HINTS TO HYDROGRAPHIC SURVEYORS

CORRECTING CLOSURE ERROR

by

GEORGE C. COMMONS.

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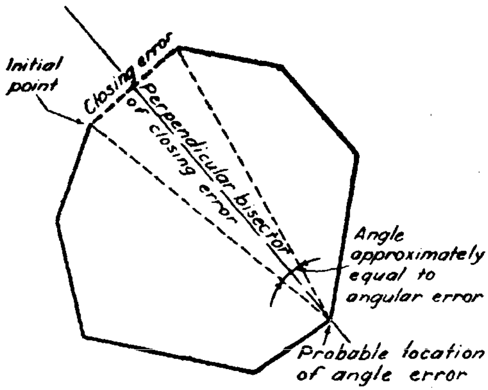
When, in making a survey, the last course fails to make an angular closure, due to an error in angles at some transit point, the method illustrated will often serve to locate the error, thus giving one angle to check in the field, instead of repeating the entire survey. The principle of the method is that in plotting the survey according to the field notes, the portion made after the angular error may be pivoted about that point to the amount of the error, so as to make a closure.



To apply this method, the survey is plotted in the order in which it was made, and the closing line is drawn in. A perpendicular is erected at the mid-point of this closing line, and the following tests are applied: (a) If the perpendicular bisector of the closing error passes through or near to an angle point of the survey, and (b) if the angle subtended at this angle point by the closing error approximates the angular error of closure, and (c) if pivoting the later portion of the survey about this angle point so as to eliminate the closing error is in the direction required to correct the angular error, then it is very probable that the error is at this angle point.

ASTRO-RADIO POINTS

by

MAJOR K.M. PAPWORTH, R.E.

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« .... *we but teach*
Bloody instructions, which being taught return
To plague the inventor; .... »

MACBETH.

Some years ago there were two or three articles in the *Empire Survey Review* on the subject of astronomical fixation, but although the subject is of general interest to surveyors, no further articles have appeared. The following notes, which refer primarily to surveys on a scale of about 1/500,000 and not to

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the more deliberate work required for triangulation, are put forward in the hope that they will start the ball rolling again.

Before any survey is commenced, standards of accuracy for the work should be carefully chosen so that there will be no weak links in the chain, but due consideration should be given to any parts which may be required for more accurate work at a later date, and for those parts it will naturally pay to increase the accuracy of work.

This point is stressed, because surveyors do not always pay enough attention to it. Seven-figure logarithms are frequently used to compute points, fixed with the minimum of observation, to the decimal part of a second, and then the answer is converted to rectangular co-ordinates to some minute fraction of a metre. Time signals are often given an accuracy greater than is warranted, and I have seen cases of signals, recorded by the eye-and-ear method, worked out to three, and even four, decimal places of a second.

In a recent survey the following standards were laid down, quite rightly, before work was commenced, but it will be seen that they are not properly balanced:—

Latitude	Greatest range	10"	P.E. ± 0".5
Longitude	» »	1^s	P.E. ± 0^s.3
Azimuth	» »	10"	P.E. ± 10"

These standards give a greater accuracy to latitude than to longitude, while the probable error for azimuth is not in sympathy with the allowable range. It should be possible to observe azimuth more accurately even in quite rough surveys.

If a number of Astro-Radio Points are being fixed in the same area, observation and computation soon become wearisome, and it is worth looking round to see if there are any short-cuts available. Some methods, as that of Gauss, are easy to observe but require considerable time for the preparation of the programme and for computation. Others require a close knowledge of the latitude, or special tables. When time and weight of instruments carried are the main considerations, on the whole, I doubt if it is possible to beat the standard methods of Latitude by circummeridian altitudes, Time by altitudes near the prime vertical. If azimuth is required only for finding out the compass "error," azimuths of Polaris will give a sufficiently accurate answer.

It is considered that the programme for fixing a point should consist of four pairs each of Latitude and Time stars, and two pairs of Azimuth stars. The fixing of a point can be divided into three parts:

(i) Preparation of a star programme.
(ii) Observation of stars and time signals.
(iii) Computation.

Preparation of Star Programme.— Lieut.-Col. Clifford (1) described his methods for making out a star programme, and the following notes only amplify what he wrote. The *American Ephemeris* includes many more stars in its data than the *Nautical Almanac,* and its use is strongly recommended (2). In addition, the Greenwich Star Catalogue is a useful book to have with one for the occasion when an unlisted star is observed. The latest list of Time Signals is also required. The Admiralty "Handbook of Wireless Signals" is a very good publication, but it is very bulky, and the Berne Handbook contains the same information in a much smaller compass.

If, as is often the case, several points are to be fixed in the same area, it pays to make lists of suitable stars under the following headings, the mean parallel of the area being adopted as the datum for latitude:—

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(1) E.S.R. vol. iii, N° 20, p. 343.

(2) An international annual catalogue of apparent places will be issued from Greenwich in 1940 and onwards. Editor, E. S. R.

Latitude Stars.

Star name.	Right Ascension.
Magnitude.	Declination.

Time Stars.

Star name.	Right Ascension.
Magnitude.	Altitude on the prime vertical.
	Hour-angle on the prime vertical.

It is always useful to note the magnitudes of stars, since many given in the Almanacs are too faint for easy observation on a moonlight night. Right Ascension and Declination should be noted to the nearest minute of arc or time; Altitude and Hour-angle on the prime vertical can be obtained accurately enough from the plates in "Field Astronomy" (H.M.S.O.).

The programme for a night's work should be laid out round the time signals available. The ideal is to get a signal before commencing work, one half-way through, and one at the end of work. Time stars should be worked out first, and then the latitude stars should be fitted in to suit meal-times etc. I is frequently difficult to get suitable stars north of the zenith at some times of the year, and observation of Polaris should not be overlooked.

With these lists of stars it should take no more than some ten minutes to make out the night's programme, with the further advantage that, if for any reason a star has not been observed, it is a matter of a minute or two only to find out the next one available.

If possible, the same star should be used for the whole series of Time observations east or west of the meridian. If it is suitably placed for altitude it can also be viewed for Azimuth as well. This will save a good deal of time in looking up the apparent places in the *Nautical Almanac* when it comes to computation.

Observation of Stars ana Time Signals. — Surveyors are still very conservative about using only one face of the theodolite, and I was very glad to read an article by Mr. Wakefield (3) on the subject. In minor surveys any saving of time is an advantage; the time lost in changing face is very appreciable, especially when working in a piercing wind or in mosquito-ridden country.

Provided that the theodolite is in good adjustment and a sufficient number of pointings are taken, I do not consider that it is necessary to keep on changing face. It is advisable, however, to arrange that half the programme is observed on opposite faces. The means obtained from face-right observations for Latitude stars north and south of the zenith should agree with those from the face-left observations; the same should also happen with the observations for Time.

This modification saves a great deal of time in observing, particularly with the small instruments of the Zeiss, Wild, or Tavistock pattern, in which it is necessary to centre the bubble on the vertical arc before making a reading. If the instrument is carefully levelled, there should be no necessity to adjust the bubble during a series of readings, all taken on one face. As an example of the time saved, with a 5-inch Micro., I used to take 22 minutes for a series of 18 readings, changing face at each alternate reading. Later on I used to taxe 16 readings, changing face only once in about 10 minutes. Observing Latitude stars I required 10 minutes for 8 readings, while I could get 10 readings in 5 minutes when not changing face.

For astronomical work, I much prefer having a graduated bubble on the vertical arc, as I consider that one can get quicker readings with it, and one does not have to keep watching the bubble to see if it is properly centred all the time (1). I should very much like to try out a Tavistock pattern theodolite with a gratuated bubble in place of its present arrangement.

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(3) E.S.R. vol. iv, N° 24, p. 79.

(1) The Editor is in full concurrence with this opinion, and would append greater accuracy as an additional advantage in astronomical work.

If azimuth is required only for finding out the compass error, observations to Polaris, which can be made in twilight, are accurate enough, and the tables in the Almanacs give the result without further computation. This also has the advantage of enabling one to put the instrument in the meridian before starting work on the Time and Latitude stars.

If no booker is available, a "split-second" stop-watch is an enormous advantage, because it allows one to start the watch against the chronometer and it need not be stopped until the end of the observation. I had one of these watches in use recently and its performance in bad conditions was extraordinarily good. Its rate was well under a second a day, and its portability, as compared with a chronometer was a great advantage. In actual fact, I had to stop using my chronometer owing to its excessive and irregular rate, and the watch was made a very efficient substitute.

I much prefer the R.G.S. method of observing time signals, and for their computation the tables in "Field Astronomy" are a great assistance.

Computation. — It is a great help to have all the tables one may want to use abstracted from the various publications and bound in one cover. Such tables are those for refraction, conversion of sidereal time to mean time, vernier time-signal intervals, the value of m for circummeridian observations etc. With such a book one has all the tables one wants to use in small and light compass, instead of having to refer to a multiplicity of books.

I estimate that the time required for computing a point fixed as outlined above is about five hours, and I doubt if this time can be cut down very much, but there are still one or two short-cuts available. One advantage of observing on one face is that the preliminary work in the angle-book is cut down, since the angles observed can be meaned before converting them to "uncorrected vertical angles". In the old method in which one kept on changing face it was necessary to convert individual readings before meaning the results.

The following approximate correction for Refraction can be used with a slide-rule, and gives a result close enough for all practical purposes:—

$$R = R_0 \ (0.10 + x/30 - t/500),$$

where x is the actual reading of the barometer in inches of mercury and t is the actual temperature in degrees Fahrenheit. If, however, refraction tables are used, those given in "Hints to Travellers" are in easier form for use than those given in "Field Astronomy".

If one star has been used for a series of Time observations. the result can be computed as under, with a saving of time:

The standard formula is :

$$\cos t = \sec\varphi \sec\delta \ (\sin h - \sin\varphi \sin\delta).$$

$$\text{Let } \tan a = \sin\varphi \sin\delta \sec h, \text{ then}$$

$$\cos t = \sec\varphi \sec\delta \sec a \sin (h - a).$$

Let $A = \sin\varphi \sin\delta$, and $B = \sec\varphi \sec\delta$. It will be noted that A and B are constant for a series of observations to one star. We then get :

$$\cos t = B \sec a \sin (h - a),$$

where

$$a = \tan^{-1} (A \sec h).$$

I much prefer to compute latitude by converting each reading to the meridian separately. The extra time involved is not great, and the computation can be speeded up by use of a slide-rule. The value of A should be computed first, and then the value of Am can be got by slide-rule.

The correction for refraction is constant for the set of readings to one star. The eight to ten values for latitude obtained from the observations can be computed very quickly, and one immediately gets some idea of the accuracy of the observation, and can, if necessary, cut out any doubtful values.

To obtain longitude, one can assume that the chronometer has kept the same rate during the same series of observations, so that computed results can be meaned, and this will give the value for chronometer error on L.S.T. or L.M.T. at the mean of the times of the various observations. Next find out the chronometer error on Greenwich time for this mean value, correcting it, of course, for rate. The sum or difference of these two values will give the longitude. This is a quicker method than correcting each computed value for chronometer error and obtaining the value for longitude for each observation, which then has to be meaned.

It is hoped that these notes may be of assistance to those who have to fix Astro-Radio points, and I hope that others too will contribute their experience, because saving of time is of vital importance to any survey work in the back blocks of the world.

WHITEWASH SIGNALS

by

LIEUTENANT L.W. SWANSON, U.S. COAST AND GEODETIC SURVEY.

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Along the northern coast of California the bluffs in many places consisted of crumbling dirt or rotten rock. Ordinarily, bluffs are ideal for whitewash signals, but on these the whitewash could not be brushed on due to the condition of the surface. Many wooden signals, requiring considerable time and material, were built in this area. . . . .

It was finally decided that if some method of spraying the whitewash could be used, the construction of many of these wooden signals could be eliminated and the time and labor of signal building reduced. A three-gallon brass garden spray was purchased locally. This spray consisted of a brass tank, the top opening of which is very little smaller than the diameter of the bank. Air pressure is maintained by means of a pump which fits into the center of the tank at the top. A piece of rubber hose about two feet long is attached to the side of the tank near the top, and attached to the other end of the hose is a piece of brass tubing with a nozzle which is used to control the size and quantity of the spray. In signal building it was found that this sprayer could be used more efficiently by replacing the short hose with a length of about 20 feet, and the nozzle was replaced by a lever nozzle which produced a fan-shaped spray or solid stream. A piece of copper window screening was used in the top of the tank when filling the container in order to prevent lumps of unslaked lime from getting into it. The whitewash used was made in the usual manner from pulverized unslaked lime. The spray gun was carried on a packboard which could be placed on the ground during operation, the 20 feet of hose allowing mobility to the operator. Ordinarily one man pumped to keep the pressure up, while another man sprayed. . . . .

Signals could be placed much higher on the bluff than usual due to the fact that the gun would spray approximately 20 feet into the air; one filling of the tank (approximately 2-1/2 gallons) sufficed for the average signal; rough and irregular surfaces were well coated with whitewash, and there was no waste or spilling of the whitewash. In places not easily accessible, the tank could be filled on the beach and pumped to the proper pressure, and then carried by means of the packboard to the desired location, leaving the operator's hands free for use in climbing. In some cases the tank could be left on the beach, the nozzle man climbing up 10 or 15 feet with the hose and then spraying a signal 10 or 15 feet above him. However, in this instance full pressure is necessary, requiring continuous pumping by the man remaining on the beach. The tank was cleaned at the end of each day's work, which kept the whitewash from clogging the hose and valve.