship and 2 tenders on the Atlantic coast and several shore parties for short periods at various points. It will be necessary to lay up the two largest ships operating on the Atlantic coast for all or the greater part of the year.

PACIFIC COAST SURVEYS AND RESURVEYS

On account of the immense area involved and the necessity for securing chart information in the shortest possible time, original surveys on the Pacific coast were mostly of a reconnaissance nature and were confined to in-shore areas. The Russian charts available when Alaska was acquired were inaccurate and entirely inadequate. The same situation existed with respect to the Spanish charts of the Philippines. While in many cases resurveys have been required from time to time on account of changes which have occurred, the principal work of the Bureau at the present time is the accomplishment for the first time of adequate surveys of these regions out to the offshore limits required for modem navigation.

Funds appropriated for party expenses, Pacific coast, will be used chiefly to purchase supplies and equipment for survey vessels and shore parties, for pay of temporary personnel in-shore parties, and for the operating expenses of field stations at Seattle, San Francisco, Honolulu, T.H., and Manila, P.I.

It is planned to operate 5 ships on a part-time basis; 2 on the California coast, 1 on the Washington coast, and 2 in southwest Alaska. The one ship provided by the Federal Government for surveys in the Philippine Islands will be laid up throughout the year. Surveys of this region will be continued by one ship provided by the insular government.

COMPILATIONS OF COAST PILOT PUBLICATIONS

This appropriation is for the field and office expenses necessary for the compilation and revision of Coast Pilot publications. The Bureau publishes 12 Coast Pilots covering all coasts under the jurisdiction of the United States and two Inside Route Pilots for the inland waterways along the Atlantic and Gulf coasts. These supplement the nautical charts by furnishing essential information not indicated on the charts or readily obtained therefrom relative to tides, currents, weather conditions, anchorages, controlling depths, port facilities, harbor regulations, descriptions of landfalls and leading marks, and sailing directions for the coast and various ports and harbors. They are an essential part of the nautical equipment of the merchant marine, Navy, and coastwise navigator. It is necessary to revise these pilots at intervals of about 5 years on account of changes which are constantly taking place.

During 1935 it is proposed to revise two Coast Pilots: covering the Atlantic coast from Cape Henry to Key West and the Gulf coast from Key West to the Rio Grande. Expenditures in 1934 will be less than proposed for 1935 due principally to the necessity for postponing certain revision work in 1934 on account of shortage of officers.

MAGNETIC SEISMOLOGICAL OBSERVATION WORK

This appropriation is to provide personnel and material for carrying on the Bureau's magnetic and seismological work.

Magnetic investigations are necessary to supply not only compass data for nautical charts, but information needed by engineers and surveyors using the compass on shore. Other users of this information include aerial navigators, geologists studying surface formations, and investigators of radio communication difficulties.

The purpose of the seismological work is to provide information in regard to earthquakes in the United States for the benefit of the public in general and engineers, architects, geologists, insurance companies, and those planning for the safety of cities during earthquake emergencies, in particular.

Aside from routine observations at its observatories and the collection of data from other stations and from a large number of volunteer observers, the principal seismologic work of the Bureau is the installation and operation of instruments to measure destructive ground movements in the central regions of earthquakes so that engi-

neers and architects may have specific data concerning earthquake forces which structures must be designed to resist. This is a new development requiring the design of special instruments and much experimentation. Instruments installed in California were highly successful in measuring ground movements at the time of the recent earthquake at Long Beach, producing records the value of which has been widely recognized.

The principal expenditure under this item is for the maintenance of the five permanent magnetic and seismological observatories operated by the Bureau. A small amount ($4,600) will be expended for the continuation of the special study of destructive earthquakes mentioned above.

FEDERAL, BOUNDARY AND STATE SURVEYS

This appropriation is for the purpose of carrying on the basic geodetic-control surveys of the country. These surveys furnish accurate latitudes, longitudes, distances, true bearings, and elevations which are perpetuated by monuments in which have been set appropriately inscribed metal tablets. While executed primarily for mapping and charting purposes, the great networks of triangulation and leveling, by means of which the above information is secured, supply essential data for highway and railroad location, hydroelectric developments, flood control, power and pipe-line transmission lines, reclamation and drainage projects, city planning, the location and perpetuation of boundaries of public and private properties, and other projects in the development of local communities.

Expenditures in the field under this appropriation are chiefly for the purchase of supplies and equipment for field parties, pay of permanent noncommissioned personnel who are experts in the various classes of work, and pay of temporary personnel hired for the duration of the field season.

With this appropriation control surveys will be continued on a reduced scale during 1935. Proposed operations include the operation of 2 variations of latitude observators, 1 triangulation party, 2 level parties, and 1 gravity party.

EXPENDITURE OF EMERGENCY FUNDS

Mr. OLIVER. Questions have already been asked you as to how you would expend, wisely and economically, the funds allocated to you by P.W.A. and the C.W.A. for this coastal work, and you stated you would supply this information to the committee.

When you take into consideration the answer which you have indicated to the committee will be the answer you feel you can make to that question, I should like for you, in answer to the last questions raised by the questions asked by the two members of the committee, to also suggest how the work would be further accelerated, and within what time it would be completed, if you were given these additional funds suggested by the questions asked.

Captain PATTON. To answer first your own question, Mr. Oliver, and supplementing what I have already said, by June 30, 1935, we contemplate spending $1,864,540 of emergency money in charting the intracoastal and other sheltered waters of the Atlantic and Gulf coasts. We can spend that money wisely and economically for two reasons: First, because the reduction in our regular appropriations releases a part of our trained personnel and equipment for use on this project; these becoming the foundation on which the project is built; and second, because the depression has thrown thousands of high-grade engineers, and many thousands of other equally high-grade men out of work and placed them in such dire need that although they may have been earning five-figure salaries before the depression they are glad to get jobs with us now; even subprofessional jobs paying $100 to $125 a month. With such a foundation on which to build, and with such men from which to build it, a large expansion of surveying work can be quickly accomplished and efficiently operated.

Now as to the method of operation: Three principal field operations are involved in chart production; first, triangulation, second, topography of the land, and third, hydrography of the waters. For maximum effciency these operations should be consecutive. The triangulation should be completed and adjusted in order that it may control the work of the topographer and hydrographer. The topography should be done next because the hydrographer needs it for his work. That consecutive method has been followed here. The triangulation is so nearly completed that we have just started on the second step. Large areas along the waterways have been photographed for us by the Army Air Service, and now we have a large number of engineers compiling the topographic detail from the photographs. In general the hydrography has not yet been started, but there are a number of areas where it is possible to carry on all three of these operations almost concurrently, and in such cases that is being done.

Similarly with respect to our control surveys. With our own trained personnel available to organize, plan, and direct the work, the maximum requirements for men to perform it are a knowledge of engineering fundamentals, skill in the use of precise surveying instruments, interest, energy, and initiative. Men possessing those qualifications were available to an extent far in excess of our capacity to employ them, so it was not difficult to bring about a large expansion of this work which would be efficient and economical.

I might add that the size of our expansion was determined by the amount of trained personnel and of equipment available, not by what was required to complete a specific amount of work in a given time. When we suggested the amount of emergency money to be allotted to us, the question we had put to ourselves was "How many unemployed men can we use within the limitation of giving the public full value in results accomplished for the money spent?" We assumed that when the actual emergency was over it would be made possible for us to round out the work and bring it to an orderly close.

I will very briefly summarize the principal features of the program:

(1) The amount involved is $6,463,120 of P.W.A. funds, plus about $3,500,000 which the C.W.A. was to pay direct to labor in our employ.

(2) The primary purpose was to relieve unemployment during the next few months, but in order to get adequate returns out of newly purchased equipment and to complete all projects, so that the public would get full value for the money spent, the work was to extend at a reduced and gradually diminishing rate into the fiscal year 1935.

(3) More than 70 percent of the money was to be paid out directly to labor. More than 17,000 of the unemployed would now be at work had it not been for the paralyzing effect of the move to curtail the program. That number can be put to work promptly whenever we are assured that the money is available. Some 8,200 are actually at work at the present time.

(4) The men employed are of the unorganized, inarticulate white collar class; engineers, college graduates, and men of that type who have found it particularly difficult to get work. We have not given them "white-collar" jobs; on the contrary, they are serving largely as rodmen, erecting steel towers, driving trucks, casting our concrete monuments, or digging the holes in which the monuments are set; in short, performing the routine labor of a surveying party.

(5) The work is being done in every State and almost entirely in the rural districts. Therefore (1) the unemployment relief is Nation-wide, and (2) the operating expenses of the parties, and the subsistence expenses of the men, which they pay out of their salaries, are spent in the small towns and rural districts and to a very large extent constitute the only direct benefits which those localities receive from the P.W.A. program.

(6) The work is being done with substantially the same effciency as we put into our normal work.

(7) Most of the P.W.A. money necessarily is being spent for construction. This involves subsequent costs for upkeep and/or operation. Our work does not involve any such costs, at least during the next decade or two. On the contrary, because of this work, during the period when the Nation is paying the huge bill now being incurred, the appropriations to the Coast and Geodetic Survey can be less than would otherwise be required.

(8) The work is in execution of projects which the Congress has investigated and found to have such public value that it has regularly and continuously supported them with appropriations.

REEMPLOYMENT OF IDLE FACILITIES

Now to answer the other question asked by the committee:

We have one ship permanently laid up in the Philippines because of

shortage of both Federal and insular funds. The need for work there does not justify carrying it on wholly with Federal funds. I believe we should keep that ship laid up until the insular government can meet its share of the cost.

We have two ships temporarily laid up on the Atlantic coast, and we must curtail the working season of our Alaska ships, both from shortage of funds.

The amount required during 1935 to operate the ships to normal capacity, and otherwise carry on an adequate program of work, will depend entirely on the action taken with respect to the emergency allotments.

At the one extreme, the total allotment may continue at our disposal. In that event, $49,930 added to the 1935 Budget, would meet the purpose the committee is considering. That sum should be distributed among the appropriation items as follows:

To the item "Pay, officers and men", add	$13, 980
To the item "Pay, office force", add	35, 950

I must explain why a shortage in the item for pay of our office force should result in temporarily laying up ships. One of our major objectives in this emergency program has been to give the public excellent value for the money spent. That value is embodied in the finished product which we turn out for public use. Field surveys merely furnish raw materials which must be processed in our Washington office before the public can use them. The appropriation for pay of office force was inadequate to do that processing. Therefore, rather than have additional raw materials accumulate and be largely wasted, we curtailed field production and laid up ships, using the money thus saved for processing the abundance of material already on hand.

At the other extreme the entire program of emergency work may be abruptly terminated. That termination would freeze a large capacity for useful work. To what extent should increases be made in the regular appropriations in order to thaw out that capacity and put it back to work?

That is such a difficult and important question that the answer I give will be based, not on my own biased judgment, which you might properly discount, but on the impartial judgment of American business.

A few months ago the Business Advisory and Planning Committee of the Department of Commerce, of which Mr. Gerald Swope is chairman, appointed a subcommittee to study the Coast and Geodetic Survey.

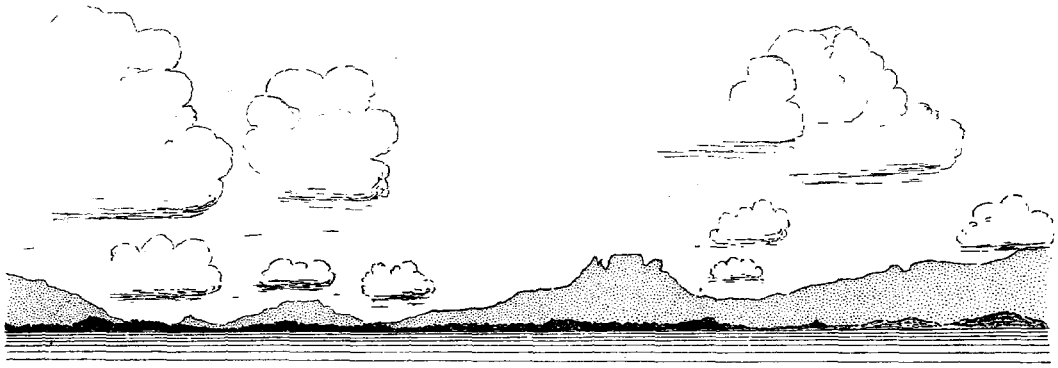
I am an ardent advocate of long-range planning, particularly for work such as ours, which consists of the gradual performance of certain large tasks. Therefore I asked that subcommittee, as one feature of its study, to formulate a long-range program for our work in which, weighing the intrinsic value of the work and the urgency of the need for it, against the unquestioned need for retrenchment, they would embody a rate of performance which they considered appropriate to present conditions.

The study was made and the subcommittee made a report which was approved by the full committee. Among other things it proposed a long-range program for the survey based on the assumption that the emergency work would continue until June 30, 1934, and which contemplated the following appropriation for 1935:

Party expenses, Atlantic coast	$447,031
Party expenses, Pacific coast	231,800
Party expenses, tides, currents, etc	13,440
Party expenses, coast piiot	5,370
Party expenses, magnetic work	89,849
Party expenses, Federal, boundary and State surveys[1]	1,086,895
Party expenses, objects not named	3,680
Repairs of vessels	58,200
Pay, officers and men	605,000
Pay, commissioned officers	624,998
Office force	578,800
Office expenses	60,500
Three small vessels	115,000
Air photo equipment	70,000
	3,990,563

The program contemplated similar appropriations for the next few years, except that the last two items would not be repeated.

As I have said, I furnish the above program as representing the judgment of American business. I do not presume to make any recommendation of my own. At your request I have endeavored in the hearing to furnish an impartial picture of the facts with respect to our service. You are so much more competent than I to weigh those facts against the need for curtailed expenditure that I prefer to leave the decision to you and to accept the result just as I have heretofore accepted the decision of the Bureau of the Budget embodied in the estimates now before you.



PAGODA CLIFF, PALAWAN ISLAND P.I.

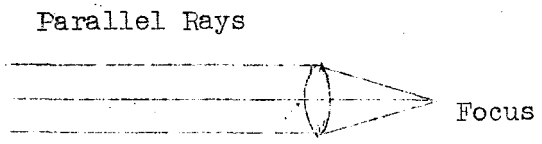
TESTING GRADUATED THEODOLITE CIRCLES

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

Principle on which test is based

Light waves traveling from an infinite distance and passing through a convex lens are concentrated at a point called the focus. Light waves traveling from an object set at the focus of a lens pass out of the lens in parallel rays.

This proposition may be illustrated by concentrating the sun's rays through a lens on a piece of paper set at the focus of the lens.



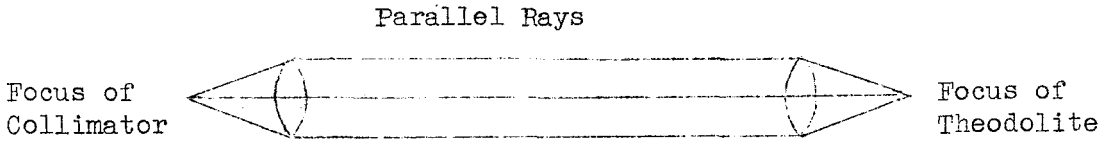
Apparatus

The apparatus consisted of five collimators, with illuminated cross hairs, set on shelves attached to brackets on the walls of a Department of Commerce store-room, the instrument to be tested with lighting attachments, an instrument support, and a sixth collimator set in sidereal focus, used as a standard for comparison.

Preliminary adjustments

The cross hairs of the standard collimator were set in the focus of its objective lens (siderial focus) by pointing and focusing on the sun. Then this instrument was set up, leveled and pointed on the theodolite to be tested with the objective at the height of eye of the observer and toward the theodolite. The theodolite to be tested was then pointed and focused on the cross hairs of the sixth collimator. Then each of the collimators set on shelves attached to brackets on the walls was leveled, pointed, and focused on the cross hairs of the theodolite to be tested.

Light, traveling from the cross hairs of a collimator set in sidereal focus, leaves the object lenses in parallel rays. This condition is equivalent to sighting on an object at an infinite distance from the theodolite to be tested.



Observing

The room was darkened and a set of observations was recorded for sixteen positions of the circle by pointing first on collimator A, then B, C, D, and E in order, reversing the telescope and pointing in the reverse order on E, D, C, B, and A. By this method a set of observations was obtained similar to observations in the field.

The cross hairs of the collimator replaced the lights used on field observations. The short distance between theodolite and collimators replaced the long distances between observer and lights on field work.

An abstract of directions was recorded. The mean of each direction was computed. Whenever the observed direction of any position varied more than four seconds from the mean, observations were immediately repeated for that position.

Computations

The differences between the observed directions and the mean direction were computed. These differences were squared and summed for sixteen positions of each collimator. The square root of the sum multiplied by 0.1742 indicated the probable error of a single direction. The square root of the sum multiplied by 0.0435 indicated the probable error of the mean of sixteen directions.

The probable error of the mean of sixteen directions computed in this manner is made up of four essential parts. First, instrumental defects; second, changes in the position of the collimators; third, personal errors; and fourth, errors of graduation of the circle.

The construction of modern instruments practically eliminates errors due to defective instruments. By using an instrument which is found practically perfect, instrumental errors may be thrown out.

Shifting of the collimators may be tested by repeating the first position at the end of the observations.

To eliminate personal errors, the following method was applied. In making observations with theodolite number 283 it was found that the circle was so nearly perfect that any differences in the directions might reasonably be said to equal the personal error of the observer. The probable error of the graduations on this circle was considered equal to the personal error of the observer and used in computing the probable error of all other circles by the formula $e^2 = a^2 - b^2$. In this formula "e" is the probable error due to the graduations of the circle, "a" is the computed probable error from observations and "b" is the personal error of the observer as computed from observations with instrument 283.

Errors of the graduation of the circle still remain after the above errors have been eliminated.

Field Observations

For the purpose of comparing the results of these tests with field observations the probable error of the mean of sixteen directions with satisfactory circles at several field stations was computed. These observations indicated the probable error of a direction determined from sixteen settings of the circle varied from 0".34 to 0".31. As these observations were made under field conditions on towers subject to wind, hazy lights, personal errors of the observer, circle errors of the instruments, and uncertain atmospheric conditions, it is probable that an instrument tested under nearly ideal conditions would show a probable error considerably less than the error computed under field conditions. So for first-order work if we accept 0".31 as the limiting probable error, all circles with probable errors (including personal error of the observer) above this limit are questionable. Probable errors considerably above this limit mark the instrument as unfit for first-order triangulation.

The results of the observations are as follows:

Circle	Probable error of 16 positions, including personal error of observer	Remarks
No. 10	0".272	Fair
No. 11	0.305	Questionable
No. 11	0.316	Questionable
No. 1	0.76	Rejected
No. 283	0.148	Excellent
No. 8	0.37	Questionable
No. 8	0.38	Questionable

Recommendations

In order to carry on tests of circles, it is recommended that a room about 30 feet on a side in the basement be set aside, heavy brackets be installed for the collimators, the collimators be so mounted that one support for the telescope be located at the cross hairs and that cross hairs which show clearly be mounted in the collimators.

These recommendations are based on the following considerations: Under present conditions the room used for testing is not locked. During observations there is a parade of employees entering and leaving the storeroom on various missions. The open room furnishes an invitation to the curious. The settings and focusing adjustment of the collimators were tampered with frequently. The collimators were mounted on wood and were not stable. So it was not possible to compare the angles measured with different circles even when the collimators had not been moved. By mounting the collimators on heavy supports, one at the cross hairs and the other near the objective, there should be very little variation in measured angles on different days. The present collimators fitted with etched diaphragms are unsatisfactory as the cross lines are not distinct.

PLOTTING THREE POINT FIXES WITHOUT THE USE OF A PROTRACTOR

L. D. Graham, E. & G. Engineer, U.S.C. & G. Survey

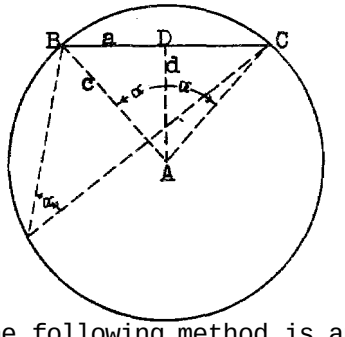
Although several reports on this same subject have been previously submitted, this method does not yet seem to be in general use. Many field officers are unfamiliar with the details of plotting the position arcs under various conditions, such as when one or more of the signals fall beyond the limits of the sheet, and also fail to realize the value of this method due to never having seen it in actual operation. Owing to the accuracy of this method, and the fact that stronger fixes are available by using signals beyond the limits of the sheet, this method of plotting should find a much wider use in the field.

For these reasons I am submitting, in considerable detail, methods used by us on the southwest coast of Palawan during the season of 1933, where shoals abound for a distance of some twenty miles offshore and detailed development was required at that distance.

Due to distortion of the boat sheet after it had been in use a short time, we found it advisable to compute all distances and not to scale any distances of over a foot on the sheet. To accomplish this it is necessary to compute two or more points on the locus of centers. This is explained in detail later.

Caution: Do not confuse α in Fig. 1, the observed angle, with α on Form 662, inverse position computation.

Fig. 1



B and C = control points or signals
a = distance between signals B and C
α = observed angle between B and C
A = center of circle which is locus of all points where angle α can be observed,
d = AD, perpendicular bisecting BC
c = radius of circle

$d = \frac{a}{2} \cot \alpha$

$c = \frac{a}{2} \operatorname{cosec} \alpha$

The following method is applicable when the signals fall beyond the limits of the sheet, but a portion of the line AD (Fig. 1) crosses the sheet. This method may also be used to advantage when the signals are on the sheet as it eliminates errors of distortion in long scaled distances.

FIRST - Make Inverse Position Computation on Form 662 for distance BC (Fig. 1). The mean of the latitude and longitude of B and C, φ_m and λ_m, gives the position of D as accurately as can be plotted, and $\alpha + \frac{\Delta\alpha}{2}$, Form 662, equals the azimuth from D to B within one or two seconds. (This applies to distances up to 25,000 meters and low latitudes. If in doubt compute them geodetically and compare).

SECOND - Erect perpendicular AD. By referring to the layout of sheets, two points are selected that fall on the sheet. Their distances to D are roughly scaled off on the layout, and a distance chosen to the nearest even 10,000 meters. Then using Form 27, Position Computation Third Order Triangulation, points are computed from the center D along azimuth (DB-90°) at the required distances. Since this azimuth differs by 90° from that found in the Inverse Computation, the logs of the sin and cos of $\alpha + \frac{\Delta\alpha}{2}$ found there may be copied onto sheet B, by interchanging the sin for the cos and vice versa. More points may be computed if desirable.

THIRD - Compute the distances "d" corresponding to the required angles by the formula $d = \frac{a}{2} \cot \alpha$ (Fig. 1). These distances are plotted along the line AD from the nearest computed point. In this way practically all distortion along the line AD may be eliminated.

FOURTH - Compute the radii "c" by formula $c = \frac{a}{2} \operatorname{cosec} \alpha$ (Fig.1) (this is necessary when both B and C are off the sheet). Select a point on one of the arcs (or more than one if the sheet is badly distorted) near the center of the work and compute its geographic position. This is readily done from one of the

centers, its computed radius and an assumed azimuth. Then compare the scaled and computed radii and apply the differences proportionally to the lengths of the rest of the computed radii. In computing d and c, we incorporated a scale factor in the formula so that the results could be scaled directly on a 1:10,000 meter scale. For any scale, the formulae are as follows:

$$d = x \frac{a}{2} \cot \alpha \quad \text{(Fig. 1)}$$

$$c = x \frac{a}{2} \operatorname{cosec} \alpha \quad \text{(Fig. 1)}$$

$$x \text{ (the scale factor)} = \frac{10{,}000}{\text{scale used}}$$

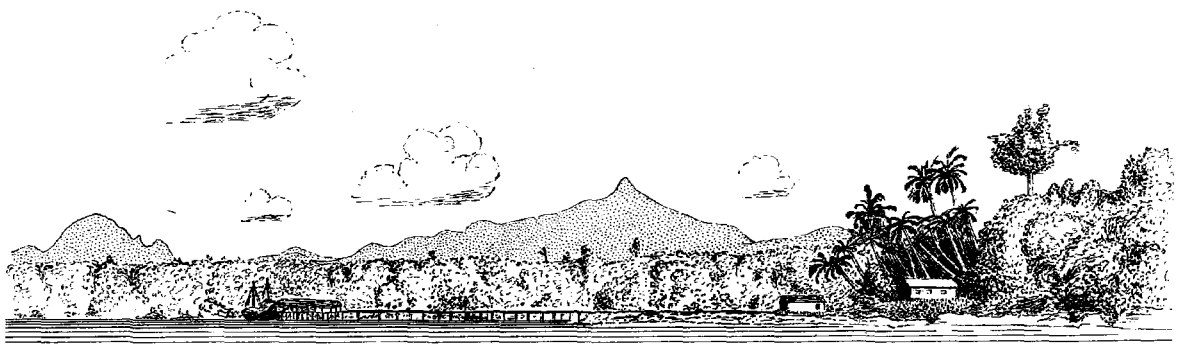
Example: If scale used is 1:40,000, $x = \frac{1}{4}$, etc.

FIFTH - Lay out the arcs with a beam compass using the centers on line AD and the computed and corrected radii. A table of logarithms of cotangents and cosecants for angle α, Fig. 1, was constructed, as we found natural functions unwieldy where a computing machine was not available. Arcs drawn for every degree down to 20° and for every half degree to 10° usually give sufficient accuracy. In plotting, small spacing dividers are used to interpolate between the arcs. This can be done more rapidly than the angles can be set on the protractor, and the resulting position is free of all protractor errors and those due to distortion of the sheet. Sheets were prepared in advance with the log cotangents or log cosecants for angle α, Fig. 1, covering the necessary range, typed in, leaving space below to add log of $\frac{xa}{2}$ (x being the scale factor to reduce to 1:10,000). Then as soon as "a" was determined, the distances "d" and "c" could be very rapidly computed.

An excellent check on the construction of the arcs is the fact that the arc of a given angle passes through the center of the arc of half that angle. In other words, "d" of the larger circle equals "d" + "c" of the smaller. Distortion in the sheet is also detected by means of this simple fact.

The line of centers can readily be extended some distance beyond the limit of the sheet, by means of a straight-edge. Even if the line of centers lies entirely beyond the limit of the sheet, there is usually a way to get around it. It may fall on the adjacent overlapping sheet. In this case the arcs may be drawn on tracing cloth and transferred to the other sheet. It may be feasible to make a new projection extended far enough to take in the line, and then after the arcs are constructed, this part can be cut off.

This method is ideal for developing a shoal with a launch far from shore and where strong currents may prevail. The lines are run parallel to one of the arcs, and by means of a sextant the launch may be held to the line as easily as with a good range. The launch is then turned on to the next line by watching the angle in the sextant. It is possible to thoroughly cover the shoal with evenly spaced parallel lines, without plotting a position until the area is completed. In doing ship hydrography, it is usually possible to tell if a change of course is necessary as soon as the angles are taken and before the position is plotted.



Mount Saint Pauls and Cleopatra's Needle from Puerto Princesa, Palawan
Philippine Islands

MORICHES INLET: A PROBLEM IN BEACH EVOLUTION *

R. S. Patton

Director, U. S. Coast and Geodetic Survey

IN February of this year, during one of the severe storms that characterized the past winter, an inlet broke through the barrier beach that separates Moriches Bay, on the south coast of Long Island, from the ocean. The occurrence raises interesting engineering and economic questions relative to beach conservation, particularly in view of the present and potential value of the land in this vicinity. The section of beach east of Fire Island Inlet, the scene of this action, is an important potential part of New York City's playground. It is nearer the city than any other ocean beach not yet extensively developed. The economic and social factors in the situation increase the importance of the physiographic problem.

He would be a rash prophet indeed who attempted to predict definitely what the situation will be at any point of this sandy cordon twenty or thirty years in the future; but, drawing on past experience, one can outline the probabilities. The inlet may close almost as suddenly as it opened. That has happened to a considerable number of inlets cut by storm waters and has been the disappointing outcome of a number of attempts to open inlets by artificial means. If closing is to occur, however, it is to be expected promptly: if such an inlet remains open long enough to establish an equilibrium it tends to be permanent.

THE CASE OF LONG BEACH

On the other hand the inlet may not close. Let us consider what happened under similar conditions at Long Beach, some miles to the westward. Events can best be understood by reference to the sketches in Figure 1.

In 1835 the easterly point of East Rockaway Inlet was situated a little to the west of longitude 73° 41'. By 1860 this point had grown to the westward a distance of about 2¾ miles, or at an average rate of about one-tenth of a mile a year. This westward growth continued, and it is stated locally that by 1872 more than another mile of beach had been added to the point; in fact it is asserted by some that by that time the growth had attained to a position a little west of longitude 73° 46', and the point had attached itself to the mainland, closing the inlet.

By courtesy of "The Geographical Review"

In 1872 a new inlet broke through the beach at about longitude 73° 41'. Apparently the inlet required some years to establish its regimen, for in 1879 the westward growth of the new easterly point had scarcely begun. By 1909 this westward growth had added 2½ miles to the length of the beach, and between 1909 and 1927 another three-quarters of a mile was added.

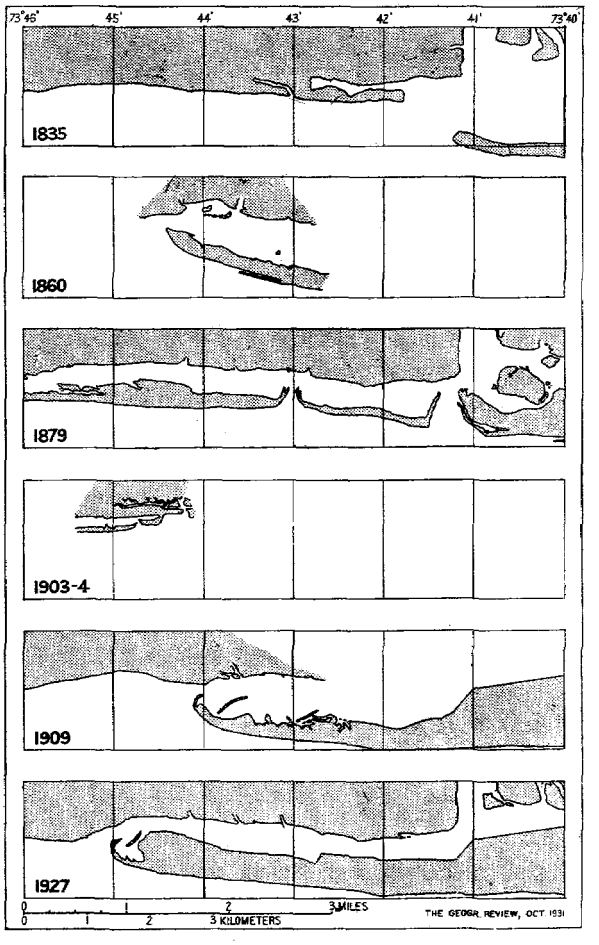


FIG. 1—Stages in the evolution of Long Beach, L. I.

When the new inlet opened, it became the principal passageway for the flow of tidal waters into and out of the interior basins. Thereupon the old inlet, some 4 miles or more to the westward, immediately closed, if in fact it had not already done so; and a long finger-like peninsula extended to the eastward from its connection with the mainland at its western extremity. This peninsula rapidly disintegrated. By 1879 it had broken into two parts. An island that constituted its eastern part had eroded to such an extent that sand dunes and vegetation had disappeared, and it consisted of little more than a low flat sand spit across which the waves broke in every storm, driving the sands to the northward, filling up the old East Rockaway channel, and, as it were, causing the island to migrate bodily toward the mainland.

Subsequent to 1879 the same process must have applied to the western half of the peninsula, for by 1903-1904 ali that remained of the old beach was the low, narrow sand spit shown which at that

time was about to lose its identity completely by merging into the main body of Long Island. By 1909 this merger had been completed, and the only vestige of the old beach that remained above low water could be traced in a slight southward extension of the south shore of the main island.

As the new point grew to the westward the inlet channel at all times was pushed ahead of it. Hydrographic surveys of this inlet were infrequent, but such as were made show depths as great as 34 feet and suggest a probable average depth of from 12 to 15 feet. Presumably all submerged traces of the earlier beach that wave action had not previously removed were scoured away by the inlet to the depths indicated.

Is this cycle of change unique, or is it typical, at least in a general way, of the changes that may be expected to occur generally with the opening of new inlets? Apparently we must accept the latter view. In the first place, a century of surveys of the coast reveals other places where similar cycles have occurred. In the second place, the available evidence suggests the probability that during earlier periods Long Beach itself went through cycles of change closely resembling the one here described. For example, one is justified in believing that the 1835 survey shows a stage of a similar preceding cycle intermediate between those shown by the 1879 and the 1903-1904 surveys, and the 1860 stage is quite similar to that of 1909. Finally, a study of the forces by which these changes are produced compels the conclusion that if some abnormal combination of circumstances starts a section of the beach upon a new cycle, one must expect that cycle quite faithfully to duplicate similar ones that have preceded it in the same general locality.

WINDS AND WAVES IN BEACH EVOLUTION

In seeking to establish the relationship between cause and effect in beach evolution, one is at once impressed by the direct and obvious connection between shore changes and the weather. Other factors enter in: for example, in the vicinity of the inlets the tidal currents become of great importance. In general, however, in the writer's opinion, the wind, through the medium of the waves it produces and of certain other concurrent effects upon the water, is the most important agency involved in the production of shore-line changes. The writer has studied the problem intensively at various sections of the coast. His conclusions may be summarized approximately as follows:

Each wind, with its accompanying waves, has its own characteristic effect upon the beach.

The ground swell, the product of distant winds, has variable

effects. It tends to approach the shore in a direction at right angles to the beach and frequently to cause a landward migration of unconsolidated material recently deposited in the shoal-water zone bordering the coasts with a consequent accretion to the beaches. However, with an increase in size the ground swell may produce effects similar to those next to be described.

A storm wind blowing from seaward at right angles to the beach produces waves that come in broadside to the shore. It backs the water up against the shore, frequently elevating the water surface there as much as 2 or 3 feet above its normal level. The resulting increased depth permits larger waves to reach the beach unbroken and expend their energy in a concentrated attack on the bare sands. The usual result is erosion. However, the sands are carried directly seaward by the returning backwash, probably aided by a seaward-flowing bottom current resulting from the piling up of the water against the beach; and, while some part of the sand probably is carried away beyond the possibility of recovery, a larger part is usually deposited a short distance out from shore, in a position from which it can later be restored to the beach if the proper weather conditions ensue.

When wave approach is oblique to the shore, erosion attains its maximum. The waves cut into the beach like scythes mowing down a field of grain. In a few hours they can cut away a triangular section, reducing the normal beach slope to the horizontal and leaving a vertical cliff in the sand to mark the limit of their penetration.

These oblique waves also produce a current which can be plainly seen flowing to leeward close to shore, like some turbid river, laden to capacity with sands eroded from the beach. The tendency of this current is to remove the eroded materials to such great distances, either out to sea or into the inlets, that their subsequent restoration to the beach becomes more difficult.

A strong wind blowing off the land tends to produce accretions, particularly if it occurs shortly after a period of erosion. Such a wind tends to increase the heights of the incoming waves and steepen their fronts. These alterations in the wave form are accompanied by corresponding changes in the motion of the water particles of which the wave is composed. The forward motion becomes a briefer impulse at higher velocity, producing a short, powerful thrust which is very effective in moving material landward. The wind also blows the surface water seaward, sometimes lowering the level from 2 to 3 feet below its normal position. This results in a bottom landward-flowing current which under favorable conditions will combine with the wave motion to restore large quantities of sand to the shore. It is axiomatic along portions of the mid-Atlantic coast that "a west wind builds up the beach."

LOCAL FACTORS ON THE SOUTHERN SHORE OF LONG ISLAND

These general characteristics are subject to modification by local factors, and one such factor dominates the situation on the south shore of Long Island. The south shore of Long Island trends mainly east and west; the shore of the northern part of New Jersey roughly north and south. Together, the two shores form the funnel-like approach to New York. Each shore, to a gradually diminishing extent eastward and southward respectively, tends to limit the arc throughout which a vigorous wave attack can be delivered against the other. Such attack therefore comes predominantly from the southeast. In consequence, there is an abnormal tendency toward a westward migration of inlets and growth of spits on the Long Island shore, and a similar northward movement on the New Jersey shore. Probably this movement is accelerated by alongshore components of the flood tide. Sandy Hook, Coney Island, Rockaway Beach, Long Beach, and Fire Island Beach are outstanding examples of this tendency.

With respect to any unit volume of sand the migration must be variable and intermittent. Even if only the part of the sand that is in transit in the alongshore current be considered, it is scarcely conceivable that the total volume delivered to that current by each wave stroke is carried intact for any great distance. The process seems to be one of constantly picking up material and carrying it to leeward and also of constantly depositing other material derived from points to windward.

There is, however, one important limitation upon this rule. At the windward extremity of any unit of beach the attack in any storm is delivered by waters that have had little or no previous opportunity to accumulate a load of sediment. Consequently they have a maximum capacity to remove material and a minimum tendency to deposit it, and the net result tends to be a permanent loss of beach.

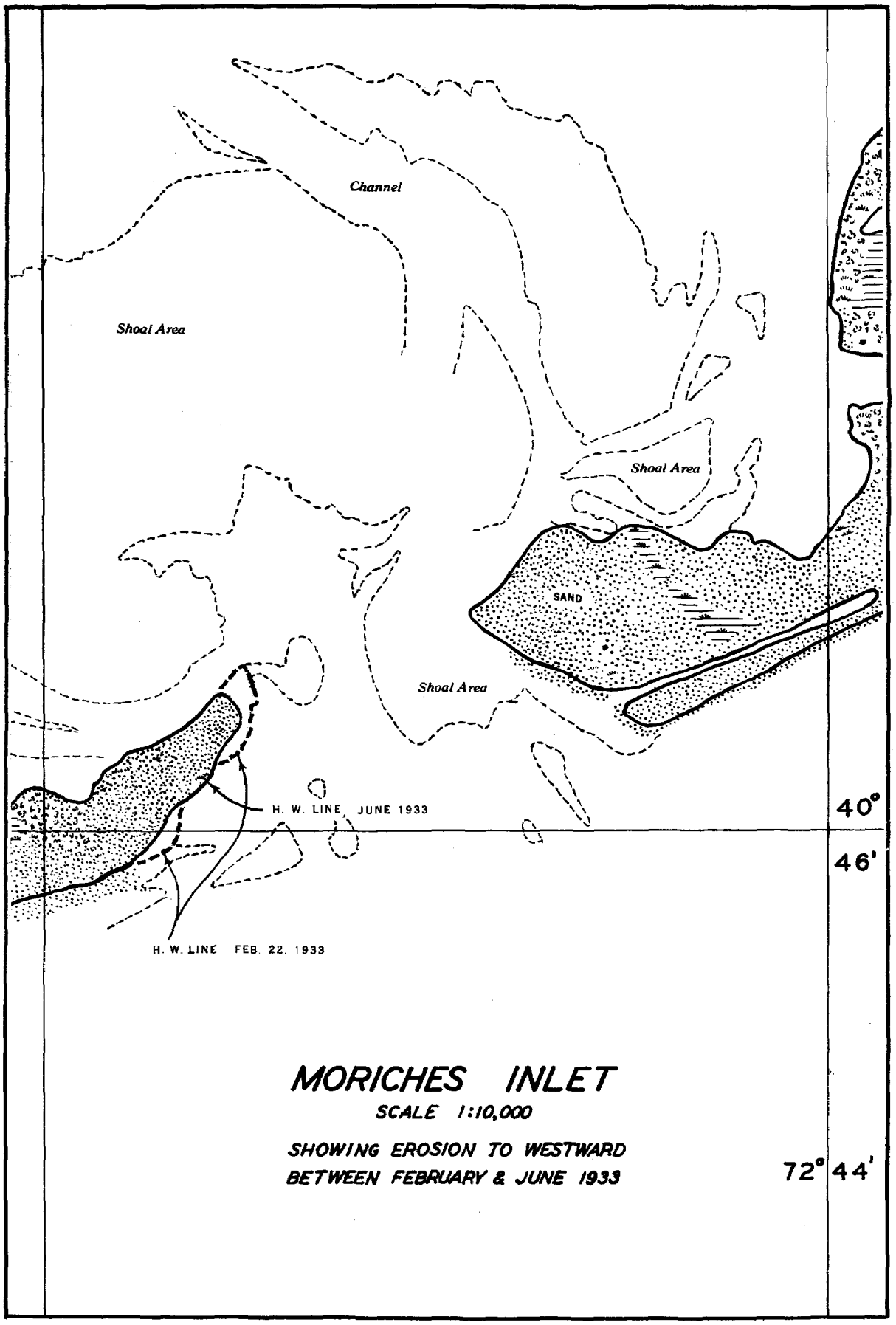
The presence of a continuous land barrier on one side is essential to the existence of the alongshore current. When the current reaches an inlet it tends to be dissipated. Its burden is either deposited at the point of dissipation or seized upon by the inlet currents and carried either into the basin or seaward, where deposition quickly occurs. In this manner shoals are formed in the basin, particularly a shoal just inside the inner end of the inlet gorge. A fanlike shoal grows ahead of the point, and material brought by wave action from this shoal to the point tends to cause the latter to advance.

In the case of an old inlet of well established regimen the sands in transit seem able to find their way past the inlet to the next adjacent section of beach. The process as it probably works out is too complicated for brief description, but it can be said that at such an inlet

the alongshore drift is not seriously and permanently interrupted and that, if in the long run the permanent losses from one inlet point exceed those from the other, the causes probably will be found to be local rather than general.

Not so, however, with the newly opened inlet. The opening consists of a ragged, amorphic gash cut squarely across the beach. Nature's first concern is to bring order out of this chaos, to rearrange materials into the systematic, orderly pattern of channels and shoals in which each existing force is brought into a delicately adjusted balance with all the others. The process takes years and, particularly during its early stages, seems to use up all the sand that can be brought to the inlet by the alongshore drift. The first crude and obvious manifestation of the process is the appearance and growth of an extensive shoal inside the inner end of the inlet gorge. Into the building of that shoal go the sands that formerly continued along the beach to help make good the toll taken by the waves from the adjacent leeward section, with the result that large, permanent losses of beach are prone to occur in that locality during the period shortly following the opening of a new inlet. Long Beach is only one of a number of similar examples.

There is no ground for expecting Moriches Inlet to prove an exception to the rule. If the inlet does not reclose and if man does not intervene during the next few years an accelerated erosion of the beach for some distance west of the opening can reasonably be expected and in due time the beginning of a westward migration of the inlet.



MORICHES INLET
SCALE 1:10,000
SHOWING EROSION TO WESTWARD
BETWEEN FEBRUARY & JUNE 1933

CRITIQUE OF AMERICAN COLLISION LAW

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Notwithstanding the fact that the international rules for the prevention of collision at sea have been in effect since 1890, and the inland rules, with slight changes, since 1897, we continue to have collisions with more or less frequency. They occur not only in close maneuvers or in thick fog but under ordinary steaming conditions in broad daylight, and on clear nights with all lights burning brightly. They occur between merchant vessels, between merchant and naval vessels, and between naval vessels. An examination of the several thousand cases that have come before the federal courts since the present rules were adopted discloses the surprising fact that only about 5 per cent of these collisions are due to what the courts call inevitable accident, and that the other 97 per cent are due to faulty navigation; that is, one or both vessels involved violated some rule of the road designed to prevent collision under the particular circumstances of the case.

When we look for an explanation of this apparently widespread disregard of the law sufficiently broad to justify the proposal of something constructive, we are confronted with three possible causes; (1) that the rules are violated deliberately, (2) that the rules are violated through ordinary ignorance, (3) that the rules themselves are too complex for the average mariner to understand and obey them.

It seems reasonable to assume that the first cause suggested can have relatively little significance in practice. Certainly there can be no real incentive to the navigator to disregard the rights of another vessel if by so doing he jeopardizes the safety of his own. The seagoing lunatic who habitually tries to get across the bow of the fellow coming from starboard is likely to suffer short shrift, whether he be in the merchant marine or in the naval service. While he may last long enough for one collision, it is much more probable that he will run afoul of the Coast Guard or the steamboat inspectors or the naval board of investigation before real damage is done. And it goes without saying that the individual with the instincts of a road hog usually has a high regard for the safety of his own skin, a deterrent which is to the advantage of his less selfish, fellow-seafarers.

One rule, however, which few will deny is quite flagrantly violated in practice, is art. 16, international and inland rules, which provides

"Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a moderate speed, having careful regard for the existing circumstances and conditions.

"A steam vessel hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over."

The moderate speed referred to in the first paragraph has been very specifically defined in two decisions of the United States Supreme Court. These decisions, in substance, provide that the moderate speed contemplated by law for any vessel shall be such that she can take off all her way in half the distance of visibility;* and that where the visibility is practically nil (less than a quarter of a mile) and traffic is to be expected, moderate speed is bare steerage way.** The wide divergence between this legal speed in fog and the speed commonly used will be admitted as a matter of course by any fair-minded navigator. A destroyer skipper would hardly think in terms of a speed below 10 knots unless he lost suction. In the merchant service, where a vessel is traveling constantly over a regular run, it is the custom rather than the exception in fog to maintain approximately the regular speed, the justification ordinarily used being that only by so doing can reasonable certainty of the vessel's position be maintained. A number of years ago the writer was employed as first officer of a passenger steamer operating between two cities on Puget Sound. A schedule of four round trips a day called for a speed of 15 knots; and however foggy might be the weather, it was unusual for this vessel, which sometimes carried a thousand passengers, to be more than a few minutes late.

As to the requirement of the second paragraph of the rule, that the engines must be stopped, not merely slowed down, at the first sound of a fog signal ahead, here again we find implicit obedience most exceptional. The navigator is much more likely to hold on until the increasing loudness of an approaching fog signal leaves no doubt of the other vessel's proximity, and then, if he stops the engines at all, to ring them ahead again almost immediately. The courts have already established the principle that the spirit of the rule is not obeyed unless the engines are kept stopped until repeated signals from the other vessel have satisfactorily indicated her position.***

Yet widely and openly as art. 16 is violated, it is doubtful if many collisions in fog are attributable to excessive speed. Inexperienced officers do not ordinarily have charge of vessels in foggy weather, and ship masters acquire great skill in judging direction and proximity of sound signals, and in feeling their way past another ship in the thickest weather. From the standpoint of legal liability, however, a strict adherence to this rule is as important as to any other. In the case of the "Martello", already cited, the court held that just outside New York Harbor in a thick fog 6 miles an hour was excessive speed and that only half that speed was justifiable. In the well-known case of the "Beaver" and the "Selja", which occurred off the California coast some years before the war, the Supreme Court laid striking emphasis on the mandate in art. 16 to stop the engines. The "Selja" was a Norwegian tramp, inbound from the Orient, and the "Beaver", later to become the navy submarine tender, was at that time a passenger liner plying between San Francisco and Portland, Oregon. The testimony showed

* The "Martello", 153 U.S. 64.
** The "Umbria", 166 U.S. 404.
*** The "Tillicum", 230 Fed. 416.

that the "Selja" was making half speed, about 6 knots, when she first heard the fog signal of the "Beaver" very faintly ahead, and 5 minutes later, after hearing several more signals, her speed was cut down to 3 knots. The vessels continued to approach each other for 5 minutes more, and the "Selja's" engines were then stopped. She drifted for another 5 minutes, and then, on sighting the "Beaver" ahead, her engines were put at full speed astern for 1 minute, when the collision came. The "Selja" was practically dead in the water when struck, while the "Beaver" had maintained excessive speed right up to the moment before the collision. It would seem that here was a case of extreme negligence on the one hand and of scrupulous caution on the other; but the Supreme Court upheld the ruling of the lower courts that both vessels were equally liable, the "Beaver" for excessive speed and the "Selja" for failure to stop her engines when she first heard the fog signal of the "Beaver", 16 minutes before the collision.

It is probable that violations of the rules which cause or contribute to collisions are much more frequently due to ignorance of what is required than to deliberate defiance of the law. This may have been true in the error of the "Selja"; it is certainly true in a large proportion of the cases that come before our courts. Nor are such instances confined to merchant vessels. As a reservist on active duty the writer was on one occasion bound up the Pacific coast in a destroyer which was making 17 knots in a thick fog when the whistle of a steamer was heard 2 or 3 points on the starboard bow. The commanding officer stopped his engines in obedience to art. 16 and immediately began to blow the two long blast signal, although the ship was forging ahead with the momentum given by a 17-knot speed. Apparently he was actuated by a hazy knowledge of art. 15, international rules, which provides, of course, that the two prolonged blasts in fog shall be given by a steam vessel under way, but stopped, and having no way upon her. The other vessel, a large cargo ship, maneuvering on the assumption warranted by the signal that we were standing still, attempted to cross our bow, and only our use of emergency full speed astern averted a collision, seemingly by inches. Had she collided with us it is obvious that the fault and the liability would have been ours.

In the unusual case of the "West Hartland",* which sank the coastwise passenger liner "Governor" a few years ago in Puget Sound with the loss of several lives on a calm, clear night, the two vessels met in the crossing situation off Point Wilson, just outside Port Townsend. The "West Hartland", a single screw turbine vessel of 8,800 tons, with a full load of lumber, was bound outward at an estimated speed of 6 knots; and the "Governor', a full powered twin screw reciprocating vessel making 15 knots, attempted to cross the bow of the "West Hartland", which had the right of way. Too late the pilot of the "Governor" discovered his error, and in trying to rectify it, succeeded in stopping his vessel across the bow of the slow-moving freighter. The testimony at the subsequent trial showed that the master of the "West Hartland", acting on the apparent assumption that he was under international rules, failed to use either the one blast crossing signal or the four blast danger signal, as re-

* The "West Hartland", 295 Fed. 547.

quired by the inland and pilot rules, but gave only a single blast a few seconds before the collision as he sheered out to the right; and in consequence, his vessel was found equally at fault with the "Governor."

To say in these pages that every government and merchant deck officer should have a knowledge of the rules of the road that is accurate and crystal-clear might seem wholly gratuitous were it not that many instances such as those already related prove that the accomplishment is by no means universal. In special classes held at the University of Washington for master mariners and other licensed officers shortly after the war, it was found through individual examinations that, generally speaking, the longer a mariner had had his master's license the less he knew about the rules of the road. If he could give the usual passing signals for inland waters, the lights he was supposed to carry, and 50 per cent of the sound signals for fog, he was better than the average. The reason for this is not difficult to find. It is a fact that most licensed officers honestly believe themselves thoroughly posted on the rules of the road. They have passed the inspectors' examinations and therefore have documentary evidence of their proficiency. That they often overrate their ability in this respect is probably due to two causes.

In the first place, the examination given on the rules by the steamboat inspectors, and it must be admitted in all fairness, by naval examining boards, too, is generally little more than a memory test of lights and sound signals, rather than a test of the candidate's ability to apply the rules in a difficult situation. In the process of acquiring various grades of license from third mate to master and first-class pilot, the writer has appeared before the inspectors on five different occasions. Without exception the questions were purely of the memory type, one examiner requiring the candidate to write from memory the entire set of sailing rules. This practice is pretty generally known, with the result that the candidate usually devotes most of his preparation to the mysteries of the meridian altitude and the time sight. The rules of the road are crammed into the last two or three days of preparation, and the various sound signals and the regular and special lights are simply Memorized parrot fashion. Naturally facts learned in this way do not stay long in the memory. And once the gauntlet of mates' examinations has been run and a master's license acquired, the mariner is then forever exempt from further professional examination of any description.

In the second place, the average merchant marine officer is not more familiar with the rules because the importance in practice of knowing them thoroughly has never been brought home to him. Unless he has actually been in a collision that resulted in a law suit for his owners, he has probably not realized what a departure from the rules might cost in dollars and cents, to say nothing of lives and property. Most seafaring men will scout the idea of attempting to become familiar with the interpretations put on the rules by the federal courts; yet it is just these interpretations, as expressed in decisions of other similar cases, that nine times out of ten determine whether or not a particular vessel is liable for her collision. The important point is not what a mariner thinks a rule

means: it is what the Supreme Court says it means. There is hardly a phrase or a paragraph in the rules that has not been clearly explained and interpreted by the courts, and unless the navigator is familiar with the ruling decisions, all the information he can get by reading or even memorizing the rules may be of little value. It is probably not even generally known that when there is a collision between two vessels and the case is brought into court there are only four possibilities of liability in the decision: (1) vessel A may be solely at fault and liable for all damage to both vessels; (2) vessel B may be solely at fault and liable for all damage to both vessels; (3) both vessels may be at fault, in which case the damages will be shared equally, notwithstanding one vessel may have violated a single minor rule and the other vessel three or four major ones; (4) both vessels may be free from fault and the collision held due to inevitable accident, in which case each will bear her own damage. The importance of knowing exactly what is required by the rules lies in the fact that the violation of any rule, however slight, is held by the courts to be a presumption of fault unless it is proved that the violation could not have caused or in any way contributed to the collision. In the words of the Supreme Court,

"It is the settled rule of this court that when a vessel has committed a positive breach of statute, she must show not only that probably her fault did not contribute to the disaster, but that it could not have done so.*"

When a collision follows a violation, this is almost impossible to do, and unless a vessel's action has been entirely in accordance with the rules as interpreted by the courts, at least half damages will almost certainly be incurred.

It will perhaps be admitted, if this article achieves wardroom discussion, that what has been said of the merchant marine officer applies in some degree to officers in the naval service. Here, too, we often find a tendency to take for granted an adequate knowledge of the collision rules as inseparable from commissioned rank. And yet for a number of reasons, the naval officer is even less likely to be an expert in collision law than is his brother-officer in the merchant service. He receives, it is true, a much better training in the subject in the first instance. The present case system of collision study taught at the Naval Academy and in naval R.O.T.C. colleges is to be very highly commended, although its advantages have, of course, benefited only the recently trained younger officers. But the naval officer has far less opportunity than the merchant marine officer to practice the rules or to see them in use. A considerable portion of his naval career is spent in shore duty. A considerable part of his service may be in engineering, or communications, or aviation, and even when he has deck duty at sea, he may have but one watch in six or eight. Then, too, protracted sea cruises are unusual, the yearly mileage of a naval vessel is far less than that of a commercial vessel on a regular run, and a large part of that mileage is likely to be in formation, where independent action with

* Belden vs. Chase, 150 U.S. 674.

regard to other vessels, except on a flagship, is decidedly restricted. All of which means that the naval officer has much greater opportunity to forget the rules than the licensed deck officer who stands one watch in three continuously through all his years of service, or until he finally obtains his own command. After all, there is much to be said in favor of the precept laid down by Admiral Knight for young officers under his command, that they should always read through the rules of the road before getting under way.

We are altogether too prone to depend upon unrefreshed memory for the details of rules which we learned imperfectly to begin with, and the true import of which, in the light of court decisions, we may never have understood. If the reader is a naval or merchant marine officer who feels satisfied that his daily experience is ample to keep the rules of the road fresh in mind, and to prepare him to act properly in any situation that may arise, it is suggested that he try himself on the following questions which were used in examining licensed students in the special classes previously mentioned:

(1) Under what circumstances is a vessel required to hold her course and speed?

(2) In the crossing situation, having the right of way, how long is she required to maintain course and speed if the other vessel fails to give way?

(3) Under what rules does a vessel operate in a voyage from San Francisco to Seattle?

(4) A steamer is at sea in a fog and her engines break down. What fog signal must she use?

(5) When should a steamer blow three short blasts in a fog?

(6) When do the rules require that a lookout be kept astern?

(7) A steamer is being towed from one dock to another in inland waters at night. What lights must she show?

(8) At sea, in the crossing situation, vessel A has the right of way over vessel B, but vessel B apparently fails to yield, what signal is provided by the rules to be given by vessel A?

(9) What important difference in meaning is there between a signal of two blasts under international rules and under inland rules?

(10) A steamer passing through an inland channel at night followed by another steamer goes aground. What lights should she show and what sound signal should she use?

If the reader can answer these questions offhand, he is probably one of the few navigators for whom this article is not written. And

yet it would be hard to find a question in the list the answer to which is not of practical value to anyone entrusted with the navigation of a yard tug, a passenger liner, or a first-class battleship. The correct answers, in accordance with the context of the rules and governing court decisions, are as follows:

(1) (a) A steamer in the crossing situation having the right of way over the other steamer; (b) any vessel overtaken by another vessel; (c) a sailing vessel meeting a steamer but not overtaking her; (d) one sailing vessel meeting another over which she has the right of way as provided in arts. 17, international and inland rules.

(2) Until the vessels are in such close proximity that in the judgment of the privileged vessel's master it is not possible for the burdened vessel alone to avert a collision.

(3) From San Francisco to sea under inland rules and pilot rules; thence to the beginning of inland waters in the Strait of Juan de Fuca under international rules; thence to Seattle under inland rules and pilot rules.

(4) One long and two short blasts of the whistle at intervals not exceeding two minutes.

(5) When the engines are going astern and there is another vessel in sight.

(6) (a) When leaving anchorage or moorings; (b) when actually going astern; (c) at all times when changing course or speed; (d) whenever under way at night if no fixed stern light is carried.

(7) All running lights including side lights.

(8) A detonating signal or flare-up light: any bright light but no whistle signal.

(9) Under international rules, it always signifies a change of course to port; under inland rules it signifies a starboard to starboard passing whether or not a change of course is made.

(10) The regular lights for a vessel at anchor; the danger signal (four or more short blasts).

Now if we accept the indictment that the average navigator's knowledge of the collision rules is subject to improvement, there are several practical suggestions that might be carried out to contribute to that very desirable end. To begin at the source, the American mariner gets his rules from pamphlets published and distributed by the Department of Commerce, and these pamphlets contain the international, inland, and pilot rules in their bald entirety, with no suggestion of comment or court interpretation. It would seem entirely practicable for the pamphlets to set forth not only the original rules, but such

court interpretation as may have subsequently modified or clarified their meaning, as, for example, the definition of moderate speed in connection with rule 16. It is possible that the supervising inspectors could provide such information under the same authority which now enables them to promulgate and publish pilot rules, diagrams of passing situations, etc. The rules are now so old that practically every debatable provision has already been construed by the courts; any new rulings might easily be made common knowledge through the medium of the Notices to Mariners put out by the U. S. Hydrographic Office and distributed weekly to merchant and naval service alike. The writer recalls a very effective circular letter sent out by the company which employed him shortly after the "Beaver"-"Selja" decision, emphasizing to the officers of his line the importance of stopping the engines in accordance with art. 16. Vessels of the Navy usually have in the wardroom library a book of comment on the rules, such as La Boyteaux's "Rules of the Road at Sea", Parson's "Collisions", or at least the chapter in Knight's "Seamanship" on the subject; but the problem is to get officers interested in reading them, and there, too, Department of Commerce material of the kind mentioned and appropriate additions to the Notices to Mariners would be valuable. A second suggestion is that the type of examination given by the steamboat inspectors and by naval examining boards be changed as necessary to test the candidate's ability to apply the rules rather than merely to remember their wording. Given a set of conditions, "what would you do?" should be more and more the form of question asked. In this connection, the individual oral examination in which the examiner places small wooden ship models in various situations and requires the candidate to designate promptly the proper action is undoubtedly the most effective system yet devised. Third, and by no means least, it might be well to keep the navigator on his toes by subjecting him to an occasional check test; the master mariner at least every five years when he comes in to renew his license, and the naval officer when he returns to sea from his tour of shore duty. Such a procedure would work no hardship on the conscientious officer who really keeps posted; and it might bring to light some of the most unsuspected but none the less dangerous cases of ignorance without the cost of a marine disaster.

That such cases actually exist may be illustrated by a surprising experience of the Writer, while serving a term as harbor master of a Pacific coast port, with the veteran skipper of an Alaska passenger liner. The latter was observed one day to back his vessel out of the blind slip between two long piers without blowing his whistle, even to the extent of the customary short toot when casting off his lines. In deference to the high standing of the captain, who was the commodore of his company, the matter was regarded as an oversight, but when the offense was repeated the next day it was considered advisable to take some restraining action. So he was followed to a wharf a mile down the water front, boarded, and confronted with his perfidy. When he had recovered sufficiently from the shock of having his action questioned, his defense was that he did not consider the long blast signal required when moving from his berth merely to go to another part of the harbor, but only when starting on a regular voyage to Alaska. It had no doubt been thirty years or more since his examination for a master's license, but he was so positive that he was

within his rights that he had the third mate vainly scurrying all over the ship to locate a copy of the pilot rules to prove it. It was the most unkind cut of all to tell him that he had not only jeopardized his license by backing unannounced into crowded harbor traffic, but in addition was subject to a fine for not having two copies of the pilot rules on board. He promised most earnestly not to let it happen again.

We may now consider a possible third factor in the large proportion of collisions due to legal fault, namely, inherent defects in the rules themselves. Are the rules, or any of them, inexplicit, ambiguous, confusing, or conflicting? Is the navigator allowed too much discretion under them, or conversely, is his action for the safety of his vessel too greatly restricted? Are there needless discrepancies in the different sets of rules that complicate intelligent obedience of them in practice? These are some of the questions which a searching analysis should seek to answer. And while it is obviously beyond the scope of this article to make such an analysis, there are certain illuminating facte which even a brief examination will reveal.

It will be found that our American fondness for lawmaking is as apparent in the field of collision prevention as in many other branches of the law, for we navigate under five different sets of rules of the road, and can scarcely proceed from one American port to another without being subject to three. The present international rules were drawn up by a conference of representatives of the maritime nations of the world at Washington, D. C, in 1889 and subsequently adopted by the respective nations concerned. They are, therefore, the law of the sea to all vessels on the high seas, or outside the limits of specified inland waters. The rules for the Great Lakes and the St. Lawrence River as far east as Montreal were passed by Congress in 1895, and apply to all vessels in the waters indicated. The rules for the Red River of the North, and rivers emptying into the Gulf of Mexico, and their tributaries, were passed by Congress in 1897, as were the inland rules, which apply to all vessels in such of the inland waters of the United States as are not covered by the two preceding sets of rules. The fifth body of collision law in the United States is known as the pilot rules, and under an authorizing section of the inland rules, with which they have co-extensive jurisdiction, they may be made or amended from time to time as desired by the supervising steamboat inspectors, subject only to the legal restriction that they must not conflict with the inland rules.

It would be presumptuous for any individual to theorize as to the soundness of the international rules. The men who drafted them after most comprehensive study and debate were eminently practical ship operators, admiralty lawyers, and high naval officers, the ablest of their time; they did their work wisely and well; and the remarkable body of rules which they formulated has thus far stood the test of time the world over. One cannot read the record of the proceedings of the international convention without being impressed again and again by the delegates' remarkable grasp of the problems involved, their conscientious attention to detail, and the collective brilliance of their final achievement. There is one factor, however, over which

they had no control, and that is the passage of time. When the international rules were passed, a 3,000-ton ship was a very large vessel, and no steamship had yet made a speed of 18 knots. The world's record for the longest day's run was still held by a sailing ship. Today we have commercial steamships of 30,000 tons and upwards making nearly 30 knots, and naval vessels with considerably higher speeds. At the present rate of progress it is becoming common for vessels to approach each other at a combined speed of from 40 to 60 miles an hour, or more than twice the speed of 40 years ago. The implication is that if the minimum visibility of running lights prescribed in 1890, and the corresponding minimum audibility of whistle signals as construed accordingly by the courts, were proper, then those minima should certainly be increased now in order that the navigator may still have the same time of preparation for meeting a vessel after discovering her.

The inland rules were formulated largely by the same representative shipping men who served as the American delegates to the international convention of 1889. It may be assumed that the differences between the international rules and the inland rules were agreed upon by them either because of the weight of local custom or because they felt that the changes were intrinsic improvements. We must recognize that while the inland rules conform in a general way to the provisions of the international rules, they differ from them, nevertheless, in several important respects. The same may be said of the pilot rules, which pattern after and serve chiefly to amplify the inland rules, but which provide certain additional lights and sound signals. It is the existence of these differences which, in the opinion of the writer, constitutes the chief weakness in our present system of collision law.

Not all of the variations in the different sets of rules are important. It probably does not matter that the fog signals must be given at least every two minutes under international rules and at least every minute under inland and pilot rules, despite the implied absurdity that vessels are closer together when approaching collision in inland waters than outside these waters. It is a matter of indifference whether an overtaking vessel discovers the vessel ahead by means of a fixed or temporary stern light, as provided for ocean steamers under international rules, or by means of the compulsory after-range light visible all around the horizon, as provided for inland steamers under inland rules. But when the navigator who obeys the regulations is compelled to recognize a fundamental difference in the meaning of sound signals, and to use one set of such signals under international rules and a different set under inland and pilot rules, then serious confusion is bound to result. And it must be remembered that, ignoring the rules for the Great Lakes and for western rivers in our discussion, one cannot steam from New York to Philadelphia or from San Diego to San Pedro without invoking, at different stages of the voyage, the international rules and the inland and pilot rules.

Perhaps there is no better way to emphasize the importance of these differences than to analyze the action required by two vessels which meet in the crossing situation, first in inland waters, and second out-

side inland waters. Incidentally, about 40 per cent of the faulty collisions occur in this situation. In the first case, consider vessel A to have the right of way over vessel B, which she is approaching at right angles at a speed which the bearings show involves risk of collision. Under inland and pilot rules, what must she do? Under art. 21, inland rules, and pilot rule VII, she is bound to hold her course and speed. Under the section of the pilot rules on signals she is authorized to blow one blast, and under a ruling of the federal court,* the authority becomes a mandate. Vessel B, under articles 19, 22, and 23, must keep out of the way, must avoid if possible crossing ahead, and shall if necessary slacken her speed or stop or reverse. Pilot rule VII says she shall keep out of the way by directing her course to starboard so as to cross the stern of the other vessel, or if necessary to do so, slacken her speed or stop or reverse. Under pilot rule III she must answer vessel A's one-blast signal with a similar blast. But supposing she does not answer it, and gives no other evidence of yielding the right of way to vessel A. Under art. 21 vessel A must continue to hold course and speed; under art. 18, rule III, and pilot rule I, she must give the danger signal (four or more short blasts); under art. 12 she may show a flare-up light or use any detonating signal; and finally, if vessel B persists to a point where it is no longer possible for her to avoid vessel A by her own action alone, vessel A must invoke art. 27. It is not lawful for vessel A to stop and back before that time, notwithstanding the apparent injunction in the closing paragraph of pilot rule VII, which has been found invalid by the federal court.** Article 27 provides:

"In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger."

In this case, the courts have construed for vessel A substantially the action indicated by the footnote of art. 21, international rules:

"When in consequence of thick weather or other causes, such vessel finds herself so close that collision cannot be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision."

In other words, any action, right or wrong, which vessel A takes in good faith to avert the collision at this point except maintaining course and speed right through vessel B will be upheld by the courts. If such action is to reverse her engines, then she must indicate it by three short blasts of the whistle. as provided in art. 28 and the signal section of the pilot rules.

Now let us consider the action of the two vessels in exactly the same situation but outside the limits of inland waters, and therefore subject

* The West Hartland", 295 Fed. 547.
** The "Musconetcong," 255 Fed. 675.

to the international rules. So far as right of way is concerned, the same rules apply; art. 21, international rules, requires vessel A to hold course and speed; arts. 19, 23, and 23 require vessel B to keep out of the may, to avoid crossing ahead of vessel A, and if necessary to slacken her speed or stop or reverse. The important differences are in the prescribed sound signals. Vessel A cannot blow one blast because under art. 28, international rules, one blast signifies intention to direct course to the right. Vessel B, on the other hand, must blow one blast, under art. 28, if she changes course to starboard to go under vessel A's stern; but the latter cannot answer the signal for the reason already given. If vessel B holds on, and gives no indication of yielding as provided in the rules, the only way vessel A can attract her attention is by the flare-up light or the detonating signal provided in art. 12. There is no other danger signal under the international rules. Vessel A must maintain her course and speed until in the jaws of impending collision; she must then take appropriate action to avert collision under the footnote of art. 21 already quoted, with the additional complication that under art. 28, international rules, she must indicate with the proper whistle signal not only a reversal of her engines, but any alteration of her course to starboard or to port.

It is evident, therefore, that as the rules now stand, at least two distinct whistle signals, the one-blast signal and the danger signal, are required of vessel A under certain circumstances in inland waters, and the omission of either constitutes legal fault; while the use of either of these signals by vessel A, once she has crossed an imaginary line bearing so many degrees from such and such a point and emerged from inland waters, likewise constitutes legal fault if a collision follows. The relative merit of the two kinds of signals in the crossing situation is not nearly so important, in the writer's opinion, as the fact that there are two kinds of signals, and the navigator, to avoid liability in the crucial situation of an impending collision, must act in accordance with well-considered geography instead of instinct. It is surely significant that if the "West Hartland" collision had occurred 15 miles to the westward off New Dungeness instead of off Point Wilson, the two major points of liability affecting the privileged vessel - failure to use the one-blast signal in a timely manner and failure to use the danger signal - would not have applied at all. This is only less significant than the fact that if the "West Hartland" had acted under the pilot rules and given the warning signal of one blast soon after sighting the "Governor," there would probably have been no collision.

There is much to be said in favor of complete uniformity in the rules of the road, even at the sacrifice of excellent advantages in one set of rules or another. Most navigators will concede that the international rules include certain features which ought to be in the inland rules, like the two long blast signal to indicate a steamer under way without way in fog, or the two red lights to show that a vessel is broken down; and conversely, the compulsory range lights and the danger signal of the inland rules would make excellent provisions for the international rules; but surely no single rule is worth keeping at the

cost of confusing the nonlegal mind of every navigator with two or three sets of collision rules, and making it necessary, in some cases, for him to take time out and cut in his vessel, in order to determine which rules govern. The writer is one occasional navigator who would be eternally grateful if the initial step were taken immediately by repealing all rules except the international rules, and for the time being those rules were made to apply to everything that floats; then with the calling of an international convention like that of 1889, the nations of the world might sit down together, make any desired changes or additions, and put out a modern edition of international rules that would serve shipping another 50 years. Only this time there should be a gentlemen's agreement abolishing all existing special rules, and providing that any nation in future perpetrating on the unsuspecting navigator inland rules of its own should be excommunicated, and its ships barred from the high seas. Unless and until some such action is taken, the professional navigator can protect himself only by being absolutely familiar with every detail of the international, the inland, and the pilot rules, with special emphasis on their points of difference and on interpretative court decisions and, for good measure, by an additional course of sprouts whenever he has occasion to enter the Great Lakes, soon to be opened to ocean shipping, and the Mississippi River. Which, after all, clinches the main argument of this article: that in the field of collision law, a little knowledge is a dangerous thing.

It is not contended that faulty collisions will cease when we have eliminated defiance or ignorance of the rules by licensed and commissioned navigators, and when we have modernized and unified and simplified the rules themselves. It will never be possible to legislate away all human frailty and there will still be collisions due to errors in judgment. We shall always have with us the unlicensed fisherman or pleasure-boat owner who answers our crossing whistle with one blast, and then keeps blithely on across our bow under the impression that a whistle signal means "Hello, how are you?'' Until the change suggested is made international in scope, there will continue to be misunderstandings between American vessels and foreign vessels without pilots in our inland waters, for the skippers of the latter are likely to know even less than we do about inland and pilot rules, and to assume that they are still under international rules. In the naval service, mishaps in maneuvers in close formation cannot always be prevented by the rules. It is not contended, either, that avoidance of legal liability, rather than prevention of collision, should be the prime desideratum of every navigator. But it is contended, with some degree of reason, that when our courts, over a period of 40 years, find approximately a 97 per cent correlation between law violation and physical collision, then any course of action which results in a better understanding and a consequent wider observance of the law is likely to prove an effective method of reducing the number of collisions.

COMPARISON Of STATISTICS & COSTS

OF SURVEYS IN SOUTHWEST ALASKA

FOR THREE-YEAR PERIODS SEVEN YEARS APART

I. DISCOVERER AMD PIONEER
1923-25 INCL.

~ DISCOVERER ~

SEASON	STATISTICS							TOTAL COST	UNIT COSTS			
	HYDROGRAPHY			TOPOGRAPHY		TRIANGULATION			HYDROGRAPHY		TOPOG.	TRIANG.
	Miles	Sq. Mi.	Soundings	Miles	Sq. Mi.	Miles	Stations		Per Mile	Per sq.Mi	Per Mile	Per Sta.
May l-Sept.30,1923	1226	168	16,461	238	329		36	62,135	24.39	178.01	57.52	318.53
May 25-Sept.26,1924	1620	752	14,075	82	109		16	54,443	25.73	55.43	58.25	292.84
May 26-Sept.l4,1925	2096	841	10,462	131	1537		40	72,070	19.96	49.75	93.07	409.80
TOTALS----------	4942	1761	40,998	451	1975		92	188,648	22.95	64.41	67.98	353.74
~ PIONEER ~												
May 2l-Oct.2,l923	1978	526	17,532	83	90		48	49,513	15.87	59.68	71.19	252.38
May 5-Sept.26,1924	2280	470	36,107	244	219		44	56,630	17.22	83.56	42.06	162.77
May l4-Sept.22,1925	1434	311	17,029	132	126		46	51,461	22.47	103.60	91.55	131.70
TOTALS----------	5692	1307	70,669	459	459		138	197,604	18.08	78.72	61.56	183.58

II. DISCOVERER AND SURVEYOR
1930-32 INCL.

~ DISCOVERER ~

SEASON	STATISTICS							TOTAL COST	UNIT COSTS			
	HYDROGRAPHY			TOPOGRAPHY		TRIANGULATION			HYDROGRAPHY		TOPOG.	TRIANG.
	Miles	Sq.Mi.	Soundings	Miles	Sq.Mi.	Miles	Stations		Per Mile	Per Sq.Mi.	Per Mile	Per Sta.
May 21-0ct.2,1930	5625	3080	44,202	242	143	140	98	67,680	7.91	14.45	36.18	147.98
May 4-0ct.3,l931	8198	3020	76,623	299	136	105	175	74.173	6.28	17.03	24.28	88.43
May 9-0ct.25.l932	10,555	3394	102,432	360	256	75	111	79.264	5.58	17.34	20.56	117.15
TOTALS---------	24,378	9494	223,257	901	535	320	384	221,117	6.35	16.31	25.98	111.93
~ SURVEYOR ~												
May8-0ct.3,l930	8465	1778	77,047	250	312	108	110	82,758	8.31	30.23	50.41	133.99
May 6-Oct. 2,193l	8532	2250	113,009	341	243	105	109	86,221	6.52	24.75	54.58	108.29
May10-0ct.25,1932	8729	3900	98,423	193	117	95	102	85,628	7.42	15.49	49.82	136.26
TOTALS----------	23,726	7928	288,479	784	672	308	321	254,607	7.34	21 42	52.08	125.98

COMPARISON OF THREE-YEAR PERIODS

I. 1923-25 (2 Ships)	10,634	3068	111,666	910	2410		230	346,252	20.34	70.51	64.74	251.64
II. 1930-32 (2 Ships)	48,104	17,422	511,736	1685	1207	628	705	475,724	6.84	18.64	38.12	118.33

STATISTICS AND COST OF EXPLORER, 1930-32, SOUTHEAST ALASKA

SEASON	STATISTICS							TOTAL COST	UNIT COSTS			
	HYDROGRAPHY			TOPOGRAPHY		TRIANGULATION			HYDROGRAPHY		TOPOG.	TRIANG
	Miles	Sq.Mi.	Soundings	Miles	Sq.Mi.	Miles	Stations		Per Mile	Per Sq.Mi.	Per Mile	Per Sta.
Apr.7-Oct.20,1930	2887	218	50,612	388	96	75	99	66,357	13.52	179.09	46.18	88.39
Mar.31-0ct.19,1931	2657	217	40,962	399	219	49	83	74,750	13.29	162.70	78.75	67.23
May 3-0ct.21,1932.	1939	155	40,659	224	290	46	63	61,686	15.62	195.35	79.18	154.07
TOTALS----------	7483	590	132,233	1,011	605	170	245	202,193	13.98	177.33	66.35	98.11

STATISTICS AND COST OF SURVEYS
GEORGES BANK

Season	Ship	Miles sounding lines	Area square miles	Soundings recorded	Days	Costs	
						** Control	Total Cost
1930	Oceanographer	5907	6559	22498	97	$4888	$47335
	* Lydonia	28	2	482	107	49000	49229
	Totals	5935	6561	22980	204	53888	96564
1931	Hydrographer	4147	3919	27713	91	15022	40104
	Oceanographer	4940	3716	31270	100	21349	52946
	* Lydonia	—	—	—	109	46996	46996
	* Gilbert	162	10	2904	82	8000	9140
	Totals	9249	7645	61887	382	91367	149 186
1932	Hydrographer	6876	6712	45873	118	12842	49762
	Oceanographer	7105	7110	47045	106	13682	54579
	* Lydonia	234	38	1597	109	37960	39855
	* Gilbert	130	10	2024	112	10290	10394
	Totals	14345	13870	96539	445	74774	154 590
GRAND TOTALS		29529	28076	181 406	1031	220029	400 340

* R.A.R. station ships.
** Cost of station ships and buoy control scheme, which was 55% of the total cost.

UNIT COSTS FOR EACH SEASON AND FOR THE ENTIRE PROJECT

UNIT	1. Including all control				2. Exclusive of control			
	1930	1931	1932	Project	1930	1931	1932	Project
Per mile	$16.27	$16.13	$10.78	$13.56	$7.19	$6.25	$5.56	$6.11
Per square mile	14.72	19.51	11.15	14.26	6.50	7.56	5.75	6.43

VELOCITY OF SOUND IN SEA WATER
(Coast of Maryland, 1933)

T. B. Reed, H. & G. Engineer, U.S.C. & G. Survey

(Sonic methods for determination of both depth and horizontal distance have been used with ever increasing reliability and accuracy by the U. S. Coast and Geodetic Survey for more than a decade. The development of instruments for measuring time intervals more accurately, and the further development of radio equipment, have necessitated a determination of the actual velocity of sound in sea water with corresponding accuracy. In seeking a relation between the velocity of the sound and physical data which may be easily obtained, it has been found that in shoal water the actual (experimental) velocity of sound is close to that obtained from the theoretical velocity for the temperature at the bottom. This relation has accordingly been used by the Coast and Geodetic Survey as a practical basis for radio acoustic hydrography. In deep water, this relation apparently does not hold, and it is probable that the so-called bottom velocity can be used only in shoal water where the thickness of the water shell, or the depth of the water, is very small as compared with the horizontal distance. In deeper water the depth is an appreciable quantity as related to the horizontal distance, and various reflection and refraction phenomena probably occur to complicate the problem. To just what depth this bottom velocity method may be applied is not definitely known as yet. It would appear that somewhere near 200 fathoms depth this method of using the theoretical velocities based on bottom temperature observations will probably fail, and in greater depths a different method must be found. In order to discover the best practical means of determining the actual velocity to be used in deep water, a series of experiments is being made with bombs and hydrophones at varying depths, and oscillograms of the wave front have been made. The results may eventually lead to the discovery of the actual path taken by the compression wave, as well as the frequency on which most of the energy is transmitted. With these pertinent facts at hand, more efficient methods may be devised.

The following report represents a determination of the experimental velocity in shoal water which is remarkably accurate, yielding a probable error of approximately one part in 7,000. It would appear that this is considerably more accurate than any theoretical tables now in use.) Editor.

The following determination of the velocity of sound through sea water was made about 40 miles off the coast of Maryland between survey buoys "George" and "Hypo", as shown on the sketch.

The station ships LYD0NIA and GILBERT were anchored near buoys "Hypo" and "George", respectively, and obtained distance and direction from buoy anchor to magnetophone at ten-minute intervals during the test.

A taut wire base line about 25 miles in length was laid down between

buoys "Hypo" and "George" by the ship OCEANOGRAPHER cruising at a speed of ten knots. The wire was laid out in the conventional manner as described in a special report previously submitted on the Taut Wire Apparatus by Commander H. A. Seran (Association of Field Engineers' Bulletin No. 7, page 1).

At the first attempt to run the line, the wire broke at a splice after about 3 miles had been run out (bombs 1 to 9), and the OCEANOGRAPHER returned to buoy "George" and began a new line. Bombs 1 to 9 were not included in the computation, as this section of line was too short and the bombs too few.

Bombs were fired when abeam of the buoy at each end of the line and at approximately six-minute intervals between. The line began with bomb No. 10 and ended with bomb No. 34 (see Abstract of Bombs). All bombs were thrown overboard from the same position at the rail of the quarterdeck and the revolution counter of the Taut Wire Apparatus was read the instant the bomb hit the water. All bombs were half-pint size.

Depths along the line varied from 22 to 29 fathoms, with a mean depth of 25 fathoms over the entire line.

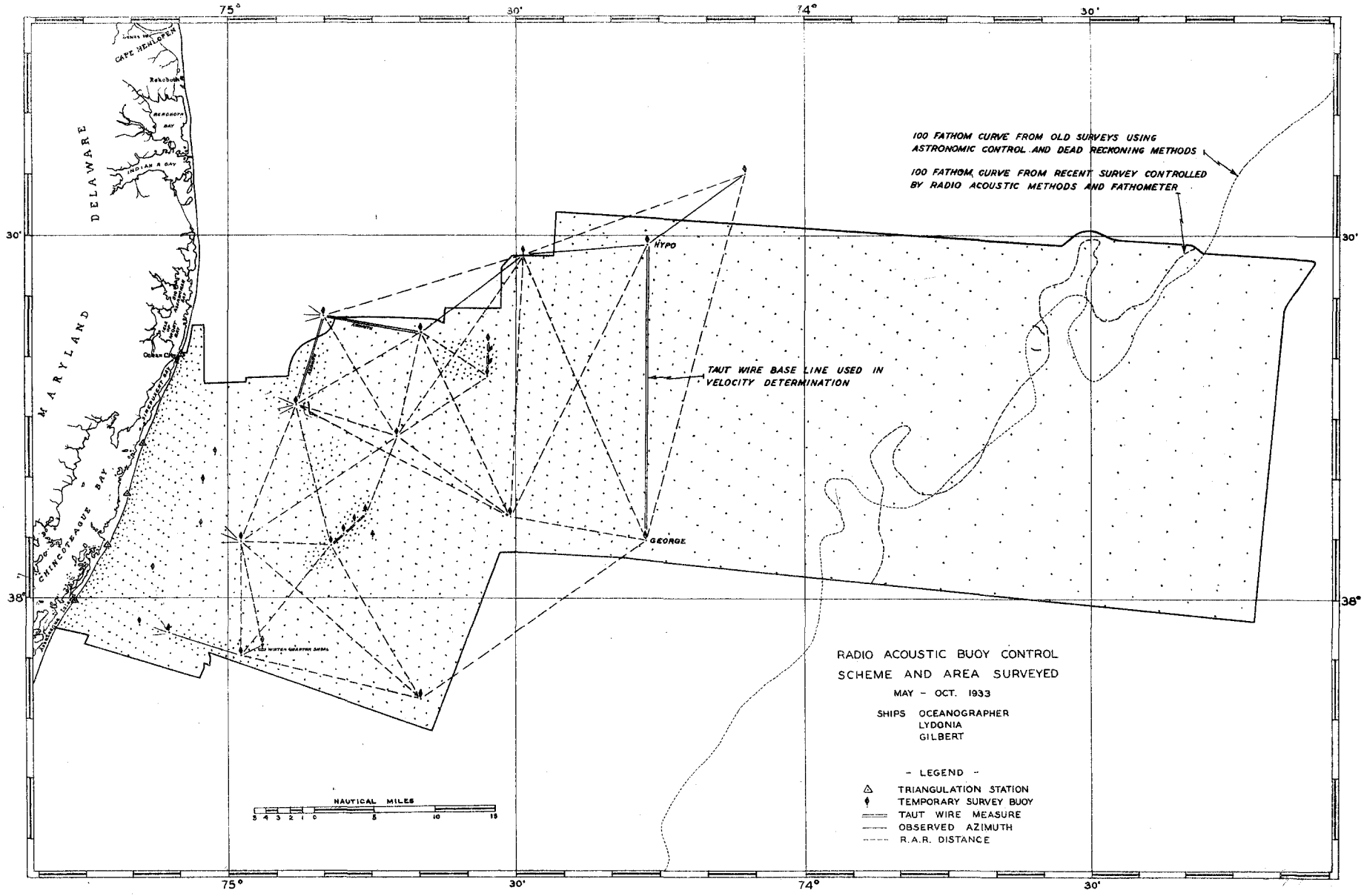
Data concerning bombs, sheave readings, courses, etc., are shown on the abstract of bombs accompanying this report. The abstract of bombs contains data copied from the bomb record and shows a complete log of the test. Two small course changes were made during the run and are shown on the abstract. The line began 10 meters from buoy "George" and ended 1460 meters from buoy "Hypo" (distance obtained by range finder).

The computations were made by using various combinations of bombs with the measured distance between, each bomb being used only once in the computations. Two sets of computations were made, one using bomb returns from the LYDONIA and the other using returns from the GILBERT.

Due to the shifting of the position of the magnetophones during the test, it was necessary to make a correction to the final results. This was done by plotting up the magnetophone data, which were obtained every ten minutes by the station ships, on a large scale and applying the change in meters between the two bombs of a set as a correction to the wire distance. It was found more convenient to apply this correction to the wire distance than to convert it into time and apply it to the scaled time of a bomb return.

Due to the fact that there were two small changes of course on the line, and that the line ended at a considerable distance from the magnetophone of the LYDONIA, the two bombs of each set and the magnetophone of the station ship involved were not exactly on a straight line. This amount was small on bombs to the GILBERT, but was considerable on bombs to the LYDONIA, especially at the latter end of the Line.

Corrections for the above were obtained by plotting the entire scheme very carefully on an aluminum plotting sheet and obtaining the corrections


75°
30'
74°
30'
38°
DELAWARE
MARYLAND
CAPE HENLOPEN
Rehoboth
REHOBOTH BAY
INDIAN R BAY
Ocean City
CHINCOTEAGUE BAY
HYPO
GEORGE
TAUT WIRE BASE LINE USED IN VELOCITY DETERMINATION
100 FATHOM CURVE FROM OLD SURVEYS USING ASTRONOMIC CONTROL AND DEAD RECKONING METHODS
100 FATHOM CURVE FROM RECENT SURVEY CONTROLLED BY RADIO ACOUSTIC METHODS AND FATHOMETER
NAUTICAL MILES
5 4 3 2 1 0 5 10 15
RADIO ACOUSTIC BUOY CONTROL
SCHEME AND AREA SURVEYED
MAY - OCT. 1933
SHIPS OCEANOGRAPHER
LYDONIA
GILBERT
- LEGEND -
TRIANGULATION STATION
TEMPORARY SURVEY BUOY
TAUT WIRE MEASURE
OBSERVED AZIMUTH
R.A.R. DISTANCE

graphically. These corrections were applied as corrections to the wire distances in the same manner as were the magnetophone corrections and are shown in the computations as "reduction to line."

The scheme was plotted on a scale of 1:40,000, and as care was taken in laying it out and in measuring distances, it is believed that no errors of more than two or three meters were made in taking out corrections.

Experimental velocity was obtained by dividing final distance in meters by scaled time differences. It was not necessary to weigh the final mean as all time differences used were about equal.

A final comparison was made between the experimental velocity and the theoretical velocities as obtained from temperature and salinity observations by the station ships LYDONIA and GILBERT at each end of the base line.

There was a difference in theoretical bottom velocity of 2.6 meters between each end of the line and a difference in depth of 5 fathoms. The velocity was therefore assumed to decrease 0.5 meters per second for each fathom change in depth between 23 and 28 fathoms. The mean depth over the line was 25 fathoms so the mean theoretical bottom velocity over the entire line was assumed as 1475.0 meters per second.

All computations were made by Lieutenant T. B. peed and checked by Lieutenant E. J. Brown.

Due to the longer wire base used in this test, and the very small variation in the results obtained, it is thought that this test for experimental velocity is the most accurate that has yet been obtained on the Atlantic Coast. From the results obtained it is believed that the mean experimental velocity is correct to ± 0.2 meters per second.

The value for experimental velocity was determined with considerable more accuracy than the theoretical velocity can be computed. Due to the fact that it was not possible to get any temperature and salinity observations at intermediate points on the line while the wire was being run out, it is thought that the values assumed for the theoretical velocities may be in error as much as one meter per second.

This test is further evidence that the bottom velocity theory for transmission of sound is substantially correct for shoal water.

In answer to a request from the editor for a few more details, Mr. Reed writes as follows:

The calibration of the Taut Wire Apparatus was made by accurately measuring a turn of piano wire around the sheave. The wire was put under the tension at which it was run out and marked across with a small sharp chisel. It was then laid out straight and measured with a beam compass and bar. This was done very carefully, and I believe the error of calibration was negligible.

No temperature correction was made to either calibration or to the

length when computing the test. The effect of temperature on the wire was discussed at the time and it was decided that too many unknown factors existed to try to make this correction. I do not believe that you should apply a temperature correction to he whole length of wire as though it were a tape. Of course the wire is measured at air temperature, then as it sinks into the colder water it should assume the temperature of the water and contract, which would have a tendency to pull more wire off the sheave and thus make the sheave reading too high. The problem is complicated by such things as how fast the wire sinks after leaving the sheave, effect of friction of the bottom on the wire in overcoming the tension put in the wire by the machine, etc.

We figures that the effect of the current on the sound wave would cancel out as the final mean was taken of the sound wave from each bomb traveling in opposite directions to both station ships.

It was at first intended to use the method of computation you suggested of summing the two distances from each bomb to the station ships and relating the magnetophones to the buoy anchors by the station ship data. However, this method was rejected as being less accurate than the method used due to any inaccuracies in the station ship data having a direct effect on the results. The computations were further complicated by not being run in a straight line and in ending about a quarter of a mile off the end buoy. This necessitated plotting the test on an aluminum sheet and obtaining the corrections to pairs of bombs on this sheet.

Comparisons

Mean experimental velocity to LYDONIA	1475.61 m. per sec.
Mean experimental velocity to GILBERT	1475.88 m. per sec.
Mean experimental velocity	1475.7 m. per sec.

Theoretical Bottom Velocity at Buoy "George" (From records of GILBERT)

Time	Velocity
16:05	1473.4
16:40	1473.6
17:10	1473.5
17:40	1473.6
18:12	1472.9
Mean	1473.4

Theoretical Bottom Velocity at Buoy "Hypo" (From records of LYDONIA)

Time	Velocity
15:31	1475.9
16:02	1475.6
16:33	1475.9
17:04	1476.0
17:33	1476.1
18:03	1476.2
Mean	1476.0

Depth at buoy "George" 28 fms. Depth at buoy "Hype" 23 fms.

Mean depth over entire line (from average of depths every mile on boat sheet) 25 fms.

Mean theoretical bottom velocity over entire line	1475.0 m. per sec.
Mean experimental velocity	1475.7 m. per sec.
Mean theoretical surface velocity (from records of LYDONIA and GILBERT)	1494.8 m. per sec.
Mean theoretical velocity, surface to bottom (from records of GILBERT)	1479.0 m. per sec.

COMPUTATION OF EXPERIMENTAL VELOCITY

Bombs to GILBERT

Bomb Nos.	Sheave Revs.	Difference meters between bombs	Correction for change in Mag. meters	Reduction to line meters	Final distance meters	Time Difference seconds	Velocity meters/ seconds
12-34	12000	22,324	+18	-10	22,332	15.15	1474.06
13-25	12000	22,324	+20	- 8	22,336	15.13	1476.27
14-26	12003	22,330	+33	- 7	22,356	15.16	1474.67
15-27	12001	22,326	+20	- 6	22,340	15.14	1475.56
16-28	11997	22,319	- 4	- 5	22,310	15.13	1474.55
17-29	12001	22,326	+20	- 6	22,340	15.14	1475.56
18-30	12002	22,328	+25	- 6	22,347	15.12	1477.98
19-31	11899	22,136	+14	- 7	22,143	15.00	1476.20
20-32	11994	22,313	+ 5	-13	22,305	15.10	1477.15
21-33	11996	22,317	0	-18	22,299	15.10	1476.75
22-34	12613	23,465	+ 2	-24	23,443	15.83	R(1480.92)

Mean 1475.88

Prob. Error = ± 0.262 m/sec.

Bombs to LYD0NIA

10-22	12092	22,495	+36	-48	22,483	15.31	R(1468.52)
11-24	13001	24,186	+37	-64	24,159	16.39	1474.01
12-25	13001	24,186	+53	-78	24,161	16.41	1472.33
13-26	13002	24,188	+62	-88	24,162	16.37	1475.99
14-27	13001	24,186	+68	-94	24,160	16.37	1475.87
15-28	13001	24,186	+57	-97	24,146	16.36	1475.92
16-29	12996	24,177	+47	-106	24,118	16.33	1476.91
17-30	13003	24,190	+48	-110	24,128	16.34	1476.62
18-31	12900	23,999	+50	-110	23,939	16.21	1476.80
19-32	12998	24,181	+55	-136	24,100	16.32	1476.72
20-33	12995	24,175	+48	-182	24,041	16.30	1474.91

Mean 1475.61

Prob. Error = ± 0.311 m/sec.

Note:

Corrections for change in magnetophone between bombs obtained by plotting graphically.

Corrections for reduction to a straight line between magnetophones obtained by plotting entire line on an aluminum sheet, scale 1:40,000.

No current correction was applied to sound wave. The current was approximately 0.8 knot and setting about normal to the wire base line.

ABSTRACT OF BOMBS (Velocity Test)

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

Project 142 Locality, Coast of Maryland Date, May 15, 1933.

Bomb No.	Time	Sheave Reading	Sealed Time LYDONIA	Scaled Time GILBERT	Remarks
					(Line begins Buoy "George"
10	15:50:15	74890	51.39		(10 m. port bm.E. Log 46.90
11	15:56:30	75978	29.90		(course 7° p.wh.c.
12	16:02:30	76979	28.66	2.65	
13	16:08:30	77980	27.37	3.94	
14	16:14:30	78979	26.13	5.17	
15	16:20:30	79979	24.85	6.44	
16	16:26:40	80983	23.57	7.71	
17	16:32:50	81978	22.32	8.96	
18	16:39:00	82979	21.06	10.22	
19	16:45:00	83980	19.79	11.49	
20	16:51:10	84984	18.53	12.76	
21	16:57:10	85983	17.28	14.02	
22	17:03:10	86982	15.98	15.30	
23	17:09:20	87980		16.55	
24	17:15:30	88979	13.51	17.80	
25	17:21:40	89980	12.25	19.07	
26	17:27:50	90982	11.00	20.33	(17:30 c/c 4° p. wh. c. (Log 62.55
27	17:34:00	91980	9.76	21.58	
28	17:40:20	92980	8.49	22.84	
29	17:46:30	93979	7.24	24.10	(17:47 c/c 2° p.wh.c. (Log 65.10
30	17:53:00	94981	5.98	25.34	
31	17:58:50	95879	4.85	26.49	
32	18:05:50	96978	3.47	27.86	
33	18:12:10	97979	2.23	29.12	
34	18:22:00	99595		31.13	(Line ends. Buoy H 1460 (meters port bm. Log 70.27

Distance by wire from "George" to "Hypo", 45,936 meters.
Distance to Buoy "H" by range finder.

ABSTRACT OF TEMPERATURES AND SALINITIES
with
THEORETICAL VELOCITIES FOR SOUND IN SEA WATER
(From British Admiralty Tables)

U.S.C. & G.S.S. LYDONIA — Ray L. Schoppe, Commanding
Lat. 38° 29.7' N., Long. 74° 16.2' W.

1933 Date	Time	Depth fms.	SURFACE Temp.	SURFACE Sal.	SURFACE Velocity	BOTTOM or DEPTH Temp.	BOTTOM or DEPTH Sal.	BOTTOM or DEPTH Velocity	Remarks
5-15.	14:04	23.0	13.7.	32.82	1497.1	7.3	33.31	1475.3	Buoy "Hypo"
	14:33		13.7	32.82	1497.1	7.3	33.31	1475.1	" "
	15:01		13.3	32.84	1495.8	7.3	33.32	1475.3	" "
	15:31		12.9	32.95	1494.5	7.4	33.50	1475.9	" "
	16:02		13.2	32.84	1495.4	7.4	33.23	1475.6	" "
	16:33		13.1	32.84	1495.1	7.5	35.10	1475.9	" "
	17:04		12.7	33.00	1494.0	7.5	33.26	1476.0	" "
	17:33		12.8	33.00	1494.4	7.5	33.36	1476.1	" "
	18:03		13.2	32.76	1495.4	7.5	33.38	1476.2	" "

U.S.C. & G.S.S. GILBERT — Herman Odessey, Commanding
Lat. 38° 04.8' N., Long. 74° 16.3' W.

5-15	13:45	28.0	12.5	33.4		6.5	33.9	1472.6	Buoy "George"
	14:10		12.3	33.1		6.5	34.0	1473.0	" "
	14:43		12.1	33.3		6.5	33.9	1472.6	" "
	16:05		13.1	33.4	1495.8	6.6	33.9	1473.4	" "
	16:40		12.9	33.6	1495.1	6.7	33.9	1473.6	" "
	17:10		12.7	33.3	1494.3	6.7	33.5	1473.5	" "
	17:40		12.8	33.4	1494.7	6.7	33.9	1473.6	" "
	18:12		12.7	33.2	1494.2	6.8	32.9	1472.9	

DRAWINGS FOR REPRODUCTION IN THE BULLETIN

In submitting reports on papers with accompanying sketches or tracings for reproduction, the field officers can materially reduce the amount of touching up usually required before photographing or blue-printing by observing the following suggestions:

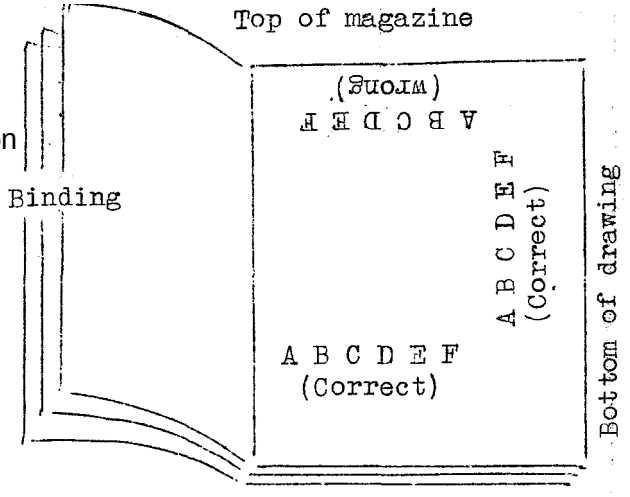
Use black ink only. Blue, or shades of blue, will not photograph or blue-print. In general, different features should be shown by different symbols rather than by colors.

A tracing is preferable to a drawing on paper, in that it can be blue-printed.

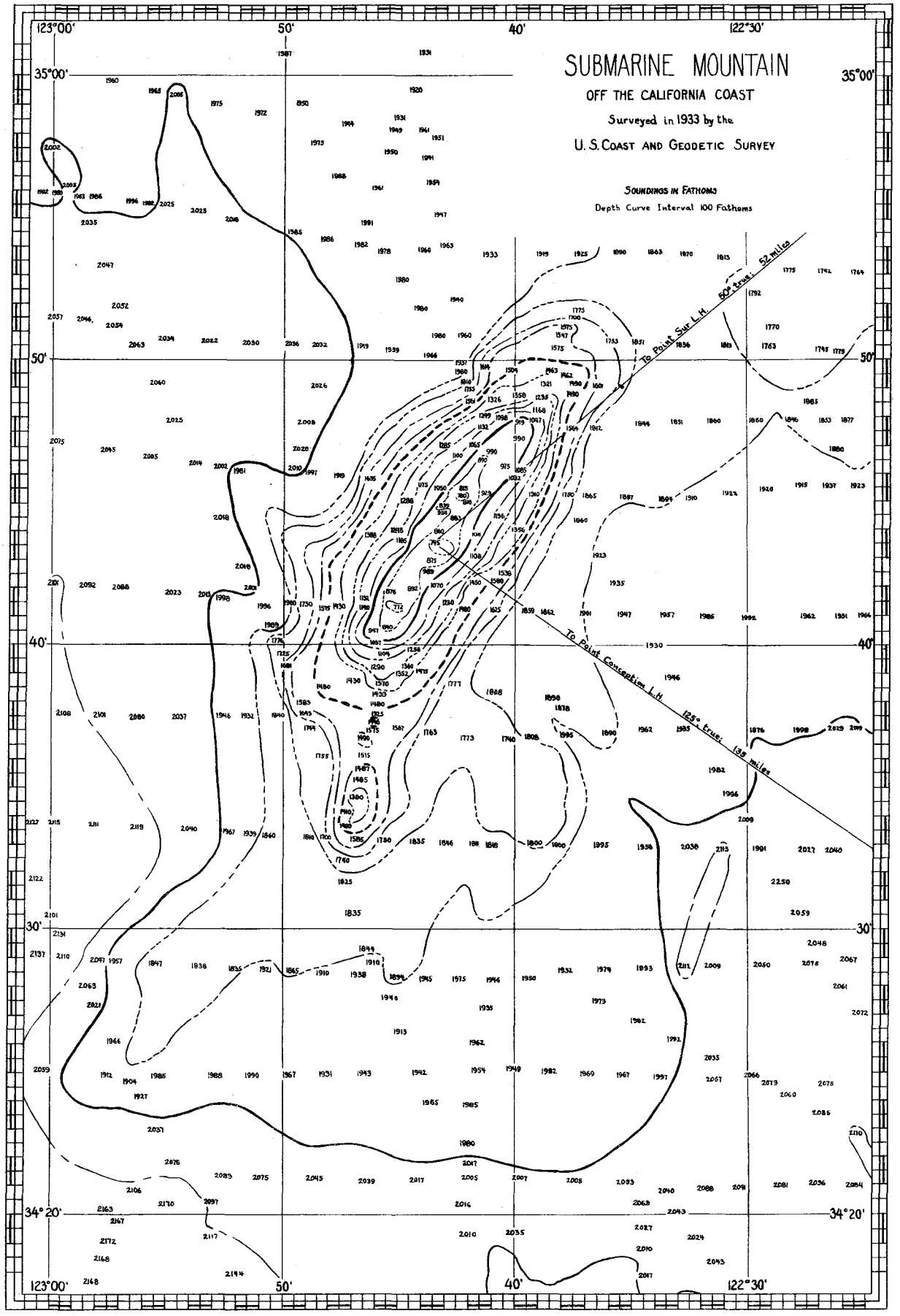
Avoid very fine lines on line drawings, as they are usually to indefinite to photograph well.

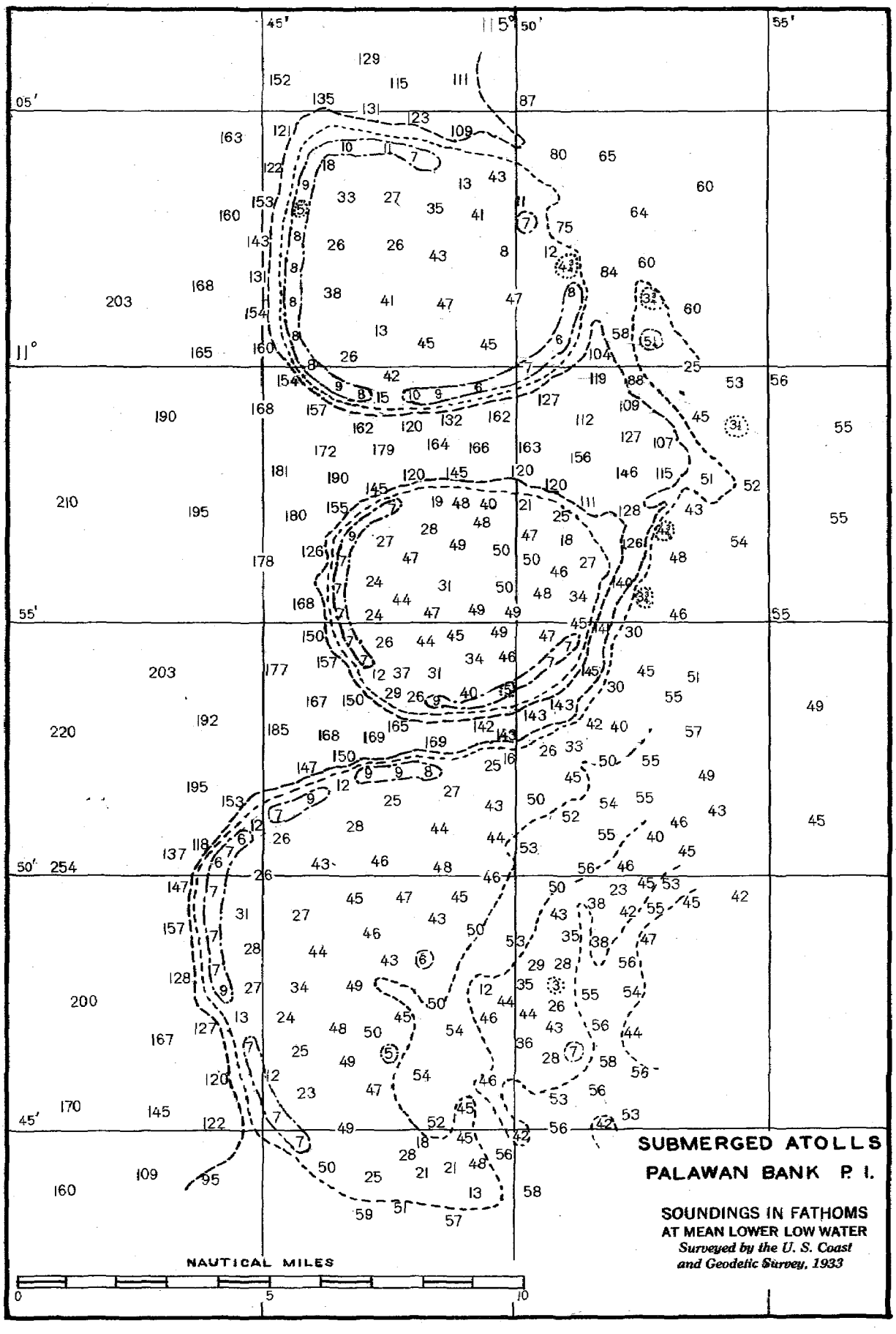
The limiting plate size for the bulletin is six and one-quarter by nine and one-quarter inches. Drawings may be made any size, provided they be in the above proportion and provided the lettering is sufficiently large on large drawings to stand the necessary reduction. Ordinary typewriting will not stand more than 35 per cent reduction. Drawings should not be made smaller than intended in the reproduction. It is better to reduce than to enlarge. Lettering guides, such as Wrico or LeRoy, should be used to insure uniformity and neatness in all printing.

The pages of the bulletin are 8" by 10½". When drawings are made so the bottom is along the 10½" side, the lettering should always be done on the vertical lines from the top down so as to read right side up when the magazine is opened and before turning the book to the right or clockwise. Such plates are always bound with the top to the left, or in the case of the bulletin, the binding edge is always the top, as plates have been printed only on one side.



Sketches of places or interesting objects should be done in ink only so that they may be lithographed. Several officers have collections of sketches, some of which would add greatly to the interest in the bulletin. They are urged to reproduce them in ink and send to the Secretary.


SUBMARINE MOUNTAIN
OFF THE CALIFORNIA COAST
Surveyed in 1933 by the
U. S. COAST AND GEODETIC SURVEY
SOUNDINGS IN FATHOMS
Depth Curve Interval 100 Fathoms
To Point Sur L.H. 60° true; 52 miles
To Point Conception L.H. 125° true; 138 miles
123°00'
50'
40'
122°30'
35°00'
50'
40'
30'
34°20'


SUBMERGED ATOLLS
PALAWAN BANK P. I.
SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER
Surveyed by the U. S. Coast and Geodetic Survey, 1933
NAUTICAL MILES
0
5
10
45'
50'
55'
05'
11°
55'
50'
45'
115°

TREATMENT OF ROCK SYMBOLS ON BIOGRAPHIC SURVEYS

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

For the purpose of assisting the verifier in properly disposing of the many questions arising in connection with the delineation of rocks and reefs on hydrographic sheets, the following rules of procedure have been tentatively adopted in the Section of Field Records. These rules supplement similar rules published under the same title in the December, 1932, issue of this bulletin. The rules divide themselves into two general groups, the first including a restatement of those practices acceptable as standard for both field and office, while the second group consists of guides to the verifier in interpreting doubtful points which, through inadvertence, have crept into the records or on the sheet.

Inasmuch as the ultimate goal is a single standardized practice, it is desirable, at this stage, to have the viewpoints of those charged with the actual prosecution of the surveys.

Group I - Standard field and office practices.

1. Without exception, where a sounding reduces to zero and the notation in the records is "rky" or "on rock", the rock awash symbol, (*), should be used.

2. Where a sounding on a rock reduces to l/2, 1 or 1-1/2 feet and the surrounding depths are considerably greater, the rock awash symbol is to be used and the notation "awash at M.L.W." or "awash at M.L.L.W." should be appended.

3. Where a sounding on a rock reduces to 2 feet or more, use the sounding with the notation "Rk" where the sounding is considerably shoaler than the surrounding depths, unless the rock is in an exposed locality where it may be desirable to emphasize the danger by using the rock awash symbol with the notation "awash at extreme low tides."

4. Notes relative to rocks awash should be inked to the nearest whole foot only, e.g., "bares 7 feet M.L.W." and not "7-1/2". Slanting letters should always be used for such notes in order to conform to the standard chart practice for notes relating to features covered at any stage of the tide.

5. Where notation in the sounding record makes the height of rock 1 foot (on East coast) or 2 feet (on West coast) "above M.H.W., show as rock awash and mark "awash at H.W." unless the topographic sheet shows the rock as a bare rock, in which case the latter should govern.

6. Where notation in the sounding record makes a rock bare more than 1 foot (on East coast) or more than 2 feet (on West coast) above M.H.W. and is shown as a rock awash on the topographic sheet or not shown at all, it should be shown as an islet and the height above H.W. shown in red close by, enclosed in parentheses. In such cases an appropriate pencil note should be added to the topographic sheet.

7. Where area between of flying rocks and shore is very rocky and rocks have not been definitely located, use the notation "foul".

8. Whenever possible field parties should include in the sounding records rough sketches of the more important reefs. It is also desirable that such information be inked on the hydrographic sheet before it is submitted to the office.

Group II - Office Interpretation of Doubtful Points.

1. The correct notation for a rocky bottom is "rky" in the bottom characteristic column. However, should the field party use the notation "Rk" or "Rock", it should be interpreted as meaning "rky", unless the surrounding depths are much greater than the sounding in question, in which case "Rk" is to be appended.

2. Where there is a cluster of rocks awash contiguous to the shoreline and descriptive notes are given for each rock, only those notes are to be inked that give the elevation of the outermost rock and of the highest rock. Where the reef is a detached one, consisting of numerous detached rocks, or is continuous in character, the highest rock or point of the reef should be described as well as such other rocks or points as the importance and extent of the feature justifies.

3. In accordance with page 145 of the Hydrographic Manual, a reef is a rocky or coral elevation. Therefore, all references to reefs in the sounding records, without further description, should be so construed, unless information from other sources indicates that a sand shoal or ridge baring at low water is meant. Where a rocky or coral reef is continuous at low water, the standard rocky ledge or coral symbol is to be used. Where it consists of a number of awash and sunken rocks, such symbols should be used.

4. Care should be taken to distinguish between fixes outlining a reef and fixes outlining a sandy low water line interspersed with an occasional rock awash.

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STRONG MOTION SEISMOGRAPHS

Extract from Report of Inspector, San Francisco Field Station

Forty-five strong motion seismographs have been installed in different parts of the state of California, most of the sites having been arranged for through this office. I have been informed that the records obtained during the Long Beach shock influenced in an important way the views of those interested in legislation relating to building codes. Work is now in progress toward obtaining records of the effects of earthquakes on different sections of class "A" buildings through the installation of several instruments on different floors of representative types of construction. Although only three installations of this nature have been completed, and those within a month, excellent results have already been ob-

tained from the instruments in two buildings. This work is considered of great value by engineers as being one of the most important means of throwing light on the problem of whether a flexible or rigid type of structure is the one best suited for areas subject to seismic activity. At present, arguments in favor of either type are based to a considerable extent on theory, unsupported by the necessary experimental or observational data. This might, to some extent, be considered as an investigation which should be conducted by private individuals were it not for the fact that the Federal Government is probably the largest owner of buildings constructed mainly on the empirical data referred to. The Federal Government is also expected to foot the bill, temporarily at least, in localities where great damage takes place through earthquakes, and loans or gifts should be secured in part, at least, by reconstruction in which defects previously existing will not be duplicated. The cost of the entire program is not even that of a medium size building; in fact, it is only the fraction of the cost of a fair size garage. Not less than twenty sets of instruments, three to a set, should be installed in California.

In earthquakes the lives of men, women and children, as well as property values, are involved, and further investigation along the lines which have been started is necessary to enable engineers to erect structures which will reduce the hazards to a minimum. The value of this work may be realized when it is considered that the Southern pacific Company offered space on its new bridge crossing Suisun Bay, as well as space in its large office building on Market Street for the installation of our instruments. The engineers of the Shell Building, one of the tallest buildings of San Francisco, also furnished space for the installation of instruments. The Bank of America furnished space for two instruments in one of its buildings. Only representative types of buildings are selected.

The property loss from the Long Beach earthquake was conservatively estimated at $41,000,000, and the most valuable data obtained for engineers came from $1200 worth of instruments installed by the Coast Survey in that area.

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ECHO SOUNDINGS IN SUBMARINE VALLEYS

The following paragraph, quoted from a letter of March 31, 1934, from Professor Francis P. Shepard, Department of Geology, University of Illinois, is of interest:

"Recently I followed a line of echo soundings across the Redondo submarine valley north of Rocky Point and found the vertical casts agreed surprisingly well with the echo soundings. I think that it is only when crossing precipitous rocky walls that echoes are unreliable. The flat muddy bottoms of the submarine valleys generally produce good echoes which stand out beyond any feeble flash that may precede them from a nearer point on the rock wall. As a result, the bottom depth of the crossing is generally the true depth without slope correction. The important thing is for the observer to be on the alert to obtain that good echo as the bottom of the valley is crossed. I hope more tests will be made some time to verify this opinion."

OUTBOARD MOTOR FOR HYDROGRAPHY

Taken from Season's Report, 1933, of
Inshore Hydrographic Survey, Island of Oahu, T. H.
H. A. Paton, H. & G. Engineer, U.S.C. & G. Survey

The party found the use of a twenty-foot dinghy, powered with an outboard motor, quite satisfactory. This motor was a nine horse-power Johnson with the extended drive shaft. On the lines running out from shore it could go through small breakers safely. In some areas it was necessary to return inshore at full speed and sound only in one direction. The boat could be turned quickly to meet an unexpected breaker making up on the stern. To cut down the speed it was necessary to tow one or two buckets on a short line at the quarter. These were kept short to prevent fouling the propeller on the turns. It could make about seven knots at full speed, with a light load, and could throttle down to about two knots with the hydrographic crew on board. The motor was reversible, so the boat could be backed in close to shore to start the lines and still keep the bow up to the threatening breakers.

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TRANSFERRING SIGNALS AND SHORELINE

(Director's letter in reply to a request regarding the method to be used in transferring hydrographic signals)

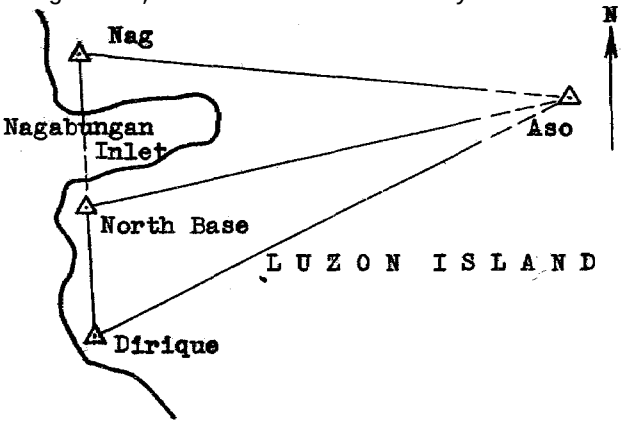
Referring to your letter of April 19, this office prefers direct transfer of hydrographic signals to the smooth sheets by means of tracing paper, provided of course, the transfer is made by individual squares and is checked by an officer.

With aluminum mounted control sheets and carefully made projections on both the control and hydrographic sheets, it would seem that corresponding squares on the two sheets should be in almost perfect agreement and that very little, if any, adjustment would have to be made to any transferred signal.

This procedure will save the scaling of all graphically located stations except, (1) those to be listed as recoverable stations for which a table of positions must be furnished in the descriptive report and on Form 524, and (2) those to be listed and reported as landmarks for charts on Form 567.

HOW A QUICK POSITION WAS OBTAINED WITH ONE ANGLE AND A RANGE ON THREE OLD TRIANGULATION STATIONS IN NORTHWEST LUZON, P. I., ACROSS NAGABUNGAN INLET

Charles M. Thomas, H. & G. Engineer, U. S. C. & G. Survey



During the spring of 1933, the U. S. C. & G. S. Ship PATHFINDER was engaged on combined operations around the northwest coast of Luzon Island. A triangulation control survey of about 40 miles was made, and also topographic and launch hydrographic surveys were being made at the same time.

The original triangulation survey in this vicinity was made in 1903. Since a sufficient number of these old stations were recoverable for control purposes, and also on account of the nature of the surrounding topography, it was deemed advisable to shorten the new scheme by means of a cut-off. This part of the scheme was from two to four miles inland, and located across a divide, back of a wide, flat, thickly wooded ridge which extended almost down to the shoreline. This section of the new survey was out of sight of Nagabungan Inlet, on which was located a lumber shipping barrio. This place was of sufficient importance that a scale of 1:10,000 was decided upon for this particular survey. Due to this large scale, the nearest triangulation station north of this inlet failed to fall within the limits of the topographic sheet. It was found necessary, therefore, to locate at once an additional control station on the north side of the inlet that would fall on the sheet. None of the new triangulation stations was visible from this vicinity, and it would have necessitated an unwarranted delay in making this connection, as the topographic party was already working on the south end of this sheet. Neither could a traverse connection be made from the old stations on the flat coral reef to the south on account of the intervening inlet.

The three old stations, established in 1903, "Dirique," "Bojeador North Base," and "Aso," had been definitely recovered and signals built over them. Upon investigation it was found that the new station "Nag" could be conveniently located on range with "North Base" and "Dirique." This was done by setting up the theodolite, ranging it in with the eye, and then slightly shifting it until only the top of the signal at "Dirique" was visible over the top of the one at "North Base," and accurately centered over the top of same, when viewed through the telescope, the verticality of the two signals being checked at the same time by means of the vertical cross-hair.

The angle between this range line and station "Aso" was measured, this being the only field work necessary to determine the position of station "Nag, 1932." It was necessary to conclude the angle at "Aso," and the angle at "North Base" was obtained from the original azimuths of the lines to "Aso," and to "Dirique" reversed. From either the large triangle "Nag, Aso, Dirique," or the small triangle "Nag, Aso, North Base," enough information was obtained for computing the position of "Nag." These triangles were not quite large enough for the spherical excess to enter into the third-order computation. The forward and back azimuths of the line "Nag - Aso" were obtained from the observed and concluded angles.

Since there was no doubt about the recovery of the three old stations, (their reference marks having also been recovered and these distances checked) no additional check angles were observed.

MAPPING FROM THE AIR*

By R. S. PATTON

Director, United States Coast and Geodetic Survey

MAN'S distinct vision is limited to a few inches and his view point usually is such that the most distant object he can see is only a few miles away. To transcend these limitations, he has invented maps—maps which place any part of the earth beneath the scope of his glance, that he may plan his actions in accordance with its geographic features. One of his most recent inventions, two properly made aerial photographs under a suitable stereoscope, furnishes a spatial or three dimensional model of the part of the earth it portrays, which is unapproached by any other method for observing and recording complete detailed information. Modern aerial cameras take these models in a few seconds and later they can be made available at any number of offices for many special studies as well as for mapping. The product of one photographic flight may be studied by foresters for forestation, by geologists for structures indicating possible mineral wealth, by agriculturists for soils, and by engineers for water power, navigability of streams, and routes for highways, railroads, or transmission lines. Each specialist can examine the photographs for the particular data he needs, data all too likely to be omitted or generalized into insignificance when a country is shown on a general map by hand drawn lines and conventional symbols.

This ungeneralized, almost unlimited detail of the photographic record is one of its principal advantages. In fact, even though an engineer makes a survey on the ground and maps it for himself with a special use in mind, in trying to save time and expense he is likely to omit information which would be of great assistance in solving problems which he can not foresee, but which arise later in the course of his work. If the model of the ground furnished by good aerial photographs under a stereoscope be available, he can get this extra information directly from them without another trip to the locality. If he can not do the mapping himself, but has the photographs at hand, he need not fear the inaccuracies and the omissions which creep in when one man interprets and records the terrain upon a map for the use of another.

The area covered by a pair of photographs, even those from modern multilens cameras, is rather small. The photographs may be joined together (after being rectified as may be necessary to a common datum plane) to form a mosaic or composite picture of larger areas. The mosaic retains the photographic detail, but an extra set of prints is necessary if it is desired to use a stereoscope to study the third dimension. Since the photographs are perspectives, any considerable differences of elevation of the terrain cause displacements of position which can be minimized only by a complicated rectification or a large increase in the number of exposures. However, much of the earth is sufficiently level to permit of making satisfactory mosaics. Their photographic detail and the ease with which they are understood by persons unfamiliar with map conventions make mosaics particularly

1 Prepared for the first assembly of the Pan American Institute of Geography and History, Rio de Janeiro December, 1932.

*By courtesy of "Bulletin of the Pan American Union".

valuable for visualizing certain problems, especially those of tax assessing and city planning. For many purposes for which variations in scale are not important, simple mosaics without rectification are entirely adequate. In fact, in areas where no large scale maps exist, strip mosaics of proposed routes for pipe lines, electric transmission lines, and highways form one of the most important commercial uses of aerial photographs. Simple mosaics can be made at relatively low cost. They insure consideration of all features adjacent to the route. The airplane taking them does not invade private property nor inflate the price of the proposed right of way, unavoidable handicaps of ground surveys.

When exact scale is required for country of appreciable relief, when it is desired to emphasize certain information needed for special purposes and to omit the remaining detail for the sake of clearness, or when the size of the area to be shown on a single sheet becomes large, it is necessary to use line maps. In the few years in which aerial photographs have been available, they have shown certain inherent advantages over ground methods which guarantee their increasing use for making such maps.

In all mapping upon the ground the precision of the resulting product is variable. A few points are located with a high degree of precision. Then there is a large group for which the precision may be characterized as good. Finally, there will be some minor features which, for reasons of economy, are merely sketched or omitted entirely. All this is necessary if the cost of the map is to be kept within reasonable limits. There is a further disadvantage in that this sketching must show the information as if viewed from above, while the topographer usually has only a limited view from the side. On the other hand, when aerial photographs are used for compiling the map, all detail visible from the air may be traced—not sketched—from the photographs with the same precision as the measured control points are plotted. The superior quality of detail thus obtained in maps compiled from aerial photographs is one of their outstanding advantages. Such superiority can not be duplicated by any economically practicable means upon the ground. It is of such value to the map user for identifying his position on the map in the field that it will undoubtedly cause an increasing demand for aerial surveys as map users become acquainted with it.

A further advantage of aerial photographs is that it is difficult in the compilation of such maps to make gross errors or blunders in measurement. Properly overlapped photographs are as self-checking as a scheme of quadrilaterals in triangulation. At times natural changes are so great as to throw doubt on former ground surveys, whether there were any errors or not. Occasionally changes in the coast line, for instance, are so extraordinary as to cause law suits over the original surveys. If due care be taken with materials and processes, the photographs form a permanent record not likely to be challenged. As a country develops, such reeords may be of great value in preventing costly legal disputes over boundaries, riparian rights, and land ownership. Data of great usefulness in the study of shore-line and river erosion, the building of deltas, etc., may be obtained from photographs taken at suitable intervals. Here again no map maker's ideas of how the changes came about modifies the photographic record, but each student may approach the data afresh, unhandicapped by the mental slant of those who have measured the data before him.

In governmental surveys the problem of making accurate maps is usually simpler than keeping the maps reasonably up to date. Because of the uniform precision of a map which has been well compiled from aerial photographs, any permanent, well-defined object, such as a building foundation, a road intersection, or a point of rock, becomes in effect a monumented control station for future revisions or resurveys of similar scales. In practically all regions of importance to man a basic aerial photographic survey will show enough permanent detail for the accurate plotting of detached multilens aerial photographs without further ground control. At very low cost such surveys may be kept reasonably up to date as to important detail during the necessarily long interval between complete revisions by using detached aerial photographs. It is seldom that any but the very best of large-scale ground surveys show enough detail with the requisite accuracy for revision by isolated photographs in this manner. However, almost all types of maps based on good ground control, except those of mountainous country, may be revised to advantage by completely rephotographing their area.

There are certain limitations to aerial photographs which may make them less desirable or even quite absurdly expensive at times, particularly for small projects. The most important of these is that practically cloudless weather is necessary for good mapping photographs. In most of the United States such days occur about four times a month, but in the winter season there may be two or three months without a single favorable day. In all except arid or semi-arid regions the cost of holding a plane and crew in readiness to take advantage of good photographic weather is usually one of the largest factors in the cost of photographs, especially for small projects.

The photographs show only that which is visible from the air. This, of course, limits their usefulness in surveys of tropical jungles so dense that the sky can seldom be seen from the ground. However, even in tropical jungles, the more important rivers and lakes as well as channels through mangrove swamps, can be delineated to advantage.

The use of aerial photographs in mountainous country, where differences in elevations exceed 30 per cent of the flying height, is apparently limited at present to small scale or exploratory surveys, unless the region is of such importance as to warrant the expense of a large scale compilation with a stereoscopic plotting machine. In mountainous terrain, particularly above the timber line where views nearly equal in scope to those from the airplane can often be obtained, terrestrial photographs offer many advantages. The accurately known coordinates, highly corrected lenses of small aperture, the finer grained, slower emulsions of terrestrial photographs give better results than are likely to be obtained in mountainous country from the air. When a modern stereoscopic plotting machine is available a combination of terrestrial photographs for steep slopes and aerial photographs for the valleys is considered to be best adapted to mountainous country.

A further limitation of aerial photographs is that all names, a very important feature of maps, must be obtained by a field inspection on the ground with the photographs, or taken from those shown on existing maps. A field inspection is nearly always necessary to obtain data for interpreting the photographs if draftsmen unfamiliar with the terrain are to compile the maps. In addition, when extensive areas must be photographed at low cost, a few details desirable on the map

ordinarily will not appear clearly in the photographs because of unfavorable light conditions, overhanging trees, or small defects in photographic materials and processes. The filling in of this information, data for interpretation of the photographs, and the names may all be taken care of conveniently while executing the ground control needed for the class of maps to be compiled.

Although aerial photographs make available decided improvements in the accuracy of map detail, they do not as yet offer much toward control surveys. An entirely different class of accuracy is required for map data from that required for the coordination of maps of large areas and for the establishment of monuments marking boundaries or precise distances on the ground. The data shown on the maps or photographs are reduced hundreds or thousands of times, and because of this reduction it becomes impossible to represent positions with high precision. A fine dot on a map or photograph on a scale of 1 :10,000, for instance, represents two meters on the ground, yet on this scale a map 50 inches long shows only 8 miles of the earth's surface. The grain of the best emulsions at present available which have the high speed necessary for aerial photography is so large, and the effects of haze, of the rapid motion of the airplane, and of indifferent objects at which to point are so great that the probable error of measurements on aerial photographs is generally about 34 microns. On an aerial photograph at 1:10,000 scale, this would represent one-third of a meter on the ground. The equivalent error in pointing with a first order theodolite would be about 1 centimeter or about one thirty-fourth the error of the photograph. In addition, it is generally possible to use figures in triangulation which span from 10 to 100 or more of the photographs, since the photographs must be overlapped more than 50 per cent to secure a satisfactory chain of measurements. Even with this tremendous difference in accuracy between triangulation on the ground and from aerial photographs, it is stilt necessary to adjust ground triangulation when measuring around the boundaries of a State or across the area usually shown on a series of maps. It is evident, therefore, that aerial photographs, while offering marked improvement in the accuracy with which it is practicable to survey detail for maps, can not as yet dispense with control surveys upon the ground whenever the maps thus made must be coordinated with others or purport to show long distances accurately.

Until recently, aerial photographs have been too expensive to compile as well as to take for thinly inhabited country, or for other areas which can not support much expenditure for surveys. The single-lens vertical photographs cover such small areas that great numbers of them are required for sizeable projects. Such a complete ground control is required for accurate compilation of single-lens photographs as to tend to limit their usefulness to comparatively level areas, or to those areas so thickly settled as to justify the high cost of large-scale surveys and the expense of machine plotting. A notable exception has been the method developed by the Canadians of compiling oblique photographs containing the horizon by superimposed grids. This method is quite efficient for flat country on scales smaller than 1:100,000, but is not adapted to country of considerable relief, such as that bordering most of the Pacific, nor to medium or large scales.

Recently multilens cameras have been developed which promise a solution of the problem of combining accuracy and economy in

mapping on medium and small scales from aerial photographs. In the United States, the Army Air Corps has developed a 5-lens camera of 6-inch (15.2 cm) focal length and 140° field. The camera is a rugged and reliable instrument. On one of its earliest jobs, the first model photographed without a single failure a project for the Coast and Geodetic Survey, which required over 400 photographs with a 10-second exposure interval. The camera produces a composite photograph in the form of a maltese cross 32 inches wide, which covers a mile of ground for each thousand feet of elevation of the airplane. Thirty-six hundred square miles were recently photographed with this camera in less than three hours on a scale of 1:40,000 at a cost of only 20 cents per square mile for operating expenses and photographic materials. The tremendous span of these photographs permits more accurate orientation of the photographs with fewer adjustments and a proportionately increased spacing of ground control. These advantages mean that increased economy in mapping as well as in photography is made possible by this camera.

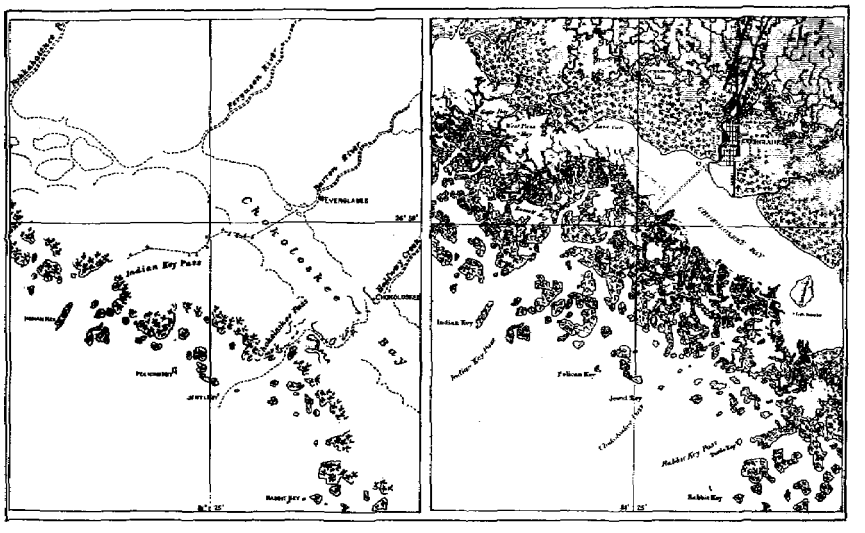
Recently the Special Boundary Tribunal, appointed to arbitrate the boundary question between the Republics of Guatemala and Honduras, ordered the photographing and mapping of a section of the disputed territory. Adequate topographical information did not exist in this area, which is very rugged and in many places sparsely inhabited. The topographic relief in the area ranged from sea level to over 7,000 feet. The aerial method of surveying was chosen as the quickest way of supplying the needed information and, in addition, its low cost was an important factor. The United States Army Air Corps photographed the project, using a 4-lens camera, which is somewhat similar to the newer 5-lens camera with the exception that the advance wing photograph is omitted. In all, 1,300 photographs covering 6,500 square kilometers were made at an elevation of 13,000 feet above sea level, giving an approximate sea level photographic scale of 1:24,000. Photography was completed in 31 days, though flying was considerably handicapped by the rainy season.

The photographs were studied stereoscopically and matched in strip mosaics. Line maps, showing the culture and drainage data traced from the strip mosaics, were assembled on a scale of 1:100,000. Existing maps supplemented by additional ground control were used as the base for map compilation. The maps and photographs were used by the tribunal in studying the topographical and culture conditions in critical areas and also to mark and describe the line of award. The ground control work was started in August 1932, the maps and photographs were delivered to the tribunal in December, and the award was rendered on January 23, 1933. The maps were annexed to and made a part of the award.

In Europe there has been developed a 9-lens camera of 5.35 centimeters focal length and the same scope as the 5-lens. If the detailed information available on aerial photographs at scales of 1:40,000 and larger can be dispensed with, as perhaps it may to advantage for small-scale maps of undeveloped areas, the short focal length of this camera offers lower costs for photographic materials and increased ease of compiling. But when one reflects that on a 1:100,000 scale an object ten meters in size occupies only one-tenth of a millimeter on the photograph, the extent to which detail is generalized or disappears on such photographs may be comprehended. Since one of the chief advantages of aerial photographs is the large amount of

detailed information they afford, the sacrifice of much of this information by the short focal length of this 9-lens camera would not appear to be justified except when the funds for photographic materials and for reduction of maps are very limited and small-scale maps only are desired.

Another European camera has four lenses of 13.5 centimeter focal length and a field of 83°. The manufacturer has also recently announced the adaptation of his stereoplanigraph machine to plot the whole field of this 4-lens camera without special adjustments for the several chambers. This should greatly increase the efficiency of the combined product of machine and camera. Until recently machine methods of plotting maps cost more than the graphic radial line methods combined with contouring on the plane table or form line sketching between spot heights, except for country difficult of access and important enough to require contours rather than form lines. So large an investment for machines and trained personnel is required that a considerable amount of important work must be in prospect to justify their use. However, such improvements as the adaptation of the machines to the use of multilens photographs with only one setting and the simplification of their adjustments, optics, and mechanical movements will probably greatly extend the field of economic usefulness of the machine method of plotting in the future.



Courtesy of the United States Coast and Geodetic Survey.

MAPPING FROM THE AIR MORE ECONOMICAL.

The plane table map at left and. the air-photograph map at right with its vast amount of detail were made at approximately the same cost.

When considering the use of aerial photographs for mapping operations of large scope, it is important to keep in mind that photographs taken with a carefully adjusted and calibrated camera may be compiled by several different, methods in turn, each method furnishing a special map which meets a particular need with the greatest economy. For example, the area may be photographed at minimum expense with a multilens camera, and a rough mosaic or a small-scale reconnaissance map may first be compiled. This preliminary work will show, let us say, that there is a good water power site, some fertile country worth developing, and two or three practicable routes for highway or railroad to this region. Diapositives on glass may be made from the films of the water-power site, and with a little extra

ground control, if a plotting machine be available, 5-foot contours may be drawn. Similarly, study of extra prints under the stereoscope will probably be sufficient to select the best general route for the highway. If much grading will be necessary, as for a railroad, a strip of photographs on a larger scale may be taken of the best route and 2-foot contours drawn with the plotting machine. In the meantime, the plotting of a topographic base map by the radial-line method may be going forward. Fairly good contours may be sketched from the photographs under a stereoscope between a number of spot heights obtained on the ground, or sheets showing the planimetric detail may be contoured in the field on a plane table, whichever method may be better adapted to the personnel of the organization and to the terrain. The completed base map may then be used to advantage for overprints showing the forestation, the types of soils, geological data, and similar information.

This discussion of mapping from the air of course applies only to the present. In no aspect of the subject is this statement more pertinent than to a discussion of costs in time and funds. In general, where the highest accuracy is required and the terrain is quite accessible, these costs seem to average about one-fourth less for aerial photographic surveys made with trained personnel and adequate equipment than for plane-table work on the ground. If the requirements for accuracy of position be relaxed or if the terrain becomes inaccessible, the saving of the photographic methods in time and money increases many fold. There are numerous areas such as mangrove swamps, deltas with complicated waterways, and forested hills where no other method of adequate mapping is economically practicable. With the reduction in costs to be expected from the future development of multilens cameras and of aviation, the opinion is hazarded that practically all the lands of this earth will be recorded on aerial photographs before the end of the present century.

Be that as it may, the use of aerial photographs in mapping now offers economy of time and money for sizable projects, a permanent record without omissions or blunders, and more exact and practically unlimited detail, all of which are important contributions.

NOTES ON THE COMPILATION OF PLANIMETRIC LINE MAPS FROM FIVE LENS AERIAL PHOTO GRAPHS

U. S. Coast and Geodetic Survey

1933.

Purpose.

These notes discuss in much detail the current methods of compiling planimetric line maps from aerial photographs, particularly five lens photographs taken with the Army Air Corps Model T 3A camera. They are written to acquaint compilers who have not worked with the five lens photographs with the detailed routine and expedients adopted for 1:10,000 and 1:20,000 scale compilations after nearly two years' experience. A brief discussion of "vertical" aerial photographs as mapping tools and of the radial line method of compilation is given for the information of those who have not compiled aerial photographs before.

Vertical Aerial Photographs as Mapping Tools.

For surveying purposes a pair of overlapping aerial photographs may be considered an extraordinarily complete record of directions from two undetermined air stations to the objects which it is desired to map.

They are an extraordinarily complete record because of their advantageous view from the air and because modern lenses and photographic emulsions record detail which the eye cannot see without a magnifying stereoscope.

The stations are undetermined in the surveying sense because the airplane moves so rapidly and is subject to such variable accelerations as to prevent accurate determinations of the space coordinates of the exposure stations as the exposures are made. There are however, numerous methods for determining the exposure stations from the directions to objects of known position which appear in the photographs.

A pair of overlapping photographs was assumed because the photographs constitute a record of directions and the intersection of at least two directions is necessary to determine the position of objects for the map.

The directions are registered on the sensitized surface of a glass plate or a film held in a plane perpendicular to the optical axis of the lens. In mapping cameras this plane is held at a fixed distance equal to the focal length of the lens.

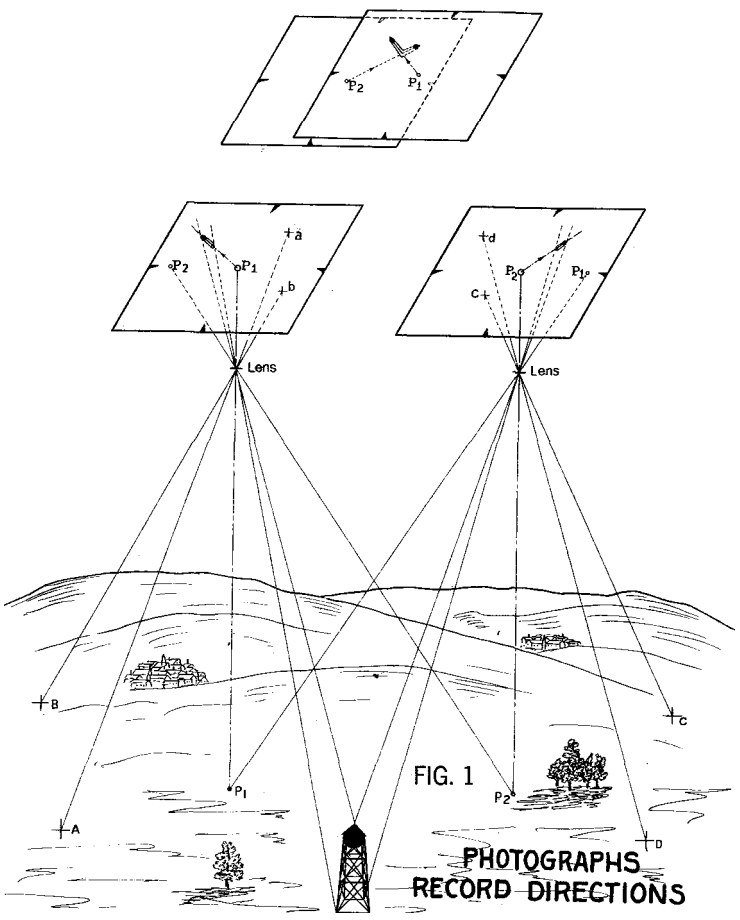


FIG. 1

The intersection of the optical axis of the lens with the sensitized plane perpendicular to it is called the principal point of the photograph. The position of the principal point is indicated directly by a mark registered by the mapping camera on each photograph during exposure or by the intersection of lines from marks registered on the margins of the photograph. The relative directions of all objects from the exposure station may be determined by means of the calibrated focal length of the lens and position of the principal point.

An aerial photograph may be considered as a record on a plane of directions to objects projected through a point (the lens) at a known distance (equivalent focal length) perpendicularly above the marked principal point of the photograph. See Figure 1. The distance and angle relations are fixed in each modern air camera and are determined by calibration.

The accuracy with which directions may be determined from aerial photographs varies with the abberations of the lenses, the grain of the high speed emulsions, shrinkage or distortion of the sensitized material, and other sources of error. In general, directions may be determined with an error of about 12 seconds when all precautions and the best equipment are used. Errors as great as six or seven minutes may occur in ordinary paper prints. The amount of displacement caused by small angular errors at typical radii are as follows:

Radii	First order theodolite	Third order theodolite	12" air camera glass plate	6" air camera non-shrink film	Tilt distortion 3 degrees	Tilt and paper distortion (maximum)
	ONE SECOND	FIVE SECONDS	TWELVE SECONDS	ONE MINUTE	THREE MINUTES	SIX MINUTES
3" 76.3 mm	.000015" .000381 mm	.000075" .00191 mm	.00018" .00457 mm	.0009" .0229 mm	.0027" .0686 mm	.0054" .137 mm
6" 152.4 mm	.00003" .00076 mm	.00015" .0038 mm	.00036" .0091 mm	.0018" . 046 mm	.0054" .137 mm	.0108" .274 mm
12" 304.8 mm	.00006" .0015 mm	.0003" .0076 mm	.00072" .0183 mm	.0036" .0914 mm	.0108" .274 mm	.0216" .549 mm
1 mile 1.609 Km	.0256 ft. .780 cm	.128 ft. 3.90 cm	.307 ft. 9.36 cm	1.536 ft. 46.82 cm	4.608 ft. 14.05 cm	9.216 ft. 280.9 cm
5 miles 8.047 Km	.128 ft. .0390 m	.644 ft. .196 m	1.536 ft. .468 m	7.68 ft. 2.34 m	23.04 ft. 7.02 m	46.08 ft. 14.05 m
40 miles 64.374 Km	1.03 ft. .314 m	5.14 ft. 1.57 m	12.32 ft. 3.76 m	61.43 ft. 18.72 m	184.29 ft. 56.18 m	368.58 ft. 112.34 m

It will be appreciated from the relative size of these errors that aerial photographs at present are not surveying instruments of geodetic precision but rather suited to fourth order control and graphic mapping. For graphic mapping however, they give advantages of speed, economy, freedom from large errors or blunders and an extraordinarily complete, detailed, and permanent record of topographic features.

Indeed, when the camera axis is truly vertical, and the terrain practically at sea level, the photographs give map positions directly. Aerial photographs taken as nearly as practicable in accordance with these special conditions are used for the photo mapping now being done by the Coast and Geodetic Survey.

There are three unavoidable departures (generally small in amount) from these special conditions, the effects of which must be eliminated from positions given by the photographs when compiling maps: (1) Differences in elevation or relief. (2) Tilt or inclination of the optical axis of the camera from the vertical. (3) Variations in scale due to variations in the height of the airplane at the exposure stations of the successive photographs.

Relief

In general, maps show the positions of objects as projected vertically upon the datum of mean sea level. A photograph shows the positions as projected through a single point (the lens). The difference is illustrated in Figure No. 2. The displacements due to elevation radiate from the point vertically beneath the exposure station called the plumb point (which in a truly vertical photograph coincides with the principal point) Figure No. 3. The plumb point has no displacement due to relief and the displacement of other points is proportional to the height of the object above the datum and its distance from the plumb point.

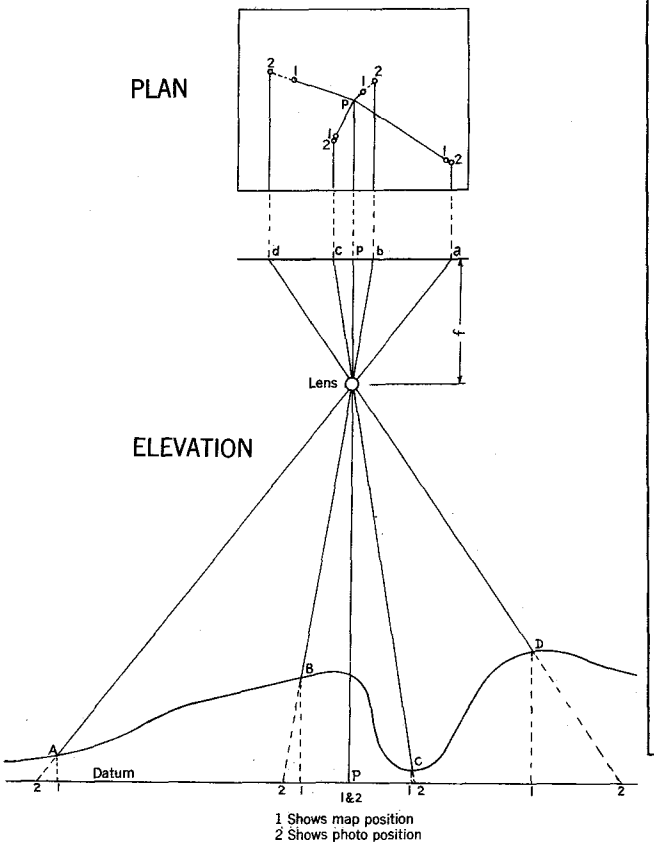


FIG. 2

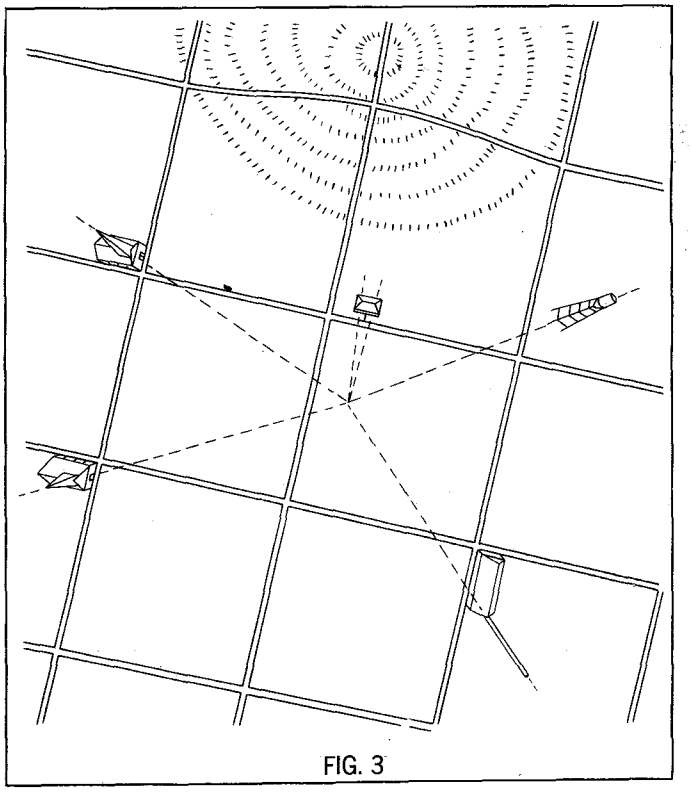
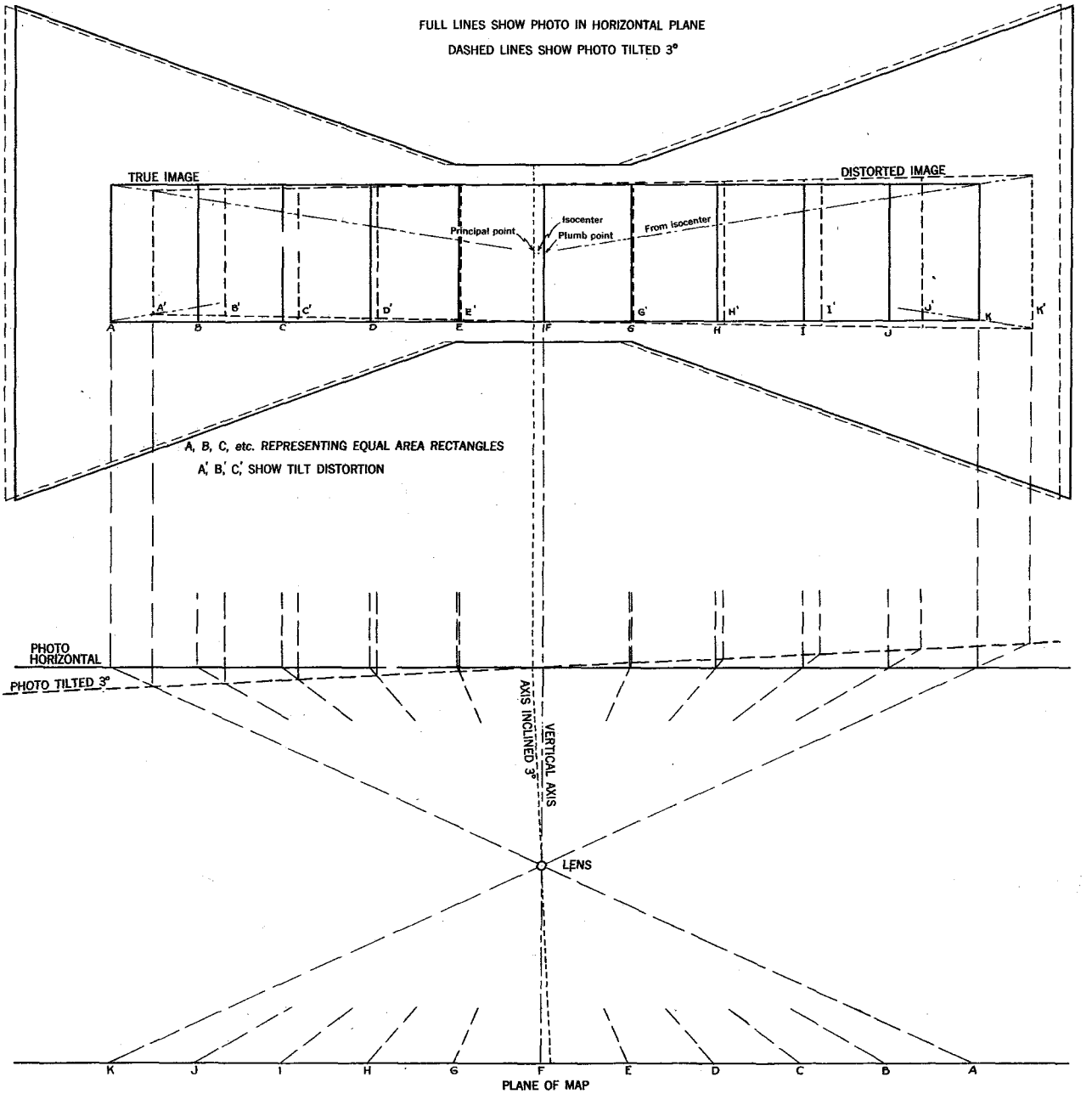


FIG. 3

Note from Figure No. 3 that the displacements of the tops of the chimneys, tank and spire all radiate from the plumb point. The hill top is displaced as much but the displacement is not so apparent from the photograph. The straight road running across the slope of the hill from side to side appears curved while the straight road running radially across its slope appears straight.

Various stereoscopic devices and plotting machines are in use to map relief from the photographs from measurements of these displacements. The areas along the coast most in need of revision surveys at present are relatively flat and the small differences in elevation are not important for charting. A simple method of reduction can therefore be used to eliminate the displacements due to relief and obtain map positions of the detail shown in the photographs.

FIG. 4
Effect of 3° Tilt to Images on Multi-lens Camera



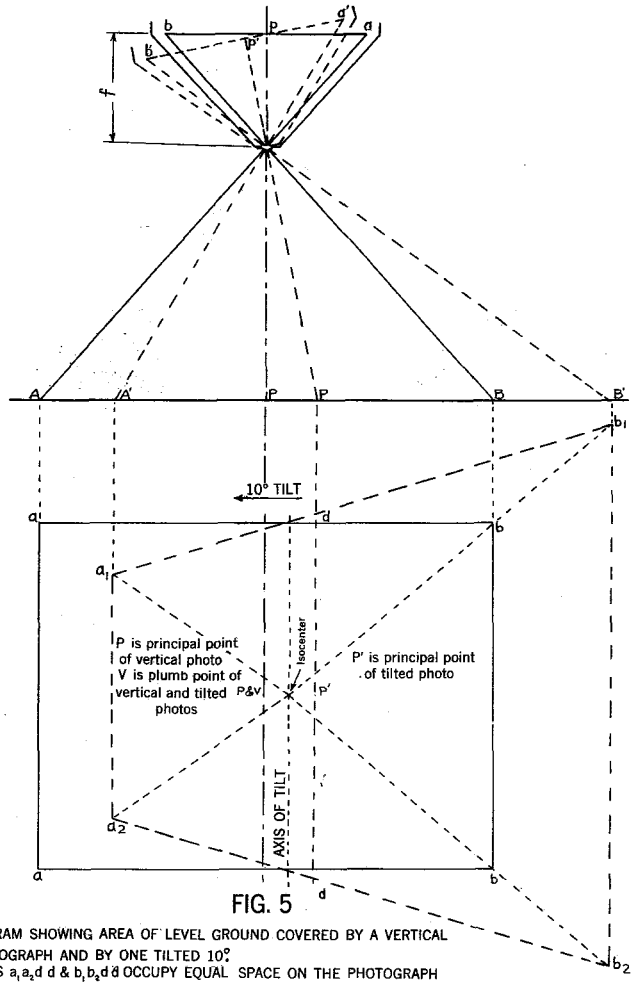


FIG. 5

DIAGRAM SHOWING AREA OF LEVEL GROUND COVERED BY A VERTICAL PHOTOGRAPH AND BY ONE TILTED 10°.
AREAS $a_1 a_2 d\,d$ & $b_1 b_2 d\,d$ OCCUPY EQUAL SPACE ON THE PHOTOGRAPH

Tilt.

From Figure No. 5 it will be apparent that when the camera axis is not vertical, a much larger area of flat ground is projected into the lower half of the photograph than the upper. The scale of the high side of the photograph is therefore enlarged and the lower side reduced about a line of equal scale called the axis of tilt. This line of equal scale is normal to the direction of maximum tilt and passes through a point half way between the principal point and the plumb point called the isocenter. The displacements of positions due to tilt radiate from the isocenter outward on the high side of the photographs and inward on the low. Figure No. 4 shows the distortion of a 6" focal length five lens camera (on l/5 scale) with a tilt of three degrees.

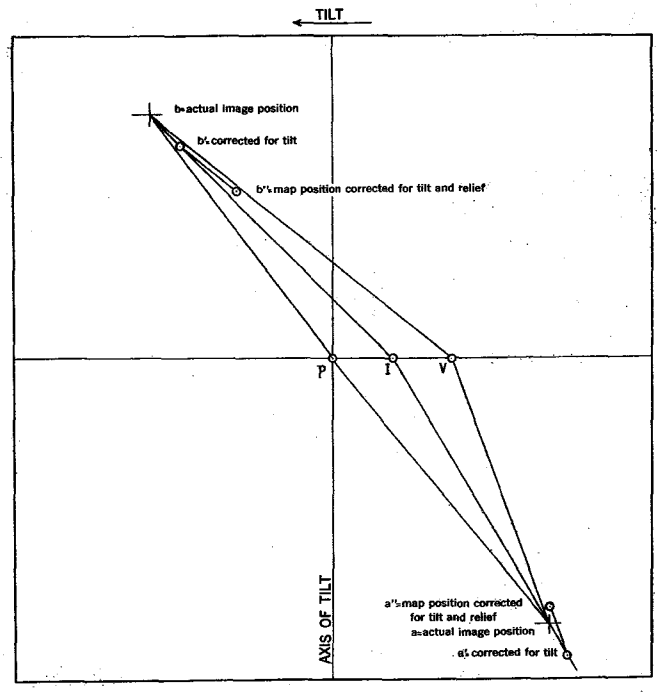


FIG. 6

In general, 85% of photographs taken by experienced personnel with modern equipment will be tilted less than one degree with perhaps 12% between one and two degrees and only in exceptional cases should any photograph be tilted more than three degrees.

The determination of the tilt of photographs is a rather complicated time consuming process at best but for a photograph having less than three degrees tilt the principal point may be substituted for the isocenter without materially affecting the accuracy of a graphic triangulation.

The different directions of displacements due to relief and tilt are shown greatly exaggerated in Figure No. 6 and to scale as nearly as practicable in Figure 7.

The maximum difference in radial direction of objects on a photograph tilted three degrees from the radial direction if the photograph were vertical is 4' 36" at 45 degrees from the axis of tilt. The maximum error in an angle occurs when both directions are 45 degrees to the axis of tilt with the direction of maximum tilt between them.

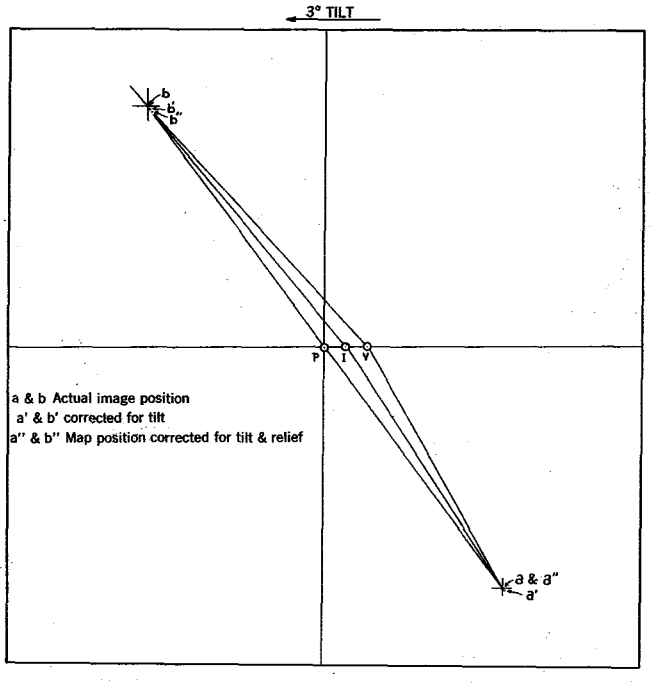


FIG. 7

ACTUAL SCALE DRAWING SHOWING EFFECT OF 3° TILT AND 100 FT. RELIEF

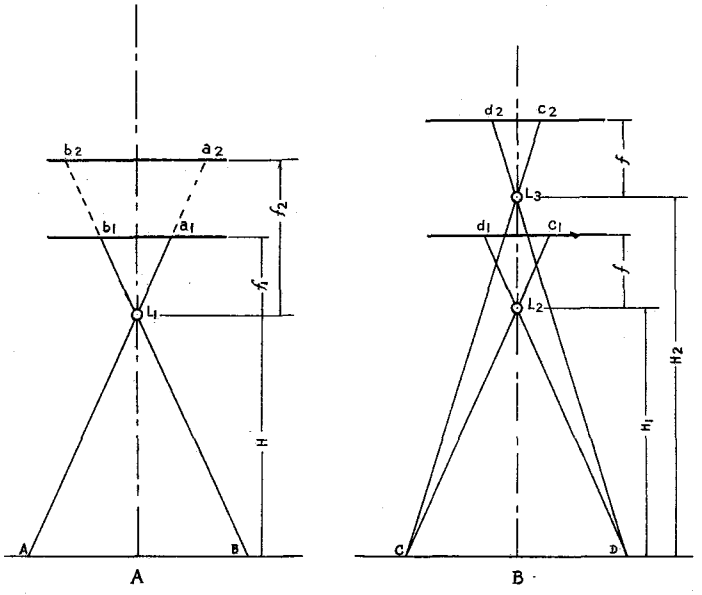


FIG. 8
SCALE · ALTITUDE · FOCAL LENGTH RELATIONS

Scale.

The scale of a photograph of level terrain taken with vertical optical axis is the ratio of the focal length of the lens to the height of the lens above ground (similar triangles). The higher the camera and the shorter the focal length the smaller the scale; Figure No. 8. Since variations in altitude of a hundred feet or more are likely on account of variable air currents and barometric pressure considerable variation is to be expected in the scale of the many photographs used for compiling a map. In general a scale variation of 2% in any one photo project is not considered excessive.

For tilted photographs of flat country or of shorelines, the lines parallel to the axis of tilt will have a constant scale ratio; the ratio differing with the distance of the line from the axis. Lines forming angles with the axis of tilt will have a varying scale. The total distance between points equally spaced from opposite sides of the axis of tilt will have about the same scale as the axis but intermediate points along a line connecting them will not be proportionally spaced. Figure No., 4. It will thus be better for one who is not experienced with aerial photographs not to try to obtain more than approximate ground data from scaling them.

When mapping from slightly tilted photographs of level ground it should be kept in mind that if the distance between the principal point and any other point on a photograph is longer (or shorter) than the map distance all intermediate points along the same line will be longer (or shorter) in approximate proportion to their distance, from the principal point. This is constantly used as a check on the accuracy of intersections when adjusting detail to a radial plot of flat country. Figure No, 4.

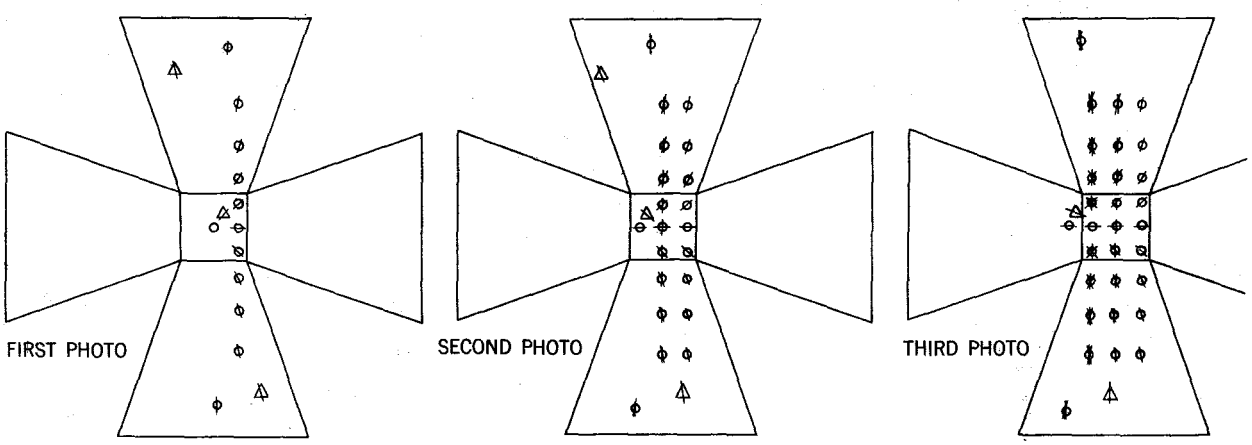
No difference in directions is caused by direct enlargement or reduction in scale.

The "Radial Line" Method of Mapping from Vertical Photographs

The principal point may be used as the origin of radial directions of the displacements of objects shown on photographs tilted less than three degrees without plottable error when the relief is less than ten per cent of the Camera altitude. The analysis of this is given in several of the references in the bibliography on photo mapping given at the end of these notes. This permissible approximation and the registering of the principal point on each photograph by collimating marks form the basis of an efficient means for finding the map positions of the more or less displaced objects on the photographs. The principal point of the photographs may be considered an "instrument station" and lines radiating from it may be drawn through objects which have been or which are to be plotted on the map. These lines will correspond to "cuts" taken with the alidade of a planetable or directions taken with a transit and plotted with a protraotor. The photograph may be plotted on a tracing of the map by causing the radial lines which pass through the control stations as located on the photographs to pass through their corresponding plotted positions on the map, just as a three point "fix" is plotted with a protractor on a hydrographic sheet. The strength of the "fix" or the accuracy with which the photograph may be plotted decreases as the principal point approaches a circle through the known points as explained in all surveying manuals.

when the photograph has been oriented and plotted on the map in this manner the lines radiating to other objects which it is desired to locate may be traced on the map to form "cuts" to these objects. A second overlapping photograph may also be plotted by its radials through the control and the radials through its new objects traced off to intersect the corresponding radials from the first photograph at the map positions of the new objects. The locations of the new objects may be used in turn to plot the next photograph along the flight and new intersections obtained to objects further along the strip. In this manner a graphic triangulation may be extended over the area photographed. Figure No. 9.

FIG. 9



First and second photographs plotted by radials through control; third and succeeding photographs plotted by radials through intersected points abreast center of preceeding photographs.

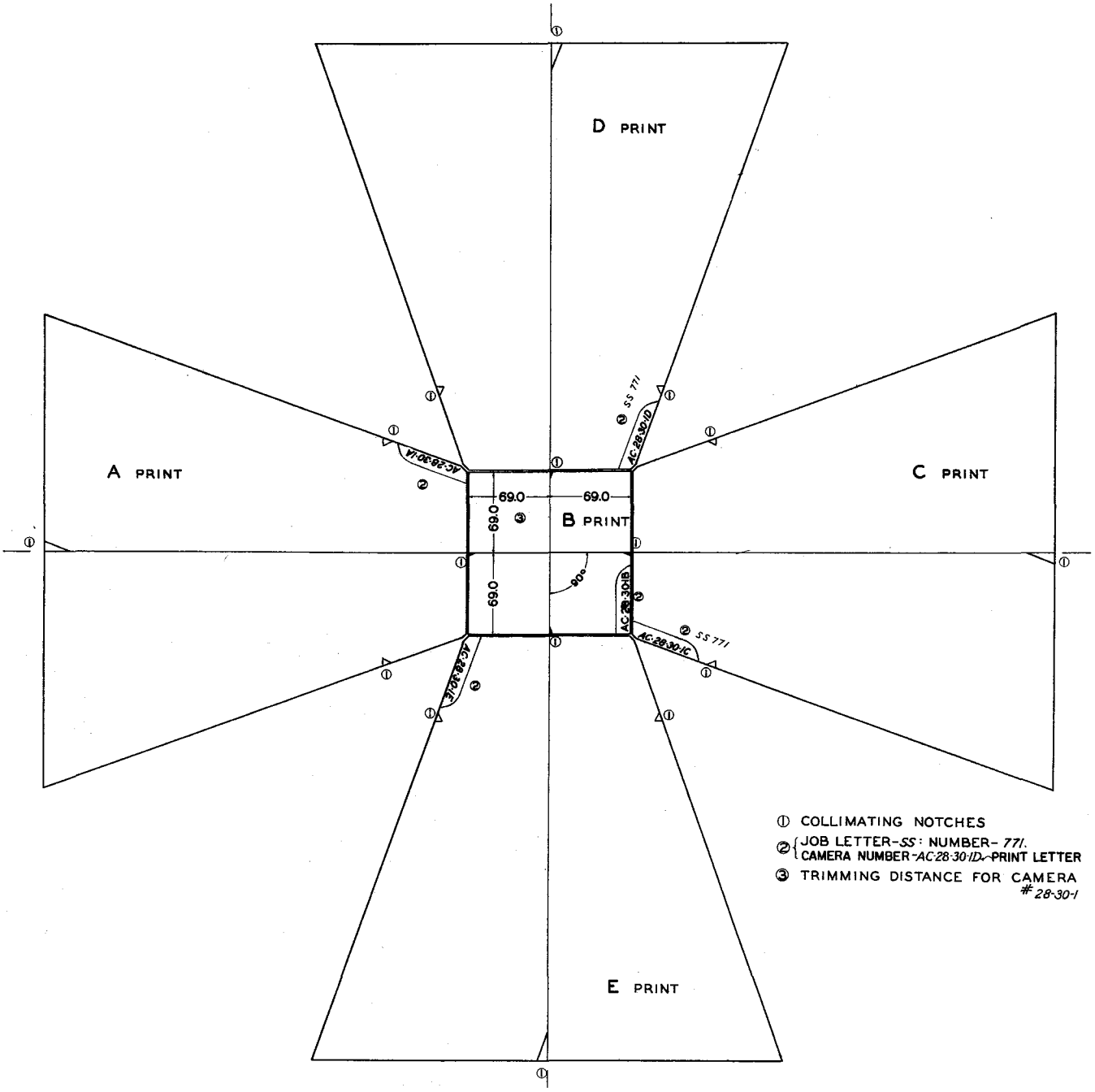


DIAGRAM OF 5 - LENS COMPOSITE PHOTOGRAPH
MADE WITH AIR CORPS MODEL T3A CAMERA

FIG. 10

COMPILATION PROCEDURE.

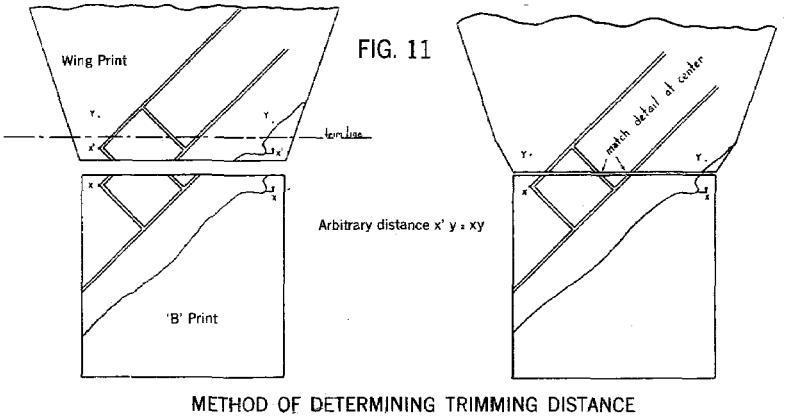
The notes which follow discuss in great detail step by step the methods used in applying the foregoing to the compilation of planimetric line maps by the Coast and Geodetic Survey. The methods described are not standardized. They are rather in the development stage and suggestions for further improvements will be welcomed.

Figure No. 10, (see preceding page), is a diagram of a composite five lens photograph showing the arrangement and letters which designate the five prints from which the composite is assembled. The positions of photo numbers and collimating notches are shown also.

1. Trimming of "B" Prints. Set the guide lines of the special trimming board to the distance from oollimating notch to edge of "B" print (usually 69.0 millimeters) as given in the calibration diagram and trim the "B" print square with edges parallel to collimating notches.

2. Trimming of Wing Prints. Trim inclined sides and long end of wing prints so that collimating notches will extend to edge of print. Inspect the white lines registered on the wing prints as they are transformed to see whether they coincide accurately with the straight sides of the oollimating notches. Mark the lines which do not register on the notches conspicuously with a colored pencil in a place that will not be trimmed off so as to call attention to the discrepancy when the prints are mounted and plotted. Then trim the edges next to the "B" print 0.3 millimeter shorter than the distance given in the calibration diagram. This shortening is specified in order to avoid buckling of the prints which might occur as the flexible card mounts are handled, particularly in damp weather. In setting the prints in the special print trimmer and later in mounting, the flat edge of the black collimating notch should be used rather than the white line whenever the two do not coincide. The detail of the trimmed edge when held 0.3 m.n. from its corresponding edge of the "B" print should be continuous within : 0.4 m.m. If not, the distance given in the calibration diagram may be rejected and the prints trimmed to match detail at the trimmed edges so as to form a composite photograph showing unbroken topography. The setting of the print trimmer should be checked every six to ten prints by comparing the trimmed edges of the "B" and wing print for continuous detail. Straight lines such as road curbs crossing the function at suitable angles are especially useful for this. The distance between objects across the junction may be checked with the distance between the same objects on the untrimmed photographs used for the field inspection. If found appreciably in error the setting of the trimming board should be changed to secure practically continuous detail and the number at which the change occurred should be noted in the descriptive report.

If it is found necessary to determine a new trimming distance, prick sharply defined point(X on Fig. No. 11) on the "B" print near the edge to be trimmed and as near the ends of the edge as sharp detail appears. Accurately recover these points (X') on the untrimmed wing print. Then with a pair of sharp bow dividers set at any convenient distance which will extend about 1/4 inch beyond the edge to be trimmed, prick points (y) on the wing prints. Place the "B" print on the wing print matching detail as closely as practicable and cheek the distance between points "X" on the "B" print and "y" on the wing print with the bow dividers still set at the same arbitrary distance. When the setting is satisfactory, with a chisel edge hard pencil draw a fine line along the edge of the "B" print and with a straight edge extend the line to the edge of the wing print. The wing print should be trimmed 0.3 millimeter from this line to avoid Jamming and bulging when the prints are mounted.



METHOD OF DETERMINING TRIMMING DISTANCE

3. Marking of Principal Point. The principal point of each "B" photograph is next pricked and marked with a small blue pencilled circle. A celluloid templet is used for pricking these points. Two fine perpendicular lines are scribed on a piece of celluloid and a hole made at their intersection. The perpendicular lines are held on the flat side of the collimating notches in the centers of the edges of the "B" print and the principal point pricked through the hole at the intersection of the lines.

The principal point is used as the origin of all radial lines on the composite photograph. Only moderate care is needed for its location since the differences between it and the plumb point (with which it seldom coincides) are ignored in the radial method of plotting.

4. Marking of Center Point. A point (called center point) of sharp, well-defined detail as near the principal point as possible (preferably not more than l/2 cm. away normal to the line of flight or 1 cm. away along the line) is pricked and marked with a small red pencilled circle. (The outer parts of the "D" and "E" wing prints of photographs along the strip should be examined when choosing this point to make sure that the point which can be most accurately located on all the photographs on which it appears is selected). The same point is then pricked on all the adjacent "B", "D" and "E" prints on which its image appears. It is important that the pricking of the point where it appears on adjacent photographs be done with all the care and precision practicable. The stereoscope and magnifying glass should be freely used to make sure that exactly the same point is pricked on the different photographs. When for any reason a suitable center point cannot be found within the specified distance from the principal point, a point on each side of the principal point at whatever distance necessary should be pricked. These two substitutes for the center point should be about equally distant from the principal point. An additional point near the principal point and at right angles to the line of flight should be pricked whenever there is any doubt as to the precision of the recovery of the center points on adjacent photographs.

USE OF THE STEREOSCOPE.

A stereoscope is an instrument for viewing a pair of photographs showing the same area from two different exposure stations in such a manner that one photograph is viewed only with one eye and the other photograph with the other eye. It is necessary that the photographs be so placed and so reflected to the eyes that they appear to fuse into one three dimensional image in their zone of overlap when so viewed. Normal eyes possess a marked degree of accommodation but in order to avoid straining them, the best practicable adjustment of the stereoscope and photographs should be made before work is commenced. Two types of stereoscopes are furnished, a portable mirror type, and a prismatic magnifying type.

To use the portable mirror type it should be set up in accordance with the photograph enclosed in its box. There are several holes in the east metal "X" frame of which the two sets which most nearly center the small mirrors below the respective pupils of the eyes of the observer should be used. One of the larger mirrors is adjustable on the two rods for the distance from its small mirror. This adjustment will permit of varying the apparent scale and thus to compensate for moderate differences in scale of the two photographs viewed. Care should be taken to keep the mirrors clean and not to scratch them in cleaning.

The prismatic stereoscope has two sets of eyepieces, one giving a magnification of two times with a field of about five inches, and the other set four times with a field of two and one-half inches. Each eyepiece may be focused and there is an adjustment for inter-pupilary distance with a scale in back of the right hand telescope. The following procedure should be followed in using the stereoscope:

1. Focus each eyepiece separately on the photograph viewed by it. (No focussing is practicable for mirror type). If glasses are worn they should be kept on.

2. Adjust pupilary distance by holding head still and closing first one eye and then the other and changing distance until the full field is seen with either eye.

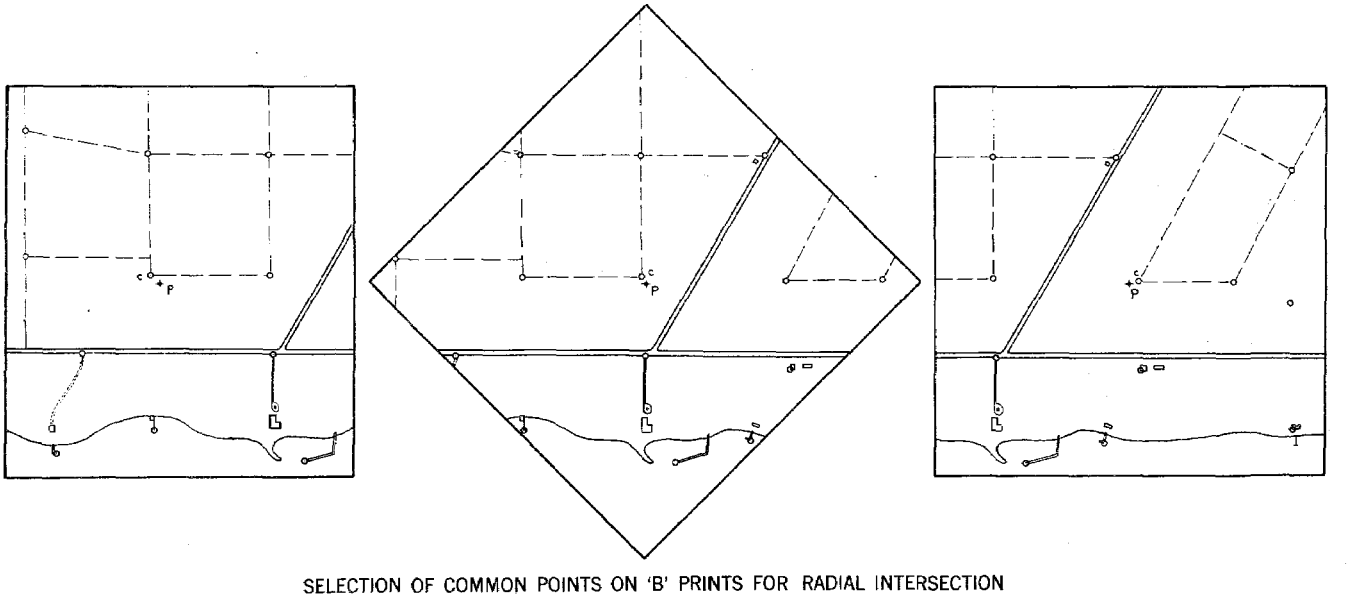
3. One photograph (usually the left) should be placed under the left mirror or objective with the area which it is desired to examine centered in the field of view and then be held in that position. The right hand photograph should be placed under the right viewing system and adjusted until the two views fuse into one without eye strain. The edges of the field should be examined as well as the center in making this adjustment. It will often be found helpful to place a finger just under the object to be centered on each print so that it can be readily noticed by the eye when making these settings.

In order to give a true stereoscopic effect it is necessary that the prints have the same azimuth relation under the stereoscope that they had when taken. The line between their exposure stations must be parallel to the line between the observer's eyes. If the prints *are* placed in reversed azimuth, elevations will appear as depressions, while if turned at right angles to the eye base and the air base, no stereoscopic effect will be obtained. An inexperienced observer will often interpret the shadows into relief effects and think that he has the correct setting when such is not the case. When first using the stereoscope it is well after examining a correctly set stereoscopic pair, to exchange the right and left hand prints and note the pseudoscopic or reversed effect. Also to change the prints 90 degress and note the loss of the stereoscopic effect. The reversed effect may be avoided by examining some objects such as a tree, house, or shoreline known to have relief when first setting the photographs. Experience will soon make it possible to tell whether a true stereoscopic effect is being obtained, The stereoscopic effect depends on the interpretation of the different views of the objects obtained by each eye. Therefore it cannot be seen by those who do not have nearly normal vision in both eyes at least when corrected by glasses.

Most individuals are accustomed to viewing objects whose relief causes shadows to fall downwards. It will therefore help somewhat if the photographs are placed in the stereoscope so that the shadows of objects in relief fall towards the observer rather than away from him. This effect should not be substituted for the best adjustment for stereoscopic effect, however,

6. Marking Intersection Points on "B" Print. Concurrently with the selection and pricking of the center point, a point near the "A" and a point near the "C" edges of the "B" print, which also appear clearly on the adjacent "B" prints, are also selected and marked. These points are also recovered and marked on adjacent "B" prints; also on two or three of the adjacent "D" and "E" prints of the flight. At the same time any features which will require very exact location, such as the ends of wharves, landmarks, or future hydrographic signals, should also be marked. See Figure No. 12.

FIG. 12



SELECTION OF COMMON POINTS ON 'B' PRINTS FOR RADIAL INTERSECTION

7. Marking intersection points on Wing Prints. About three points along the center of each "A" and "C" print are selected, marked, then recovered and marked on the adjacent "A" and "C" prints. On flights which have their alternate photographs crabbed 45 degrees the points are selected on the "A" and "C" prints, then recovered on the "D" and "E" prints on which they appear. Other things being equal, points should be selected that appear on as many adjacent photographs as possible.

It is desirable that the points be chosen at street intersections, turns in shoreline, and similar places so as to furnish exact locations for important detail and at the same time to divide the photograph into small areas seldom more than two inches across to furnish a convenient framework for adjusting and tracing intermediate detail. All features which require specially careful location should be marked and transferred to adjacent photographs. When pricking common points, in street systems, it is advisable to prick street intersections on the same side of the street, of the same street, in several places in addition to the regular "three in line" points. Additional points along railroads, through highways, etc., are useful. See Figure 13.

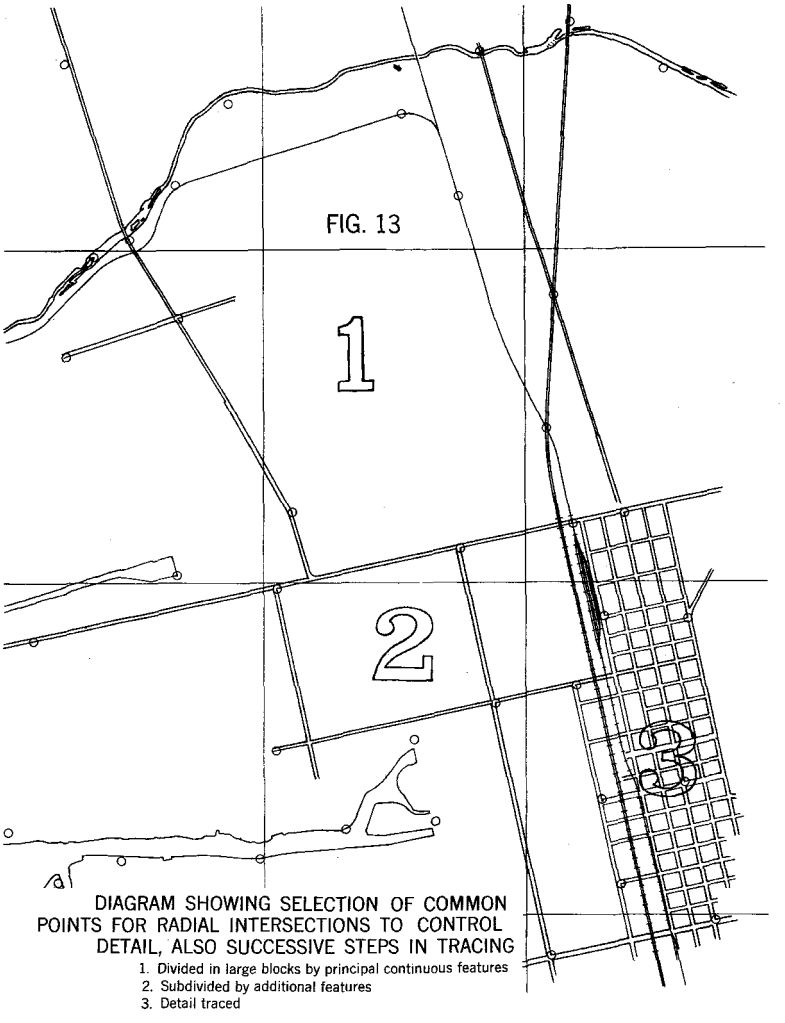


DIAGRAM SHOWING SELECTION OF COMMON POINTS FOR RADIAL INTERSECTIONS TO CONTROL DETAIL, ALSO SUCCESSIVE STEPS IN TRACING

1. Divided in large blocks by principal continuous features
2. Subdivided by additional features
3. Detail traced

If there are overlapping flights of photographs it is desirable that the points selected for one flight be used in the overlapping flight as far as this may be done without materially slowing up the work. Care should be taken to make sure that exactly the same point is selected in each case, particularly because the points are viewed from different sides in the different flights. An effort should be made to secure at least two points common to the overlapping flights, one near the center and one in the outer half of the wing print. The center points of the "B" prints should be used when they can be clearly identified on the overlapping flight. When only a few points common to both flights can be identified, they may be distinguished by a small red penciled square instead of the usual circle.

8. Marking Control Stations. All control stations spotted on the field set of photographs are marked on all the office photographs on which they appear with small green triangles.

Great care should be used in identifying and marking all of the points from photograph to photograph because the accuracy of the plot depends directly on this. A magnifying glass or stereoscope should be freely used where such instruments will help in identifying the exact points, Special care is needed when marking points in wooded country. The shadows from trees will be partially obscured from different directions and cause much trouble in selecting exactly the same points.

9. Mounting prints. When the prints have been marked with the common points and control, they are ready for mounting. Card mounts will be furnished on which lines have been printed on which the different prints are mounted in their correct relations to form the composite photograph. The number printed on the card must be the same as the camera number as different cameras require different relations of the lines.

A piece of photo dry mounting tissue about an inch larger than the "B" print is "tacked" centrally on the "B" print with the heated iron, allowing the edges of the tissue to project about 1/2 inch beyond the edges of the print. The "B" print is then fastened in correct position on the card with the flat edge of its collimating notches in line with the lines printed on the card, using the tip of the heated iron. The wing prints are then fastened in position with the iron along their "B" edges and with scotch oellulose tape around their other edges.

When all the prints have been fastened in position a piece of chart paper is placed over the area under which the mounting tissue lies and heat applied with the iron to stick the prints thoroughly to the card. After applying the heat, it is helpful to rub the print gently with a piece of paper until it cools somewhat to insure bond. There is a tendency for the print to curl at the edges unless the iron is at exactly the right temperature. A temperature which bolls drops of water slightly but does not make them "pop" or assume spheroidal shape is best for the iron used for mounting with tissue.

When mounting wing prints, if the detail along the trimming edge of the "B" and wing print does not coincide all along the edge, make the middle detail coincide without regard to the oorner detail or the white transforming line. If on most of the prints the white transforming line of the wing print has nearly coincided with the black cOllimating notch of the "B" print with detail matching at the center, but suddenly fails to do so, delayed shutter action is indicated. (That is, provided no note as to the failure of the transforming line to register on the wing print collimating notch was made when the prints were inspected for this prior to trimming.) In such a case, the outer colllmating notch should be offset the same amount and the same direction as the white line is offset from the collimating notch of the "B" print in all other cases the outer collimating notch should coincide with its line printed on the card. The straight sides of the black collimating notches should be made to coincide with the printed lines instead of the white transforming lines when these differ. These remarks apply to any method of fastening the prints to the card mounts.

The accuracy of the mounting may be tested by means of a straight edge after the marks around the edges of the "B" prints have been covered up. For many of the fire lens cameras the collimating notches on the outer edges of the wing prints and those on the "B" prints should lie on the same straight line. For other cameras a small offset is used for the outer wing notches as shown on their calibration diagram.

10. Drawing Radial Lines on Photographs. After the photographs have been satisfactorily mounted, the next step is to draw short radial lines through the points which have been pricked and marked on the successive photographs. These lines are drawn to radiate from the principal point (marked with a small blue circle). When plots are being made on the scale of the photographs, lines half an inch on either side of the points in the inner half of the wing prints and about an inch on either side of the point in the outer half of the wings are usually of sufficient length.

The present practice is to use a crow quill, (or #290) pen with a special bevelled edge radial line ruler made from celluloid for drawing radial lines on the photograph. A fine needle stuck into the photo is used to hold the hole in the end of the ruler over the principal point and any convenient edge of the ruler is used for drawing the radial lines. The celluloid ruler should be supported by the fingers near the line to be ruled. The ruler is so flexible that it will bend with the pressure of the pen if held at a distance from the line being ruled. A steel straight edge may be used to rule the radial lines. One end of the straight edge is held near the principal point needle by sticking the needle through a loop of cellulose tape fastened to the ruler. Yellow water color is used for the lines on the darkest photographs and orange vermillion for lighter or mixed shade photographs. Water colors in pans (such as Windsor and Newtons), which may be purchased at art stores, are recommended. These colors when shaken up with some pebbles in a small quill stoppered bottle, about two pans of color to the bottle, are convenient to use and are somewhat smoother and easier to apply than show card colors. The colors dry rapidly and are hard to use if too thick. A brilliant red writing fluid may be used instead of the colors if the photographs are not too dark.

Great care should be taken to draw these radial lines accurately through the pricked points and to keep the lines as fine as practicable. Where the image is not of such character as to indicate the location of the point pricked on the radial line, this may be done by a short cross line or by twisting a sharp point pencil in the prick point, being careful not to enlarge the point. Some draftsmen prefer to stop the radial line just short of the point pricked and continue it again on the other side.

11. Finding Average Scale of Photo Flight. The average scale of the photo flight is next found by a preliminary "spotting" plot as follows:

The first photograph of a flight is placed under a scrap sheet of celluloid and oriented so that the flight will not run off the sheet. The position of its center point and the center point of the following picture are marked on the sheet. Radial lines are also drawn through any control stations appearing on that photograph. The following picture is then placed under the celluloid sheet, making the images of the same points coincide with the dots previously marked on the celluloid. When these points will not coincide due to a difference in scale, the difference is averaged and the azimuth retained. The position of the center point of the following picture is marked and radial lines are drawn through all control stations on this picture. The intersections of the radial lines traced from the picture locate the triangulation stations on the preliminary plot. The same procedure is followed throughout the sheet with the remaining photographs. Due to the averaging of the differences between centers of pictures, a triangle of error may appear at the positions of some of the triangulation stations. The most probable positions for such stations are marked on the celluloid. The distances between all triangulation stations appearing on the celluloid are measured and tabulated and the scale factor found as shown in Figure No. 15 (b).

The value for the scale factor thus found should be rounded off that is 1.059 x 20,000 should be used as 1.06 x 20,000 for the individual photographs will vary considerably from the mean scale at best. For this reason little time should be spent on this preliminary scale finding plot.

If two or more flights are to be shown on one sheet the average scale is taken if the difference is not more than about five per cent. If larger than five per cent, the flights are compiled separately or the scale is chosen for title most important flight and alternate photographs of the other flight are rephotographed to the scale selected for use in tracing off detail. The following considerations should govern in selecting the most important flight for determining the scale:

1. Length (Do both flights run the full length of the sheet?)
2. Location of the main features (usually shoreline).
3. Constant scale (if one flight has a varying scale and the other a constant, choose the constant scale for the projection.)

12. Layout of Projections. In general the layout of the projection for a single or double strip of photographs along a waterway or coast line should be made so that the length of the sheet roughly parallels the trend of the shoreline, without regard to orientation with the meridians. Such sheets should not exceed 29 x 46 inches in size when reproduced to standard scale on account of the limitations of the reproduction machinery now available.

Where a large area is to be covered with many non parallel waterways, it will be best to use an atlas layout of the sheets of 3-3/4 minutes of latitude and longitude if 1:10,000 or 7-1/2 minutes if 1:20,000 scale fitted into the even 15 minute quadrangle system. Such projections can be used on a 24 x 30 planetable. Several such projections may be bound together temporarily with cellulose tape and their control pricked off on an overlay celluloid sheet for the radial plots. The positions determined by the radial plots, may in turn be pricked off on the projections and the detail traced directly on the projections from the photographs.

The limits of the sheets should be indicated by fine straight neat or border lines. Where a projection line forms one of the limits no border line need be drawn. The neat lines should be drawn in black on the atlas sheets and in blue on the coast strip sheets. The work should be traced in black to the border lines and in blue beyond them (as far as may be necessary to insure a satisfactory junction with adjacent sheets). These neat lines will assist materially in the reproduction and joining of adjacent sheets. Where work is traced to the limit of the photographs, notes to that effect should be shown and no border need be drawn.

13. Preparation of Data Folder. A diagram of the sheet to be compiled showing the projection to be drawn is made unless an atlas layout is to be used. The projection distances are taken out of the tables of Special Publication No. 5 and multiplied by the scale factor. A table is also made of the geographic positions of all control and the d.m.'s and d.p.'s in meters are multiplied by the scale factor. It has been found convenient to keep these data in a special folder for each sheet as the work on it progresses. The outside of the folder can be labeled with the number and title of sheet, time and date of photographs, sources and date of control, planetable sheets referred to, etc. Figure 15 (a). In the folder are kept the scale factor computations, (Figure 15(c)), the projection diagram, (Figure (d)), the list of geographic positions with d.m.'s and d.p.'s multiplied by scale factors, (Figure 15(b)), and notes made from time to time for the descriptive report of the compilation. The use of such a folder for each sheet is strongly recommended as a time saver.

When these data have been prepared and checked (by another compiler if practicable), a polyconic projection is drawn on low shrinkage celluloid to the average scale of the photographs. This is checked and all the control is plotted thereon and checked. The use of a few longer diagonal distances between control stations when multiplied by the scale factor is recommended as an additional check of the plotting of both control and projection.

The topography from other reliable surveys and that along the margins of sheets which join the one to be compiled, should be traced on the projection in light blue, and any discrepancies with such information discovered in the course of compilation should be carefully investigated and discussed in the descriptive report of the compilation.

T-4690

SAN JOAQUIN RIVER, CAL.
ELDORADO PUMP TO STOCKTON

Photos taken Jan. 10, 1932 at 1:45 p.m.-2:10 p.m.
Photos ss-833 to ss-851 and ss-852 to ss-870

Scale Factor-0.944

Projection by F.G.E. Oct. 26, 1932 Checked by J.H.W. Oct. 26, 1932
Control plotted by F.G.E. Oct 27, 1932 Checked by J.H.W. Oct. 27, 1932
Photographs plotted by F.G.E. Oct.-Nov. 1932
Sheet inked by F.G.E. Nov.-Dec. 1932

Sources of material: Sanborn Map; Geological Survey Quadrangles and Blue Prints from L. P. Raynor

(a) COVER OF DATA FOLDER

FIG. 15

Portion of Specimen Pages from Data Folder

(a) Cover of Data Folder

(b) Control Data, Page 2 of Folder

(c) Scale Factor Computations

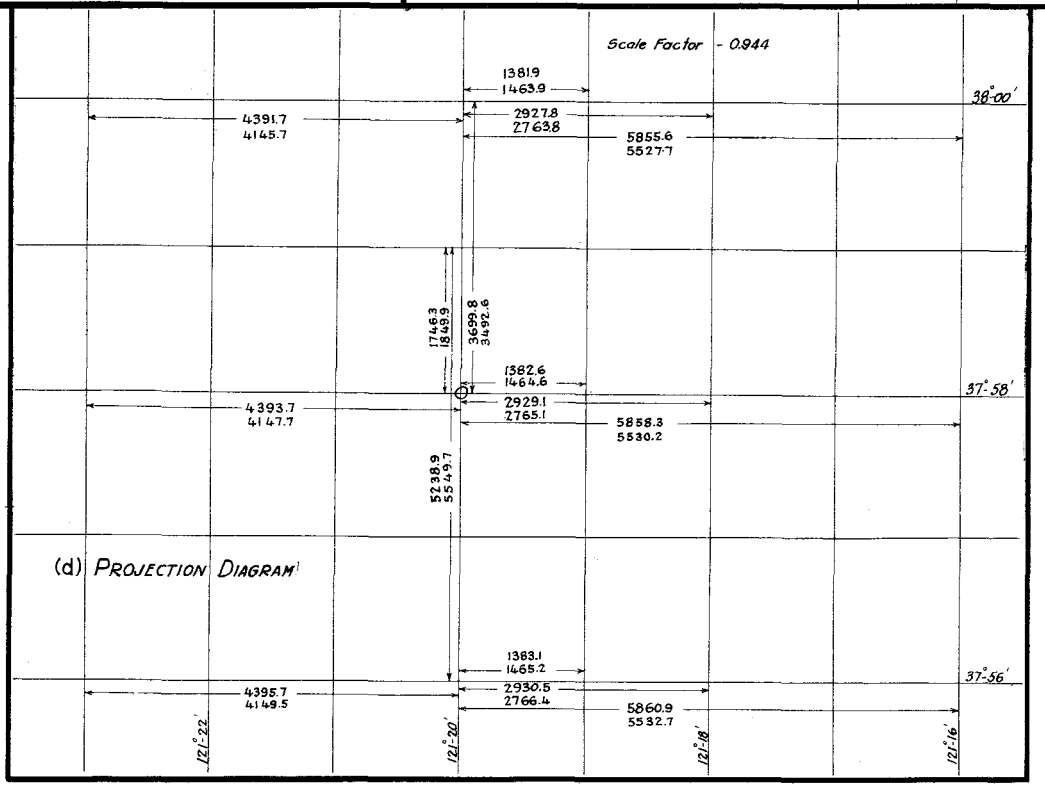
(d) Projection Diagram

STATION	°	'	"	m.	x Scale Factor
CALAVERAS	37	58	36.918	(711.6) 1138.3	(671.8) 1074.6
U.S.E.D.	121	20	34.556	(621.2) 843.4	(586.4) 796.2
1931					
PACIFIC	37	58	43.863	(497.5) 1352.4	(469.6) 1276.7
U.S.E.D	121	19	01.873	(1418.9) 45.7	(1339.4) 43.1
1931					
STOCKTON	37	57	22.072	(1169.4) 680.5	(1103.9) 642.4
1931	121	17	07.384	(1284.6) 180.3	(1212.7) 170.2

(b) CONTROL DATA

	Measured Distance	Computed Distance	Scale factor Measured Computed
Calaveras to			
Pacific	2144	2272	.942
Tank, Stockton Box Co.	4987	5270	.946
Tank, Stockton Box Co. to			
Section Corner	7308	7740	.944
Stockton to			
Tank, Fibre Products Co.	1862	1959	.950
Section Corner	6005	6366	.944
Tank, Fibre Products Co. to			
Section Corner	4176	4443	.939
Average Scale Factor			.944

(c) SCALE FACTOR COMPUTATIONS



(d) PROJECTION DIAGRAM

14. Preparation of the Celluloid Sheets. A low shrinkage celluloid is now available which shrinks and expands quite uniformly and seldom more than one tenth of one per cent with changes in humidity. Celluloid does not give a particularly good surface for drafting though if a number of precautions are observed quite satisfactory drafting can be done on it. If clear celluloid is supplied it must first be given a "frosted" or grained surface by rubbing with pumice or steel wool and pumice. If 00 or finer steel wool is available, the pumice may be dusted into a pad of it and the sheet rubbed briskly with a circular notion. Pumice alone may be used on a cloth pad, the pumice being renewed as soon as it fails to cut rapidly. About 30 minutes' rubbing is required with steel wool and pumice and the surface will show some scratches. The pumice alone requires about two hours but the resulting surface shows fewer scratches. The graining should be done on a very smooth firm surface. After this treatment, the sheet will take soft pencil and celluloid ink quite well. If care is used to handle the sheet only by the edges no further use of pumice should be necessary. It is very important to keep grease from the fingers and dirt off the sheet as far as practicable. Some draftsmen have trained themselves to touch the sheet only with their finger nails or with a stylus, and to rest their pen hand on a light board such as a cigar box lid supported by small pieces of rubber glued to its bottom. Other draftsmen use white cotton gloves. Still others have several sheets of paper with which they keep the sheet covered except where they are working. If the sheet does become somewhat greasy and refuses to take ink well, a good rubbing with powdered pumice or some of the patented tracing powders of the area about to be traced helps considerably.

The low shrinkage celluloid has had much of its solvent removed and the sheets have a tendency to break along the edges with use. As there is a tendency for such tears to extend into the body of the sheet, it is well to bind the edges with scotch tape applied without tension to the back of the edges.

15. Drawing the projection. The projection may be drawn in pencil on the celluloid sheet. This must be done if the draftsman is not familiar with such work. Care should be taken not to scratch the sheet or puncture holes unnecessarily as such abrasions cause the ink to run and spread. A 2H or 3H pencil will show quite strongly on the celluloid surface. The pencilled projection should be checked for accuracy then inked and checked again. So errors in excess of 0.2 mm should be accepted in the projection or plotting of control. The sheet is then ready to have the control plotted. When the oontrol has been checked for accuracy, it is well to ink it on the reverse side of the sheet in blue. This retains the position but does not interfere with the drafting. The proper symbol can be inked on the upper surface when it will no longer interfere with the compilation. All triangulation symbols should be equilateral triangles with the sides 3 millimeters long and with bottoms parallel to the latitude lines of the projections. [Figure No. 19).

16. Use of Special Celluloid Ink. A special celluloid ink is now available which adheres firmly to the celluloid but which is difficult to apply evenly. The thickness of the ink is all important in securing a good dense line but to keep it so requires continual attention. A small quantity in two bottles can be kept more nearly correct than when one bottle only is used. A slight amount of thinner can be added if the ink is too thick and the bottle can be allowed to stand uncorked over night if it is too thin. Only a small amount of ink should be used in the pen. It may be necessary to run the ruling pen over lines twice. The ink is difficult to erase and usually leaves a yellow stain when erased which photographs almost as black as the ink itself. It is therefore necessary to erase it very thoroughly. The ink also gives off fumes which turn the oelluloid yellow. It is important not to lay a pen wiper used with the ink on the sheet for even though the ink does not touch the sheet, its fumes will cause a yellow stain to appear on the sheet. Pens, triangles, in fact all things that have the special ink on them are likely to discolor the sheet. A heavy sheet of paper should be laid between inked sheets when storing them in a pile to avoid staining. Celluloid triangles should not be used with the special ink for their edges will be corroded quickly and ruined.

17. Radial Plot. When all the control data, the margin of adjoining sheets and relevant information from previous surveys have been drawn on the celluloid sheet, it is ready for the radial plot. The general principles or this method of plotting are discussed on page 7. The photographs which are most strongly fixed by ground control are plotted first. It is good practice to plot about every fifth photograph before plotting adjacent photographs when there is sufficient control for this. The radial line plotting, being graphic, is liable to errors which are most easily avoided with the five

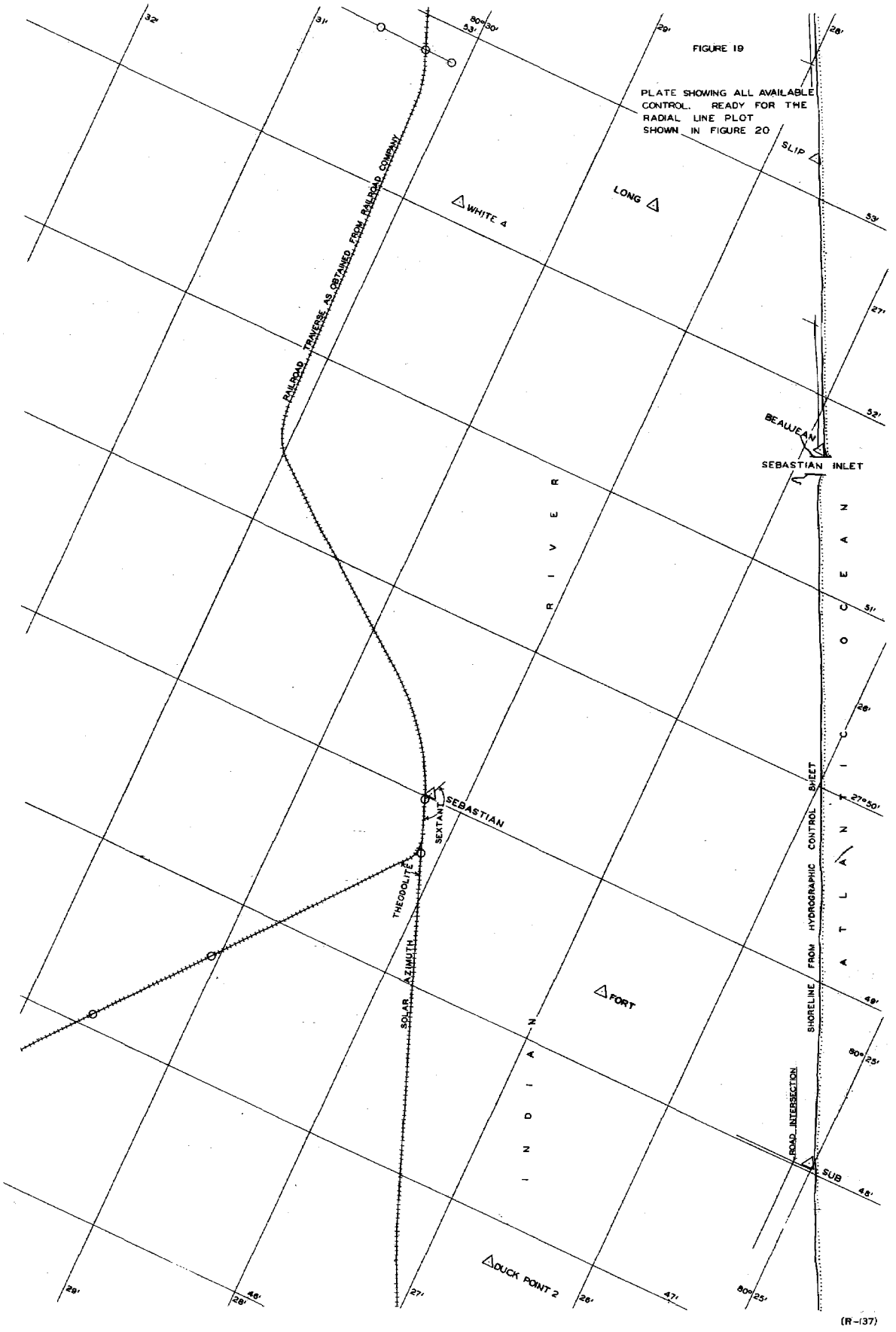


FIGURE 19
PLATE SHOWING ALL AVAILABLE CONTROL. READY FOR THE RADIAL LINE PLOT SHOWN IN FIGURE 20
RAILROAD TRAVERSE AS OBTAINED FROM RAILROAD COMPANY
WHITE 4
LONG
SLIP
BEAUJEAN
SEBASTIAN INLET
RIVER
ATLANTIC OCEAN
SEBASTIAN
SEXTANT
THEODOLITE
SOLAR AZIMUTH
FORT
INDIAN
SHORELINE FROM HYDROGRAPHIC CONTROL SHEET
ROAD INTERSECTION
SUB
DUCK POINT 2
27°50'
80°30'
80°25'
(R-137)

lens photographs by plotting independently as many photographs as are strongly fixed by ground control. In many areas there will be so much control that the azimuths as carried through the "D" and "E" prints will almost overlap. It is almost certain that there will be errors on each sheet compiled in plotting the control, spotting it on the photographs, or in mounting the photographs. These errors will be most readily found and corrected if the independently controlled photographs are plotted first. A failure of the flight lines to join indicates error at once, whereas when the continuous strip is plotted until more control is reached, it will often be found that some small error has caused considerable deviation of the plot and the whole must be erased and done over.

The finest lines which it is practicable to draw without unduly slowing up the work should be used when tracing the radial lines in order to keep the graphic errors as small as possible. The center point of each photograph should be spotted and numbered with the photo number as the photograph is plotted.

After the independently controlled photographs have been plotted and all their radials have been traced in blue ink on the celluloid sheet, the intermediate photographs are plotted by the radial line method. For the first plot of the intermediate photographs, it is well to trace only a few of the radial lines - say about three on each side of the center - one at the edge of the "B" print and one in the inner and one in the outer half at the wing print. One radial in the outer half of each wing would be sufficient if all the graphic work were precise, but three are considered desirable in order more readily to isolate errors in mounting, pricking points and drawing radial lines. It is preferable that these points be common to overlapping flights when there are any. For the radial plot of the main flight use a non-waterproof blue ink; a good grade of fountain pen ink is all right. For other overlapping flights use non-waterproof red ink. For additional flights, other colors. The non-waterproor ink is readily cleaned off with water if it is necessary to replot or revise the intersections. Nearly always these intermediate plots will require some adjustment and replotting in order to get as good intersections as possible with no sudden adjustments or discrepancies in the plot, either between the individual or overlapping flights. It will be found that even with the greatest practicable care in draftsmanship the graphic methods will permit of quite a large amount of stretching in the direction it is desired to go without appreciably changing the character of the intersections. The present practice is to replot until a smooth adjustment of both azimuth and distance is obtained between controlled photographs, an adjustment which does not exceed the graphic error of plotting (about two-tenths of a millimeter), Any error greater than this in flat country indicates something wrong in pricking points, mounting or plotting which must be run down and eliminated. Sometimes no error can be found in several points which give poor intersections because the objects are so indefinite that the different angles of light in adjoining photographs cause slightly different locations to be pricked, points pricked in forests are especially liable to such errors. The remedy for this is to select the most definite unmistakable objects for the radial plot and disregard the indefinite intersections. The area within about an inch from the sides of the wing prints is subject to large distortions due to errors in transformation and to shrinkage of paper. Radial directions to object in this area are likely to be displaced and should be given less weight in the plotting, particularly along the edges of the inner half of the wing prints.

Look for the causes of poor intersections in the following order:

1. Spotting
2. Mounting
3. Drawing radial lines off center
4. Distortions of photograph, particularly near edges
5. Computation and plotting of control
6. Combination of tilt and relief

In tilted photographs with large differences in elevation radials from the principal point will not give good intersections, particularly in the "B" print. Usually the principal point of a tilted photograph will fall to one side or ahead or astern of the regular flight line and interval. A substitute origin for radiala which give more regularity to the flight line may be used to advantage in country of much relief. Where elevations are known, as along a shoreline, the direction

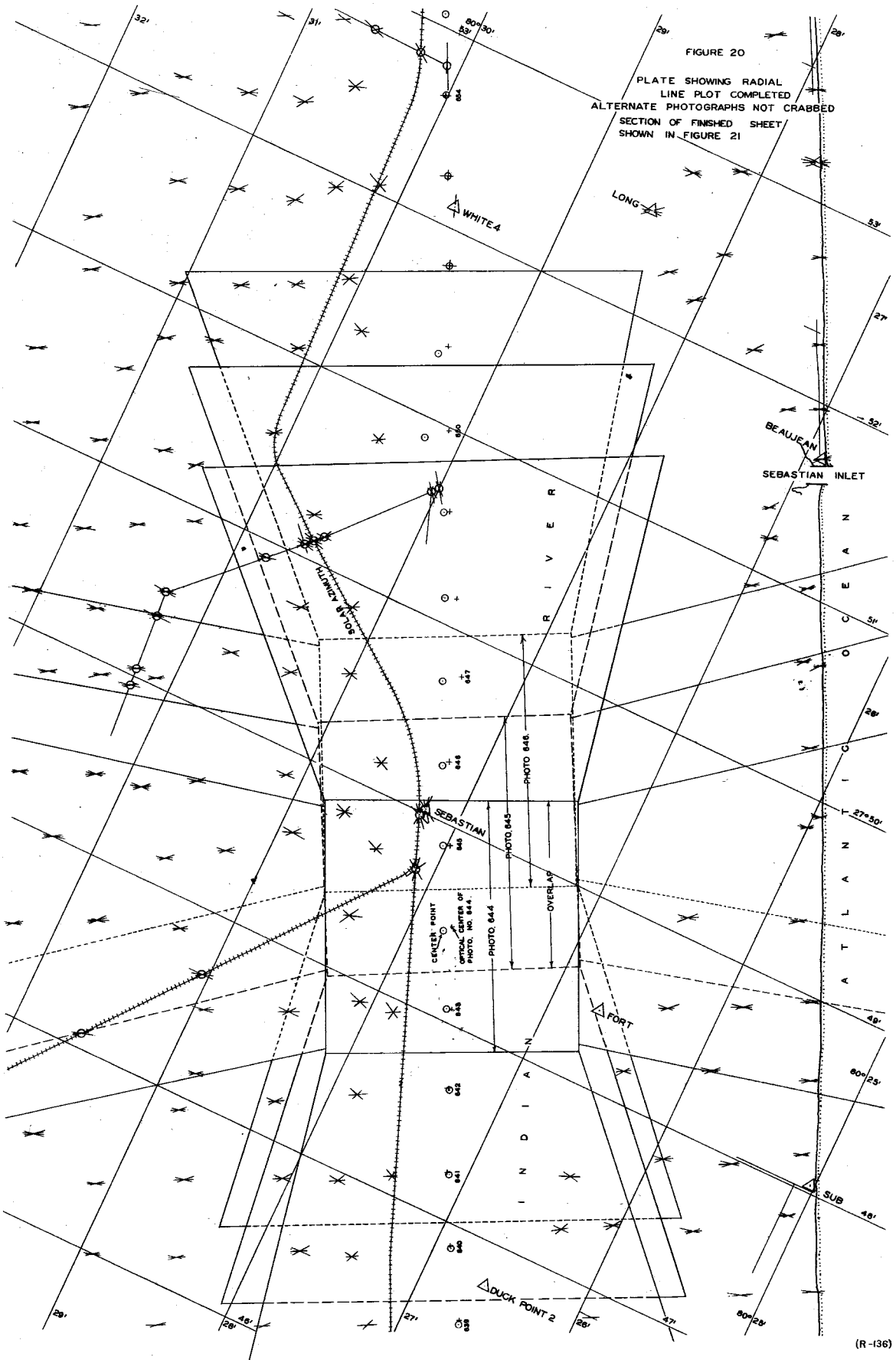


FIGURE 20

PLATE SHOWING RADIAL LINE PLOT COMPLETED ALTERNATE PHOTOGRAPHS NOT CRABBED SECTION OF FINISHED SHEET SHOWN IN FIGURE 21

and amount of tilt can be approximated from the differences of displacement of the points from the radial intersections. From these differences and approximate position of the plumb point may be obtained. Often in ordinary compilation the remarkable span of the five lens composite makes it possible to bridge over badly tilted photographs and reject their radials.

The plots of the various flights must be continued on to a satisfactory junction with the adjoining sheets, at least those of the same project. If a satisfactory junction is not obtained at the margins of the sheets previously plotted, an extra piece of celluloid should be fastened to the sheet with cellulose scotch tape and the graphic triangulation should be carried on until a satisfactory agreement is obtained, preferably on a fully controlled photograph. In general, the radial plots should be extended to begin and end with fully controlled photographs, regardless of sheet layouts or the amount of detail to be traced. The plots should not be extended beyond control save in exceptional cases and such cases should be fully discussed in the report of compilation. Any difficulty in joining the previously plotted sheets should also be fully discussed in the report of the compilation. The statement that the previous sheet was in error at the junction is not enough, but the plot must be extended through to satisfactory control and the cause of the discrepancy determined if practicable. There have been several cases where errors in control or the location of control stations on the photographs near the margins of the sheets have resulted in discrepancies which might have been discovered and eliminated had the radial plots of the following sheets been extended through to fully controlled photographs. The correction of these discrepancies later in the office has been a very slow and uneconomical process.

After a radial plot has been obtained which fits all control and all adjacent flights or sheets without appreciable discrepancies or sudden displacements, a final smooth plot is made. In this plot all radials on the photographs are traced and all points desired for control of the tracing of detail from the photographs are intersected. At this time all unsatisfactory intersections are investigated and corrected. On completion of the smooth radial plot the centers of the intersections are carefully pricked. The sheet is then turned over and each prick point is dotted and circled with blue ink. The sheet is then turned right side up and the radials cleaned off with a soft cloth moistened with warm water as the drafting progresses. It will be found that the ordinary ink will come off quite easily. Care should be taken not to rub the projection lines more than necessary. If only light blue lines remain when the radial plot is completed these will not reproduce when the sheet is photographed and need not be cleaned off. (Figure No. 20).

17. Tracing Information from the Photographs. The sheet is now ready for the tracing of information from the photographs to form the line map. The best general guides to the amount and character of information to be traced on the sheet are (1) The instructions for the project, (2) the Topographic Manual {Special Publication No, 144), (3) sample sheets from the office.

Most draftsmen prefer, especially on their first few sheets, to transfer shoreline, roads, and prominent features first, with great attention to position, and then fill in details, topographic symbols, etc., later with more attention to draftsmanship. One method of compiling found very satisfactory is to trace first the through highways, canals, railways, etc., thus dividing the sheet up into controlled squares, then gradually subdivide and reduce the size of these squares with more roads, field lines, etc. Figure No. 13. If the objects which have been located by intersection were well chosen, it is usually practicable to trace detail close to them and proportion the detail along lines between them, thus blocking off little areas usually two inches or less across which can be filled in with slight adjustments and little chance of tracing too far without adjustment.

When a parallel straight street system bounding a level area exists, the adjustments of intermediate street intervals or other detail on level ground may be made readily by means of a paper strip stretched across the area. Fine marks or ticks are made along the strip where the streets on the photograph cross under it. The strip is then inclined so that the outside streets, as plotted on the celluloid, fall under their respective marks on the paper and the intermediate marks will then indicate the spacing of the intermediate detail.

If it is found difficult to reconcile features with radial directions, additional points should be selected and plotted by intersection. In areas with much relief, the points should be very close together. Points as close as half an inch have sometimes been found necessary for accurate plotting of important detail where large differences of elevation exist.

It is well on first placing a photograph under the tracing to orient it as for radial plotting and make sure that all detail previously traced lies in a radial direction from its position on the photograph. This should also be done for the detail traced from the photograph just before removing it from under the tracing. If this radial check be carefully observed, there is little chance of appreciable error creeping in to the adjustment of detail.

Although it is necessary to keep the lines used for radial plotting as fine as possible to promote accuracy, the limitations of the processes used in reproducing the sheets require that stronger lines be used for the map information shown in black. It is essential that the finest lines used be not too fine to be drawn clearly and solidly upon the celluloid. It is necessary that the clear or white space between any lines on the sheet be not less than three times the width of the finest line drawn anywhere on the sheet. The width of roads or the position of roads alongside the high waterline (as on top a steep levee) may be varied slightly to avoid crowding the lines closer than this. When showing topographic symbols in crowded areas such as hachuring on levees between the highwater line and road lines, keep the Interval between hachures about four times the width of line. The weight of lines on the examples of page 117 of Special Publication No. 144 (Topographic Manual) is about that desired. The texture of symbols shown thereon is correct rather than those shown in lists of standard symbols such as given on page 109. The latter are intended for use on small scale charts. In general, uniformity of line rather than extreme fineness is desired.

When several features which it is desirable to show on the map are so close to each other that it is impossible to show them all clearly without appreciable distortion of position (such as a road along a steep sided levee with a transmission line on it), the most important information should be shown (such as shoreline and road) and the other detail explained by printed notes. (Road on levee with steep side next to water, transmission line runs along inshore side of road).

In general, second class roads on levees should be shown by a double dashed line and the levee symbol. It has been found that it is very difficult to get a good photographic reproduction of this symbol. It is recommended, therefore, to show all roads on levees with a double solid line and the levee symbol and label the unimproved roads specially. Where practicable, keep the levee symbol from touching the road.

When the light conditions with which the photographs were taken have been good and the customary overlap has been obtained, only the middle third or half of the wings and center print of each photograph where the distortions are small need be traced. If only one of several successive photographs is badly tilted, it will usually be possible to reject the tilted photograph and trace its center area from the edges of the adjacent less distorted photographs.

In regard to the triangulation, topographic and landmark symbols on the sheet keep symbols open except where, in so doing, essential information would be lost. Where detail must be shown omit symbol, if necessary, and indicate station point with leader. See Figure No. 16.

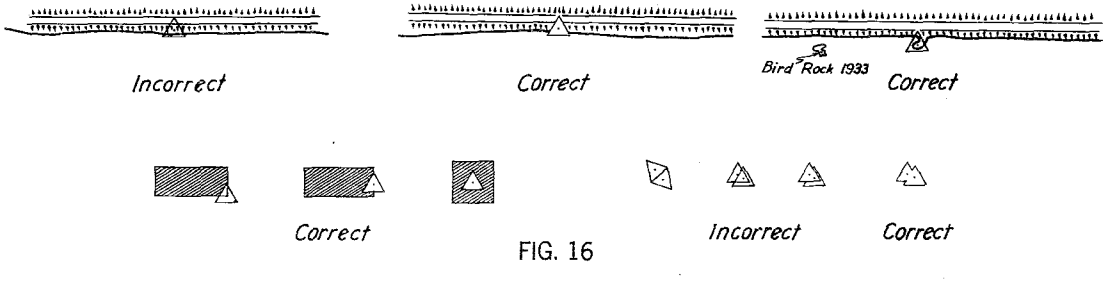


FIG. 16

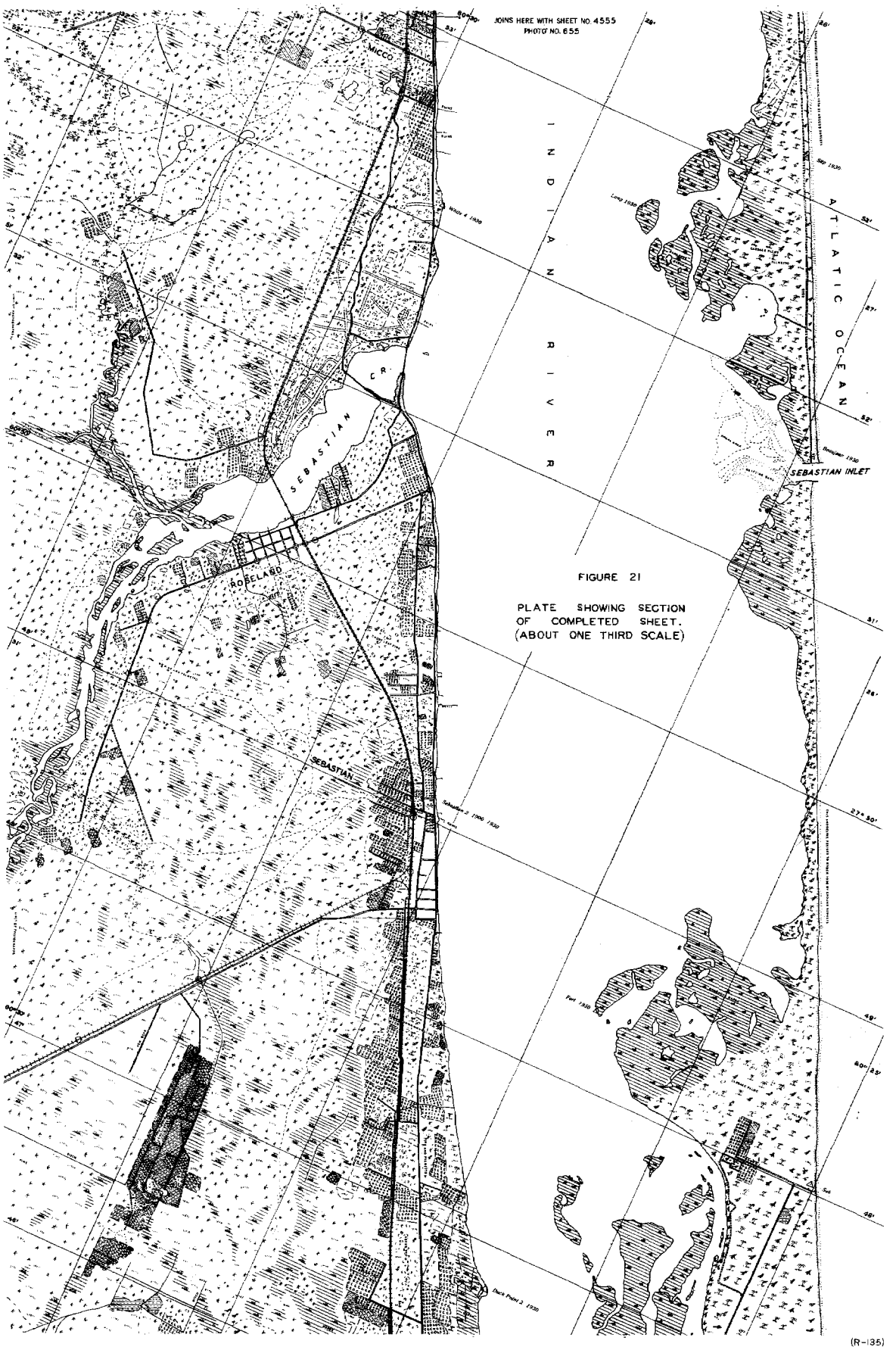


FIGURE 21

PLATE SHOWING SECTION OF COMPLETED SHEET. (ABOUT ONE THIRD SCALE)

(R-135)

18. Lettering. The larger names and blanks in the title forms may be inked in with the LeRoy or Wrico lettering sets. Names and notes printed on celluloid will be supplied by the Washington office on receipt of typewritten or lettered lists specifying each size and style of type needed. The style and nomenclature given on the specimen type sheet should be followed and requisitions should be placed as far in advance as practicable. From two to four weeks will be required for filling requisitions for printing.

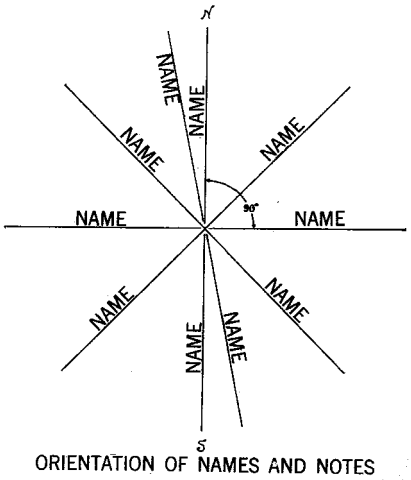
The free use of notes to explain all symbols used and all unusual features on the sheets is desirable.

Notes and names should be kept out of water areas wherever practicable.

Care should be taken that names and notes are oriented so that they may be read from the south and/or east side of the sheets. See Figure No. 17.

Several adhesives have been tried for attaching the printed notes to the celluloid but the most satisfactory thus far found is the testor film cement. This adhesive must be used sparingly or it will warp the celluloid on drying. Just a touch at each end of a short note is sufficient. Longer labels may be stuck with the smallest practicable amount applied with a toothpick at intervals of about an inch. Title labels may be attached with small drops at each corner, the center and the middle of the long edges. Figure No. 21 shows a completed sheet about 1/3 scale.

FIG. 17



ORIENTATION OF NAMES AND NOTES

19. Title Sheet and Descriptive Report on Compilation.

When the drafting of the sheet has been completed a title sheet, in duplicate, should be prepared on Form 537a, giving the information indicated in the sample, Figure 18, below:

Form 637a. DEPARTMENT OF COMMERCE
U. S. Coast and Geodetic Survey. (Sample)

AIR PHOTO TOPOGRAPHIC TITLE SHEET

The Topographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

REGISTER NO. T 5033

State California

General locality Southern California

Locality Long Beach

Scale 1:10,000 — Date of photographs January 24, 1932; Date of compilation June 30, 1933

Vessel Army Air Corps F1A airplane

Reviewed and recommended for approval

Chief of Party Lieut. R. W. Knox — June 30, 1933

Photographs plotted by T. P. Pendleton, K. B. Walker — June 30, 1933

Inked by D. L. Ackland

Heights in feet above _____ to ground to tops of trees

Contour Approximate contour Form line interval _____ feet

Instructions dated October 24, 1932

Remarks: Compilation of aerial photographs Nos. S.P.23-S.P.43

Reduced to scale and printed by photo lithographic process

TYPE SPECIMEN SHEET

NEWS GOTHIC

WASHINGTON Washington 6 Point
WASHINGTON Washington 8 Point
WASHINGTON Washington 10 Point
WASHINGTON Washington 12 Point
WASHINGTON Washington 14 Point
WASHING Washing 18 Point
WASH Wash 24 Point

(Topographic Features)

NEWS GOTHIC CONDENSED

WASHINGTON Washington 6 Point
WASHINGTON Washington 8 Point
WASHINGTON Washington 10 Point
WASHINGTON Washington 12 Point
WASHINGTON Washington 14 Point
WASHINGTON Washington 18 Point

WASHING Washing 8 Point Paragon Plate Italic
WASHING Washing 10 Point Paragon Plate Italic

(Signal Names)

CLEARFACE ITALIC

WASHINGTON Washington 5 Point
WASHINGTON Washington 6 Point
WASHINGTON Washington 8 Point
WASHINGTON Washington 10 Point
WASHINGTON Washington 12 Point
WASHINGTON 14 POINT
WASHINGTON 18 POINT

(Hydrographic Features)

LIGHT COPPERPLATE GOTHIC CONDENSED

WASHINGTON 6 PT. NO. 31 WASHINGTON 6 PT. NO. 32 WASH 6 PT. NO. 33 WASH 6 PT. NO. 34
WASHING 12 PT. NO. 35 WASHING 12 PT. NO. 36
WASHING 12 PT. NO. 37 WASH 12 PT. NO. 38
WAS 18 PT. NO. 39 WA 18 P. NO. 40

ALTERNATE GOTHIC

WASHINGTON Washington 8 Pt. No. 3 WASH Wash 10. Pt. No. 3

CHELTENHAM BOLD

WASHINGTON 10 PT. COND. WASHINGTON 12 PT. COND.
WASH 14 PT. WAS 14 PT. EXT.

The original title sheet is filed separately in Washington and forms a record of those responsible for and of those executing the work. The title sheet should be attached to the compilation when it is forwarded to Washington for reproduction. The duplicate of the title sheet is filed with the descriptive report of the compilation, which should next be written. The draftsman responsible for compiling the sheet should keep a complete set of notes to be used in writing the descriptive report. These notes should be turned over to the officer in charge, to be used by him in reviewing and accepting the compilation. A complete list of the material this report should contain follows:

20. DESCRIPTIVE REPORT OF INDIVIDUAL COMPILATION. (Office)

1. General Information
   - (a) Duplicate of title sheet with additions and corrections, Figure No. 16. The individuals responsible for the various operations should sign the title sheet over their typed names. This information will not be shown on the compilation sheet. (65)
   - (b) statistics - square statute miles of area, miles of shoreline (more than 200 meters from nearest opposite shore), miles of rivers and sloughs (less than 200 meters wide).
   - (c) If no general report affecting sheets is available, so state and give brief general description of the area from data obtained from photographs and remarks written thereon by field party.
   - (d) Give numbers and flight strip locations of photographs used in compiling the sheet with date, time and stage of tide of each strip.
2. Control
   - (a) Sources - Mention specifically each source of control used (i.e. triangulation by J. Bowie, 1931; O. W. Swainson, 1922; theodolite three point fixes and 3rd order traverse along W.P.R.R. by L. P. Raynor in 1932; aluminum control sheet No. 4701, etc.) State whether control has been adjusted to 1927 N. A. Datum (66c)
   - (b) Errors - Give distance in meters and approximate azimuth of any errors in control found by photo plot. List any errors in excess of 0.4 millimeters in location of control stations on photographs by field inspection party, (66e)
   - (c) Discrepancies - Mention differences in meters of each discrepancy in position of any control stations established by other organisations.
3. Compilation
   - (a) Method - Give name only of method used with detailed description of any departures from standard practice of each method. (66e)
   - (b) Adjustments of plot - Describe each case of uncertainty or marked adjustment in plot of sheet with method used for adjustment. such statements should refer to specific photo numbers, named areas, or latitudes and longitudes. (66d)
   - (c) Interpretation - Describe any difficulties in interpreting the photographs with reference to completeness of field inspection notes. Also describe any special graphic symbols with reasons for their use. (Printed labels or explanatory notes should always be used on the sheets to describe such special symbols) (66i)
   - (d) Information from other sources - Describe specifically any information not obtained directly from the photographs (such as high water line of broad sand beach run in by plane table, new fills, dredging, wharves, landmarks, etc., from field inspection data or from blue-prints). Give full data on the source, control and extent of each part of such information (28).
   - (e) Conflicting names - Give sources and authority for each case of conflicting names not covered by the field inspection report. (64, 66k)
4. Comparison with other surveys.
   - (a) Junctions with adjoining sheets with number of meters, differences and statement of character of control and intersections verifying differences, or statement that junctions are satisfactory.

(b) Describe each discrepancy with previous surveys (large enough to be shown on largest scale chart to be compiled) with explanations if any. (66h)

5. Landmarks

(a) Mention any failure to recommend landmarks or recoverable objects by field party.

(b) In absence of field list give recommendations for showing objects, if any, union are known to be prominent through studies of photographs under the stereoscope. (See remarks on Page 33)

6. Recommendations for further surveys.

(a) State that the compilation is believed to have a probable error of - - - meters in position of well defined detail of importance for charting and of- - - -meters for other data.

(b) Describe any part of the work that is incomplete, or unreliable, or requires further examination (with reference to explanations furnished in other parts of the reports.) (66h)

21. REVIEW.

On completion of the compilation, title sheet and descriptive report of the compilation, the whole should be reviewed by the Chief of Party or someone designated by him as to the extent to which the following requirements have been complied with.

1. The survey and preparation for it conform to the requirements of the Topographic Manual Paragraphs Nos. 7, 8, 9, 13, 16.
2. The character and scope of the compilation satisfy the instructions.
3. The control and adjustments of radial plots were adequate.
4. The high water line on marshy and/or mangrove coast is clear and adequate for chart compilation (Par. 16a, 43 and 44)
5. The representation of low waterlines, reefs, shoal areas, coral reefs and rocks and the legends pertaining to them are satisfactory (Par. 36, 37, 38, 39, 40, 41).
6. Rocks and other important details shown on previous surveys and on the chart were verified. (Par. 25, 26, 27).
7. The span, draw, and clearance of bridges are shown (Par. 16c).
8. The data furnished by the field inspection is adequate. Manual (Par. 64, 65, 66, 67).
9. The compilation descriptive report covers the requirements of the compilation notes section.
10. Descriptions of recoverable stations and reference to shoreline were accomplished on Form 524 by the field inspection manual,(Par. 29, 50, 57, 67 (except scaling of d.m.'s and d.p.'s) and 68)
11. A list of landmarks for charts was furnished on Form 567 by the field inspection and the plotting of the landmarks was checked (Par. 16d, e, 60).
12. The geographic datum for the sheet is North American 1927 and the reference station data has been correctly given.
13. Junctions with contemporary surveys are adequate.
14. Geographic names are shown on the sheet and are covered by the Descriptive Report (Par. 64, 66k)
15. The quality of the drafting is satisfactory (Par. 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 45, 46, 47, 48, 49, 50)
16. No additional surveying is recommended.

The Chief of Party will sign the title sheet recommending approval of the compilation after a satisfactory review has been accomplished.

22. FINAL RETOUCHING.

Before packing the sheets for shipment to the office, the sheets should be carefully examined and the inking touched up as necessary. Each control station, landmark or specially located object should have a fine black dot indicating its position. All shorelines should be of even weight and continuous. Buildings should be true rectangles with sharp corners and straight sides (generally). They may be trued up with the small scraper or steel point as necessary. Hachures should be open, also closely spaced parallel lines such as roads and canals. It will generally be found that the ink has been chafed or chipped off in a few places on the sheet and these should be strengthened.

23. Packing and Shipping. Great care should be used in packing the sheets to prevent chafing when shipping them to the Washington Office for reproduction. It is well to fasten each sheet to a backing of chart paper and add a cover of tracing paper over then, binding the whole with scotch tape laid down without tension. The names appearing on the sheet and the more important notes may be roughly lettered on the tracing paper cover in their proper positions so that if the stickup names become detached or lost from the original it will be possible to replace them accurately.

The chart paper backed and tracing paper covered completed celluloid sheets should be packed between two sheets of wall board and shipped by express on Government bill of lading to the Washington office.

BIBLIOGRAPHY.

The following is a very short bibliography of important books on the subject of photogrammetry and the use of aerial photographs in mapping. Space does not permit a complete listing of books which are devoted chiefly to aerial photography. Books are in English except where otherwise noted.

1919 Hugershoff and Cranz. Grundlagen der Photogrammetric aus Luftfahrzeugen (in German) Stuttgart, Konrad Wittwer.

1920 Macleod, M. N. Mapping from Air Photographs. London, H. M. Stationary office.

1923 Report of the Air Survey Committee. London, H. M. Stationary Office.

1925 Jones and Griffiths. Aerial Surveying. Cambridge University Press (England).

1928 Zeller, Max. Stereophotogrammetry. Wild Surveying Insts. Co., Heerbrugg, Switzerland.

1925 King, L. N. F. I. Graphical Methods of Plotting from Air Photographs. London, H. M. Stationary Office.

1926 Fourcade, H. G. (1) The Optical Transformation of Projections. (2) On some Conditions for the Correct Vision of Stereoscopic Pictures. (3) A New Method of Aerial Surveying. Transactions of the Royal society of South Africa. Vol. IIV Part I.

1926 Tymas and Porri. Flying for Air Survey Photography. London, H. M. Stationary Office.

1927 U. S. Army, Aerial Photographic Mapping Training Regulations 190 - 27, Supt. of Documents, Washington, D. C.

1927 Hotine, M. Simple methods of Surveying from Air Photographs. London, H. M. Stationary Office.

1927 Hotine, M. The stereoscopic Examination of Air photographs. London, H. M. stationary Office.

1928 U. S. Geological Survey Map Compilation from Aerial Photographs. Supt. of Documents, Washington, D. C.

1928 Fourcade, H. G. A. New Method of Aerial Surveying. Transactions of the Royal Society of South Africa. Vol. XVI Part I and Vol. XVII Part I.

1929 Hotine, M. Calibration of Surveying Cameras. London, E. M. Stationary Office.

1929 Fourcade, E. O. A New Method of Aerial Surveying. Transactions of the Royal Society of South Africa. Vol. XVIII Part III.

1929 Hotine, M. Extensions of the "Arundel" method. London, H. M. Stationary Office.

1929 McKinley, Ashley C. Applied Aerial Photography. New York, John Wiley and Sons.

1930 Hotine, M. The Fourcade, Stereogoniometry, London, H. M. Stationary Office.

1930 Hugershoff, R. photogrammetry and Luftbildwesen. Sien, Julius Springer. (In German).

1931 Hotine, M. Surveying from Air Photographs. New York, Richard R. Smith.

1932 Von Gruber, O. photogrammetry. (Translation by G. T. MoCaw and F. A. Cazalet) London, Chapman and Hall.

1933 Salt, J. S. A. Simple Method of Surveying from Air Photographs. London, H. M. Stationary Office.

NOTES ON TEE FIELD INSPECTION OF AERIAL PHOTOGRAPHS.

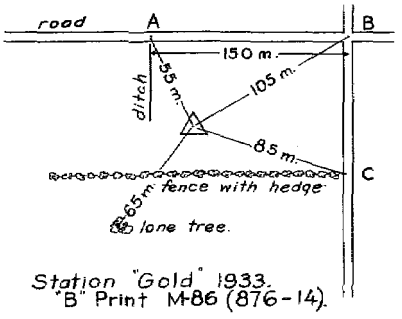
After the photographs have been obtained and control established, the next important step, in the compilation of aerial photographs is the field inspection of the photographs. The proper field inspection is essential, for the remaining steps in the compilation depend directly on the data secured from the inspection. Notes should be secured by the inspection party in such a manner that a draftsmen not familiar with the territory can evaluate the information and properly interpret the detail on the photographs. When making field inspections the photographs must be taken to the area which they cover and the notes necessary for interpretation written as the area is examined. It is not necessary that a complete set of notes he written in the field but enough notations should be made that a complete set of notes can be made at the end of each day's work, or when the inspection of a particular area is completed. If the compiling is done in a field office, the inspection should be planned so that the information obtained will be in coordination with the compiling unit.

LOCATION OF CONTROL STATIONS ON THE PHOTOGRAPHS.

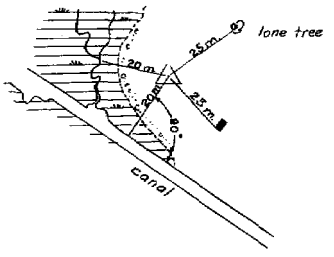
The most important step in the field inspection is the securing of data to properly plot triangulation stations and other control points on the photographs. The correct plotting of control points on the photographs is absolutely essential to the accuracy of the radial line plot. No effort should be spared in securing this accuracy.

The photographs are taken to the sites of the control stations and sketches are made so as to furnish data for accurately plotting the control stations on the photographs on which they appear. The making of this sketch is the most important step in the location of control stations on photographs. In making the sketch of a control station, points on the ground are selected that can be identified in the photograph without question. The closer these points are to the control station, the more accurate the plotting of the location. It is very desirable that the measurements to the point or detail be kept within 25 to 30 meters. It often happens that the measurements will be much longer than 25 or 30 meters, and when this is the case, extreme care should be taken in selecting the points of detail. In all instances measurements are made to at least three objects that can be identified in the photographs, more measurements do no harm and serve as a valuable check. The objects to which measurements are made should be selected so that the arcs will intersect at an angle of not less than 30 degrees. After the sketch has been made, the number of the photograph is written on the sketch.

The following sketch illustrates the proper selection of points of detail for measurements:



Station "Gold" 1933.
"B" Print M-86 (876-14).



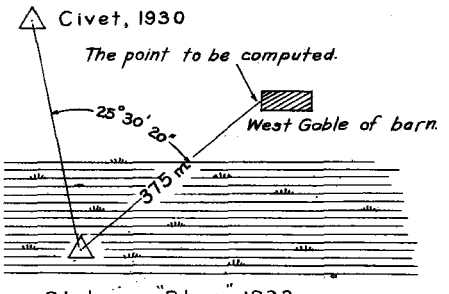
Station Veras, 1933.
"B" Print (SS-850.)

The type of point suitable for photo-control or measurements will vary greatly from place to place, but generally speaking, the intersection of roads and streets, tall chimneys and water tanks and other definite cultural features appearing in the photographs, are suitable. If the field inspection can be accomplished immediately after the photographs are made, it will be found that every small rock or bush large enough to be imaged in the photographs is entirely suitable for control measurements. Such points can usually be found in great numbers and as their images are very small they make more satisfactory points than cultural objects. Such points must be located on the photograph with great care by the field inspection party, the use of a magnifying glass being usually required if a good determination is to be made. Very small objects should not be marked by a needle if to do so will destroy the image so that the office force cannot recover it on

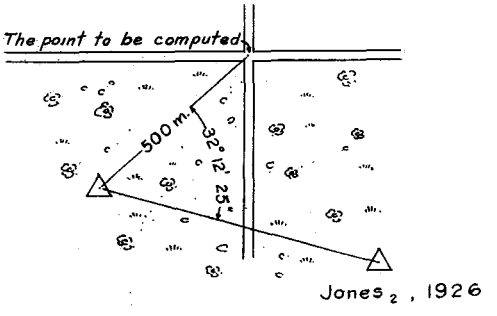
other photographs. In such cases the object should be circled and a careful description and a sketch should be made on the back of the print. When a considerable interval intervenes between the taking of the photographs and their use growing vegetation will generally make the identification of such objects difficult.

The photographs are very seldom true to scale. Their approximate average scale is usually 1:20,000 or 1:10,000 depending on the altitude at which they were taken. In view of the fact that the actual scale of the photograph may vary considerably from the scale intended, it is necessary to take this difference into account when plotting control stations on the photographs. This difference from the true scale is taken into account in the following manner: In the foregoing sketch the distance A to B is measured on the ground between two points of detail that can unmistakably be identified on the photographs. This distance as measured on the ground was found to be 150 meters and the distance as sealed from the photograph on 1:10,000 was found to be 155 meters. The scale factor of this particular photograph is 155 ÷ 160 = .90. The distances used in locating the control station on the photograph are now multiplied by the factor .9 and the factor distances are used in the final plotting. If the faotor obtained for a station is on a "B" print, it may be necessary to obtain a new factor as the station gets out in the wing prints due to distortion and tilt. The advantage of the factor distances is that the station is correctly related with the surrounding detail. The proper scale factor and the correct location of the station on the photograph will cause the measurements from three points to intersect in a common point. The plotted position of a control station must be within two-tenths of a millimeter of its actual location. Only the clearest photograph should be used in making the sketch. The transfer to the office prints will be made under the stereoscope.

It often happens that a control station is so located on the ground that no identifiable objects are nearby to which measurements can be taken. This is especially true if the station is located in wooded areas, marsh land, or in a large pasture. When this is the case, it is necessary to occupy the station with a theodolite and turn off an angle from another station or observe a solar azimuth to some object or point that can be identified on the photographs. The distance to the object selected is measured from the control station and the geographic position of the object computed. This point should be located within third order accuracy as it now becomes the control station for the photographs instead of the main control station. The following sketches serve as illustrations:



Station "Blue" 1933.
"C" Print M - 273 (876 - 15).



Station "Fry" 1933.
"A" Print M-339 (876 - 16).

When the control station consists of a spire, tank, cupola, or tower, which can be clearly seen in the photograph, the point need not be pricked but should be circumscribed with a small penciled triangle. When there are roads or streets within 200 meters of such stations, it is desirable that the distances from the center of the station to the center of adjacent streets be measured.

When the sketchbook is completed, an index of the control stations and the photograph numbers is made and attached to the front page of the sketchbook.

INFORMATION FOR INTERPRETATION OF THE PHOTOGRAPHS.

Enough information shall be furnished to enable a draftsman who is not familiar with the locality to plot a conventional topographic sheet. The draftsman is much more apt to overlook detail inconspicuous on the photographs but important for charting than one who has had the advantage of seeing such features on the ground. The list of notes desired, which follows, is intended as a general guide only and should be freely supplemented by any additional information you may consider useful for interpreting the photographs or calling attention to features which should be shown but might be overlooked.

a. Names of towns, wharves or docks, works or plants adjacent to the water, ferries, bays, rivers, navigable canals or sloughs, railroads, landmarks, etc., which should appear on the topographic sheets but are not on current charts, should be noted. If names differing from those shown on current charts, Engineer Corps maps, or Geological Survey maps, are recommended, a full description of the sources and authorities for the changes should be furnished.

b. Notes calling attention to all landmarks, buildings, and other features recommended for charting, including flying fields and beacons or lights for aerial navigation. Special attention should be called to these objects by circling them with green pencil on the photographs.

c. Notes calling attention to railway spurs or sidings leading to wharves which are not clearly apparent on the photographs.

d. Any features which should be shown on the photo-topographic sheets, but for any reason are not clearly distinguishable in the photographs should be traced out on the photographs or re-run as may be necessary. (At times a slight difference in light and shade may be recognized as the high water line and so traced in the field when it is too faint to be so used in the office. Similarly, it is important to distinguish between flat square barges or floats alongside wharves and the wharves themselves. Important buildings may be obscured at one end, roads or streams may be covered by trees. A few measurements and a sketch will usually suffice to clear up such places.) It is not planned to use detail in the outer half of the wing pictures, except when necessary near the water areas.

e. Each type of culture or vegetation should be noted on the photographs a sufficient number of times to make certain that the draftsman will interpret the photographs correctly in the office. The standard topographic symbols or a brief descriptive phrase may be used such as pines, eucalyptus, salt marsh, fresh marsh, mud flat, cultivated field, truck farms, dykes with road on top, grass, brush, etc. in Florida, the culture was noted with a code letter while riding past along the roads between control stations and written up at the end of the trip.

The shoreline, wharves and all structures immediately adjacent to the water will be shown on the charts. A green pencil shall be used to circumscribe all other objects recommended for charting (including, but not necessarily limited to landmarks). A list of landmarks for charts in duplicate on Form 567 shall be furnished for all areas photographed.

NOTES ON DESCRIPTIVE REPORTS FOR AIR PHOTO TOPOGRAPHIC SHEETS.

General Requirements for Reports

The Topographic Manual (Special Publication No. 144, paragraphs 65 to 68) specifies that certain information of importance for the compilation of the charts and the Coast Pilot shall be furnished in descriptive reports. Prior to 1832 aerial photographic projects were compiled by or under the supervision of men who had made the field inspection of the photographs. When this method is possible, ample notes may be taken in the field and the descriptive reports may be written from them when the photo topographic sheets are compiled as usual.

Recently circumstances have forced the compilation of air photo topographic sheets by draftsmen who are not familiar with the terrain and for some projects without the supervision of the persons who made the field inspection of the photographs. When such is the ease or when the field inspection of the photographs is done before definite plans have been made for the compilation, experience has shown that a particularly full and careful report or series of reports on certain classes of information must be furnished by the field inspection party if a satisfactory survey is to be obtained.

Each photographic project usually consists of a number of adjoining sheets showing a comparatively uniform unit area. It will usually be impracticable to divide this area accurately into individual sheets in advance of the compilation. All of the reports referring to the area will, therefore, be filed as one combined descriptive report of the several sheets concerned.

It often happens that information from new surveys is used in the office for several different purposes at the same time. Also the manuals require that Coast Pilot notes and lists of landmarks be forwarded separately. To prevent interference and elaborate cross referencing in the files, duplicate copies of Coast Pilot notes, of lists of landmarks, and of descriptive reports of field plane table sheets should be forwarded with the field set of photographs when they are returned to the office. whenever the project is so large that the compilation is commenced before the field inspection is completed, it is desirable that each sheet of the lists of landmarks and of the lists of geographic positions be given a consecutive page number, whether completely filled in or not. Each partial report or set of Coast Pilot notes should also be given a consecutive letter. Since these data are used by many different persons, the consecutive numbering and lettering will assist materially in assembling and filing the data.

PURPOSES OF THE COMBINED DESCRIPTIVE REPORT.

1. Additional Emphasis; It is difficult, if not impracticable, to judge the relative prominence of landmarks or the importance of topographic features from the compilations. These data, together with notes for the coast Pilot, must be obtained by the field inspection party.

2. Clarifying Representation: Nearly always some difficulty occurs when interpreting the photographic record into topographic features and again in expressing those features by conventional graphic symbols on the sheets. In the reports the written word may be used to supplement or explain the photographic record and graphic symbols. At least, attention may be called to the difficulties in order that the user of the survey may not be misled into believing that the symbols exactly fit the topography, or that the photographs could be interpreted without question when such is not the case.

3. Evaluation of Data: The methods of surveying used, the control available, the errors and adjustments made and the changes and differences with other surveys should be described fully in order that the user of the sheet may evaluate its information in comparison with data from other sources. The explanation for failure to comply fully with the instructions or field manuals should be given in this connection also.

Contents of Combined Report

The combined descriptive report will include the following component reports:

(a) Reports of the chief of the field inspection party:

When the operations consist only of triangulation control and field inspection of the photographs, care should be taken to note down and supply all the information called for herein under "Reports to be furnished by the chief of the field inspection party."

When the field inspection of the photographs is made in connection with the location on plane table sheets of hydrographic signals, high inter-line, aids to navigation, landmarks, etc., the information called for may be supplied in the descriptive reports of those sheets. Care should be taken to insure that such reports give complete information in accordance with the check list.

(b) Report of officer in charge of photography and compilation.

This report should contain all the general information regarding the photographs and the methods of compilation used.

(c) Report of the compilation of each sheet written by its compiler.

(d) Report of the review of each sheet.

LIST OF TOPICS FOR CHECKING COMPLETENESS OF REPORTS.

(Field and Office)

A. Reports to be furnished by the chief of the field inspection party: (Either as descriptive reports of special control sheets or as special reports. If several lists or reports are furnished for one project, each report should be numbered or lettered consecutively with those of the same project which precede it.

1. General description of topography and supplemental control:

(a) Descriptive notes on physiography, culture, forestration, characteristics of high and low water lines or foreshore, etc., for the better interpretation of photographs•

(b) Control - Description of (1) methods of executing control other than triangulation, adjustments made and/or checks obtained; (2) specific difficulties or questionable locations of control on photographs referring to each case by photo number. Special Publication No. 144, paragraphs 66, c, d, 3.; (3) Reasons for not complying fully with instructions or field manual when such is the case.

(c) List of names (66, k, 64). in addition to the sources of all new names a full account of the reasons and authority should be given for each name which differs from those on published charts or maps of an official character.

(d) List of recoverable objects. These objects should be spotted on the photographs and described on Form 584, to be forwarded with the field photographs. Heights should be given when practicable. Position will be filled in by compiler when not readily obtained by field party. List of scaled positions described in paragraph 67 is no longer required. All objects described on Form 524 shall be indicated on sheets with lower case letter (d) in parentheses after the name.

(e) Changes in prominent objects and features (paragraph 66 g.); coast line changes with evidence (66,n.); verification of rocks and other important details of previous surveys. (Paragraphs 25, 26, 27).

(f) Character of marshes. Vegetation, extent covered by high water, whether bounded by marked berm or gradually deepening and thinning into water; other explanation or discussion for recommendation for showing high water line as indicated on photographs (66,c.).

2. Control Data.

{a} Lists of geographic positions determined with computations. (Smooth computations on standard forms, progress sketches, etc., to be submitted on completion of project in accordance with field manuals. Each sheet of whole project to be given a consecutive page number).

(b) Description of triangulation stations (Form 525).

(c) Sketch books and azimuth observations and computations when used.

3. List of Landmarks on Form 567 (Section 66. par. b).

(All landmarks or other objects recommended for charting should be circled with green pencil on the photographs).

(a) List should distinguish between landmarks for large scale and small scale charts.

(b) List should include recommendations for expunging landmarks or features which no longer are prominent or no longer exist.

(c) List should include all aids to navigation not correctly shown on current charts (includes all echo boards, cable crossing signs, transmission line crossing towers, airway beacons in area surveyed.) Original copy list to be forwarded separately (60).

(d) Duplicate of each list with consecutive page numbering continuing through all lists to be forwarded with field photographs or field control sheets.

4. Coast Pilot notes as described in Hydrographic Manual (Special Publication 143, pages 149-154)

(a) Description of coast mentioning first landfalls or objects identifying locality and aiding navigation, or a statement that the current Coast Pilot description is adequate and up to date.

(b) Report any omission and give completeness of survey sheets, photographs, current charts and/or coast pilot with respect to the following:

1. Aids to navigation - sea or air.
2. Obstructions, offlying rocks.
3. Cable crossings, transmission line crossings
4. Bridges; type span, draw, and clearance. (In highly developed localities these data will be obtained by the office from the Engineer Corps.)
5. Description of shore with respect to landings.
6. Supplies, communications, berthing accommodations, water and fuel (in remote localities).
7. Recommendations for expunging notes which no longer apply.

(c) Original of Coast Pilot notes to be forwarded separately (61). Duplicate copy of Coast Pilot notes to be fowarded with field photographs.

B. Report by officer in charge of photo compilation. (To be filed with combined descriptive report of project. (Office).

1. Organization, personnel and equipment for photographs.
2. Duplicate copy of specifications for photographs and comments on departures of photographs from specifications.
3. Describe or list index maps of photographs and diagram of sheets compiled and state where they are filed.
4. Duplicate of analysis of costs and recommendations for future projects.
5. Comments on overlap, tilt and clarity of detail of photographs (general description).
6. Methods of compilation used with references to complete descriptions of method.

SUPPLEMENT TO "NOTES ON THE COMPILATION OF PLANIMETRIC LINE MAPS FROM FIVE LENS AERIAL PHOTOGRAPHS"

Page. 25, par. 19, change the first sentence in this paragraph to read as follows:

When the drafting of the sheet has been completed, a Title Sheet should be prepared on Form 537A, giving information indicated in the sample, Fig. 18 below, and attached as part of the descriptive report. *A* duplicate copy of the Title Sheet is no longer required.

Page 27, strike out the first three lines on this page.

Page 27, par. 20, sub-par. la, change this sub-paragraph to read:

Title Sheet made out as shown in Fig. 18, page 25.

Page 27, par. 20, sub-par. 1c, add the following sentence as the first sentence in this paragraph:

The general report by the field inspection party should be attached as part of the descriptive report for one sheet in the area; references to the general report should be made in the descriptive reports for other sheets in the area by referring to the General Report filed with Descriptive Report Register No._____."

Page 27, par. 20, sub-par. 1, add the following sub-par. le:

(e) Give the following data:

In some of the larger compilation parties the work has been so subdivided that the title sheet (Form 537a) on page 25 does not give a satisfactory account of the responsibility for the several operations. A special job sheet shall, therefore, be included in the descriptive report naming each part of the compilation performed by a separate individual with the date of completion and name of the individual typed under his signature. The data required in par. 7, page 4, of the Topographic Manual need not be shown on the air photo sheet or on the title sheet, but it shall be included on the job sheet. The job sheet will be filed permanently with the descriptive report as evidence of the individual's responsibility and of his proficiency in the work.

Page 28, par. 20, sub-par. 5b, after sub-par. 5b, add the following sub-par. 5c:

(c) When the list of land-marks for charts has been submitted by the party making the plane table control surveys, a duplicate list need not be attached to the descriptive report for the photo-topographic sheet, but a statement should be made in that report as follows: List of Land-marks for Charts on Form 567 for the area covered by this sheet has been submitted by (name of Chief of Party) in (year).

Page 28, pap. 20, sub-par. 4b, add the following sentence:

Mention any important detail such as rocks, lights, beacons, prominent objects, bridges, docks, etc., which should be removed from the chart and give reasons. (26, 27.)

Page 28, par. 20, after sub-par. 6, add the following sub-par. 7*:*

7. Recoverable Objects. Refer to page 34, par, A, ld. Mention any failure of field inspection party to submit descriptions of recoverable objects on Form 524.

Those recoverable objects shown on the photo topographic sheet which have been described on Form 524, submitted with the plane table control sheets need not again be described but should be listed with the statement "Described on Form 524, submitted with air photo control sheet, Field Letter_____, Register No.,_____, year." The space for the register number to be left blank for filling in at the office. The list of such objects should give also the topographic station name for the object as shown on the plane table control sheet.

Pago 28, par. 21, for the last two lines in this paragraph, substitute the following:

The Chief of Party will fill out and sign the special form furnished for review of photo-topographic sheets.

Page 34, par. A, sub-par. le, after the line ending "(Paragraphs 25, 26, 27)", add the following sentence:

List with remarks any important detail such as rocks, lights, beacons, prominent objects, bridges, docks, and structure of importance to navigation which should be changed or removed from the chart (26, 27.).

Page 34, par. A, sub-par. ld, change entire paragraph to read:

List of Recoverable Objects: Where plane table control surveys are made, recoverable objects will be described on Form 524 by the topographic party and submitted with the plane table control sheets. In the absence of plane table control surveys, recoverable objects will be spotted on the photographs and described on Form 524 to be forwarded with the field photographs. Heights should be given when practicable. Positions with D. M's and D. P's will be

filled in by the compiler when not readily obtained by the field party. All objects described on Form 524 will be indicated on the sheets with lower case letter (d) in parentheses. The scaling of positions will be checked. See following copies of letters of instructions for location of recoverable objects and descriptions on Form 524:

Coast and Geodetic Survey Circular No. 30-1933 December 26, 1933.
Descriptions of Recoverable Topographic Stations

To All Chiefs of Parties:

The attention of chiefs of parties is called to paragraph 57, page 10, of Special Publication No. 144, Topographic Manual.

Descriptions of recoverable topographic stations, both of natural objects and marked stations, shall be submitted on Form 524 with all topographic sheets and plane table control sheets. The descriptions and sketches may be continued on the back of this form.

A sufficient number of recoverable topographic stations shall be located carefully and so distributed between the triangulation stations as to furnish control points for future surveys and for air photographs at distances of approximately one mile apart along the coast and through navigable waterways. In so far as practicable, stations shall be so selected and distributed as to furnish strong orientation lines for future topographic surveys.

Natural objects should be used for such stations where available. On rocky coasts it will usually be possible to select offlying rocks or rocky knobs and projections along the shoreline which will be readily recovered. Isolated trees or small buildings will be adequate when so situated as to be easily identified. Tanks, stacks, cupolas of buildings, and towers will usually make excellent recoverable stations.

Station marks and bench marks of the Army Engineers and of local engineers shall be located on the topographic sheets and described on Form 524 when not located by triangulation

Where natural objects are not available, it is not intended that each recoverable topographic station shall be marked by a standard bronze disk. In marsh lands or swampy areas, such as prevail along the inside water routes of the Atlantic and Gulf Coasts, a cedar, cypress, or other hardwood stake, not less than four inches in diameter, and projecting at least one foot above ground, will be adequate. A galvanized pipe may be used for this purpose if considered desirable.

Future topographic surveys will often be supplemented by air photographs. In so far as consistent with the provisions of the above paragraphs, stations should, therefore, be objects which you consider could be identified on air photographs or readily referenced to detail shown thereon. (See pages 28 and 29 of the pamphlet entitled "Notes on the Compilation of Planimetric Line Maps from Five Lens Air Photographs").

The descriptions of recoverable stations on Form 524 shall be submitted with, and as a part of, the records of each topographic or plane table control sheet.

(Sgd.) J. H. Hawley, Acting Director.

To: Chiefs of Hydrographic and Topographic Parties March 3, 1934.
From: The Director, U. S. Coast and Geodetic Survey.
Subject: Description of topographic stations on Form 524.

Some uncertainty has been expressed regarding the number of recoverable topographic stations which should be described and submitted on Form No. 524, in accordance with circular letter No. 30 dated December 26, 1933, on this subject.

It is the intent of circular letter No. 30 that a sufficient number of recoverable topographic stations be described on Form 524 and so located and distributed between the triangulation stations as to make it practicable to take up new hydrographic and topographic surveys without the necessity of establishing new triangulation or running long plane table traverses.

It is not the intent of those instructions that a large number of closely grouped stations shall be described on Form 524. Where a greater number of recoverable stations are located than are necessary to satisfy the minimum requirements of paragraph three of circular letter No. 30, the Chief of Party should select for description on Form 524 those stations most likely to be permanent and useful for future surveys. A practical method of making such a selection would be to visualize the best distribution of recoverable objects for control of surveys in the same locality some years hence.

Where plane table control surveys are made in conjunction with the air photo compilations, the descriptions of recoverable topographic stations on Form 524 for the area covered by the plane table sheets will be made by the control party and submitted with the plane table sheets. These descriptions should only be furnished for stations which are located accurately, as indicated by a perfect intersection of at least three cuts, or a closed traverse which needs no adjustment; provided that for comparatively long and difficult traverses such as are often necessary in Alaska and on the outside Pacific Coast, the limits of traverse closure and adjustment as prescribed in the topographic manual may apply.

Descriptions on Form 524 should not be written by compilation parties unless field notes for the descriptions are available.

(Sgd.) J. H. Hawley, Acting Director.

Coast and Geodetic Survey Circular No. 20-1934 May 25, 1934.
Recoverable Topographic Stations: Form 524

In the new edition of Form 524 several changes have been made and there are several new requirements in the data to be furnished.

Recoverable stations selected in accordance with circular letter Ho. 30-1933 and the Director's letter dated March 3, 1934, whether marked stations or natural objects, and which are located with an accuracy of a lower order than third order triangulation shall be reported on Form 524, and these stations shall be reported on this form regardless of the method of location. However, reports should be furnished only for stations which are accurately located, as indicated by a perfect intersection of at least three cuts, or a closed traverse which needs no adjustment; exceptions being in areas where comparatively long and difficult traverses are necessary, in which cases, the limits of traverse closure and adjustment as prescribed in the Topographic Manual may apply.

Stations reported on Form 524 may be marked stations or recoverable natural objects. In the case of marked stations attention is called to the fact that standard bronze hydrographic station marks are provided and may be used for marking any stations reported on this form, regardless of the method of location.

The datum shall be entered in the proper space above the geographic position.

Where spaces are provided for the names of members of the party, initials are not sufficient; the last name should be given in full.

The method of location shall be shown; when applicable by crossing out two of the three printed methods; when none of these three methods is applicable, the method used must be entered and fully explained.

The detailed description shall follow the general form used in describing a triangulation station. This description may be continued on the back of the form when necessary, although the necessity for such lengthy descriptions should seldom occur.

The shoreline data desired are fully explained in paragraph 30, Topographic Manual.

The reference points for aerial photographic use should be prominent and definite enough to be identified in the photographs and should consist of center of road intersections, large buildings, isolated trees, wharves, etc.

The distances given must be actual horizontal measurements made in the field and under no circumstances are such distances to be scaled from the topographic sheet. These distances preferably should be measured with a tape, but telemeter readings may be substituted where the distances are short enough to give accurate readings.

The directions may be measured with a small theodolite or sextant, but this is not necessary. A simpler method will consist of alidade orientation lines to each object or point, the extension of the lines being lightly drawn on the sheet, from which the directions can be later scaled by protractor. In this case care must be taken that the plane table point is accurately centered over the station. One distant object (preferably a triangulation station) should be used as an initial. The azimuth of this initial line should be scaled by protractor from the sheet and used to reduce the other directions to true azimuths.

The sketch should be on a large scale, actually drawn in the field and should contain details which might not be shown on the smaller scale topographic sheet. All of the reference points and the points to which shoreline measurements were taken shall be shown, in addition to the adjacent shoreline and topography. The top of the sketch should always be approximately north.

Descriptions of Recoverable Stations, Form 524, shall be submitted with all topographic and plane table control sheets. The submission of these forms, however, shall not be considered a substitute for Form 567, Landmarks for Charts, which shall also be submitted. These two forms serve entirely different purposes and are filed in different sections of the office.

Attention is called to the fact that a list of scaled positions of all topographic signals is no longer required in the descriptive reports. (See p. 128 No. 7 Association Bulletin.)

The attention of all topographers shall be called to this new form and to the specific requirements, mentioned in Circular No. 30-1933, and the letter dated March 3, 1934, for locating and describing a sufficient number of recoverable topographic stations.

References: Topographic Manual, paragraphs l6e, 29, 30 57 and page 52
Hydrographic Manual, paragraph 167
Circular No. 30-1933, and the circular letter dated March 3, 1934.

(Sgd.) R. S. Patton, Director.

Circular Letter Sent to All Chiefs of Air Photo Compilation Parties

The following supplementary notes have been written by. Mr. T. P. Pendleton, who has had much experience in topographic mapping and map compilation from aerial photographs. It is recommended that the chief of each photo compilation party try the methods indicated in these supplementary notes and write a report to this office with recommendations concerning them. The report should be accompanied by additional notes which the chief of party has found of value in his own work.

Preliminary office comments have been inserted at various places in these notes.

In view of the conditions under which the compilations are being made and the volume of data being received at the Washington office, it is recommended that each chief of party make certain that the review and checking of the sheets include the items described in the paragraphs on proof reading.

Notes on Photo-compilation
by T. P. Pendleton

It has been found entirely feasible to work on celluloid with pencil instead of ink, drawing the projections, the radial lines and the map itself, in exactly the same manner as one would do if working on paper. A Castell 2H or 3H pencil will be found satisfactory if the celluloid sheet has been well grained. It is well to indicate the intersection of the projection lines on the back of the sheet by a fine needle hole which can be filled with ink. This will preserve the original projection and postpone inking of the lines until the compilation is finished. In this way damage to these fine lines is avoided which otherwise is bound to occur. The grade of pencil most suitable for the work will vary with the manufacturer, but in any case, it is necessary to sharpen them frequently to secure the necessary fine lines. (Office comment recommended for experimental field test. Authorized if satisfactory.)

The compilation of the chart is completed in pencil for all cultural and hydrographic features. Hachures are not placed on the pencil drawing although proper space allowance for them should be made to avoid the congestion that will occur where a road is located on a levee, or embankment, adjacent to a river or canal. Sand and marsh symbols are also omitted on the pencil drawing.

It has been found advisable to reduce the tracing of details from the photographs to a minimum locating by intersection all roads, ditches, fence lines and other, features of this kind. Hydrographic features, such as shorelines of bays and sloughs, or low islands, should be fitted to position on the pencilled drawing by radially intersected points that can be positively identified on the various photographs. Care should be used in choosing points for this purpose to select those which are on, or very near, the elevation of the water surface. Tracing of shoreline features should not be done until at least three adjacent points have been located which agree well in scale with the photographs. The discrepancy in distance

between such points on the photographs and on the radial plot should not exceed 0.3 millimeter; otherwise, additional points should be intersected to reduce the discrepancy to this amount or less.

Office comment: This tolerance would apply only to important areas such as wharves or shoreline approached closely by vessels. For less important shoreline, it should be practicable to adjust to the nearest 0.3 millimeter between intersected differences of 1 millimeter.

The importance of choosing points varying but little in elevation from the detail to be traced will be recognized after computing the displacement of a point on a photograph due to a known difference in elevation. The displacement will vary with the distance of the point from the center of the photograph and the difference in elevation involved. Considering photographs at the scale of 1:10,000 and a point 5 meters above the water surface, the computed displacement away from the center is 6.6 meters for a point 20 centimeters out and 11.5 meters for one 35 centimeters out from the center of the photograph. These figures indicate that the use of points even 5 meters, above the water surface should in general be avoided in tracing detail, except possibly very close to the nadir point of the photograph. Features such as water tanks and transmission towers are generally unsatisfactory as points for use in adjusting photographic detail on the map as the bases of such objects are generally difficult of positive identification although this does not detract from their value as signals for radial intersection work. If a point in the vicinity of such signals is needed for adjustment of detail, it is well to intersect some nearby well-defined point suitable for the purpose.

When the compilation of the pencilled drawing has been completed it should be subjected to examination by some draftsman other than the compile. This examination should consist of a general inspection for accuracy of junction with other work carried on simultaneously and with sheets previously compiled of which preliminary reproductions are available. All discrepancies with published sheets should be examined to determine positively the sheet in error, the most effective test for this purpose being the introduction of a new control point if this can be accomplished. If error in the new work is indicated, the necessary correction should be made; otherwise, overedge compilation should be carried into the body of the published sheet until satisfactory junction is secured, or as far as the photographs on hand will permit.

Office comment: Important.

Junction of edges between sheets can best be accomplished by joining on definite straight lines, either projection lines or other arbitrary liner suitable for the purpose which can be definitely located on each sheet.

Office comment: This should apply to inking with black celluloid ink. Detail from adjacent sheets should be transferred in blue or pencil, and a junction made with definite objects rather than to a line limiting an area.

No discrepancy whatever should be allowed to remain between sheets being compiled at the same time.

Office comment: Important.

In the case of small differences of the order of two or three meters with sheets previously published, the discrepancy should be absorbed in the new work to show exact junction with the older work.

In low coastal or delta areas it is often possible to test the accuracy of the compilation by means of straight lines drawn in any direction between clearly defined points in the photographs. Corresponding lines on the map or chart should cut all intermediate, features in an identical manner. Points adjacent to such straight lines should agree closely for distance therefrom, providing large tilts do not exist.

Office comment: A valuable test A fundamental principle of descriptive geometry is that a straight line appears as a straight line (or a point) in any projection or perspective thereof.

Inking may proceed after correction of the discrepancies noted in this examination. Width of roads should be governed more by their importance than by the width of the right of way. It is well to draw the desired spacing of lines for roads on heavy white paper to be slipped under the celluloid sheet as a guide in inking these features. In this way, the same spacing of road lines can be secured by all draftsmen in the party. Curves of paved roads and railways can usually be put in with a bow pen, particularly if the compiler has marked the center of the circle of which they are part.

Meandering lines, such as shorelines of water bodies or double-lined streams, can be inked uniformly using a small French curve over the opening in a triangle. The curve can be manipulated over the triangle in such manner as to follow closely the curvature of the feature, very short sections being inked at each setting. The ordinary right-line pen is suitable for this work. Experience will enable the draftsman to obtain the desired uniformly smooth lines without the mechanical appearance which might be expected. The French curve may be built up with small pieces of celluloid to eliminate the triangle.

Shorelines of sloughs or narrow rivers should be drawn so that the white space between the shorelines will represent the distance between mean high water on each bank; otherwise the stream will seem narrower than it is and the hydrographic party will lack sufficient space to properly record the soundings.

Fence lines and ditches running toward the waterways, as well as isolated trees and buildings, should be shown on the photo-compiled sheets as they are of value in providing control for sounding operations, For this reason, features of this kind should be located by radial intersections; otherwise much of their value as landmarks is destroyed.

Office comment: Important when of value for hydrography.

A transparent oversheet should be prepared by the compiler showing all the lettering to be placed on the map in its exact position.

Proofreading and Inspection.

Proofreading of the drawing should always be done by some one other than the compiler, preferably one skilled in such work. The name sheet should be examined as though the names it carried appeared on the map itself. The object of the proofreading is to bring to the attention of the compiler features which have been omitted or misinterpreted, or incorrectly shown. A proofreading oversheet with the projection lines roughly traced from the original will provide a place for the proofreader's notes.

Among the important points to be examined are the proper representation of landmarks, the width of small water bodies, the junction with other sheets and the correctness of representation of mean high water in the bays and on the coastline. Comparison should be made between the aerial photographs and the map for correctness of interpretation, fence lines and ditches, for example, being difficult of proper identification in many places. Examination of the notes of the field inspection party should be made to see that all comments have been given proper consideration and names correctly placed on the name sheet.

Questionable spelling should be investigated and every effort made to secure correct spelling of all lettering appearing on the sheet. When several names for the same feature are available, the older one is generally of the greater value. It will often be found that a name used in legal records differs from the name used by the general public, in which case the latter should be adopted.

Comment: Each case of conflicting names should be completely described with authorities, and the decision left to the office.

The title block and the notation as to datum used on the sheet should be shown in an appropriate space. Notes referring to adjoining sheet register numbers should appear in the margins if such are provided; otherwise they should be placed adjacent to the edge of the map in an open space of the map.

Conventional signs and symbols should conform to recommendations of the Board of Surveys and Maps. Familiarity with these symbols will eliminate many explanatory names. For example, overpasses and underpasses need no description as symbols for them will be found on the sheet of standard symbols; the words "railroad" and "railway" may be omitted from the name of a railroad line as the track symbol itself supplies the same information. On the other hand, brief descriptions should be used whenever the map symbols are inadequate to designate the feature satisfactorily.

Office Comment: Notes are desirable when there is plenty of room for them without crowding on these sheets, even notes describing standard symbols, for the sheets will be used by persons unfamiliar with the symbols. "Vegetation symbols should be used sparingly.

The drawing should be inspected for imperfections in inking such as fuzzy or broken lines, lack of sharpness at intersections of roads and streets, inadequate erasures and congestion of lines. Horizontal control

should be re-plotted to see that the exact positions of these points are correctly shown. This should be done before the radial plot is commenced. In general, the examination should be such that the sheets as submitted will be correct so far as the scale and quality of the photographs and the amount of control will permit.

The original drawing with the proofreader's comments and notations appearing on his oversheet should be returned to the compiler, who will make the necessary corrections or answer satisfactorily questions raised by the proofreader.

The sheet should then be cleaned front and back to prepare it for the "stick-up" lettering. As the sheets must be handled with care to avoid dislodging the names, it is advisable to postpone the lettering until the sheets are ready for submission to the Washington office. It requires some experience to apply the lettering in a neat and satisfactory manner so this duty may well be delegated to one person in the compilation force. It has been found that "Bifocal Cement" made by the American Optical Company is quite satisfactory as an adhesive because it does not buckle the celluloid nor cause the celluloid ink to run. As it is rather slow drying, there is ample time to properly adjust the lettering in position and orientation. After all the lettering is in place, the celluloid sheet should be put aside to dry thoroughly. The excess cement can be removed from the drawing with a cloth moistened with alcohol, avoiding unnecessary rubbing on the inked surface.

Office Comment: Preliminary test of the optical cement indicates that it dries with white margin which interferes with satisfactory reproduction of the lettering. It should not be used pending further experiments.

Field Inspection.

To connect control stations to the detail appearing in the photographs, as indicated in "Notes on the Compilation of Planimetric Line Maps," page 28, it is advisable to indicate the direction as well as the length of the various reference lines in the List of Directions for the station.

Office Comment: Recommended if practicable without great expense.

This information enables the personnel of the compilation party to compute the geographic position of any of these object points if advisable. It has been found that some one of these reference marks is often very clearly defined on all photographs on which the point appears and may readily be used in lieu of the control station itself, providing it is possible to compute its position. The labor in computing such positions is much less than that required to locate a control point by scaling from all the reference marks concerned. The method is also advantageous in its freedom from errors introduced by relief of the various objects and no limitation need be placed on their distance from the instrument set-up. However, the point to be indicated on the map or chart should be the instrument set-up and not the reference object.

Notes of the field inspection party are often difficult to decipher if written in pencil on dark toned photographs and may be overlooked on this account. It is better to make such records in ink on the face of the print, if the background is light in tone or else on the back with proper reference on the face of the print. Colored pencils do not give a permanent record and, consequently, should be avoided for this type of record. Colored inks suitable for use in fountain pens make a lasting record and are easily handled in the field. Schaeffer's "Script" inks can be obtained in red, blue, green, purple as well as black, and it is probable that other inks on the market are equally satisfactory.

Office Comment: Recommended when an extra set of prints is known to be available for field inspection. Care should be taken not to obliterate important detail with ink.

Identification and description of all features should be included in the field inspection records which are not clearly apparent on the aerial photographs. The stereoscope is a valuable instrument for the study and interpretation of aerial photographs, but it has no power to reveal buildings overhung with trees or features hidden by the elevation of higher objects.

Office Comment: Important.

Comment by E. H. Kirsch
Jr. H. & G. Engineer, U.S.C. & G. Survey

Working on celluloid sheets with pencil has in general been found very unsatisfactory. A pencil projection soon rubs off and sections of the projection lines must be redrawn when transferring data from control sheets, checking triangulation stations, and when securing sheets together to carry through the plot; when the sheet shrinks or expands unevenly, it is impossible to draw a straight inked line through all projection points. Tracing of detail in pencil has also been found unsatisfactory because some of the detail is invariably lost. Drawing radial lines in pencil has worked very well. The lines can be kept fine, and they are easily erased in case of adjustment, and the plot is always finished before the first cuts rub off.

Mr. Pendleton has brought out some valuable points under proofreading and inspection. The straight line test is used often to check the compilation as it progresses.

This party has found that clean, smooth erasures can be made on celluloid by rubbing the area with 00 steel wool. When an erasing shield is used, very small areas can be effectively erased in this manner.

When working with single lens pictures, and it is found that three pictures can be definitely fixed at each end of the sheet, with a long run the length of the sheet with a few scattered control stations, the following procedure has been found a big help in getting a correct plot through: Radial plot a definite point near the center of the picture at one end.

Through this point on the picture, project a fine straight line in the direction of the flight. Recover points on this line on the next picture and continue the line. Continue the line in this manner until it runs through pictures that can be definitely fixed. Recover a point at this end of the line and radial plot it in. Connect the two points on the celluloid with a straight line, which is the same line which has been projected across the pictures. A picture with one control station can then be fixed by holding the azimuth as determined by the straight line and sliding along this line until the control station comes on. If the line is carefully projected across the pictures, the plot will usually fall right in; if the line is not accurately projected across the pictures, an adjustment of the plot is necessary.

In one or two cases, when a control station has failed to fit into the plot, the station as spotted on the picture has been radial plotted in. The distance and direction of the error can then be scaled from the celluloid. The corrected photo position is then spotted on the photo with a fine pointed soft pencil and the field notes worked around this point. In several cases we have located the field inspection error in this manner.

When securing sheets together to carry a radial plot through, we have done the binding with cellulose tape. In some cases when the tape is left on the celluloid sheets for several days, a light brown stain is left on the celluloid. Cellulose tape should not be left on celluloid sheets over a long period of time.

Comment by R. C. Bolstad
Jr. H. & G. Engineer, U.S.C. & G. Survey

I. Making Projection in Pencil.

Drawing the projection in pencil had been tried out previous to receipt of the above notes, but as it proved unsatisfactory in so many respects and with the type of celluloid then on hand, it was abandoned. However, when the new grained celluloid sheets were recently received, tests were resumed resulting in the following:

Advantages.

1. Reduction in initial time of making projection; this allows the projection to be checked before any definite change can take place. (Only important where a variation in room temperature and humidity would cause appreciable sheet distortion) This advantage would not apply to the new grained celluloid sheets, as they are not subject to large distortions.

Disadvantages.

1. Increase in gross time of completing projection (i.e., to final inked projection which is ultimate goal). If accuracy of the finished inked projection is to result, the following procedure must be carried out: (a) Projection in pencil; (b) checked and necessary corrections made; (c) intersections marked - these are best marked by an ink filled fine scratch mark on the meridians and parallels (+) in place of the dot recommended by Mr. Pendleton. It was found that in the final inking a line could be followed easier than a dot, with greater accuracy, and with-

out mistaken identity from the numerous other specks accumulated on the sheet; (d) marking of intersections must be checked; (e) final inking of projection lines - As the longer time interval between penciled projection and final inking would provide more chance for sheet distortion, the final inking may have to be accomplished by a series of broken lines. Attention is called to an error recently discovered by this party on one of the topographic sheets completed by a field party in 1928. An investigation in the Washington office disclosed many erroneously plotted positions of triangulation stations. Since there was a certain amount of uniformity in discrepancies, it appears the inked projection lines may have been incorrectly inked slightly off the faded penciled projection lines. Such an error would not have resulted with a projection inked in at the start; (f) final checking of projection lines - This must be done to see that all lines properly pass through the correct intersection points.

All steps outlined in the above procedure are necessary if errors are to be avoided and will involve an additional four steps if projection is to be made in pencil.

2. Wear of the pencil lead against the straight-edge and celluloid sheet is so great that a long projection line of hair-line thickness can not be drawn with a single full stroke. The knife-edge of the pencil lead must be frequently resharpened and a break in the projection line will result. An extension of this line may result in a slight jog at the break due to the difference in the knife-edge slant of the pencil against the straight-edge, slight elevation of straight-edge from the celluloid surface due to uneven desk, etc. There is also the objection of a varying thickness of the line, even though the pencil is repeatedly sharpened. These chances for errors and objections do not exist with the inked projection.

3. Increased difficulty of plotting geographic positions - The appearance of a penciled line on the celluloid sheet is not as pronounced as an inked line, especially when rubbed over a few times with the hands and arms. It was found more difficult and a greater eyestrain to plot geographic positions correctly from these lines than from inked projection lines.

4. When erasures are made the celluloid must be pumiced down again in order to take the pencil line properly. With ink this is not necessary.

5. Comes off easier than ink - The draftsmen on this party have become accustomed to the special celluloid ink (Craftint) which will stand more chafing with the hands and elbows than pencil. The results obtained with this ink are well worth the extra efforts.

Conclusions: .

The inked projection method on celluloid sheets is far superior to the penciled projection, it is quicker, results in less eyestrain, and is least liable to be in error. It should be retained in preference to the penciled method.

II. Radial Lines in Pencil.

Advantages.

1. Faster

2. Easier to erase without destroying grained surface of celluloid.

3. A fine intersecting line can be obtained. Blue ink has the tendency to spread out and cause a wide line unless care is taken in holding the Crowquill pen almost perpendicular to the sheet.

Disadvantages.

1. Increases eye-strain - While working under the artificial light required by this party at this time of the year in New York City it was evident that the pencil was more difficult to work with than the ink.

2. Adjustments to radial plot are more apparent with ink. For example, in scanning the plot it became evident that by pulling photo No. 12 up and swinging the azimuth slightly the intersections of some radials could be improved without affecting the other intersections. With penciled radials the necessary adjustments do not "loom out" as with the ink, and it is more difficult to foresee the effects of adjustments.

Conclusions:

Blue inked radial lines have proved better than the penciled radial lines for this party. As special talent had to be developed for the smooth radial plot, which is being carried on by the same parties, these men soon became accustomed to the continued use of ink and are able to draw fine blue lines with the pen. The use of ink for this purpose should therefore be continued in preference to pencil.

III. Detail in Pencil.

Compiling the sheet in pencil for all celluloid and hydrographic features, in preference to ink, was found to give the following results:

Advantages

None which are not equally applicable on the celluloid sheet with ink. An inked line can be erased with the steel eraser without difficulty. No greater accuracy results because it is necessary to increase this operation to two steps instead of one; there is greater chance for error to exist, especially so since the pencil line does not remain distinct after rubbing over with the elbows and arms.

Disadvantages.

1. Increase in compilation time. Though the initial step of penciling may be reduced, there is no saving in the final result.

2. The pencil line is not as distinct as the inked line. In an area of fine detail such as small docks, etc., confusion may result and even small specks and marks accumulated during the compilation may be mistaken for these features, or vice versa. It has not been found practical to clean the sheet thoroughly until it has been completed because it is impossible to keep it clean. (This is partly due to the construction of the Scotch mounting tape which leaves exposed sticky surfaces. The contraction of the tape is not caused by its being put on under tension but

because it shrinks as it drys out.) Unless natural light conditions are extremely good (not so in New York City during the winter months) an eye-strain will result in working with the penciled line. Artificial lighting does not increase the prominence of the penciled line as an inked line and only adds to eye-strain.

3. Greater chances for errors (as explained above). The finished compilation sheet will be no more accurate than the accuracy in which it is finally inked.

Conclusions:

No advantage of penciling the compilation was discovered by this party. A penciled compilation only increases eye-strain, the time of compilation, and increases the chances for error. The usual inked method should be continued.

IV. Testing Completed Sheet for Accuracy.

The method proposed for testing the accuracy of the compilation by means of straight lines drawn between clearly defined points on the photographs is applicable only to topography where the elevation is extremely low and, even there, should be used with caution. This can be understood by the following:

Taking a 6-inch focal length camera (which is approximate focal length of camera used in taking photos of New York area) and 1:10,000 scale photographs, an elevation difference of only 20 feet (not at all uncommon) will cause a displacement of over 0.3 millimeter even at the edge of the "B" print, and when about 12 inches from the center (this is about the maximum traceable limits and the coastline is usually at least this distance from the center of the flight line) will cause a displacement of 1.2 millimeters.

Conclusions:

Not practicable or dependable for the area on which this party is carrying on the compilation at present. Also tests recently conducted by this party have shown the photographs to be subject to unequal expansion and contraction which would prove this test valueless.

It has been found on this party that the best means of obtaining accuracy is to develop several smooth radial line plotters to make all the smooth radial plots. If overlapping junctions are carried on by different plotters, a check will result.

The best method of review checking is the radials themselves and to test several intersections to see if the detail has been correctly proportioned by the compiler.

V. Miscellaneous

1. The special celluloid ink used in photo-compilation work has a tendency to stain into the celluloid, French curves and triangles and will roughen the edge unless the ink is removed at once.

2. The transparent over-sheet showing all the lettering is a good idea and will aid the office in replacing labels which have become loosened.

3. It is best to use the labeled notes freely, even for conventional symbols. The compiler may make a mistake or incorporate his own idea into the symbol, but if labeled there can be no mistake.

4. Dupont Household Cement applied sparingly to the labels was found to give excellent results. The compiled sheet must not be folded or bent after it is completed or the labels will become loosened.

5. It is not practical to obtain directions (except approximately for sketch) of tie-in lines at control stations in order to locate them accurately on the photographs. Of the 296 stations visited on field inspection, no trouble was experienced in spotting them on the photos except in cases of the control station being far out on the wing prints and the detail appearing indefinite. Directions would not have aided in its spotting.

AIR PHOTO COMPILATION METHODS

Roswell C. Bolstad, Jr. H. & G. Engineer, U.S.C. & G. Survey

Relative Humidity Effects on photographs and Celluloid Sheets

About the latter part of October, difficulties were encountered by this party with the mounted five-lens aerial photographs. The four outer prints (A, C, D, E) pulled away from the center print (B, Fig. 2) and in many cases in so doing had caused the "B" print to slightly change orientation and alter the correct alignment of match marks. This necessitated remounting of all prints before the radial plot could be resumed, and resulted in retarding the progress of compilation.

Even after remounting, the same difficulty was again encountered, and it began to appear that a slight daily variation was taking place.

The "Scotch" tape used in mounting had contracted considerably as though being dried out.

(A) Preliminary Test.

In order to "trouble shoot" the difficulty, a preliminary scale test of three mounting cards was made. All three cards were the new mounting cards received from the office and were room-seasoned for three days prior to the tests.

Although the tests were general, and only for a short duration, the following results were apparent:

(1) An expansion and contraction of the mounting cards was taking place (the maximum change observed was 0.15%).

(2) The greatest change was consistently in the same direction (parallel to the DE alignment axis). This is probably due to the parallel arrangement of pulp fibre produced in the manufacturing process.

(3) A daily variation was occurring. It appeared consistently on all cards that at 4:00 P.M. the cards were expanded more than at 9:00 A.M. of the same day. (Here a maximum of 0.15% was noted). This daily variation showed a relation to the relative humidity which was at a higher value in the afternoon than in the morning.

(4) The greatest change occurred on the first day. A humidity gage showed a relative humidity of 27% in the room at a temperature of 73° F. on the last day of the test. Since the average outside relative humidity for New York City is about 67%, any hygroscopic material brought inside from such a condition (mounting cards were subject to this condition while in transit from Washington, D. C., to this office about one week previous to the date of tests) would be expected to show shrinkage, which is precisely what happened even though room-seasoned as stated. This would indicate that three days of seasoning to local room conditions was insufficient.

(5) It was also observed that the DE alignment line on the mounting card was distorted. A straight-edge, laid along this line, showed an offset distance toward A at the center varying from 0.0002 meters to 0.0006 meters (2 to 6 meters on 1:10,000 scale). The AC line remained correct. These observations were made on twenty-six of the mounted

and unmounted cards with consistent results. Since the error is on the DE line, it can easily be seen that the azimuth carried ahead to the succeeding photograph would be in error unless the mounting were revised.

(B) Revised Mounting.

In order to overcome these effects, the system of mounting the five lens photo prints was revised. The two side strips of cellulose mounting tape were run only about one-half inch beyond the match marks. Two short strips of tape were used to hold the outer corners down with an additional short piece at the alignment line. The rest of the mounting is the same as before.

With this type of mounting the maximum adhesive surfaces are concentrated near the center of the mounting card and variations in the tape, print or mounting card would only produce a slippage at the outer ends or a slight buckling of the print which could be easily rectified. However, as the exposed edges of the prints tend to curl slightly, the card must be handled with deserving care, particularly during filing or pulling out a photo from a group, and in no case should the mounted photo be badly bent. (It seems to be common practice among draftsmen not well acquainted with air-photos to bend them, especially when looking for a particular photo in a group). This will have a damaging effect on any type of mounting and should be avoided.

Also, with this type of mounting, the wing prints at the outer extremities may easily be shifted the slight amount necessary to rectify the azimuth error (mentioned in paragraph A-(5)) without disturbing the central portion of the mount. This is an important time-saving factor in addition to a considerable saving on cellulose mounting tape (since the tape can not be removed from the mounting card without the cardboard face adhering to it).

Although this type of mounting has shown a decided advantage over the former Scotch tape mounting (see paragraph E, items 3 and 4), it still allows slight variations and changes in orientation of the "B" print to occur which can not be entirely eliminated by tape mounting. Therefore, a new type mounting was developed (see Fig. 3) to meet the defects noted in tests conducted by this party.

An 8" x 10" sheet of dry mounting tissue was used at the center of the mount with the longitudinal axis along the AC alignment line. This takes care of the extra strain developed by the unequal length changes of the wing prints and the mounting card along this axis. (See paragraph E, items 3 and 4). Short pieces of Scotch mounting tape were used as shown in Fig. 3.

Although this type mounting may take slightly more time, it has the advantage of being decidedly stable at the center since the maximum adhesive area is concentrated there. The small sections of tape are sufficient to keep the print edges from curling; they allow for tape shrinkage without affecting the mounting; they may be easily removed to correct

the slight error in the DE alignment line (paragraph A, item 5) without disturbing the rest of the mounting; and they offer ample adhesive surface to hold the extremities of the wing prints securely.

(C) Humidity Conditions in New York.

The results of the preceding tests and additional observations made it clear that the relative humidity was an important factor in causing these variations.

A study of temperature and relative humidity conditions in New York was therefore made. The U. S. Weather Bureau statistics gave the mean monthly temperatures (46-year record) as shown on the graph, Fig. 4; also an average relative humidity of 67% with a minimum monthly mean occurring in April of 53% and a maximum monthly mean in September of 78%.

By assuming an inside room temperature of 73° F. (this is within the "comfort zone" as determined by the American Society of Heating and Ventilating Engineers), the three curves corresponding to the relative humidities stated above were computed. These curves show the inside relative humidity obtained by admitting the outside air (at temperature shown and relative humidity as indicated) and heating to room temperature (75° F.). Slight departure from these values may be expected depending on human respiration, perspiration and moisture absorbent qualities within the room, et cetera.

Figure 4 also shows that, unless artificial means of supplying additional moisture in the room is provided, the inside relative humidity of a room maintained at 73° F. would be below 40% for all outside temperatures in New York below 57° F. (see dashed line), or during the months of November, December, January, February, March, April and part of October. (It was in the latter part of October that the first difficulties were experienced, as previously stated).

(D) Humidifiers.

In December two portable Emerson humidifiers purchased for this unit were set in operation.

Each humidifier consists of a water reservoir (about 6 gallon capacity) in which set 28 revolving metal discs. The breeze from the fan evaporates the water picked up by the partly submerged discs. it is believed this principle is superior to the "spray" type which places objectionable free moisture in the air.

The two humidifiers were connected (in parallel) with a humidistat for automatic control of the humidity. As the differential between "make" and "break" is approximately 5% relative humidity, a close enough regulation for our requirements was obtained.

(E) Detailed Tests.

A series of detailed tests was run on the cellulose mounting tape, mounted five lens photos, enlarged single lens print and three sheets of celluloid to determine the effect of relative humidity upon them. Fluc-

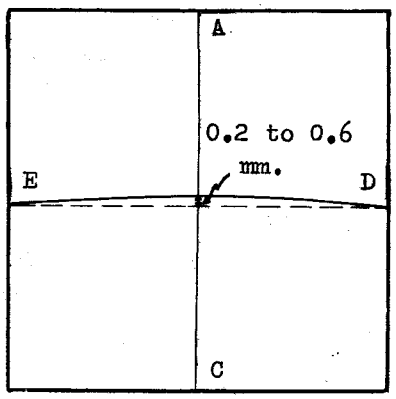


Fig. 1

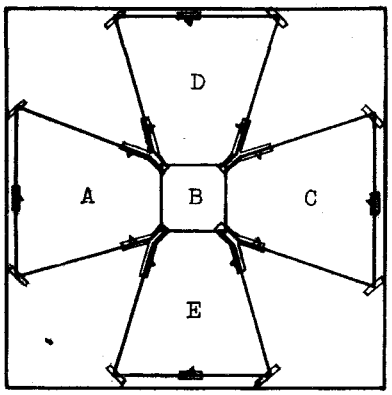


Fig. 2

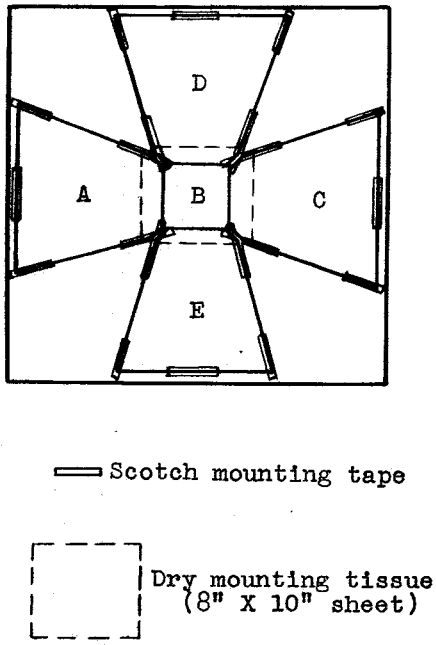


Fig. 3

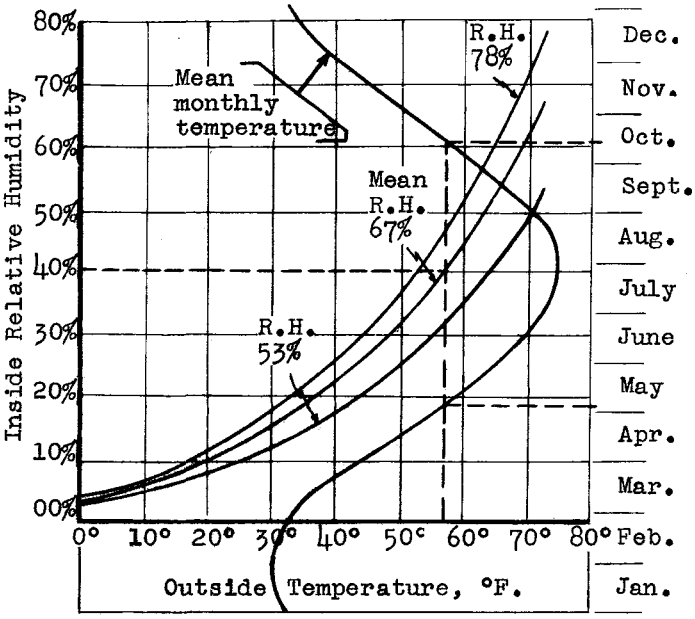
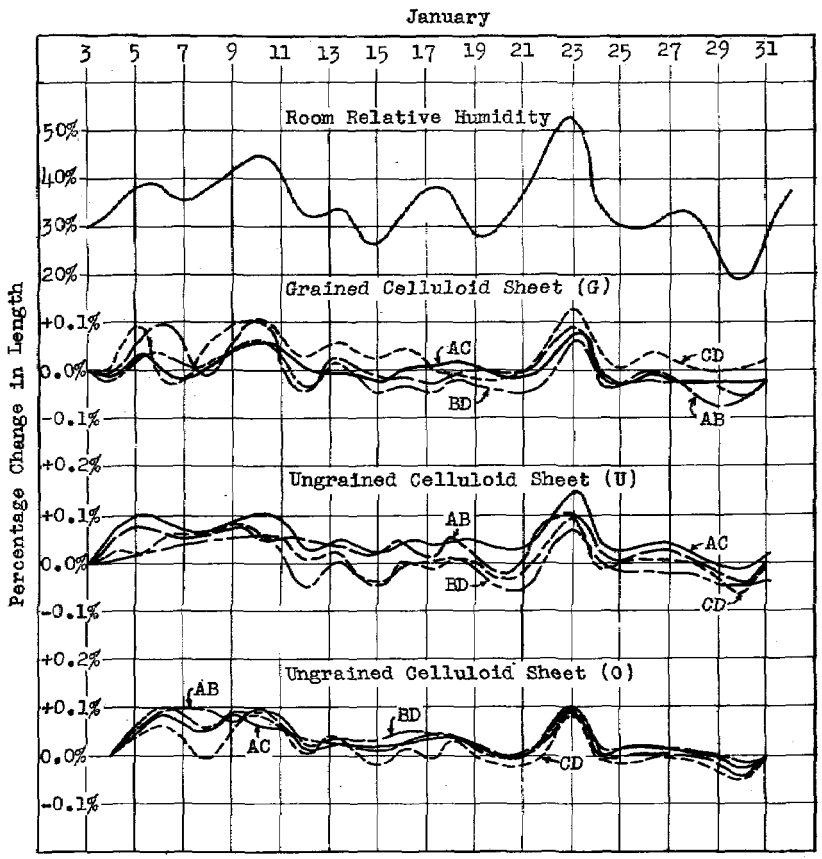


Fig. 4



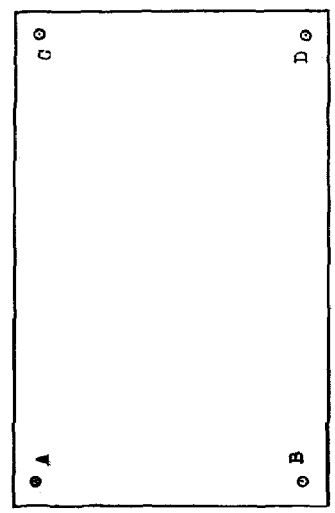
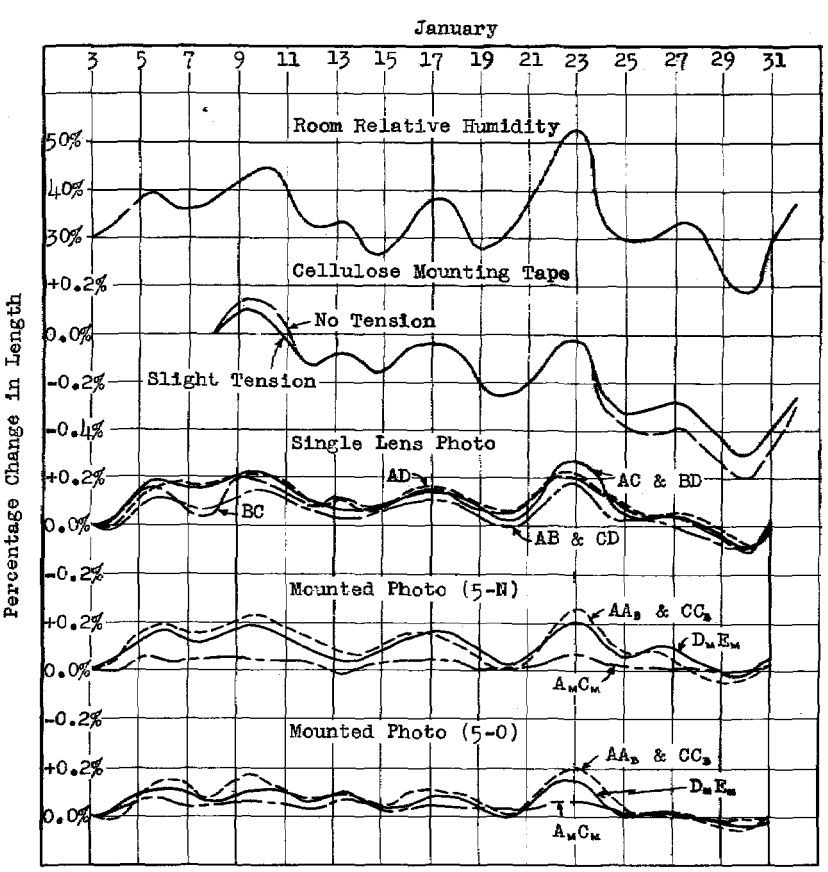
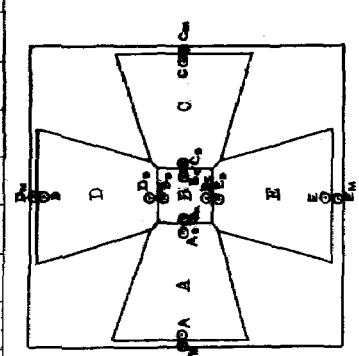
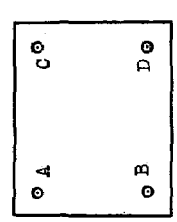


Figure 5







Single Lens Photo

Figure 6

tuations in the room relative humidity were purposely made so as to approximate the actual conditions to which the materials are normally subjected in New York City. As extreme fluctuations could be made for only short durations, in order not to seriously affect the mounting of all five-lens photos, the results of these tests do not, therefore, represent the extremes to be expected.

The high relative humidity (shown by peak of curve on graph) encountered during the latter part of the test was caused by plastering operations being conducted in the room during alterations.

The humidity readings were taken with a wet and dry bulb hygrometer which was recalibrated to give more accurate results.

The graphic results of tests are shown in Figures 5 and 6. A distinct relationship between the relative humidity and distortion of materials is apparent. During the three peak humidities, there were corresponding percentage increases in length of all materials.

A brief outline of the most important facts gained from a study of the curves is given below:

(1) Cellulose Mounting Tape. Fig. 6. ("Scotch," 3/4 inch width, manufactured by Minnesota Mining and Manufacturing Company, St. Paul, Minnesota; test conducted after one day of room-seasoning.)

The gradual trend downward of the curve indicates the tape is drying out. Even though subjected to high relative humidities, it fails to resume its former proportions. This shrinkage of the tape affects the mounting of the five-lens photographs. Contraction of the tape causes an unequal slippage and results in incorrect alignment of prints on mounting card. A maximum variation in length of three-fourths of one per cent was noted.

(2) Single Lens Phonographic Print. Fig. 6. (Enlarged print by Aero Service Corporation, 1612 Chancellor Street, Philadelphia, Pennsylvania; test conducted after two months of room-seasoning.)

The longitudinal axis shows a greater length variation (0.4%) than the transverse (0.37%).

The diagonal distances expand and contract about equally; a maximum of 0.3% was noted.

It is surprising to note the high values obtained here, even though the mounting cardboard shows less variation than the paper upon which these photographs are printed.

The angular error in lines radiating from the principal point, due to this unequal expansion and contraction along the two axes of the print, will, however, be negligible (somewhat less than $4\frac{1}{2}$ minutes of arc).

(3) Mounted Five-lens Photograph. (5-0, Fig. 6) (Regular mounting; test conducted after two months of room-seasoning.)

The oblique photographic prints expand and contract longitudinally with changes in humidity and show a maximum length variation of 0.25%, whereas the mounting card was only 0.09% along the AC line and 0.21% along the DE alignment axis. It is this large difference in length variation between the prints and the mounting card along the AC align-

ment axis that causes most of the trouble with this type mounting. Not only do the wing prints pull away from the "B" print (under reduced humidities), but in so doing produce an unequal strain on the center print causing it to change alignment. This is exactly the trouble encountered during the latter part of October, at which time reduced relative humidities within the room began to occur.

Additional measurements, showing no plottable relationship, gave results as follows:

The "slippage" of photos at their junctions (A_B-B_A, B_E-E_B, etc., on diagram, Fig. 6) varied with the humidity; a maximum of 0.38 mm. was noted.

The "slippage" of photos on mounting card at outer edge of mounting (A-A_M, E-E_M, etc., Fig. 6) varied with changes in humidity; a maximum of 8.30 mm. was observed.

The "B" print (center print) match mark alignment varied with humidity changes; a maximum of 0.25 mm. off alignment was observed, causing an incorrect orientation of the print.

(4) Mounted Five-lens Photograph. (5-N, Fig. 6) (Revised mounting as shown in Fig. 2; test conducted after ten days of room-seasoning.)

The A, C, D, and E prints expand and contract longitudinally with changes in the relative humidity. A maximum variation of 0.32% was noted, whereas the mounting card showed only 0.10% change along the AC alignment line and 0.24% along the DE axis.

Additional test measurements, showing no plottable relationship, gave the following results:

The "slippage" of photos at their junctions (A_B-B_A, B_E-E_B, etc., Fig. 6) varied upon changes in the relative humidity; a maximum of 0.2 mm. was noted.

The "slippage" of print on the mounting card at outer edge of card (A-A_M, E-E_M, etc., Fig. 6) varied with changes in the humidity; a maximum of 0.5 mm. was observed.

The "B" print (center print) match marks failed to align at times during a change in the relative humidity; a maximum of 0.15 mm. off alignment was observed, causing an incorrect orientation of the print.

Although the difference in length variation between the prints and the mounting card is more pronounced (at ten days' seasoning) than the preceding photograph, 5-0, (2 months' seasoning) the slippage (A_BB_A, B_EE_B, etc.) at the center print was only about one-half as great. The slippage at the outer edge of the card (AA_M, EE_M, etc.) was somewhat less than twice as much, which is what would be expected. Further advantages of this type of mounting are evident since the orientation error of the "B" print has been reduced to almost half with the former type mount (5-0).

To reduce all these errors to a minimum, the mounting shown in Fig. 3 was adopted and has proven the most satisfactory. (See paragraph E (8)).

(5) Grained Celluloid Sheet. (G, Fig. 5) (Cellulose acetate, special low shrinkage in sheets 40" x 50", 0.0075" thickness, AE finish, manufactured by Celluloid Corporation, 10 East 40th Street, New York City; test conducted after three weeks of room-seasoning).

The sheet expands and contracts more equally in a lengthwise direction and in a lesser amount (maximum variation 0.13%) than in a

transverse direction (maximum variation 0.16%).

(6) Ungrained Celluloid Sheet. (U, Fig. 5) (Smooth, unfrosted, 42" x 50½", about same thickness as above sheet. Sheet had been room-seasoned three weeks prior to tests.)

This sheet appears to expand and contract about equally in all directions. A maximum variation was noted of 0.17% in the length.

(7) Ungrained Celluloid Sheet. (0, Fig. 5) (Smooth, unfrosted, 42" x 50½". about 0.0075" thickness. Compiler had been working on sheet for over two months before test was conducted on this sheet.)

This sheet shows the smallest length variation of all the celluloid sheets tested, being only 0.13% maximum change.

(8) Mounted Five-lens Photograph. (Revised type, Fig. 3)

Tests conducted on this type mounting have shown the slippage at the center print (A_BB_A, B_EE_B, etc.) to be less than 0.1 millimeter, whereas the old type mount produced as much as 0.6 millimeters when under the same humidity conditions. Both type mounts were subjected to unusually severe extremes of relative humidity in order to clearly bring out any defects of either type mount. There was no slippage of the center print with this new mounting. It is decidedly stable and has been adopted by this party as the standard because of the numerous advantages.

Attention is called to the fact that the results of these tests (with exception of (8) above) are based on a change in the relative humidity of only 33.7%, whereas under actual conditions (in New York during winter without controlled humidity) the difference may run well over double this amount.

(9) Mounting Card Regain Test. On January 23rd, at time room relative humidity was 52%, a test of the moisture content of one of the mounting cards was made with the following results:

Date 1934	Time	Weight in gms.	Per cent moisture of bone-dry weight	Remarks
Jan. 23	7:45 p.m.	311.6		natural
"	8:45 p.m.	288.9		1 hr. of drying at 105° C.
		22.7	7.8	original moisture content
Jan. 23	10:15 p.m.	304.3	5.3	After 1 hr. storage in moist closet.
Jan. 24	4:30 p.m.	329.0	13.8	After 18 hrs. storage in moist closet.
Jan. 26	7:00 p.m.	353.0	22.2	After 68 hrs. storage in moist closet.

The original moisture content of 7.8% shows a close relationship to U. S. Bureau of Standards tests on four different types of paper which approximate this value very closely for a relative humidity of near 50%. However, the mounting card shows a much higher regain (22.2% at near 90% R.H.) than does the U. S. Bureau of Standards tests (14% regain at near 90% R.H.). It therefore appears the mounting cardboard

is extremely susceptible to moisture in order to show such high variation in moisture content.

This is an important factor where appreciable differences in the relative humidity takes place, as the distortion of the cardboard would be related to its moisture content (Fig. 6).

(F) Desirable Relative Humidity.

A relative humidity of about 45% has been adopted as the most desirable value on this party. A higher value is not easily maintained in New York in winter time, as condensation takes place on windows not equipped with storm windows. Any value lower than 40% is generally conceded to be on the dry side, conducive to low regains, a brittle condition of fibrous material and a tendency toward human discomfort. From the tables, Regain of Hygroscopic Materials (American Society of Heating and Ventilating Engineers), it appears that for equal changes in the relative humidity, a corresponding smaller change in regain results when the relative humidity is at about 40%. Therefore 45% was taken as the most suitable value to be maintained.

(G) Conclusions.

With the present materials, controlled humidity is essential for correct photo compilation work carried on in winter climates.

The following advantages of controlled humidity are apparent:

(1) Increased accuracy. (Reduced distortion of materials; uniformity of projections.)

(2) Saving of time. (Photo remounting unnecessary; less revision of projection at time of checking.)

(3) Reduces tendency of celluloid sheets to become brittle and crack. (Sheets dry out at low humidities. Previous to use of humidifiers, five sheets had cracked. No trouble has been experienced recently.)

(4) Increases efficiency of personnel. (Increased comfort, celluloid ink more workable with controlled humidity.

(5) Labels more permanent. (Low relative humidities dry out the adhesive agent causing labels to "pop off")

Miscellaneous Notes.

Brief mention is made of the following items found to be of value to this party in carrying on the air photo compilation work:

(A) Supplementary Control Stations.

Supplementary control stations, such as aluminum control sheet signals, are shown on the celluloid sheet by a double blue circle (◎). Where the radial lines disagree with any control station, they are left on the sheet and the correct location pricked at their intersection. All other radial lines are removed from the sheet after the proper intersection has been pricked and circled with a single blue circle. In this way the person reviewing the completed sheet can see at a glance the extent of control and also any errors to be investigated.

(B) Lettering.

The lettering required on the celluloid title label and junction

labels may best be done on the celluloid compilation sheet, which takes the ink better. The labels may then be lightly glued in place over the lettering. The transparent covering offers protection to the lettering, which would otherwise be defaced due to chafing of the raised inked surfaces.

(C) Bromides and Photostats.

It appears that there is sufficient distortion in bromides and photostats within the one-minute rectangle to make it necessary to sub-divide the topographic sheet into half minute intervals before photographing.

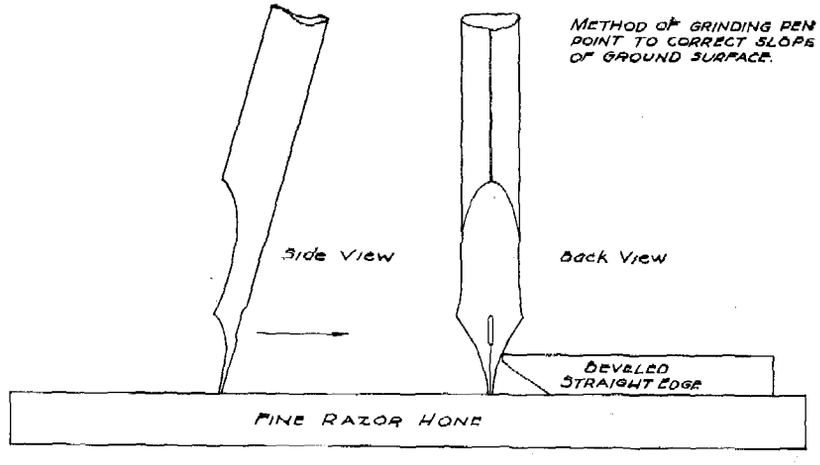
(D) Shipping Case.

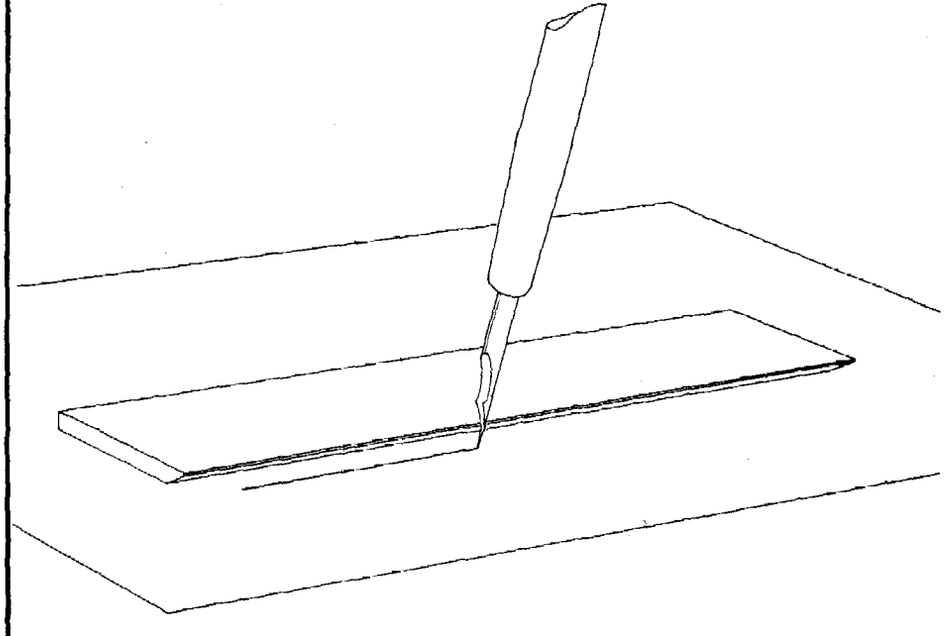
A suitable shipping case for the completed celluloid compilation sheets may easily be constructed from two l/4-inch, 3-ply wood sheets. A l/4-inch cleat bounding the ply wood allows the necessary space for the celluloid sheets, together with corrugated cardboard fillers to provide suitable pressure against the sheets. Diagonal cross braces, slightly sprung at their centers, increase the pressure against the celluloid sheets to hold them securely in place. The container is fastened together with wood screws. This case may also be used in forwarding a new supply of celluloid back to the field parties, as celluloid when rolled cracks much more readily, besides lengthening the seasoning period.

(E) Pens.

Some of the draftsmen on this party prefer a No. 42 Spencerian dome pen point (with attachment) to the Crowquill. The attachment consists of an ordinary pin bent upward at the head end and extending through the tapered slot of the pen point into a small hole drilled in the center plug of the penholder. The pin may be moved in or out to cause the nibs to separate slightly. This regulates the flow of ink and governs the weight of the line. The point may be stoned down to suit the requirements of the individual draftsman. The results obtained by draftsmen using this pen appear to justify its use.

Many other aids, not mentioned here, have been used with some success on this party. However, as their merits over previous methods have not been demonstrated and may be open to question, they have not been included in this report.





GRINDING THE BACKS OF THE POINTS OF CROQUILL PENS FOR INKING CELLULOID PHOTO-TOPO SHEETS

S. B. Grenell, Jr. H. & G. Engr., U.S.C. & G.S.

Several of the draftsmen working on celluloid sheets in the Savannah field office have been experimenting with croquill pens by grinding down the BACK of the point of these pens.

The following results were noted:

1. A clearer and more even line can be obtained because slight variations in pressure - caused by the unsteadiness of the draftsman's hand - leave no variation, in width of line due to the spreading of the nibs. This is particularly true when making fine, straight lines with a straight-edge.

2. When the pen is held nearly vertical, a more uniform quality of free-hand line - such as shoreline - may be obtained.

3. A pen especially ground for the work will give a clear, round dot for sanding low water line.

4. The weight of line desired may be obtained by grinding the point the correct amount. Where different weight lines are required on a sheet - such as shoreline, fine marsh Symbol, roads and highways, etc. - a set of pens of varying fineness will give uniform results for the different features.

A fine, razor hone is best for grinding.

For work with a straight-edge the pen should be held exactly in the position to be used in drafting while being drawn along the surface of the stone. Be careful that the slope of the pen does not vary with the stroke.

The stroke should be even and very light so that the flexible nibs of the pen are not "sprung" while being ground. If the pen is held in nearly a vertical position, a very fine line may be obtained.

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