International Hydrographic Review, Monaco, LVII (2), July 1980

FIFTY YEARS AGO...

Anxiety about the correct computation of a ship's position at sea from observed "Star Sights" appears to have concerned navigators for more than fifty years as indicated by the extracts from an article published below : "Machine for calculating position" which appeared in the *Hydrographic Review* in November 1930.

Despite the present-day use of short and long range electronic positioning systems for coastal and ocean navigation, this concern over calculation of the ship's position from celestial observations continues even today as evidenced by two papers published in this issue describing such calculations using pocket calculators.

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MACHINE FOR CALCULATING POSITION

(LE SORT System — *Patented*)
Constructed by the Ateliers J. CARPENTIER, 20, rue Delambre, Paris (14^e)

It is generally known that the problem of fixing the ship's position at sea consists in calculating the unknown quantities *H* (altitude of the heavenly body) and *Z* (azimuth of the heavenly body) in terms of the data :– *L* (estimated latitude), *D* (declination of the heavenly body) and *P* (the hour angle of the body).

H must be determined very closely. It is usually calculated by logarithms by means of the following formula :–

$$\sin H = \sin L \cdot \sin D + \cos L \cdot \cos D \cdot \cos P$$

The azimuth may be determined to the nearest degree.

For a trained and experienced navigator the calculation of the ship's position requires about ten minutes. It necessitates considerable mental concentration however, if no error is to be made in the signs, the logarithms or in the various operations.

The fear of making a mistake in the calculation, the result of which may cause the vessel to be put off her course or even lead to the loss of the ship, is ever present in the minds of navigating officers, because they know from experience that even the most expert are never entirely exempt from error, since there is no possible method of checking the calculations.

For the past fifty years a large number of seamen and scientists have sought to simplify the calculations for position in order to diminish the chances of error and above all to make them more rapid. They have endeavoured to substitute the use of special tables for that of logarithms (in France, for instance, the tables of DELAFON, of SOUILLAGOUET, of BERTIN, of Commander GUYOU, Member of the Institute, and others have appeared).

None of these new methods has succeeded entirely in gaining the favour of the mariner who has always preferred, and always will prefer, the use of logarithms because with this method he knows what he is doing and therefore there is less chance of a mistake. All of the above-mentioned tables are based on special and complicated theoretical considerations which may easily be forgotten, the more so since one is required to recall the various and numerous cases which may arise in each of them. The user is therefore compelled to follow blindly the rules given for the employment of the tables without understanding them — a practice which fails to inspire complete confidence in them.

Advantages of the calculating machine. — In the calculation of the ship's position at sea, the main object is to obtain the results with :—

1. the greatest possible rapidity;
2. every possible guarantee of accuracy.

It may be stated that there is no other problem in which the use of a calculating machine would be better than in that of fixing the ship's position at sea.

The machine invented by Captain LE SORT and constructed by J. CARPENTIER's workshop, appears to have solved the problem completely. Based on a novel principle it is simple and incapable of derangement, since it has gear wheels which are always in mesh and are not thrown in and out of gear. Consequently there is nothing to get out of order.

The three principal advantages *viz,* great rapidity of calculation; great accuracy in the result and elimination of the causes of error, are fundamental. With this machine, which can be installed in the wheel house, the calculation can be made on the bridge itself or in the chart house and requires only the time necessary to determine the data to be set on the dials. The position can therefore be plotted on the chart a few moments after the observation.

In practice, it is usually only the navigating officer who takes observations and makes the calculations. In any case the Commanding Officer has confidence in the results furnished by this officer only, since he alone is experienced and is less liable to make mistakes. The other officers, unless they receive direct orders to do so, take few observations because the calculations which must follow are tiresome, because they have too little time for this work and also because they do not wish to take the trouble to make calculations to which they are not accustomed and the result of which may perhaps be wrong. Sextant observations are not displeasing to them and might prove a welcome distraction were it not for the disagreeable calculation which follows. In those vessels which have a calculating machine all the officers will doubtless amuse themselves by determining the ship's position. Further, the petty officers and even the other ratings such as the helmsmen may readily be trained to manipulate the sextant, which simply requires a slight amount of practice. As soon as they are competent to take observations they are able to calculate the position of the ship since no theoretical knowledge is necessary. The vessel may then navigate at sea by star observations almost as easily as in sight of land by bearings of the coast.

When sextant observations are taken it is usual to take several altitudes of the heavenly body observed. Since it is impossible to work out all these altitudes by the ordinary methods, it is customary to make the calculations with one or two altitudes which are chosen from the series — those being selected which inspire the greatest confidence. The machine has the very great advantage of permitting all of the observations in the series to be used. Therefore, by comparing the results, we have a means of determining which of the observations are in harmony and of eliminating those which are poor, thus getting rid of accidental errors of observation and using the mean of the results which are retained.

DESCRIPTION OF THE MACHINE

External appearance. The calculating machine patented by LE SORT is in a hermetically sealed box in the form of a parallelepiped, on one of the sides of which there are the eight windows, f_1, f_2... f_8 and the two dials C_1 and C_2.

Each of these windows is fitted with a glass, in the middle of which is engraved a fine horizontal line which serves as an index. Under the glass a celluloid band, graduated either in numbers or in angles, may be moved either automatically or at will.

The voluntary displacement of the bands is done by means of the hand-wheels m_1, m_2, m_3, m_4, m_5. In order to set to a certain angle or number, the handwheel is turned until the desired graduation appears under the fine line engraved on the glass.

The windows f_1, f_2, f_3, f_4, f_5 are marked *L*, *D* or *P*, and the window f_8 is marked *H*.

In order to obtain the unknown quantity *H* the following operations suffice :—

1. Set f_1, f_2, f_3, f_4 and f_5, to the values of the data *L*, *D* and *P*.
2. Turn the dial C_1 to the number indicated by f_6 and the dial C_2 to the number shown by f_7.

Operation of the machine. We have stated that the formula which gives the value of the unknown quantiy *H* in terms of the data is :—

$$sin\ H = sin\ L \cdot sin\ D + cos\ L \cdot cos\ D \cdot cos\ P \qquad (1)$$

Let :

$$a = sin\ L \cdot sin\ D \qquad (2)$$

$$b = cos\ L \cdot cos\ D \cdot cos\ P \qquad (3)$$

Then :—

$$log\ a = log\ sin\ L + log\ sin\ D \qquad (4)$$

$$log\ b = log\ cos\ L + log\ cos\ D + log\ cos\ P \qquad (5)$$

$$sin\ H = a + b \qquad (6)$$

The celluloid bands f_1, f_2... f_8 are the usual type of commercial cinematograph films. These films are graduated in *log sin*; *log* cos; and the logarithms of numbers.

All the materials used in the construction (films, hand-wheels, gear-wheels, rollers, etc.) are identical in all respects with those employed in the cinematograph industry, and they have already been fully tested in practice.

In cinematography, the gear wheels play a very important role; they not only serve to wind the film, but above all to hold the film in a rigorously exact position in front of the objective. In this machine the wheels have an equally important role. While they serve to move the film, one may say also, that the film serves to regulate the position of the gear wheels; or, in other words, when the film, starting from the zero position, is unrolled until the graduation *m* appears on the index line of the window *f*, it causes the gear wheel to be turned through a certain number (and fraction) of revolutions which is exactly proportional to *log sin m*, *log cos m* or *log m* as the case may be.

ACCURACY OF THE MACHINE.

The operation of the machine may be compared exactly to a slide rule of very great length. The closeness of the approximation of the result is evidently dependent on the length of the films used.

The CARPENTIER Works have constructed two types of machines : one for maritime navigation (Type *M*) and the other for aerial navigation (Type *A*). These two types differ in the length of the films only.

NOTES ON USE OF THE MACHINE.

Check on Calculations.

In most calculating machines a check on the accuracy of the calculation can be obtained only by repeating the entire operation. In this machine, all data used remain "recorded". It is easy therefore to see at a glance whether the films had been properly arranged in accordance with the data and the counter settings correctly made.

Work preliminary to the calculation.

The quantities L (latitude) and D (declination of the sun) vary very little from day to day. Consequently the positions of the films L and D need only be changed by a few centimetres from one observation to the next. Further, they may be set approximately before the observation is taken.

This feature is of particular importance in the M type in which the films are relatively long.

For the machine of *A type*, in which the films are short, the setting of the films is accomplished very rapidly whatever their initial position may be.

Treatment of a series of Altitudes.

When using several altitudes of one series of observations, the settings of the four films L and D and the counter C_1 need not be changed, for they remain the same for all observations of the series. It will be necessary to change the film P and the dial C_2 only. This is very quickly done.

General use.

The uses of the machine are very general. It may be employed for all star observations (except Polaris) in all latitudes and at every season of the year. It may be employed also for circummeridian and circumzenithal observations.

However, it cannot be used for values of P comprised between 5 h $57^m\ 42^s$ and 6 h $02^m\ 18^s$; that is, during $4^m\ 36^s$ — a negligible interval.

Special Plate.

Inside the cover of the machine there is a plate made of special material on which the tables of altitude corrections are engraved. The principal elements of the observable stars may be inscribed on this plate in advance. Finally there is a special frame, prepared as a form for calculation, in which the additions and subtractions necessary for the preparatory work of the calculation can be made in pencil. This may also be employed to plot the results, obtained with the machine, graphically.