

SYSTEMATIC TRIALS WITH THE DECCA NAVIGATOR CARRIED OUT ON BOARD THE FRENCH SURVEYING VESSEL "AMIRAL MOUCHEZ".

Object of the trials.

From 14th to 29th October, 1947, the French surveying vessel *Amiral Mouchez* carried out in the English Channel and in the Straits of Dover, a series of systematic trials of the Decca navigator, at anchor and underway.

The purpose of the trials was to determine the accuracy of this apparatus within a radius of from 200 to 300 kilometres from British transmitting stations and to study the anomalies arising from the propagation of the waves (night effect, interference by the reflected wave with the direct wave).

It was intended to reach thereby, definite conclusions concerning the use of the Decca apparatus for surveys in the offing as well as on its value from the point of view of control of coastal navigation, particularly in the Channel during fogs.

Characteristics of the receivers.

The receivers used were three decimeters of the Marine Mark IV type, corresponding to the three (green, red and violet) hyperbolic nets. They were installed on the navigation bridge facing the helmsman so as to make it possible to con along one of the hyperbolae of the net. At Dover on 20th October, 1947, these three decimeters were replaced by three indicators of similar type : modified Mark IV. The inverted V antenna was arranged on the signal-yard and the receiver unit in the look-out house.

Trials at Anchor.

These trials consisted of continuous day—and night—observations in order to determine the dispersion of the fixes given by the Decca navigator.

The observation stations at anchor were :—

<i>Boulogne</i>	Alongside the quay (from 18th to 20th October). In Carnot roadstead (17th October, from 23rd to 25th, from 27th to 28th October). Off Wimereux (25th October).
<i>Dunkirk</i>	In the roadstead (from 28th to 29th October).
<i>Dover</i>	Prince of Wales Wharf (21st October). In the roadstead (22nd October).
<i>Deal</i>	In the offing (22nd and 23rd October).

The observations at the fixed station were plotted as accurately as possible, account being taken of the various headings of the ship under the action of wind and tidal stream. In this way it was possible to refer the discrepancies between the exact position and the location determined by Decca indications to a single position for any one series of observations at the same anchorage.

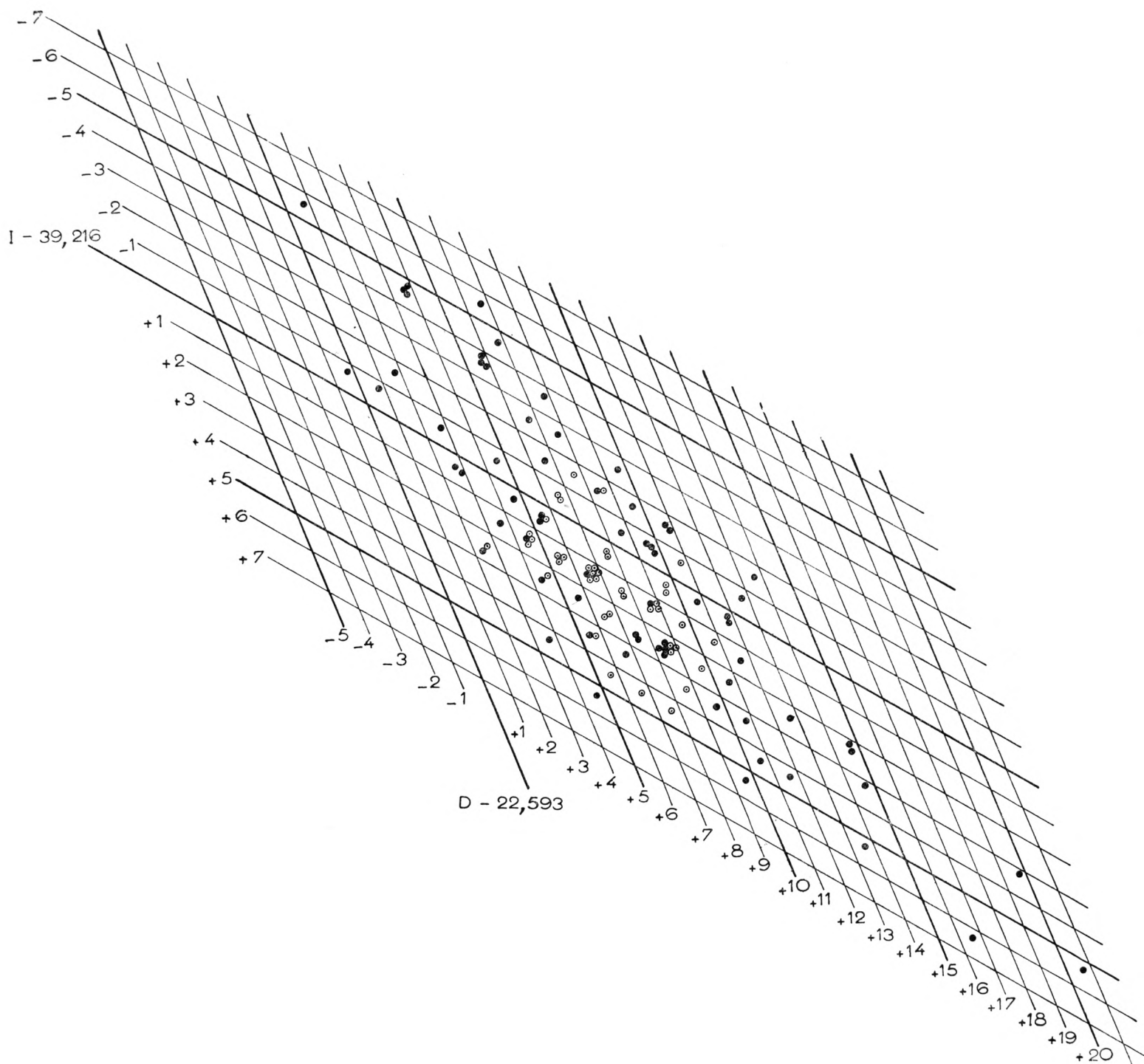
The results obtained are shown in two ways :—

(a) In the form of dispersion diagrams to scale of 1 : 2 000 for the various observations made at Boulogne, Dover and Dunkirk (see diagram No. 2).

Day fixes and night fixes are recorded separately.

(b) In the form of curves giving in terms of time during the day the departure existing between Decca indications and those plotted on the charts (or calculated) for the observing point (see diagram No. 2 bis).

The dispersion diagrams reveal a variable departure, depending upon the different stations, between the geographical position as determined by means of land-marks and the



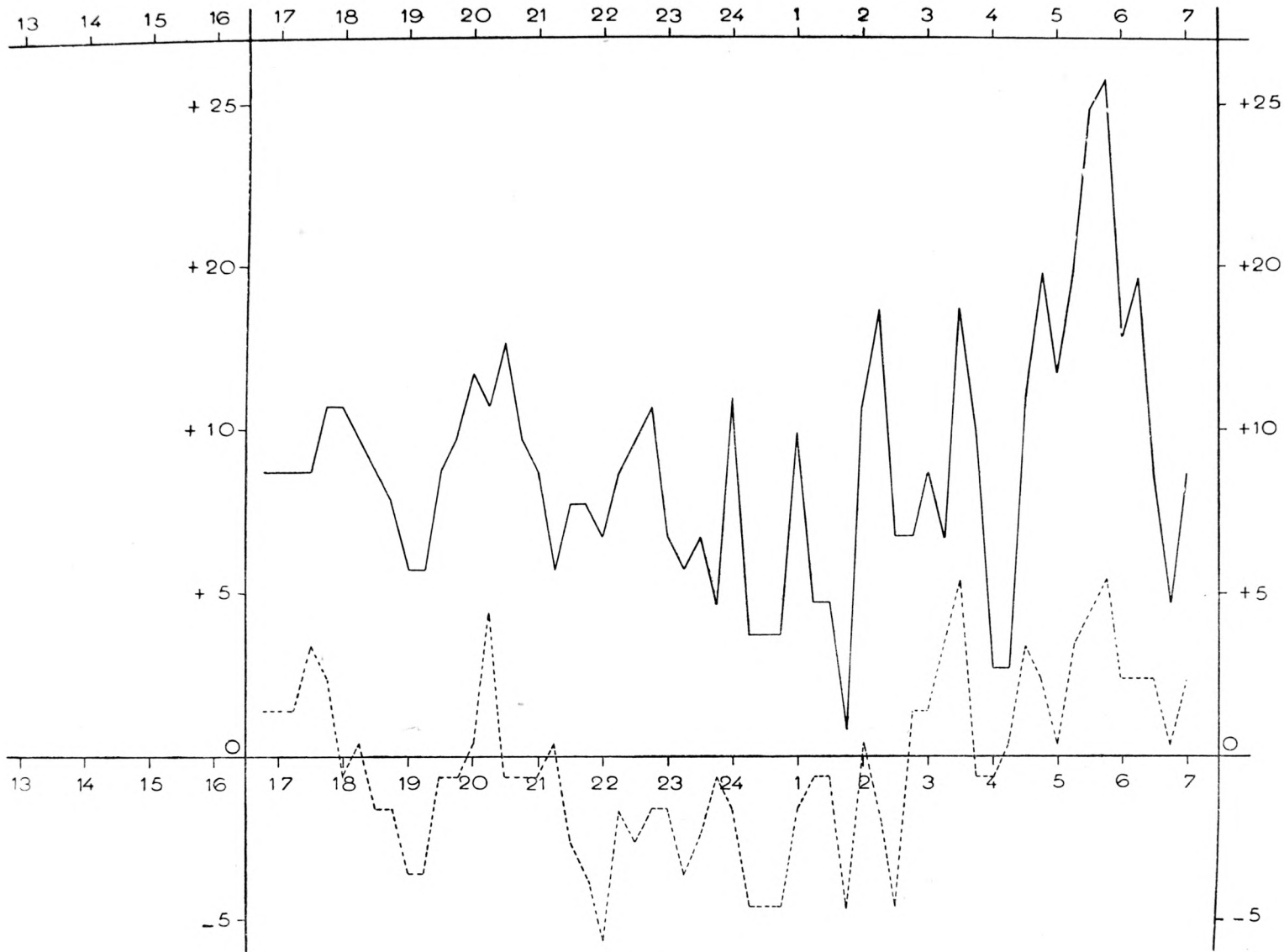
Pl. 1.

MISSION HYDROGRAPHIQUE DES COTES DE FRANCE

Boulogne 23-25 octobre 1947

Mouillage en rade Carnot

Position géographique moyenne	} L = 50° 44' 069 N. G = 1° 34' 236 E (Gr.)
Coordonnées DECCA	
Positions observées	} Nuit (Night) : ● Jour (Day) : ○



Pl. 1 bis.

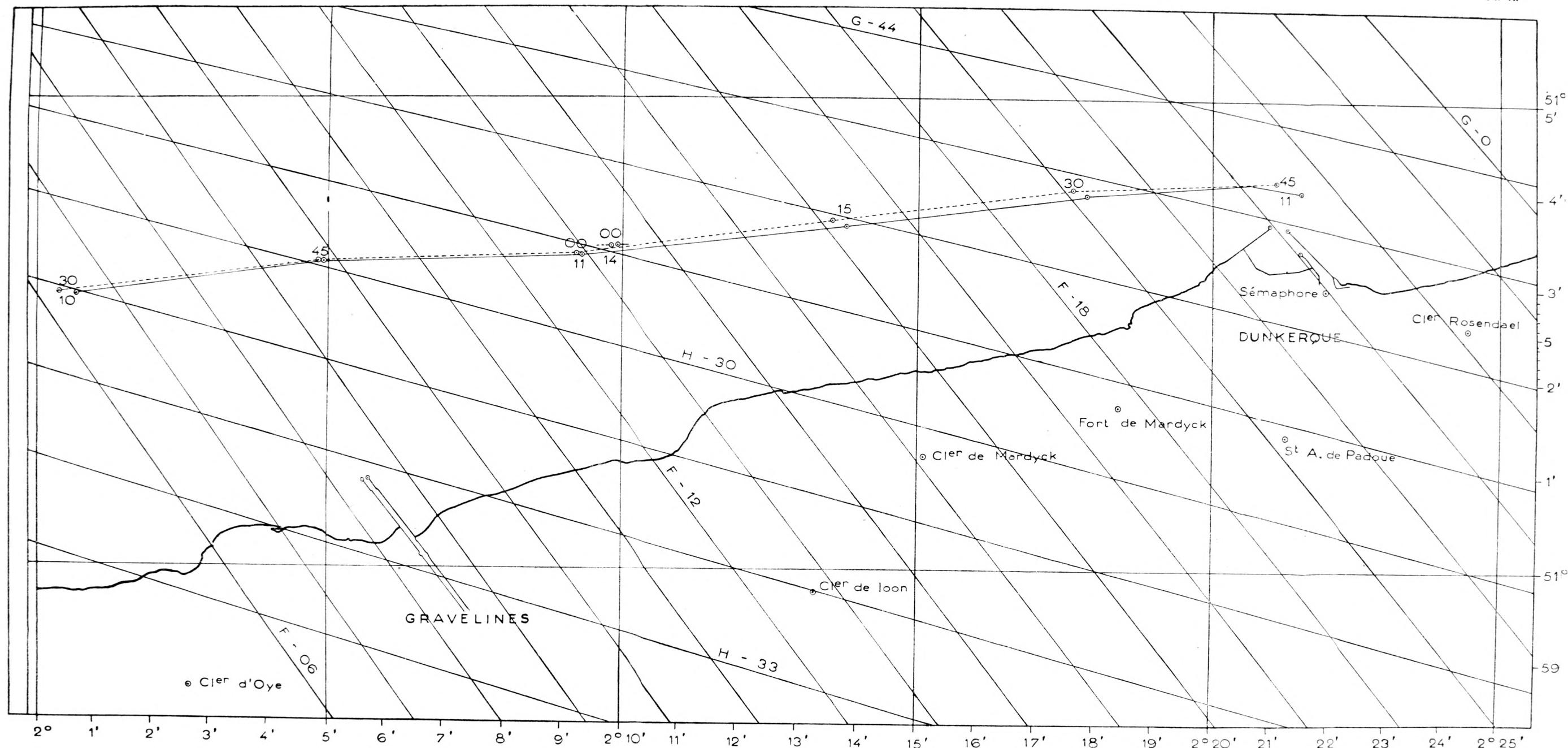
MISSION HYDROGRAPHIQUE DES COTES DE FRANCE

Boulogne 23-24 octobre 1947

Variations des lectures des phasémètres en fonction de l'heure. (Phasemeters reading change in terms of time).
 (Ces variations sont exprimées en 1/100 de chenal. — Differences are expressed in 1/100 of the lane).

Position } L = 50°44'0"69
 } G = 1°34'2"36

Nota : Trait plein (full) = hyperbole rouge (red). — Trait tireté (pecked) : hyperbole verte (green).



ROUTE BOULOGNE-DUNKERQUE

17 octobre 1947

Carte française 5513

Trait plein: route observée au cercle hydrographique. — Trait tireté: route DECCA
(Full line: track derived from surveying circle observations. — Pecked line: DECCA trade)

mean position indicated by the Decca apparatus. The maximum observed departure in the area under consideration was 300 metres.

A major part of this departure was doubtless due to differences which may exist between the French and British geographical positions.

For observations made in such harbours as Boulogne, there may be, in addition, noticeable perturbation due to the shape of the coastline, which would explain the difference between the average departure in the Carnot roadstead and at Wimereux and the average departure along the wharf in the wet-dock-basin.

The curves showing the observed departures in terms of time during the day do not suggest any precise law. The departures are dispersed at random; they are, however, much smaller during the day than during the night and it was this that led to the separation of day and night dispersion on the diagrams.

Trials underway. These trials took the form of :—

1° Plotting at regular intervals the position of the ship, obtained on the one hand from Decca indications, on the other hand from observations made with the surveying circle, by bearings or by radar ;

2° Making hyperbolic tracks, steering the ship direct on one of the decometers ;

3° Determination of the sensitivity of the hyperbole of one net, bearing away from a hyperbola in perpendicular of the track and estimating the distance run before the next-following hyperbola is reached.

The tracks followed were as follows :—

<i>Cherbourg-Boulogne</i>	16th-17th October.
<i>Boulogne-Dunkirk</i>	17th October
<i>Dunkirk-Boulogne</i>	17th October
<i>Boulogne-Dover</i>	21st October
<i>Dover-The Downs</i>	23rd October
<i>The Downs-Boulogne</i>	23rd October

In the navigational area used, the accuracy value of the Decca hyperbolic nets arises from the following table which shows for a certain number of stations the distances in kilometres from the transmitters, the intersecting angles of the hyperbolae and the breadth in metres of 1/100th of channel (lane) (1).

Areas	Distances from transmitters				Values of 1/100 of lane		Intersecting angles of red and green hyperbolae
	Master	Violet	Red	Green	Red	Green	
Dunkirk	200 km.	300 km.	190 km.	160 km.	13 m.	19 m.	34°
Boulogne	170 »	265 »	190 »	120 »	12 »	18 »	42°
Dover	118 »	213 »	140 »	87 »	13 »	13 »	52°
The Downs	120 »	215 »	132 »	100 »	13 »	14 »	54°

In the first place the plotting of the observations was established provisionally on the special Decca British charts to mean scale of from 1:70 000 to 1:100 000.

Then the accurate transfer of the tracks followed was made on the French 1:45 000 charts onto which the Decca hyperbolae had been transferred point by point. (See Diagrams A, B, C and D.)

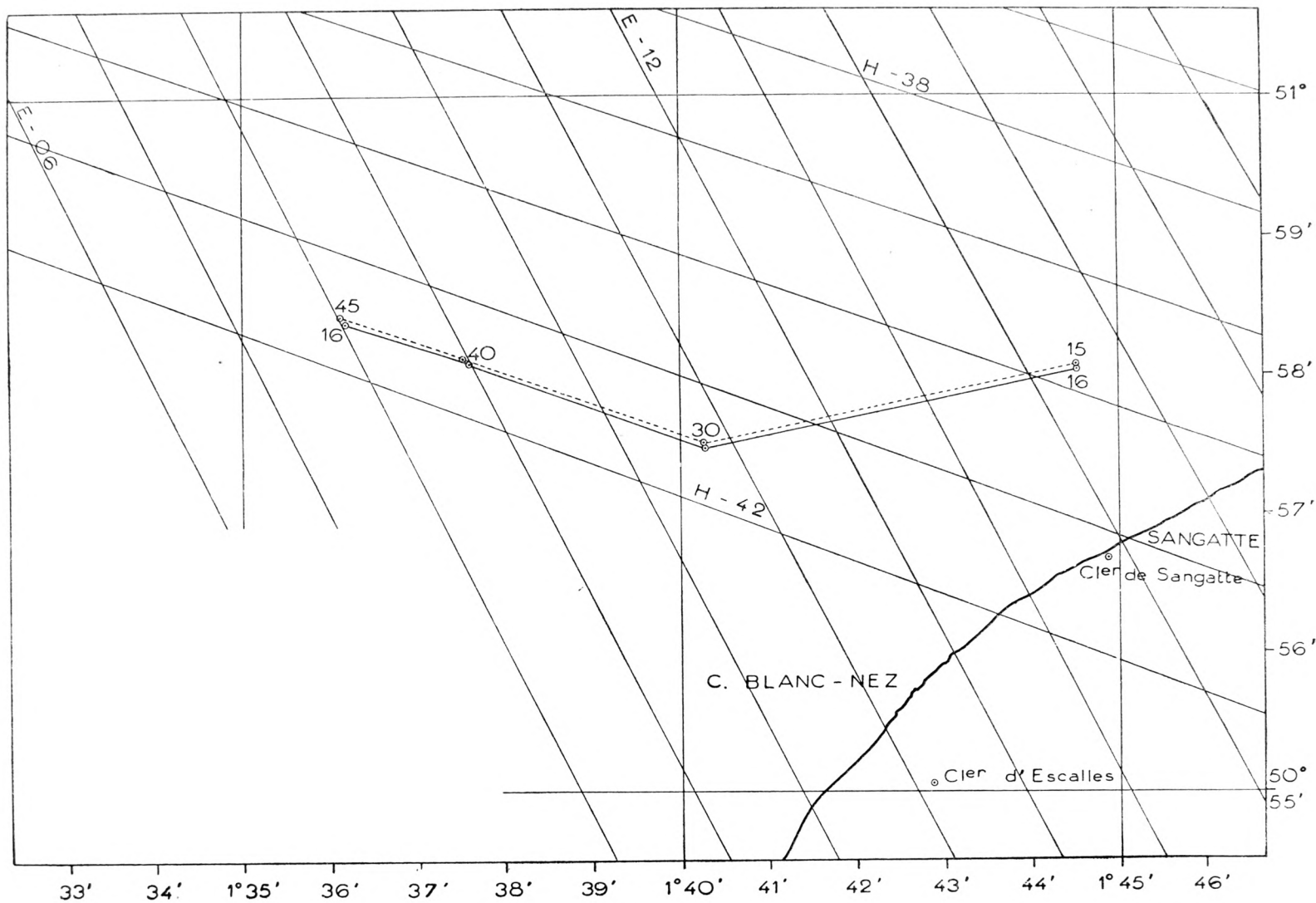
Tracks resulting from surveying-circle observations or from bearings were plotted as a continuous line; tracks resulting from Decca indications were plotted in pecked lines.

Details of the trials underway are given below :—

1° *Cherbourg-Boulogne track* (16th-17th October, 1947).

A first series of observations was carried out from the moment of weighing at Cherbourg for Boulogne at 1700h. on 16th October, in a mediocre area, the red transmitter (the farthest-off) being 200 miles distant and the green transmitter (the nearest) being at a distance of about 110 miles. The angle of resection of the hyperbolae was 28°, the value of the green lane was 2000 metres and that of the red lane, 3300 metres.

(1) It should be borne in mind that in the Decca system a channel (lane) means the distance separating two hyperbolae the phase difference of which equals 2 radil. This distance is variable according to the area considered; it equals a half-wave-length along the straight line joining the two transmitting stations.



Pl. B.

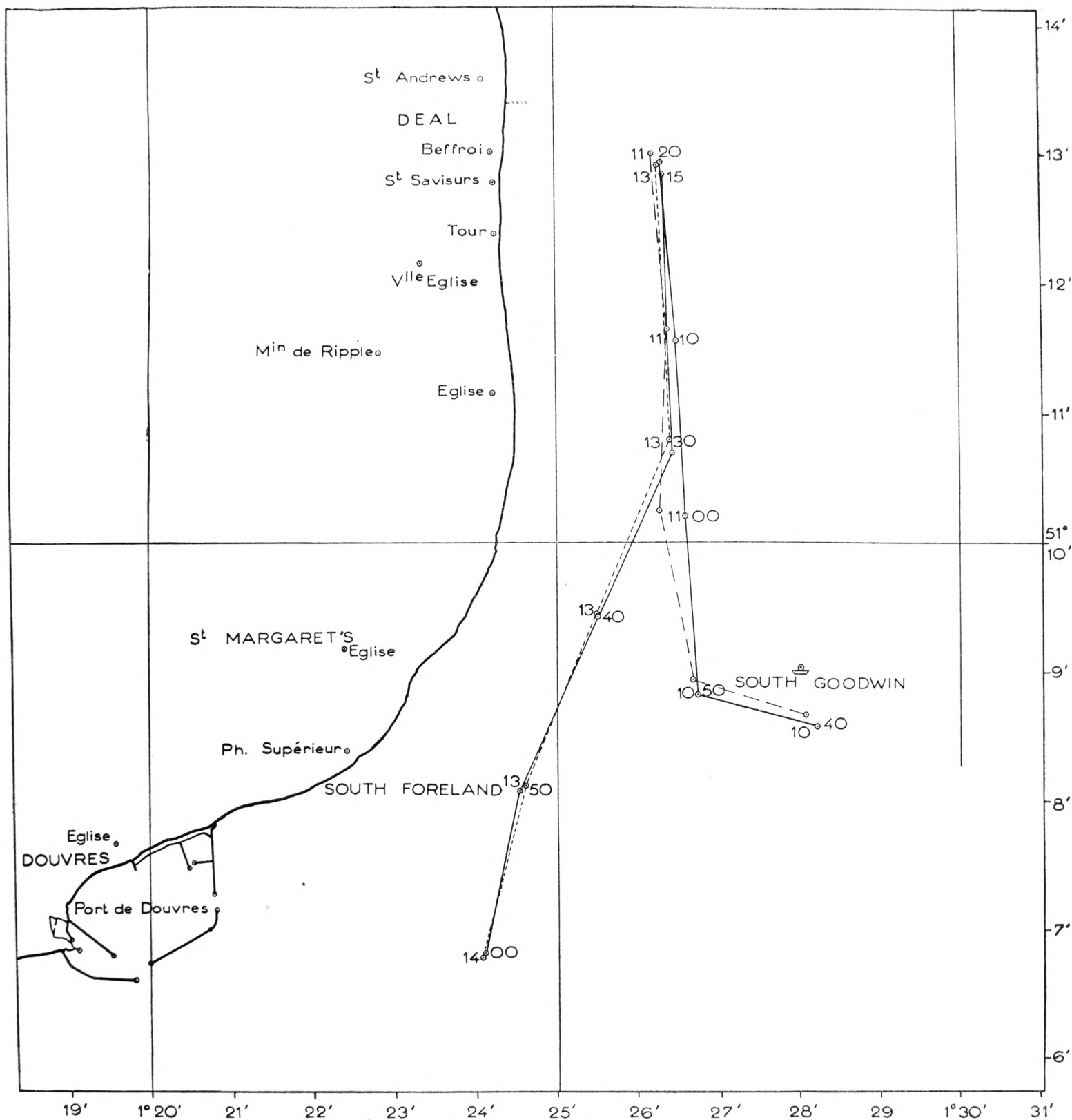
ROUTE CALAIS-GRIS-NEZ

17 octobre 1947

Carte française 5519

Trait plein: route observée au cercle hydrographique. — Trait tireté: route DECCA
 (Full line: track derived from surveying circle observations. — Pecked line: DECCA trade)

Nota: A partir de 16 h. 30 suivi hyperbole n° H-41-55. (From 16.30 hyperbola No. H-41-55 has been followed).



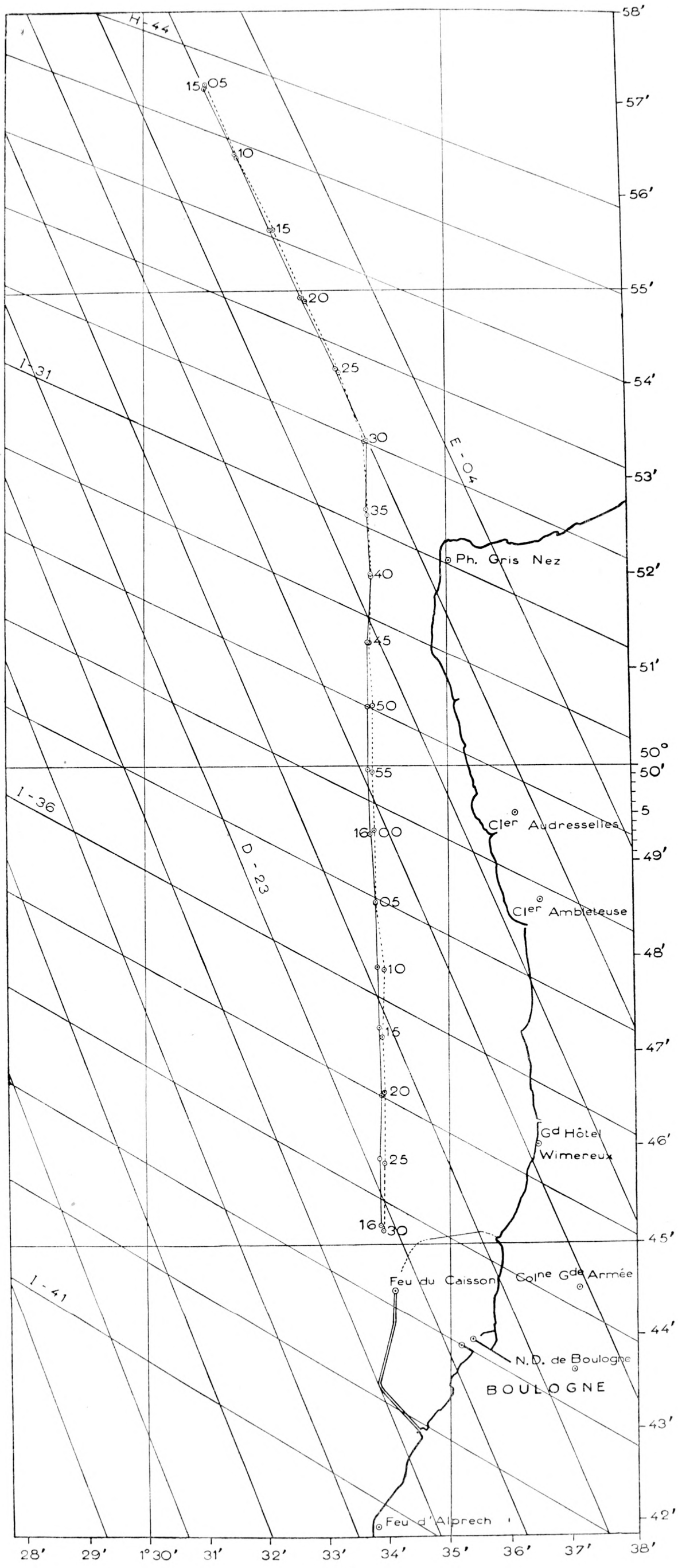
ROUTE DOUVRES-DEAL

23 octobre 1947

Carte française 5087

Trait plein: route observée au cercle hydrographique. — Trait tireté: route DECCA
 (Full line: track derived from surveying circle observations. — Pecked line: DECCA track)

Nota: La lecture de l'hyperbole rouge à 11 h. semble douteuse. (The reading of red hyperbola for 11.00 seems doubtful).



Pl. D.

ATTERRISSAGE SUR LE CAP GRIS-NEZ ET BOULOGNE

23 octobre 1947

Carte française 5525

Trait plein: route observée au cercle hydrographique. — Trait tireté: route DECCA
 (Full line: track derived from surveying circle observations. — Pecked line: DECCA trade)

Before getting under way, an accurate check made in the harbour of Cherbourg, using a 1:10 000 chart showing the hyperbolic nets, had given the following mean departures:—

- Red : 4/100 lane (122 metres) ;
- Green : 2/100 lane (40 metres) ;
- Violet : illegible and variable.

From 1800 h, course 69, speed 12 knots, W.N.W. wind force 4, moderate rolling, Decca observations every 30 minutes. Up till 0330 on 17th October, fixes were determined by dead reckoning only and the lack of Decca charts did not permit of the Decca navigator indications being put to any profitable use.

From 0330 the lights at the mouth of the Somme permitted a continuous check, although rather approximate than otherwise owing to the uncertainty of the compasses.

The departures between Decca fixes and positions obtained by bearings were as follows : 1'.5 - 0'.5 - 0'.75 - 1'.1 - 1'.6 - 1'.2 - 0'.7 - 1' - 0' - 0'.2 up to the entrance of the Boulogne lane. The mean distance to the central Master Station of Burlingford in the North of London was about 90 miles. No notable incident except the lack of charts and the impossibility of using the violet net.

2° *Boulogne-Dunkirk*, 17th October, 1947. (See tracing A.)

Weighed at 0730, coastal track inside the Bassure de Bas, speed 8 knots, hazy, smooth sea. Fixes were made every 15 minutes and, from 1030, using the surveying circle. Departures recorded were as follows : 0'.2 - 0'.1 - 0'.1 - 0'.3 - 0'.2 - 0'.55 - 0'.1 - 0'.2 - 0'.1 - 0'.2 - 0'.3 - 0'.4 - 0'.1. No incident; violet unusable.

3° *Dunkirk-Boulogne*, 17th October, 1947. (See tracing B.)

Weighed at 1330, smooth sea, visibility good then feeble improving at 1600h, speed 10 knots. Fixes made every 15 minutes using the surveying circle. Discrepancies recorded : 0'.3 - 0'.2 - 0'.2 - 1'.2 - 1'.25 - 1'.2 - 0'.95 - 1'.15 - 1'.4. *To be noted*: Between 1530 and 1615, *lane-slipping* of a red hyperbola causing an error of about 1 mile to appear. This lane-slipping corresponded with the bursting of a fuse in the mains on the bridge.

Sensitivity trial : From 1658h. to 1705h. left hyperbola H 4,156 up to H 4,356 : departure on chart, 0'.62. Distance run : 0'.65.

4° *Boulogne-Dover*, 21st October, 1947.

Weighed at 0700, visibility 1 mile, speed 10 knots, rolling, cross-current 2 knots to N.N.W. Rounded the Bassure de Bas and followed the track of red hyperbola D 23 at 0754 until 0936. Check of the fix was impossible but it was easy to con the ship on the indications of the red decometer the inertia of which is of the same order as that of the compass. The only difficulty lay in acquiring the "sense of the yaw" to be made to return on the hyperbola, a sense, moreover, rapidly acquired by the helmsman. At 1018h. dropped on the Eastern pass of Dover. *To be noted*: From 0936, ten minutes' stoppage of the violet.

5° *Dover-The Downs*, 23rd October, 1947. (See tracing C.)

Weighed at 0910. South wind, force 3, rough sea, visibility good, speed 7 knots. At 0931 followed the track of the green hyperbola H 34 until 1012 when the red hyperbola E 08 was followed, which led to South Goodwin Lightvessel at 1038.

From this moment various tracks were followed to reach The Downs roadstead, with check by means of the surveying circle every 15 minutes. The observed departures were : 0'.2 - 0'.2 - 0'.3 - 0'.2 - 0'.1. No noteworthy incident.

6° *The Downs-Boulogne*, 23rd October, 1947. (See tracing D.)

Weighed at 1300. Wind S.S.E., force 3, moderate sea, visibility good, navigated towards hyperbola E 03 which joined the South Foreland Memorial at a point situated 0.6 miles South of Gris Nez Lighthouse. Within The Downs, check by means of the surveying-circle which disclosed a departure of 1/10th -mile. At 1355, the Memorial being astern, the ship was coned by means of the red decometer along hyperbola E 03. Speed 9-10 knots, tidal stream 2.1 knots to N.N.W. From then onwards the check on the position was almost continuous and disclosed average departures of 0'.05—an accuracy certainly greater than that within the possibilities of the chart and of transmission. At 1530h., the course having been easily kept to near to 2/100 lane, the Gris Nez Lighthouse appeared 7° to port on the prescribed track.

This extremely interesting result qualifies the Decca system as a new means by which a correct track can, in this region so satisfactory for the purpose of such trials, be made in spite of wind and current, the only means hitherto, and available exclusively in clear weather, having been to follow a course along an alinement in transit.

Performance of the apparatus.

While the green and red indicators showed great stability, the violet decometer, subject to continuous oscillation of about 20/100 lane amplitude, very quickly became unusable. According to the mechanics of the Decca firm, this defect, due to the absence of pilotage and of automatic locking of the transmissions, is being eliminated.

On several occasions *lane-slipping* was noted.

Lane-slipping, the causes of which are dealt with later on (see: Various sources of error), makes it necessary that the apparatus be used with precaution, above all when only two hyperbolic nets are employed without the check of a third geometrical locus. Off Calais, it happened that the Decca observations fixed the position of the *Amiral Mouchez* as touching the shore while the vessel was, in fact, one mile offshore; an error in the opposite direction would have been serious in fog.

In order now to evaluate as far as possible the qualities of stability of the Decca receiver under the influence of foreign transmission, full-power (450 watts) transmission trials were carried out using the ship's transmitter. If no perturbation was noted, it is not possible to draw from that fact any definite conclusion as to the protection of the Decca system from interferences because of the low-power transmission and its frequency of 458 kilocycles, which is quite different from the receiving frequencies of 70 to 127 kc.

A more serious danger of interference came from the transmissions of two Dutch stations: Ruislède (ORH3), transmitting on 84.03 kc. and Kootfnick (PER), transmitting on 84.5 kc. These transmissions may trouble the transmission of the Master Station and the harmonics of the other transmitters. They were watched as carefully as possible without it being possible to detect them in activity during the watch-period.

Other checks were tried-out; in particular, when alongside the Dover wharf an endeavour was made to detect a variation of the Decca indications in terms of the altitude of the antenna according to tidal level. In view of the existing impossibility of separating the various causes of absolute error, it was not possible to detect any clearly-defined law.

Various sources of error.

Given the number, the diversity and the non-determination of the sources of errors brought to light by the British experimentists, it is difficult to formulate a law governing each source of error and to separate those errors from one another.

Among the systematic errors there should in the first place be specially noted the error resulting from the propagation on shore, and which arises from the combined effect of the variability of the propagation velocity and alterations in direction when crossing the shoreline. This error was manifested during the trials carried out at the fixed station in the Deal roadstead.

Another cause of permanent error is uncertainty concerning the transfer of geographical positions in both English and French charting. This error does not exceed 300 metres as seen above (Trials at Anchor).

The usual accidental errors are due :—

1° to the automatic locking system of the transmitters which at present cannot guarantee a stability greater than 2/100 lane. Under this heading uninterrupted progress has recently been made ;

2° to variation in voltage of receiving ship's mains, which should be reduced as far as possible. Abrupt variations of voltage, when the charge is being altered, may lead to *lane-slipping* ;

3° to interferences caused chiefly by powerful transmissions made on a neighbouring frequency. These interferences may cause lane-slipping, but they are destined to disappear with the introduction of international distribution of frequencies. Transmissions from the ship's radio station seem to involve only slight oscillations of the decometers' handles. The new type of receiver governed by quartz and already used by aviation will be better protected from these inconveniences ;

4° to normal night effects which may induce oscillations of the order of 1/10 lane. These errors seem to be maxima between 2 a.m. and 5 a.m.

Abnormal accidental errors manifesting themselves for even a very short time may cause lane-slipping. They are due :—

1° to a sudden lowering of receiver feeding ;

2° to combinations of the direct and indirect wave during the night.

The lane-slipping due to the latter source of error is less frequent inside the utilisation area of 240 miles, admitted by the British Admiralty ;

3° to the careless handling of the "Test" and "Zero" controls when the handle showing the hundredths of lane is in the middle part of the dial. These errors may be avoided by noting exactly the true indications before each operation.

Even while admitting, although it is not always the case, that knowledge of a sufficiently accurate dead-reckoning position enables the round lower number of the hyperbolae to be checked or established, the above-mentioned incidents constitute so many imperative reasons for having a lane identification system for the hyperbolae. This system, the principle of which is well-known, was tried-out at Portland in March, 1947, on a special experimental chain. At present the trials are being carried out on the Admiralty chain and it may be hoped that the system will be put into action on the main chain during the year 1948.

Conclusions.

1° *Accuracy of Observations.*—Generally speaking, in the navigational area Cherbourg-Boulogne, situated at a distance exceeding 100 miles from the transmitting stations, the accuracy obtained was always of the order of 1.2 miles, account taken of the various uncertainties concerning the observed fix and the plotting of the hyperbolae on the chart.

At distances less than 100 miles, the error was never greater than 0.5 miles and in a number of cases did not exceed 0.1 miles, i.e. 180 metres.

2° *Utilisation of the Decca system for navigation.*—If the stability and the locking system of the transmission as well as the selectivity of the receiving apparatus continues to improve, the Decca system will provide during fog and in regions where the tidal streams are uncertain and fairly strong, a new means of accurate coastal navigation within a range of about 100 miles from the Master transmitting station; and a means which is comparable in accuracy to the astronomic control for ranges up to 200 miles from the central transmitter.

In addition, if the net is judiciously distributed, the Decca system permits the geographically-determined track to be followed with great accuracy without estimation or calculation of the drift due to wind and current.

3° *Utilisation of the Decca system for hydrographic surveys.*—It seems very possible that the Decca system can be employed for hydrographic surveying, making use of a movable chain of transmitters adapted to a predetermined operation.

The range of this system is greater than that of the radio-acoustic method.

Operating at distances from the transmitter not exceeding 100 kilometres, it may be expected to obtain with the Decca apparatus an accuracy of 100 metres, i.e. 1/1000, which is comparable with that obtained by means of radio-acoustic ranging.

It seems possible to eliminate errors due to instability by correcting the Decca observations of the surveying vessels by means of the Decca observations made on board a vessel at anchor in an accurately determined position in the centre of the area to be surveyed.

