

CHART WORK

FOR

MARINERS

By

CAPT. S. K. PURI

*Senior Nautical Officer, T. S. Rajendra,
Bombay.*

Preparation : Farzad Jadidi
Mahdi Bordbar

MARINE PUBLICATIONS OF INDIA

5B/1, GOOD EARTH HOUSING SOCIETY,
CHEMBUR, BOMBAY 400 071.

Copyright

All rights reserved

First Edition February 1977

Second Edition March 1981

Price Rs. 60/-

Printed by Mrs. Ramma Puri, at Creative Artists, Printers and Publishers, (Proprietors: Engineering Profile Publications Pvt. Limited) P.B. No. 2606, Bombay 400 002, Phone: 29 28 19 and published by her for Marine Publications of India, 5B/1, Good Earth Housing Society, Chembur, Bombay 400 071.

Dedicated to
the youth of our nation
who are our future
NAVIGATORS.

INDIAN NATIONAL SHIPOWNERS' ASSOCIATION

Capt. J. C. ANAND
President.

Scindia House,
Ballard Estate,
Bombay-400 038.
Grams: "Hindships"
Phone : 2 6 8 1 6 1

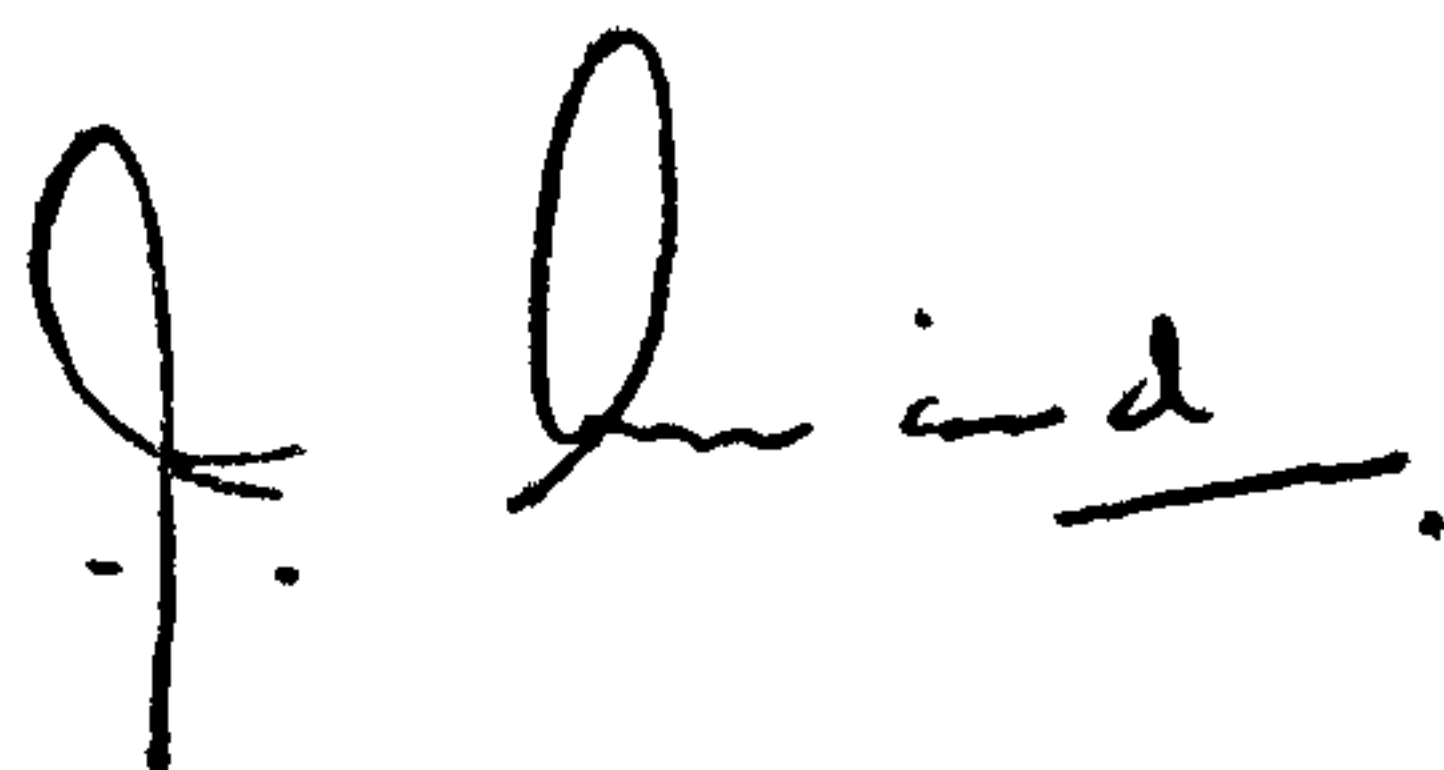
23rd February, 1977.

FOREWORD

Literature on various aspects of maritime science and technology is gradually growing in India as more and more marine technologists with interests wider than day to day routine enter the precincts. Nevertheless, production of such literature in our country may be said to be scarce still. Technical personnel, and particularly those engaged at sea are normally not well-equipped to follow the pursuit of successful Men of Letters but considering the large amount of highly specialised and diverse talent and brilliant technical men the shipping industry can claim to have, as I have often observed, it is surprising that it should be so—I am sure the cause for it does not lie in want of willingness or of disposition for necessary application. Perhaps, we may look for the cause elsewhere and means have to be explored to remedy the situation.

In the event, Capt. S. K. Puri deserves special compliments for taking up a challenge. I need hardly commend the importance of the subject matter of his present work to

Mariners, whose chief responsibility is to ensure safe navigation of vessels and of transport of the cargo and men carried on board entrusted to their care, avoiding in the process, dangers of deviation and other unsafe elements below and above the surface of the waters traversed. A thorough theoretical knowledge and practical grounding of Chart Work for them is too obvious to need emphasis. Capt. Puri's effort endeavours to assist in this and proposes to serve as a text book on the subject for the Mariners, and particularly for those preparing for MOT Examination for all grades of Certificates of Competency. I have no hesitation in commending it to them as well as to all Mariners who can keep it handy for reference in their Library on board or in their office, or for that matter at home if they so desire. I wish Capt. Puri success in his venture and hope it will prove a precursor of other works to follow in succession.

A handwritten signature in black ink, appearing to read 'J. C. Anand'. The signature is fluid and cursive, with a long horizontal stroke at the end.

J. C. ANAND

P R E F A C E

The need for an upto date text book on Chart Work for the Shipping Personnel in India has been acutely felt for sometime now. This book has been specifically written to fill this gap and presents the latest principles of the technique of Chart Work and Coastal Navigation.

Syllabi for the Ministry of Transport & Shipping examination for the certificates of competency for all the grades have been covered fully in this book.

The book is based mainly on one Chart i.e. "English Channel (Eastern Portion) B. A. Chart No. 2675". Only 4 Test Papers on the Chart "Ceylon" South Part (South of $7^{\circ}20'N$) B.A. Chart No. 813 are included in this book.

The use of the position lines and the technique of obtaining a "Fix" by various methods including the use of Radio D.F. and astronomical observations are explained in details. The text is illustrated fully with clear diagrams and supplemented by worked examples. In addition, many exercises and Test Papers have been provided to give the students sufficient practice.

In this edition, in order to keep the book upto date, the Chapter on "Tides" has been revised and other useful information has been added.

I am thankful to Captain Indrajit Singh, Captain Superintendent, T. S. "Rajendra"; Captain K. V. Hora, Ex-Senior Nautical Surveyor, Mercantile Marine Department, Bombay and Captain S. S. S. Rewari, Senior Nautical Officer, L. B. S. Nautical and Engineering College, Bombay for the help given to me whilst I was writing this book.

Every effort has been made to ensure accuracy. I shall, however, be pleased to hear of any errors that may have occurred.

Bombay,
20th March, 1981.

S. K. PURI

C O N T E N T S

	Page No.
CHAPTER I	
Introduction	1
CHAPTER II	
Salient Features of The Charts	4
CHAPTER III	
Miscellaneous Admiralty Publications	14
CHAPTER IV	
To find Position, Course and Distance	21
CHAPTER V	
Fixing Ship's Position	28
CHAPTER VI	
The Variation, Deviation, Magnetic and The Compass Course	33
CHAPTER VII	
Running Fix	48
CHAPTER VIII	
Some Worked Examples and Exercises	54
CHAPTER IX	
Horizontal Angles	63
CHAPTER X	
Current and Leeway	70
CHAPTER XI	
Dipping and Rising Bearing of The Lights	85
CHAPTER XII	
Position Lines by Astronomical Observations	102

CHAPTER XIII

Running Fix With Current			109
--------------------------	------	------	-----

CHAPTER XIV

Wireless Bearings			114
-------------------	------	------	-----

CHAPTER XV

Three Point Bearings			123
----------------------	------	------	-----

CHAPTER XVI

Picking Up a Line of Soundings			128
--------------------------------	------	------	-----

CHAPTER XVII

Tides			132
-------	------	------	-----

TEST PAPER I			162
--------------	------	------	-----

TEST PAPER II			165
---------------	------	------	-----

TEST PAPER III			168
----------------	------	------	-----

TEST PAPER IV			171
---------------	------	------	-----

TEST PAPER V			174
--------------	------	------	-----

TEST PAPER VI			177
---------------	------	------	-----

TEST PAPER VII			180
----------------	------	------	-----

TEST PAPER VIII			183
-----------------	------	------	-----

TEST PAPER IX			186
---------------	------	------	-----

TEST PAPER X			189
--------------	------	------	-----

DEVIATION CARD I			192
------------------	------	------	-----

DEVIATION CARD II			193
-------------------	------	------	-----

DEVIATION CARD III			194
--------------------	------	------	-----

APPENDIX			195
----------	------	------	-----

TERMS AND ABBREVIATIONS

The following terms when used in this book and in M.O.T. examinations, have the meanings indicated:—

TERMS

- (a) 'DR position' is that obtained by allowing for courses and distances only.
- (b) 'Estimated position' is that obtained by allowing for courses and distances and for leeway and current, if any.
- (c) 'Chosen position' is that position nearest to the observer chosen so that the latitude is an integral degree and the longitude is such that the local hour angle of the body at the time of observation is also an integral degree.
- (d) 'Sextant altitude' is that read off a sextant.
- (e) 'Observed altitude' is the sextant altitude corrected for index error, if any.

ABBREVIATIONS

The following abbreviations and symbols have been used in this book, for which, the MKS system using SI units has been generally adopted.

Admiralty	ATT	Compass	C
tide tables		Course	Co
Altitude	alt	Dead reckoning	DR
Apparent altitude	App alt	Departure	dep
Azimuth	AZ	Difference of latitude	d'lat.
Bearing	brg	Difference of longitude	d'long.
Co-latitude	co-lat.	Distance	dist

Estimated	EP	Meridian	mer
Geographical	GP	Minutes	m
position		Nautical mile	M
Greenwich	GMT	Nautical almanac	NA
mean time		Observed	obs alt
Height of eye	HE	altitude	
Hours	h	Position line	P/L
Index error	IE	Prime vertical	PV
Intercept	Int	Refraction	refr
Intercept	ITP	Seconds	s
Latitude	lat.	Sextant altitude	sext alt
Longitude	long.	True	T
Local mean time	LMT	True altitude	T alt
Magnetic	(M)	Zenith distance	ZD
Mean latitude	m lat	Zone time	ZT



CHAPTER I

INTRODUCTION

When the ship is being navigated along or near the coast, the art of fixing the ship's position graphically, laying a safe course to destination and checking ship's position whilst on, the course to ensure the vessel's safe arrival is called "Chart Work."

This naturally involves the use of a suitable graphical representation of the earth's surface on the plane of the paper, which when constructed to suit the special needs of a navigator is called the "Navigational Chart."

Navigational charts are mostly drawn on Mercator's projection, which ensures that all meridians and parallels of latitude are straight lines, at right angles to each other and all angles on the earth's surface are equal to the corresponding angles drawn on the chart. A special feature of this projection is that rhumb lines are also represented as straight lines.

As the safety of the ship depends upon the accuracy of the navigational chart, utmost care is taken in its construction and upkeep. It is drawn precisely giving full details of all the information required by the navigator.

The chart must naturally cover more area of the sea, as compared to the land, and should highlight the information that a mariner requires to navigate his ship safely from one position to another, that is to say the chart must show clearly the depth of water, nature of the bottom, details of coastline and off lying dangers and the various navigational aids e.g. light houses, prominent land marks, light vessels and radio beacons.

FATHOM CHARTS AND METRIC CHARTS

The unit used for indicating the depths i.e. "Fathom" or "Feet" or "Metres" is boldly displayed just below the title of the chart.

British Admiralty charts, which have traditionally been using fathom and feet for depths and also feet as unit for height, are being changed to adopt metric units, thus conforming to charts of most of the other countries. The words "DEPTHS IN METRES" are printed in bold letters under the title of these charts.

The British Admiralty plans that all new charts will be metric, and that existing charts will also be converted to metric form as soon as possible. However, it will be many years before all the charts will be converted.

The metric charts differ in appearance from old fathom charts by their improved design and greater use of colour. Full details of symbols and abbreviations used on metric and fathom charts are given on British Admiralty chart and publication No. 5011.

CATEGORIES OF CHARTS

Navigational charts may be generally classified in three categories.

OCEAN CHARTS

These charts are prepared on a very small scale, covering large portions of the globe e.g. Indian Ocean, North Atlantic Ocean. On such charts only the outstanding coastal features and important ports etc. are shown. These charts are used for planning and executing long voyages across the oceans and are obviously unsuitable for coastal navigation.

COASTAL CHARTS OR COASTAL SHEETS

These charts are of medium scale and cover only a portion or a part of the coast. They show all the aids to navigation e.g. lights (their characteristics), Radio & D.F. beacons, important navigation marks including offlying rocks and other dangers. Such charts are used, when the ship is being navigated along the coast. Coastal charts thus highlight the features on and along the coast and the adjoining portions of the seas.

PLANS

These charts are drawn on a very large scale and each plan covers only a small area e.g. Plan of Bombay Port.

They contain all the information required when navigating a ship in harbours, and other congested and enclosed waters. Every possible information of use to a navigator is shown in great detail.

The scale of these plans enables the mariner to plot his position with great accuracy and thus avoid the dangers which are frequent in ports and in harbours.

SOME SPECIAL TYPES OF CHARTS

DECCA CHARTS

These are normal basic navigational charts with the appropriate Decca lattice superimposed on them, and can be used in place of corresponding basic navigational charts. The number of Decca chart is the same as that of the basic chart but is prefixed L (D) and suffixed with Decca chain number.

CONSOL CHARTS

These are mostly used in air-navigation but may be used as an aid to ocean navigation also. They show great circle bearings of the consol stations. Details of consol systems e.g. in USSR and USA are shown in Admiralty List of Radio Signals.

LORAN CHARTS

Loran chains used for ocean navigation cover most of the northern hemisphere, and parts of central Pacific Ocean. British Admiralty Loran charts cover only the North Atlantic. The U.S. Oceanographic office publishes Loran charts for the Pacific Ocean.

ROUTEING CHARTS

These charts give important information for planning of passages across the oceans. Separate charts recommending routes for different months of the year are published for each ocean and they give recommended tracks and distances between ports, average meteorological and ice conditions and ocean currents.



CHAPTER II

SALIENT FEATURES OF THE CHARTS

HOW CHARTS ARE MADE

Navigational charts in U.K. are published by the Hydrographic Department of the British Admiralty, under the Hydrographer of the Royal Navy. The Hydrographer of the Navy is responsible for the preparation, correction and issue of the charts and other navigational publications. He is also the authority for surveying the British and other connected waters.

In India, the Hydrographic Department of the Indian Navy, with its Headquarters at Dehradun, prepares and issues the charts and other navigational publications. However, its activities and publications are restricted at present, to the Indian and adjacent waters only.

The Hydrographic Department of the British Admiralty issues charts for almost all the parts of the world. This task has now become easier, because the Admiralty gets the necessary information from the Hydrographic Departments of the countries, which are responsible for the publication of the charts for the waters under their jurisdiction.

To start with, the surveying department carries out an extensive survey of the area required to be covered by the chart and all information from various sources is collected and carefully analysed.

A modern survey, with all the resources of such inventions as Radar, Echo sounders, Hi-Fix and DECCA systems is a very thorough and detailed operation. The depths are closely sounded and elaborate examination is made of reported or suspected dangers. The actual Latitude and Longitude of some key stations is also determined.

From the data thus obtained, the charts are produced, ready for the engravers, by the specialist staff of the Chart Branch. Projections are computed and all important points are plotted accurately before the actual drawing of the chart begins.

This drawing is very accurately engraved on a copper plate by coating it with wax by using special ink on the drawing. The engraving of this copper plate is transferred to a lithographic stone or a zinc plate by contact or by Photo lithography. The plate is then ready for printing on paper, which is done by lithography or multicoloured off set printing. The paper used is high grade non-distortion paper.

Every new chart, in its final proof is examined by the officers of the Department responsible for such details. No effort is spared to ensure the accuracy and completeness of the chart.

After the chart is published and distributed, it must be kept up-to-date by incorporating any changes or corrections, which may have occurred subsequently. Such corrections and changes in charts of various parts of the world are issued as "Notices to Mariners" by the Hydrographic Departments.

DESCRIPTION OF THE CHARTS

TITLE OF THE CHART

The title of each chart is printed in some convenient, conspicuous place on a chart, where it does not hinder the navigational use of it.

Under the title, the information about datum, bearings, lights, Natural scale, Projection etc. are shown. Below this "cautions" are given in respect of the use of chart. Examples of titles are "Arabian Sea," "Karachi to Vengurla."

NATURAL SCALE

Natural scale is the relationship between the actual length of something on the earth and the length by which that thing is shown on the chart e.g. $\frac{1}{12,500}$ natural scale. The numerator of the fraction is always unity, and both the lengths (that on the earth and that on the chart) must be in the same units. e.g. Natural Scale of $\frac{1}{12,500}$ means a feature of 12,500 cms. length on the earth would be represented by a length of one cm. on the chart.

Natural scale of the chart is shown below the “Title of the chart.”

SCALES OF LATITUDE AND LONGITUDE

Whenever a three dimensional earth's surface is represented on two dimensional plane of paper, distortion must occur, as is evident from different types of “Projections.”

Mercator's projection, which is mostly used in the charts, is one such method by which earth (which is three dimensional) is represented on the paper. This projection has the following properties and principles:—

- (a) Direction lines on the earth's surface are represented by straight lines on the chart, called “Rhumb Lines.”
- (b) All angles on the chart are true and equal to the corresponding angles on the Earth's surface.
- (c) On the chart the Meridians are shown as equidistant parallel lines, perpendicular to the Equator, whilst on Earth's surface they converge at the poles.

Hence to retain the property of “correct angles” on the chart, the parallels of Latitude are shown as straight lines, parallel to Equator, but at increasingly larger distance apart (and not equidistant) as one moves away from Equator. Hence on the Mercator's chart, the Latitude scale is increased gradually as the latitude becomes higher and higher, with Longitude scale being kept constant all over. To be more precise the length of 1' D' Lat. = Length of 1' D' Long X sec. Lat. Thus on a Mercator's chart all distances are measured along the latitude scale (1' of Lat. scale representing one nautical mile). The Longitude scale is used for measuring Longitude and the difference in Longitude only.

All charts have two scales, Latitude and Longitude. The former is shown at both the sides and the latter at the top and bottom edges of the chart. These are properly and accurately graduated in minutes and degrees.

NUMBER OF THE CHART

Each chart has a serial number assigned to it. This is shown at the bottom right hand corner and the top left

hand corner, outside the margin. The chart catalogue gives the list of charts with the title and number for the various parts of the world.

DATE OF PUBLICATION

The date of publication alongwith the name of the Hydrographer to the Admiralty or Government authority is printed at the bottom, in the middle just outside the margin. Recent publication would mean a more reliable chart, incorporating all corrections, large and small, upto that date.

DATE OF PRINTING

This is shown as the number of the day in the year, printed at the top right hand corner, outside the margin e.g. 335.75. This means that the chart was printed on the 335th day of 1975.

SMALL CORRECTIONS

As stated earlier, various Hydrographic departments issue "Notices to Mariners." These include corrections to be made to the navigational charts already printed. Notice number under reference is called "small corrections" and is shown at the bottom left hand corner, outside the margin. These corrections are entered by hand e.g. 1968-1462, 1973-1225 mean Notice to Mariners No. 1462 of 1968 and Notices to Mariners No. 1225 of 1973 respectively and refer to the corrections made on the chart, vide those notices.

Prior to 1954, the corrections, which were of temporary nature or of minor importance, in general, were shown as 1943 5.12 which means 12th May 1943 or 1945 VII-25 which means 25th July 1945. Small corrections with date enclosed in a rectangle have been discontinued.

Temporary (T) and Preliminary (P) notices are not shown in small corrections.

NEW EDITIONS AND LARGE CORRECTIONS

Large corrections are shown near the new edition dates, at the bottom, in the middle (outside the margin).

These are the corrections involving major changes in the chart, which a navigator normally cannot incorporate in the chart himself. So a new chart is published/printed, whenever large corrections occur on the same. So whenever a chart is revised throughout or modernised in style, a new Edition is published.

All notations of earlier large and small corrections are at the same time erased in the new editions and old copies of the charts are cancelled.

From 1972 onwards, large corrections are discontinued and only New Editions are shown.

CHART BLOCKS

Sometimes a "Notice to Mariner" includes a reproduction of a small area of a chart, in which the corrections have been carried out. This is called a chart block and it is cut and pasted in its appropriate position on the chart as a part of "Small Corrections."

SOUNDINGS AND THE CHART DATUM

Soundings mean the depths of water below the chart datum and are thus one of the most important features of the navigational chart. The units used for Soundings are clearly shown below the "Title" of the chart.

Soundings figures are scattered on the chart, and their distance apart from each other is a measure of the extent of survey and hence the "Reliability" of the chart. On all charts the position of sounding is the centre of space occupied by the Sounding figure.

Sometimes during survey the lead is lowered to only a certain predetermined depth and if no bottom is detected then such a sounding is shown as "No bottom sounding".

e.g. $\frac{\cdot}{110}$ means "No bottom at 110 fathoms."

On Metric charts, generally soundings are shown in metres and decimetres in depth of 20 metres or less and in metres elsewhere.

On Fathom charts soundings are shown in fathoms and feet in depths of less than 11 fathoms and in fathoms elsewhere.

Soundings on the chart are the depths below the chart datum. CHART DATUM being an imaginary datum, beyond which the sea level rarely falls. In modern practice, the datum is established at or near the Lowest Astronomical Tide (L.A.T.)

The height of tide at any given time is thus an “error on the safer side.”

Chart datum is also the level above which tidal levels and predictions are given in Admiralty Tide Tables. This datum is also used on the charts for giving “drying heights” of features which are periodically covered and uncovered by the tide.

NATURE OF BOTTOM

Under certain soundings, the nature of the sea bottom, is also indicated e.g. soM (Soft mud), Co (Coral) Sh (Shells) Sn (Shingles).

This information is very useful when anchoring a ship. The nature of bottom also becomes helpful in estimating the ship’s position, when worked alongwith the soundings.

DEPTH CONTOURS

The soundings in the chart are very useful to a navigator but if these soundings on the chart are shown very closely, the chart will become confusing and impracticable. Hence all areas, having certain selected equal soundings are shown as below :—

.....	One fathom line
.. .. .	Two fathom line
— — — — —	Six fathom line
— . — . — . — . — . — . — . — . — .	Ten fathom line
— — — — —	One hundred fathom line
(10)SD	Sounding of doubtful depth
120	No bottom found at 120 fathoms.

HEIGHTS

All heights, unless otherwise stated are given in metres or feet above Mean high water springs or in places where

there is no tide, above Mean Sea level. Heights of small islets and of the tops of artificial features are enclosed in brackets. Brackets are used wherever the figure expressing height is necessarily set apart from the objects.

DRYING HEIGHTS

Underlined figures, on rocks and banks which uncover, express the heights (in metres and decimetres or in feet as appropriate) above the datum of chart.

BEARINGS

Bearings are always from seaward and are always true bearings.

SEA MILES

A Sea Mile is a length of one minute of Latitude at a place and it is the principal unit of distance.

PLATE DIMENSIONS

The figures in brackets shown outside the lower right hand border of the chart thus (425.0 × 860.0 mm) or (34.46 × 25.49) express the dimension (in millimetres or inches) of the plates from which charts are printed. The dimensions of the charts are measured from the inner rectangle of the chart and exclude the chart borders.

A check on these dimensions serves as a good guide to assess the distortion of the chart in use.

INFORMATION REGARDING LIGHTS

- (1) All the heights of the lights are given above the Mean High water springs.
- (2) Range of the light is given in nautical miles. The range of the light may be Geographical or Luminous. "Geographical Range" is based only on its height above sea level (assuming the observer to be at a 15 feet height). The "Luminous" (nominal) range, on the other hand is based on the intensity of the light. Until 1971, the charts showed the lesser of the geographical and luminous ranges but on the new charts now, only the luminous range is shown. The Lists of Lights also give the luminous range now.

LEADING LIGHTS

Quite often, at the entrance or approaches to the harbour, two lights of different characteristics are erected, some distance apart, in such a manner that a mariner entering the harbour correctly and properly, would see them in one line, thereby indicating to the navigator that the ship lies on a line joining the two lights.

ADVANTAGES OF THE LEADING LIGHTS

- (1) The leading lights indicate the safe passage of the ship in a channel.
- (2) The leading lights help in fixing the position of the ship.
- (3) The leading lights also helps the navigator in finding the compass error. The (actual) true transit bearing of the two leading lights is read off the chart and the compass bearing of the two lights, when in transit is taken, and the difference between the two bearings is the compass error.

COMPASS ROSE

Compass roses for laying off bearing and courses are engraved on charts, and they are referred to as compass roses to avoid confusion with ship's compass.

The compass roses are printed on the chart, at two or three places, wherever it is possible, so that it does not interfere with any useful information given on the chart.

The compass rose is printed as two concentric cards, the outer compass rose is on the true north and the inner card is on the magnetic meridian, at the place where the centre of the compass rose is shown on the chart. The number of degrees by which the magnetic north is to the east or west of the true north is the Variation, and is shown on the compass rose on the 90° & 270° line. The year for which the variation is given, is shown within brackets (next to variation) and the annual change (variation) at that place is indicated in italics, alongside the variation.

HINTS TO REMEMBER WHEN USING CHARTS

- (1) Always use the largest scale charts available for the area.

- (2) Note carefully the units in which soundings are given.
- (3) Familiarise yourself thoroughly with graduations on the chart before reading the Latitude and Longitude.
- (4) When measuring distance, along the Latitude scale, the dividers should be used along the mean latitude between the two points.
- (5) When using the compass rose, the ruler must pass through the centre of compass rose and 180° on the opposite direction.
- (6) If in doubt about a "Cocked hat" always assume the ship to be closest to danger.
- (7) Always keep the chart dry. Keep bottles and pens away from the chart. Use soft black pencils and soft erasers. Never use copying pencils.

LARGEST SCALE CHART ALWAYS TO BE USED

The large scale charts show in greater detail all the useful information required by a mariner. These charts are always corrected first and it may happen that a large scale chart of a particular locality may have received corrections of coastline and water-work from a major new survey.

CAUTION IN USING SMALL SCALE CHARTS

Whenever approaching the land or dangerous banks, only large scale charts should be used. A small error in laying down a position on a large scale chart means a few metres difference; while on a small scale chart, a small error may mean difference of a few cables or a mile.

THE INTERNATIONAL HYDROGRAPHIC ORGANISATION

The first International Hydrographic conference was held at London in 1919 and it was attended by 24 nations only. At the end of this conference it was agreed that a permanent organisation should be established, firstly for the purpose of carrying through the decisions taken and secondly for maintaining close liaison among the various Hydrographic offices.

The International Hydrographic Bureau started at Monaco in 1921, with 19 member countries. The Hydrogra-

phic conferences were held nearly every 5th year. In 1967, a convention was adopted with the aim of establishing the Bureau as Intergovernmental Organisation. This convention came into force in 1970 and since then the new title "The International Hydrographic Organisation" came into effect.

The organisation's principal objective, as stated in the convention are: -

- (1) The Co-ordination of the activities of national Hydrographic offices.
- (2) The greatest possible uniformity in nautical charts and documents.
- (3) The adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys.
- (4) The development of the sciences in the field of Hydrography and techniques employed in descriptive Oceanography.

There are lots of useful hydrographic publications published by this organisation.



CHAPTER III

MISCELLANEOUS ADMIRALTY PUBLICATIONS

ADMIRALTY NOTICES TO MARINERS

Notices to Mariners, which contain important information for the mariners, are issued by the Hydrographic Department of the British Admiralty.

In India also, the Hydrographic Department of the Indian Navy, at Dehra Dun issues the Notices to Mariners.

The “Notices to Mariner” enable a navigator to keep his charts and other books corrected for the latest information. They are published in Weekly Editions. These Notices and Weekly editions are numbered consecutively, commencing at the beginning of each year. However, the Notices to Mariners issued by the Indian Hydrographic Department are issued once every fortnight.

Temporary & Preliminary Notices have their consecutive number prefixed by (T) & (P) respectively.

The Symbol * when it appears in the Notices to Mariners of the British Admiralty means that the notice is based on original information as opposed to one that republishes information from another country. Obviously, almost all notices pertaining to the English coast would bear * mark.

The Weekly Editions of the Notices to Mariner can be obtained gratis from the Admiralty chart agents and depots, Mercantile Marine Department, Customs House and Shipping offices.

WEEKLY EDITIONS

Each Weekly edition of the Notices to Mariners contains the following six sections :-

- (1) Index.

- (2) Admiralty Notices to Mariners.
- (3) Navigation Warnings.
- (4) Amendments to CHINPACS (China Sea, Indian & Pacific Oceans) and the Notice in the Annual Summary of Notices to Mariners relating to these publications.
- (5) Corrections to Admiralty List of Lights.
- (6) Correction to Admiralty List of Radio Signals.

NO. 1 WEEKLY EDITION

No. 1 weekly edition published at the beginning of every year is different from the typical Weekly Edition described above.

It contains in a consolidated form, the information of important and permanent nature. The topics covered are as under :-

- (1) Admiralty Tide Tables.
- (2) Admiralty Agents for the sale of Charts, etc.
- (3) Official Radio Messages to U.K. Registered Merchant Ships. "The GBMS Organization".
- (3A) Official Messages to U.K. Registered Merchant Ships. (Small Craft and Fishing Vessels).
- (3B) Official Radio Message—The Merchant System.
- (4) Distress and Rescue at Sea—Ships and Aircraft.
- (4A) Distress and Rescue—Indian and S.W. Pacific Oceans—Ships' position Reports.
- (4B) The AMVER Organisation (Automated Mutual-Assistance Vessels Rescue System).
- (5) Firing Practice and Exercise Areas.
- (6) Areas Dangerous due to Mines, Swept Routes and Instructions regarding Explosives picked up at Sea.
- (7) British Merchant Ships—Use of Radar in time of Emergency or War
- (8) Information concerning Submarines.
- (9) British Isles—Warnings Broadcast by Coast Radio Stations.
- (10) Minelaying and Mine Countermeasures Exercises—North Sea, English Channel and waters around the British Isles.

- (11) North Atlantic and North Pacific Oceans—Ocean Weather ships.
- (12) Territorial Waters and Fisheries Jurisdiction Claims.
- (13) Radio Navigational Warnings.
- (14) Availability of Notices to Mariners and Chinpacs Route-Book.
- (15) Under-Keel Clearance—Reliance on Charts and Predicted Tides.
- (16) Protection of Historic and Dangerous Wreck Sites.
- (17) Traffic Separation Schemes.

ANNUAL EDITION OF THE INDIAN NOTICES TO MARINERS

The Indian Hydrographic Department also publishes similar Annual Edition of Notices to Mariners in the beginning of each year, the contents of which are as follows :—

- (1) General Notice.
- (2) Availability of Notices to Mariners.
- (3) Under-Keel Clearance—Reliance on Chart & Predicted Tides.
- (4) Caution when approaching Indian Ports.
- (4A) Andaman and Nicobar Islands—Restrictions.
- (5) Weather bulletins issued to ships by the India Meteorological Department.
- (6) List of Storm Signal Stations.
- (7) Distress and Rescue at Sea—Ships and Aircraft.
- (8) Firing Practice and Exercise Areas.
- (9) Caution with regard to Ships Approaching Squadrons.
- (10) Information concerning Submarines.
- (11) Radio Navigational Warnings.
- (12) Long Range (H/F) Radiotelegraphy Service for Indian Merchant Ships in Area IN.
- (13) Submarine Cables.
- (14) Indian Merchant Ships—Use of Radar in time of War.
- (15) Reports of Shoals obtained by Echo Sounding—Instructions.

- (16) Decca Naviagtor System.
- (17) The International Hydrographic Organisation.
- (18) Information about Radar Responder Beacon.
- (19) List of Charts published by Naval Hydrographic office.
- (20) List of up-to-date Corrections to Charts.

List of Temporary and Preliminary Notices in force on 31st December.

ADMIRALTY PUBLICATIONS & BOOKS

SAILING DIRECTIONS

Sailing Directions or generally known as PILOT Books are also issued by the British Admiralty.

Indian Hydrographer also issues similar Sailing Directions for Indian waters.

The Sailing Directions amplify the information given on charts and also give other useful guidance to the mariners for approaching the ports and harbours.

The whole world is covered by approximately 75 volumes of the Sailing Directions, numbered consecutively. A new volume is republished at intervals of about 12 years and between the editions, it is kept upto date by means of successive supplements every 18 months. Whenever a new supplement is published, the previous one is cancelled. The supplement must be referred to, when consulting Sailing Directions.

A small number of Notices to Mariners are also published each year to correct Sailing Directions.

The limit of the area covered in each Sailing Directions is shown in the Chart Catalogue.

ADMIRALTY LIST OF LIGHTS

Admiralty List of Lights and Fog Signals, usually termed as "Admiralty List of Lights" give details of lights, light structure, and fog Signals available throughout the world. There are 12 volumes, numbered alphabetically, covering the whole world and the limits of each is shown in the Chart Catalogue.

Details of light vessels, light floats and light buoys, exhibiting lights at elevations exceeding 6 metres are also included in the "Lists".

A new volume of "List of Lights" is published every 18 months approximately and during this time, it should be kept corrected from section V of the Weekly Editions of Notices to Mariners.

ADMIRALTY LIST OF RADIO SIGNALS

Admiralty List of Radio Signals are published in six volumes as follows:—

VOLUME I (COMMUNICATIONS)

This Volume contains particulars of Coast Radio Stations, Distress and Rescue procedure, Medical advice by Radio, and the AMVER Organisation, Regulations for the use of Radio in Territorial waters, Arrangement for Quarantine Reports, Locust Reports and a brief extract from International Radio Regulations.

VOLUME II (NAVIGATIONAL AIDS)

This Volume contains particulars of Radio Direction finding Stations, Radio Beacons, Calibration Stations, coast Radar Stations providing navigational assistance and Radio Stations which give "Q T G" services etc.

VOLUME III (METEOROLOGICAL SERVICES)

This Volume contains particulars of Radio weather messages and certain meteorological codes provided for the use of shipping.

VOLUME IV (METEOROLOGICAL OBSERVATION STATIONS)

This Volume contains the list of Meteorological Observation Stations of the world.

VOLUME V (MISCELLANEOUS SERVICES)

This Volume contains particulars of Radio Time Signals, Standard Times, Radio Navigational Warn-

ings and Position fixing systems (Decca, Consol, Loran).

VOLUME VI (PORT RADIO STATIONS AND PILOT VESSELS)

This Volume contains particulars of Stations Working in the Port operations and information services.

These services, concerned with the critical initial and terminal stages of voyages, are designed to assist vessels requiring pilots, to regulate port entries and departures, to aid the berthings etc., to provide ship/agent liaison facilities, to control the safe flow of traffic in busy waterways, to broadcast routine and urgent information and in emergencies to co-ordinate safety and rescue operations in their respective spheres of operations.

ADMIRALTY TIDE TABLES

Admiralty Tide Tables are issued annually in three Volumes :--

VOLUME I

European Waters (including Mediterranean Sea).

VOLUME II

Atlantic and Indian Oceans.

VOLUME III

Pacific Ocean & Adjacent Seas.

Each Volume is divided into 2 parts. Part I gives daily predictions of times and heights of high water and low water for a selected number of ports, known as "Standard Ports".

Part II gives data for predictions of the rest of the ports known as "Secondary Ports".

The Indian Hydrographic Department at Dehra Dun also issues one volume of Tide Tables known as "The Indian Ocean Tide Tables".

OCEAN PASSAGES OF THE WORLD

The British Admiralty also issues "Ocean Passages of the World" which helps the mariner to plan his passage across the oceans. It gives recommended routes and distances between various ports of the world, with the details of wind, current data and ice hazards.

ADMIRALTY CHART CATALOGUE

Admiralty chart catalogue is issued annually by the Admiralty and gives the numbers etc. of the charts published, and the area the chart covers. It also gives area covered by each of the "Sailing Directions" and the List of Lights.

The Indian Hydrographic Department at Dehra Dun also issues similar Chart Catalogue.



CHAPTER IV

TO FIND POSITION, COURSE AND DISTANCE

[English Channel (Eastern Portion) Chart B.A. No. 2675]

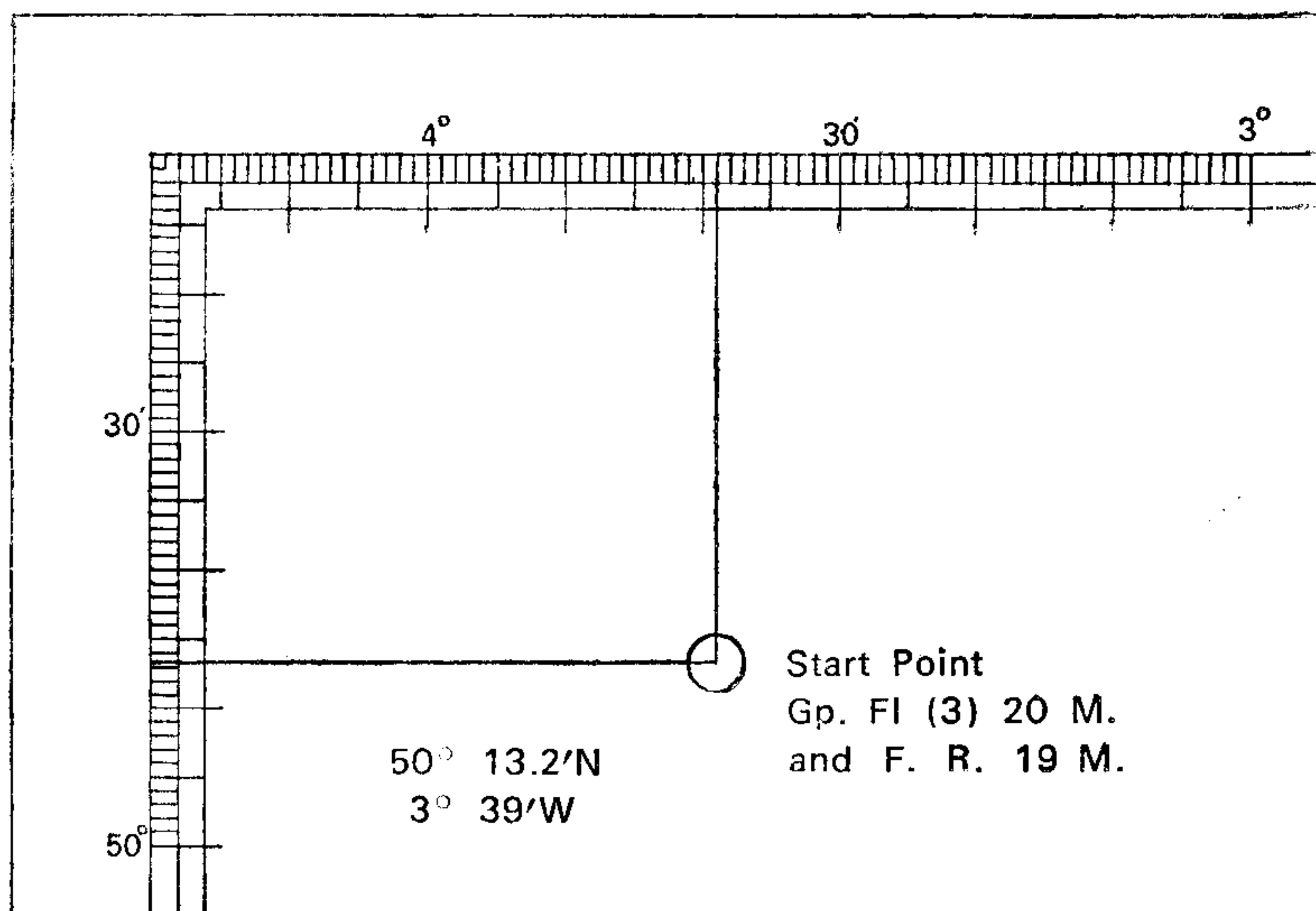
Position :

A Position on a chart may be stated in one of the two ways:

- (a) By the Latitude and Longitude.
- (b) With reference to another position i.e. by giving the bearing and distance of, or from, that position.

Example 1.

To find the Latitude and Longitude of Start Point Light house.



(1) To find the Latitude.

Place the parallel ruler on the chart with one edge set along a parallel of Latitude. Carefully open/roll parallel ruler out until one edge passes through the required position. Where this edge (or the continuation of this edge) cuts the scale of Latitude, at the side of the chart, read off the Latitude of the light house i.e. $50^{\circ} 13.2'$ North.

(2) To find the Longitude

Place the parallel ruler on the chart with one edge set along a meridian. Carefully open/roll parallel ruler out until one edge passes through the required position. Where this edge (or the continuation of this edge) cuts the scale of Longitude at the top or bottom of the chart, read off the Longitude of the Lighthouse i.e. $3^{\circ} 39'$ West.

Hence Position of Start Point Lighthouse :—
Lat $50^{\circ} 13.2'$ North Long. $03^{\circ} 39'$ West.

NOTE : A position is always given by the Latitude first then the Longitude.

SECOND METHOD

Dividers may also be used to find the Latitude and Longitude. This is done by measuring the perpendicular distance between the nearest parallel of latitude or longitude (meridian) and the required position and transferring these measurements to the appropriate latitude and longitude scale.

Exercise :

Find the Latitude and Longitude of the following positions on the chart.

- | | |
|-----------------------------|-------------------------|
| (1) Bill of Portland Lt. Ho | (2) Anvil Point Lt. Ho. |
| (3) Les Sept. Iles Lt. | (4) Casquets Lt. Ho. |
| (5) Pte de Barfleur Lt. Ho. | (6) Beachy Head Lt. Ho. |
| (7) C. d' Antifer Lt. Ho. | (8) Dungeness Lt. Ho. |

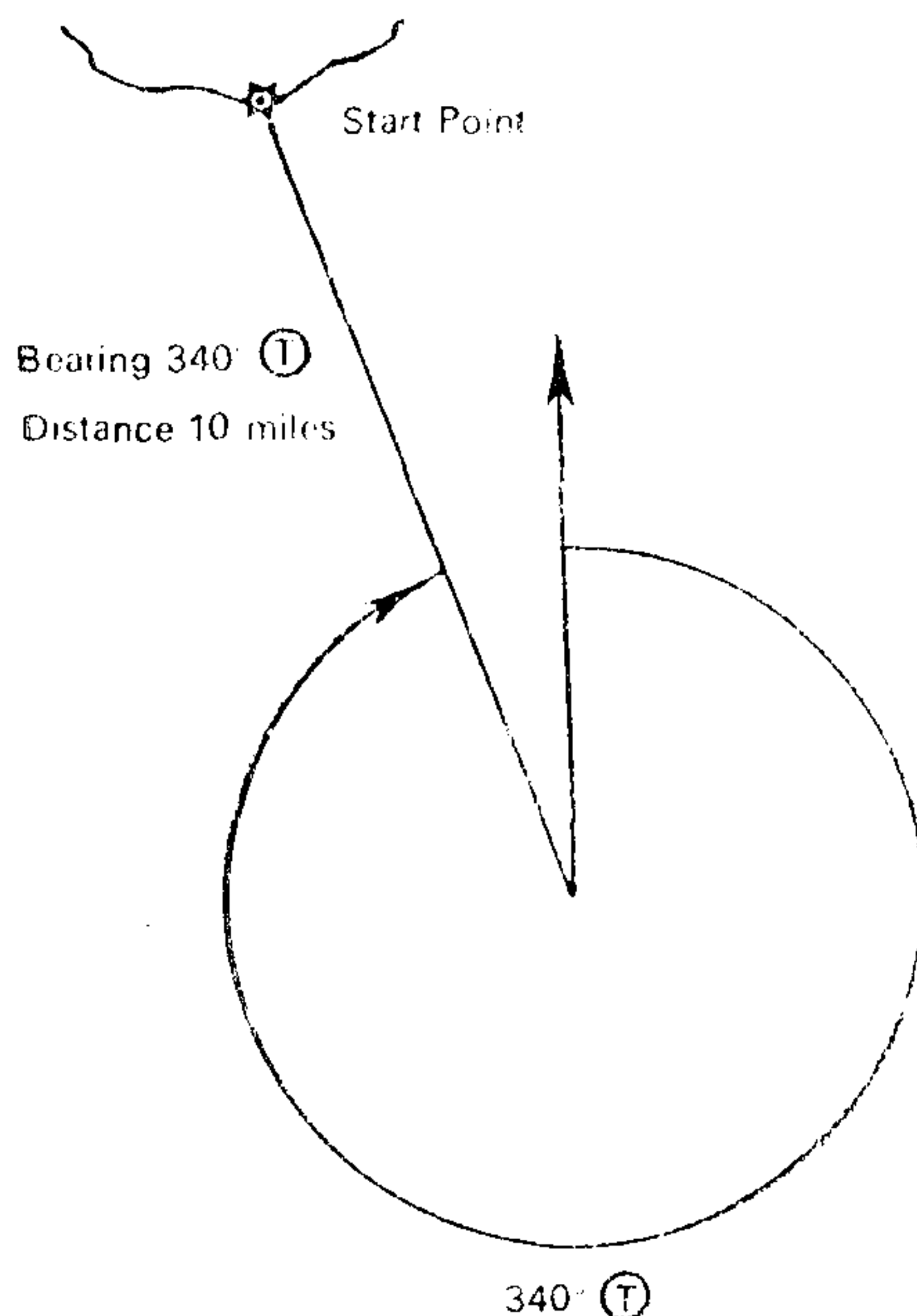
Answers :

- (1) Lat. $50^{\circ} 31' N$ Long. $02^{\circ} 27.5' W$ (2) Lat. $50^{\circ} 35.8' N$ Long. $01^{\circ} 57.7' W$
 (3) „ $48^{\circ} 52.8' N$ „ $03^{\circ} 29.4' W$ (4) „ $49^{\circ} 43' N$ „ $02^{\circ} 22.7' W$
 (5) „ $49^{\circ} 41.4' N$ „ $01^{\circ} 16.0' W$ (6) „ $50^{\circ} 44.4' N$ „ $00^{\circ} 14.5' W$
 (7) „ $49^{\circ} 41.1' N$ „ $00^{\circ} 10' E$ (8) „ $50^{\circ} 55' N$ „ $00^{\circ} 59' E$

POSITIONS BY BEARING AND DISTANCE

A Position can also be indicated or found by a bearing from a lighthouse (or a navigational mark) and the distance from the light house :—

Example : A vessel is in position with Start Point Lt. Ho. bearing 340° (T) distance 10 miles off. Find the ship's position in terms of Latitude and Longitude.



(1) To lay off true bearing :—

Place the parallel ruler on the nearest compass rose in such a manner that one edge passes through the exact centre of the compass rose and the required true bearing i.e. 340° in this case. Transfer the parallel ruler until one edge passes through the point of which bearing is given (Start Point in this case) and draw a line through this position. This is the required bearing.

(2) Set the divider apart to the given distance (i.e. 10 miles in this case) and cut off the same along this line of bearing from the point reference (Start Point in this case). This will give the required position.

Answer :

Latitude $50^{\circ} 04'N$ Longitude $03^{\circ} 32.7'W$

Exercise :

A vessel is in position with Pte. D'Ailly light bearing 128° (T) distance 12 miles off. Find the ship's position in terms of Latitude and Longitude.

Answer :

Latitude $50^{\circ} 02.8'N$ Longitude $00^{\circ} 43'E$

Exercise :

A vessel is in position with Le Havre Lt. vessel bearing 115° (T) distance 9 miles off. Find the ship's position in terms of Latitude and Longitude.

Answer :

Latitude $49^{\circ} 36'N$ Longitude $00^{\circ} 21.5'W$

Exercise :

A vessel is in position with Roches Douvres Lt. bearing 076° (T) distance 10 miles. Find the ship's position in terms of Latitude and Longitude.

Answer :

Latitude $49^{\circ} 3.9'N$ Longitude $03^{\circ} 04'W$

THE COURSE AND DISTANCE

Example :

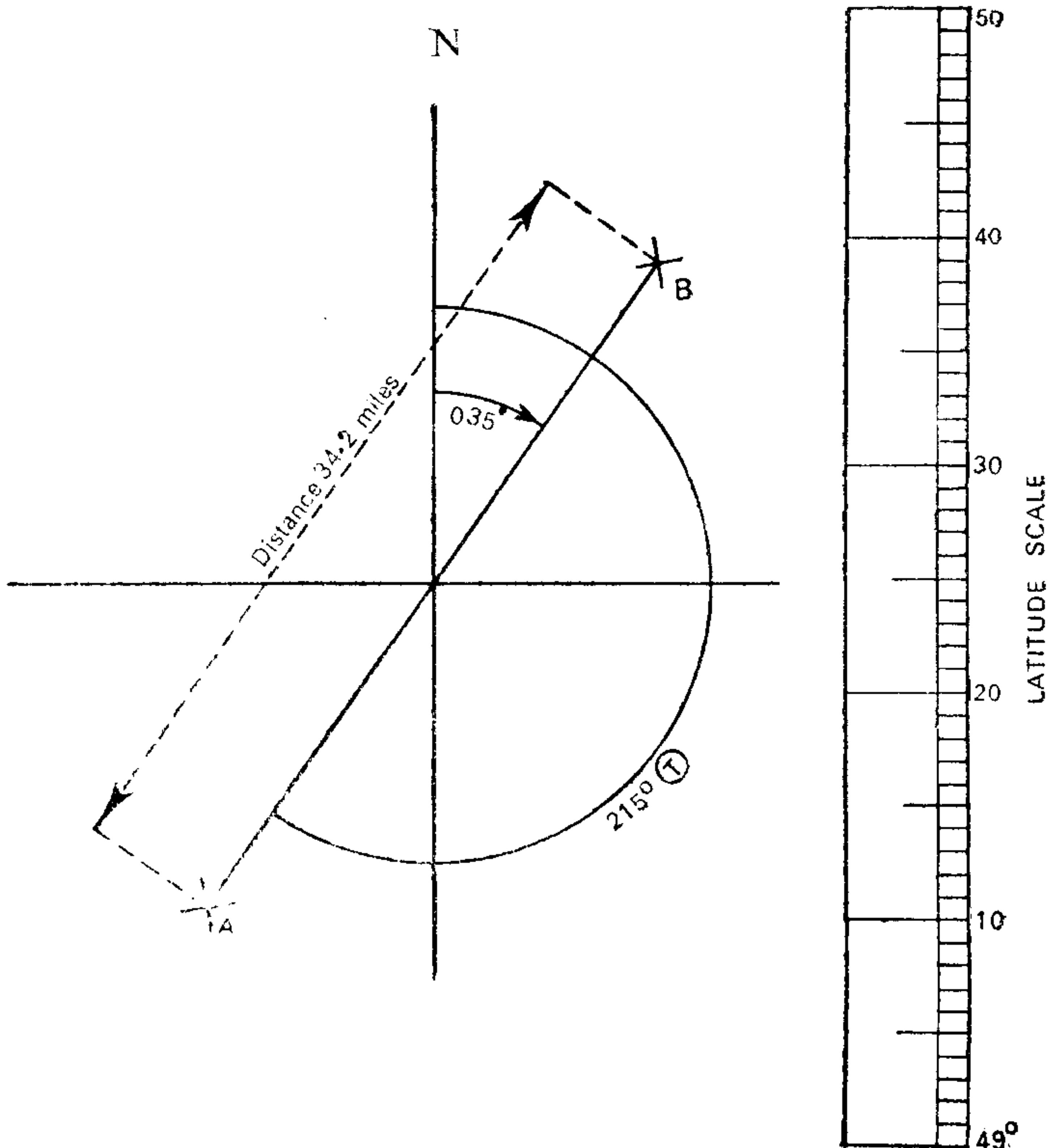
Find the true course and distance from position (A)

Lat. $49^{\circ} 05'N$ Long: $03^{\circ} 40'W$ to a Position (B)

Lat. $49^{\circ} 33'N$ Long: $03^{\circ} 09'W$.

SOLUTION

- (1) Plot the two positions on the chart, using the reverse procedure to that given in the previous Example.
- (2) Join the two positions by a straight line; the direction of this line represents the course and the length of the line is the distance between two positions.



(3) To find the true course :

(a) **First Method :**

Set the edge of the parallel ruler along the course line and carefully transfer them to the nearest compass rose, placing one edge through the exact centre of the rose. Read off the true direction from the compass rose, taking care not to read off the reciprocal course (i.e. 180° away) (True direction or the course being from starting position towards the destination).

(b) **Second Method :**

The angle that the course line makes with the meridian, measured in a clock wise direction from north and given in the three figure notation, is the true course i.e. 035° (T). If the true course was required from position (B) to (A), it would be 215° (T) .

(4) To Find the Distance :—

One nautical mile is equal to one minute of the arc on the latitude scale. Using the dividers and the scale of the latitude between two positions, measure the distance i.e. 34.2 miles.

The distance between any two positions must be measured in the region of the mean latitude between these positions. When large distances are involved, set the dividers to a convenient distance e.g. 10 miles, or 20 miles along the mean Latitude; step off along the course line making a note of the number of steps taken, measuring the final portion of a step separately.

Answer :

True Course 035° (T) Distance 34.2 Miles.

Exercise I.

Plot the following positions on the chart and find the true course and distance between the two points:—

- (a) From Lat. $49^{\circ} 50'N$ Long. $02^{\circ} 04'W$
to Lat. $49^{\circ} 46'N$ Long. $01^{\circ} 06'W$
- (b) From Lat. $49^{\circ} 43'N$ Long. $00^{\circ} 02'W$
to Lat. $50^{\circ} 27'N$ Long. $00^{\circ} 56'E$
- (c) From Lat. $50^{\circ} 39'N$ Long. $00^{\circ} 35'E$
to Lat. $50^{\circ} 32'N$ Long. $00^{\circ} 57'W$

Answer :

- (a) Course 096° (T) Distance 37.8 Miles.
- (b) Course 040° (T) Distance 57.5 Miles.
- (c) Course 263° (T) Distance 58 Miles.

Exercise II.

A vessel started from a position in Lat. $49^{\circ} 42'N$ Long. $00^{\circ} 57'W$ and steered true course 066° (T) for a distance of 48 miles. Find the position reached.

Answer :

Latitude $50^{\circ} 02'N$ Longitude $00^{\circ} 11'E$

Exercise III.

A vessel is in a position Lat. $50^{\circ}04'N$ Long. $03^{\circ}40'W$ and steers a true course of $072^{\circ}(T)$ for a distance of 56 miles. Find the position reached.

Answer :

Latitude $50^{\circ}21.2'N$ Longitude $02^{\circ}16'W$

Exercise IV.

A vessel is in a position, Latitude $49^{\circ}44'N$ Longitude. $01^{\circ}17'W$ and steers a true course of $117^{\circ}(T)$ for a distance of 39 miles. Find the position reached.

Answer :

Latitude $49^{\circ}26'N$ Longitude $00^{\circ}23'W$



CHAPTER V

FIXING SHIP'S POSITION

[English Channel (Eastern Portion) Chart B.A. No. 2675]

A ship's position during a voyage has to be ascertained, at short intervals, in order to maintain the ship on the course line laid on the chart. This can be done by observation of terrestrial objects.

A Position Line

A position line is a line drawn on a chart, on which the position of the ship is known to be. Hence bearing is also a position line.

A FIX

The intersection of the two or more position lines, which have been obtained at the same time will give the position of ship.

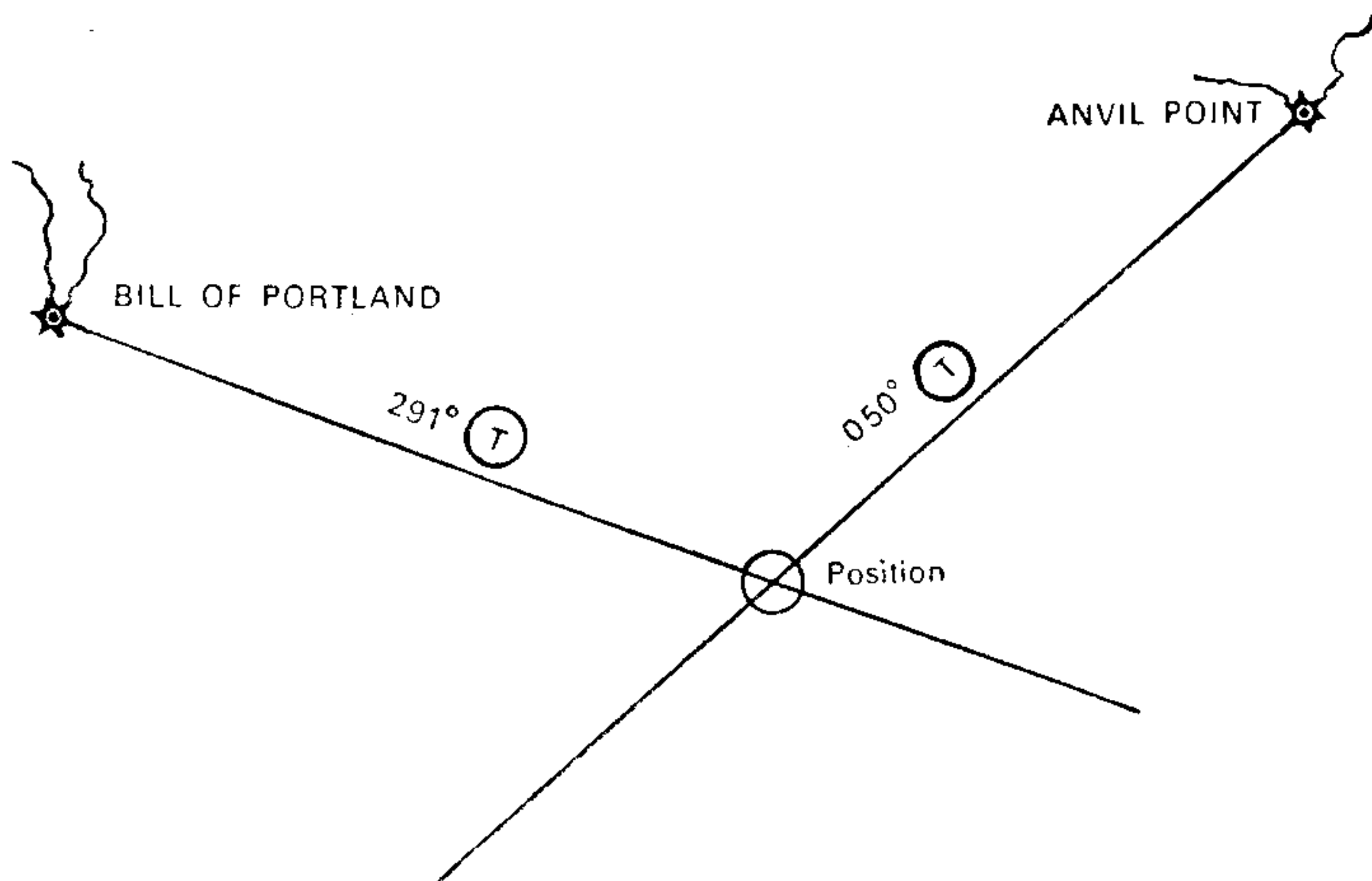
VARIOUS METHODS OF OBTAINING A POSITION LINE

- (1) A visual bearing of a terrestrial object.
- (2) A transit bearing. (Two Terrestrial objects in a line).
- (3) A radio bearing of a radio D.F. beacon.
- (4) A circle of position obtained from a vertical sextant angle.
- (5) A circle of position obtained from a horizontal (sextant) angle.
- (6) An observation of a celestial body giving the position line.

POSITION BY CROSS BEARINGS

Example I.

A ship steering 085° (T) Anvil Point Lt. Ho. bore 050° (T) and Bill of Portland Lt. Ho. bore 291° (T). Find the ship's position.



SOLUTION

Lay 050° (T) bearing from Anvil Point Light (as explained earlier).

Similarly lay 291° (T) bearing line from Bill of Portland Light.

The point where the two lines intersect is the position of the ship.

Now read off the position in terms of Latitude and Longitude as explained earlier.

Position of the ship :—

Latitude $50^\circ 27'N$ Longitude $02^\circ 13.2'W$

Exercise I.

A ship steering 255° (C), at 2100 hrs. St. Catherine Point Lt. bore 285° (T) and Nab Tower bore 000° (T). Find the ship's position at 2100 hrs.

Answer :

Ship's Position at 2100 hrs :—

Lat. $50^\circ 31.2'N$ Long. $00^\circ 57.3'W$

Exercise II.

- (a) At 1800 hrs. Beachy Head Light bore 335° (T) and Royal Sovereign Lt. vessel bore 045° (T). Find the Ship's Position.

- (b) From the Position obtained at 1800 hours, find the true course and distance to a point 9 miles due South of Nab Tower.
- (c) Find also the Position 9 miles due South of Nab Tower.

Answer :

- (a) Position at 1800 hours :—
Lat. $50^{\circ} 38.2'N$ Long. $00^{\circ} 19'E$
- (b) True course $262^{\circ} (T)$ Distance 48.4 Miles.
- (c) Position off Nab Tower :—
Lat. $50^{\circ} 31.2'N$ Long. $00^{\circ} 57.3'W$

Exercise III.

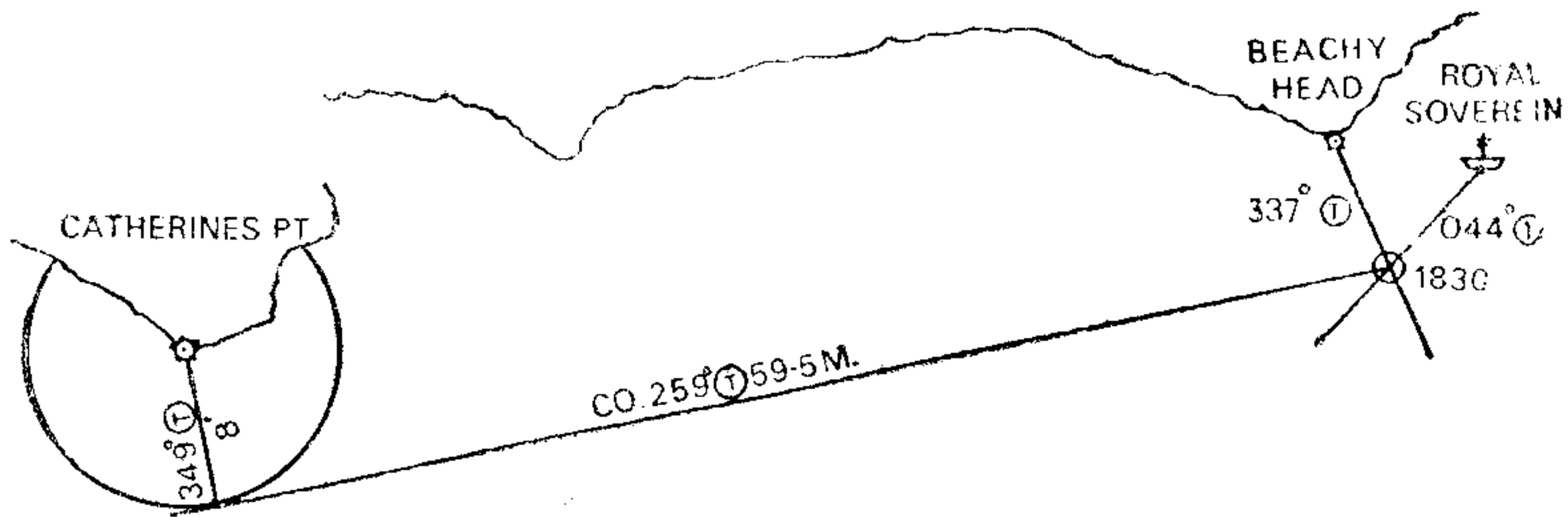
- (a) At 2000 hours, Le Havre Lt. Vessel bore $187^{\circ} (T)$ and C. d'Antifer Lt. bore $101^{\circ} (T)$. Find the ship's position.
- (b) From the position at 2000 hrs. obtained in (a), find the true course and distance to a position with Pte. d'Ailly Lt. bearing $128^{\circ} (T)$ 12 miles off.
- (c) Find the position off Pte. d'Ailly light.

Answer :

- (a) Position at 2000 hrs. Lat. $49^{\circ} 43.5'N$ Long. $00^{\circ} 07'W$
- (b) True course $059^{\circ} (T)$ Distance 38 miles.
- (c) Position off Pte. d'Ailly Lt. :—
Lat. $50^{\circ} 03'N$ Long. $00^{\circ} 43'E$

Example II.

- (a) From vessel steering $270^{\circ} (T)$, at 1830 hrs. Royal Sovereign Lt. Vessel bore $044^{\circ} (T)$ and Beachy Head Light bore $337^{\circ} (T)$. Find the ship's position.
- (b) From the position obtained at 1830 hrs. find the true course to steer to pass St. Catherine Point Light 8 miles off when abeam to starboard.
- (c) Find the time when St. Catherine Pt. Light will be abeam, if ship's speed was 12 knots?



SOLUTION

- (a) To find ship's position at 1830 hrs.
Draw a line with Royal Sovereign Lt. Vessel bearing 044° (T) and Beachy Head light bearing 337° (T) and where the two bearings intersect is the position of the ship at 1830 hrs. Ship's position at 1830 hrs. :—

Lat. $50^\circ 38'N$ Long. $00^\circ 19'E$

- (b) To find true course to pass 8 miles off St. Catherine Point when abeam.

With St. Catherine Pt. Lt. as centre and 8 miles as a radius, draw a circle.

From 1830 hrs. position draw a tangent to this circle then this tangent will be the true course to steer.

True course to steer 259° (T).

- (c) Beam bearing off St. Catherine Pt. $259^\circ + 90^\circ = 349^\circ$ (T)
Draw the beam bearing i.e. 349° from St. Catherine Pt. The point where the above bearing cuts the course steered is the position when St. Catherine Pt. Lt. will be abeam.

Measure the distance from 1830 hrs. to this position.
Distance is 59.5 Miles.

Now calculate the time taken to cover 59.5 Miles at 12 knots.

The Ship will arrive at this position at 2328 hours.

NOTE :

Beam bearing is ALWAYS on the course steered i.e.
Course steered $\pm 90^\circ$

Exercise IV.

- (a) At 0300 hrs. Le Havre Lt. vessel bore 185° (T) and C. d'Antifer Light bore 078° (T). Find the ship's position.
- (b) From the position at 0300 hrs. find the true course to steer to pass Pte. de Barfleur Lt. 10 Miles off when abeam to port.
- (c) Find the time when Pte. de Barfleur light will be abeam, if ship's speed was 13 knots.

Answer :

- (a) Position at 0300 hrs. Lat. $49^{\circ} 39'N$ Long. $00^{\circ}09'W$
- (b) True Course to steer 288° (T)
- (c) Beam bearing of Pte. de Barfleur Lt. 198° (T)

Distance is 42 miles.

The ship will arrive beam bearing position at 0613 hours.



CHAPTER VI

THE VARIATION, DEVIATION, MAGNETIC AND THE COMPASS COURSE

TRUE MERIDIAN

A true meridian is a great circle, passing through the geographical North and South Poles of the earth and cutting the Equator at right angles.

MAGNETIC MERIDIAN

Magnetic meridian is a great circle passing through the magnetic North and South Poles of the earth.

It is the direction in which a magnetic needle lies when freely suspended, and acting under the influence of the earth's magnetism only.

VARIATION

Variation is the angle between the true and the magnetic meridian that is to say, the angle which the freely suspended magnetic needle makes with the true meridian.

If the magnetic needle is drawn to the right of the true meridian, the Variation is said to be **EASTERLY** and if the magnetic needle is drawn to the left of the true meridian, the Variation is termed **WESTERLY**.

Variation differs from place to place but is constant for different ship's head i.e. it does not vary with the course of the ship.

DEVIATION

Due to the earth's magnetism, the vessel, which is built mainly of steel, also acquires a certain amount of magnetism and thus the compass needle of the ship does not lie in the magnetic meridian, but may be deflected to one side

or the other from it. The angle which the compass needle makes with the magnetic meridian, is known as the "Deviation."

If the compass needle is drawn to the right of the magnetic meridian, the deviation is called Easterly and if the compass needle is drawn to the left of the magnetic meridian, the deviation is called Westerly.

The deviation varies in name and amount, as the ship's head turns in azimuth.

The value of the deviation, on the different courses or ship's head, usually 10° apart, are ascertained by the observations and a table called "Deviation Card" is drawn up. This Deviation Card is usually kept pasted at a conspicuous place in the Chart Room. A few typical Deviation Cards are shown at the end of this book and these cards will be used in the questions given in this book.

It may, however, be mentioned that the Deviations of the magnitude shown in these tables seldom exist on board a ship as these Deviation Cards have been prepared specifically so that the navigator is made fully conversant with the correct application of this error.

COMPASS ERROR

The resultant of the variation and the deviation is called the compass error. Compass error thus is the angle between the compass needle on board the ship and the true meridian and is computed by finding the algebraic sum of the Variation and Deviation.

If both Variation and the Deviaton are of the same name then add the two and give the same name to the compass error; and if different in names, subtract the two and give the name of the higher quantity.

Example :

- (a) If Variation is 8°W and Deviation for the ship's head is 4°W , then the compass error will be 12°W .
- (b) If Variation was 6°E and Deviation for the ship's head was 3°W , then the compass error will be 3°E .
- (c) If Variation is 7°W and Deviation is 12°E , then the compass error will be 5°E .

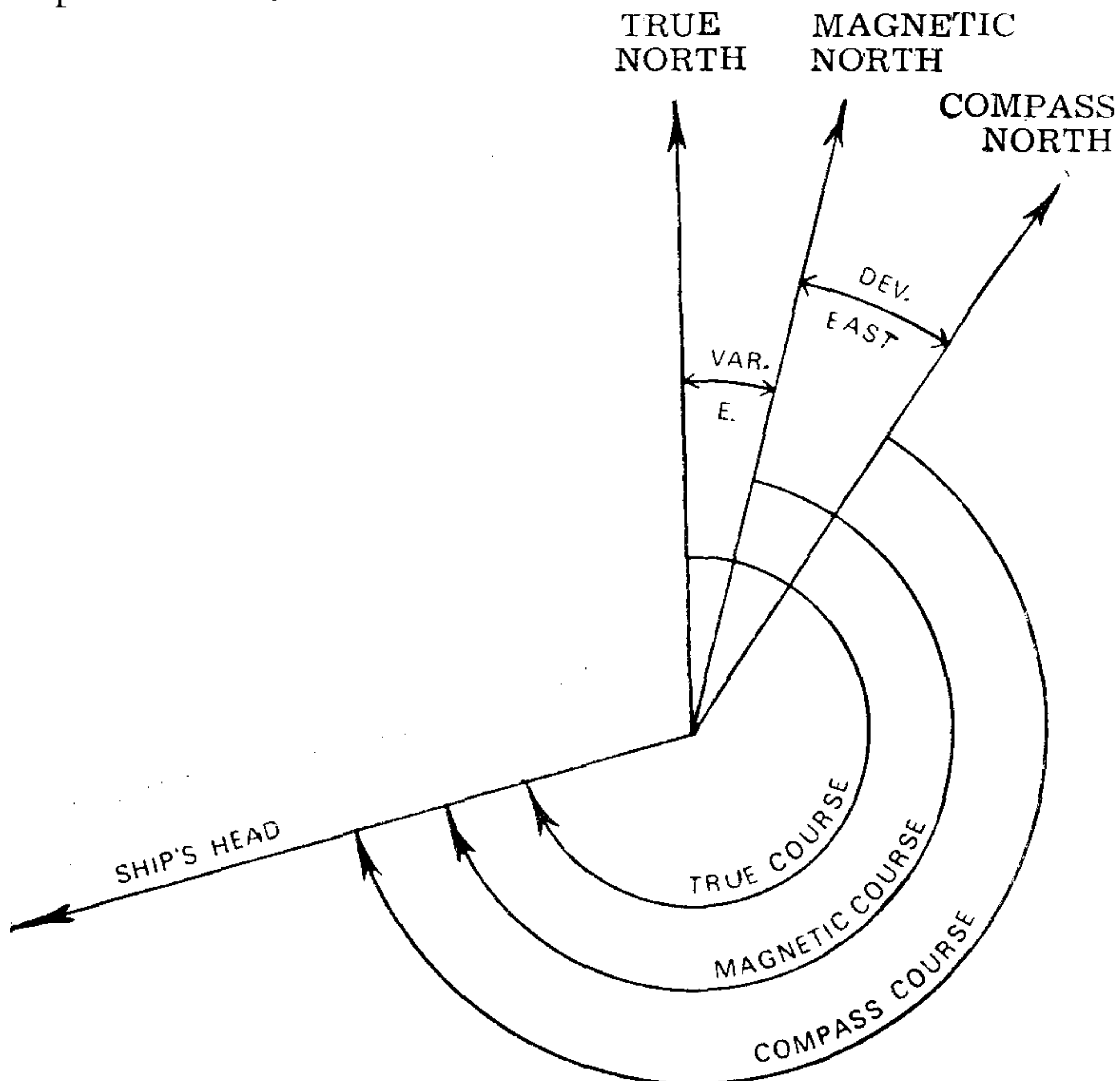
TO CONVERT COMPASS COURSES TO MAGNETIC COURSES AND VICE VERSA

To convert compass course into magnetic course, it is only necessary to apply the Deviation.

If the deviation is Easterly, it means that the compass needle has been drawn to the Eastward or to the right of the magnetic meridian and if the deviation is Westerly, the compass needle has been drawn to the Westwards or to the left of the magnetic meridian.

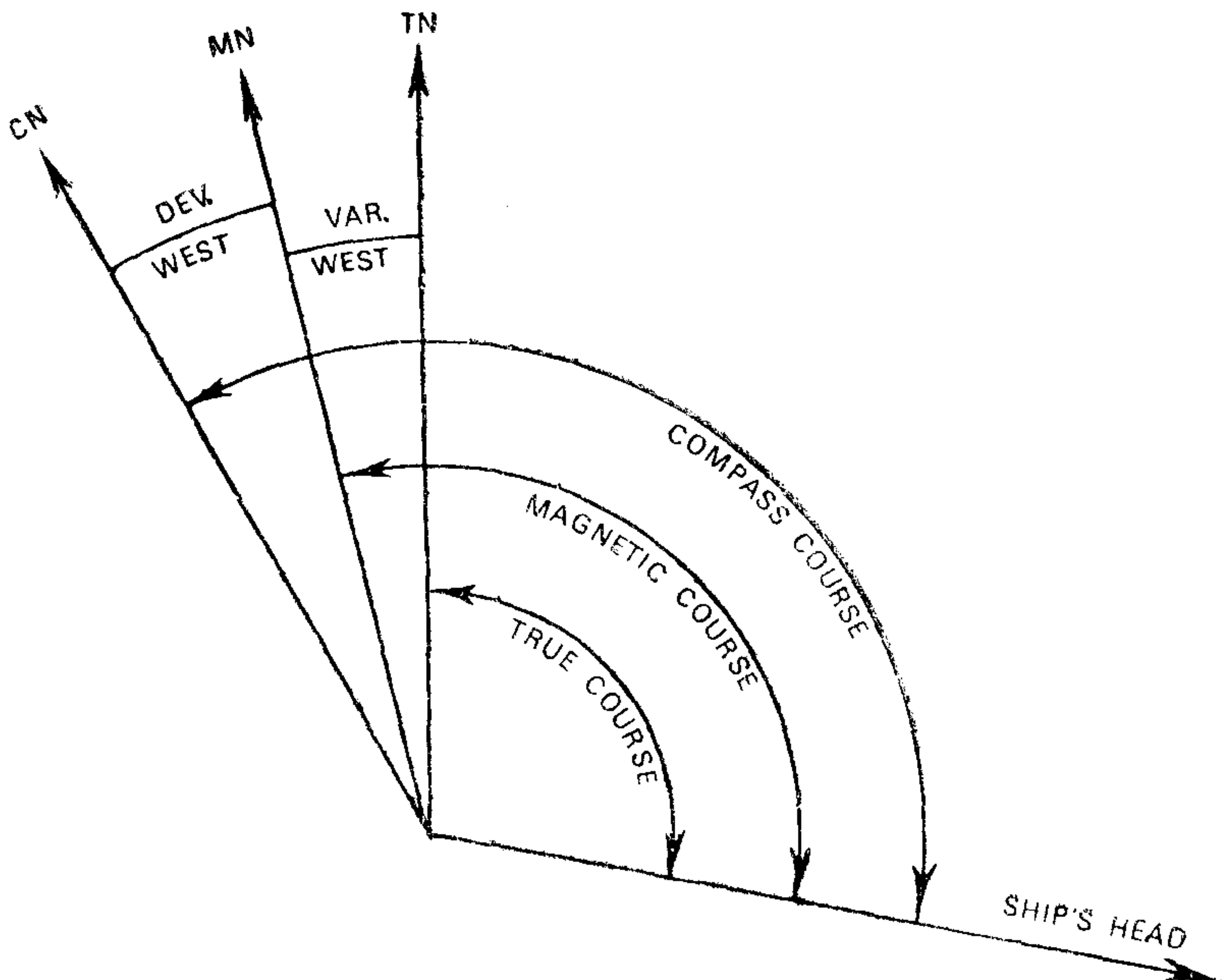
Now consider a compass affected by Easterly deviation, the "Compass North" will be to the right of the "Magnetic North" and therefore the compass course will be less than the magnetic course.

So in order to convert compass course to magnetic course, the navigator has to add the Easterly deviation, because the magnetic course will read more than the compass course.



Now consider a compass affected by the Westerly deviation, the "Compass North" will be to the left of the "Magnetic North", so the compass course will be more than the magnetic course or in other words the magnetic course will be less than the Compass course.

So in order to convert Compass course to Magnetic course the navigator has to subtract the Westerly deviation.



NOTE: COMPASS COURSE TO MAGNETIC COURSE
EASTERLY ADD AND WESTERLY SUBTRACT.

Example 1.

Given Compass course 035° (C) Deviation 6° E. Find the Magnetic course.

Compass course 035° (C)

Deviation 6° E

Magnetic course 041° (M)

Example 2.

Given Compass course 185° (C) Deviation 3° W. Find the Magnetic course.

Compass course	185° (C)
Deviation	3° W
Magnetic course	182° (M)

Example 3.

Given Magnetic course 300° (M) and Deviation 8° E, find the Compass course.

Magnetic course	300° (M)
Deviation	8° E
Compass course	292° (C)

Example 4.

Given Magnetic course 160° (M) and Deviation 5° W, find the Compass course.

Magnetic course	160° (M)
Deviation	5° W
Compass course	165° (C)

TO CONVERT MAGNETIC COURSE TO TRUE COURSE AND VICE VERSA

The convert Magnetic courses to True courses, it is only necessary to apply the variation, which is usually given in the question itself.

However, in practical chart work, the variation can be obtained from the chart itself (it is shown in the Compass rose). When taking off the variation from the chart, always use the variation shown on the compass rose nearest to the position of the ship.

It may be noted that the magnetic course is converted to the true course in accordance with the same rule as stated earlier in the case of conversion of Compass course to Magnetic course.

MAGNETIC COURSE TO TRUE COURSE EASTERLY ADD and WESTERLY SUBTRACT

Example :

Given Magnetic course of 050° (M) and Variation 8° E, find the true course.

Magnetic course 050° (M)

Variation 8° E

True Course 058° (T)

Example :

Given a true course of 310° (T) Variation of 6° East, find the Magnetic course?

True course 310° (T)

Variation 6° E

Magnetic course 304° (M)

TO CONVERT COMPASS COURSE TO TRUE COURSE

In many cases, the direction of the ship's head by compass is given, and therefore it is necessary to apply the compass error (Deviation and Variation) before the course can be laid on the chart. It must always be remembered that only True courses and bearings are laid on the chart.

The deviation is easily obtained from the Deviation Card and if need be, the deviation for a particular ship's head is interpolated between the two ship's head nearest to the course in question. For example if the Deviation for 035° (C) is required, then we find (from the Deviation Card I) that when ship's head by compass is 030° (C) Deviation is 7° W and when ship's head by compass is 040° (C) Deviation is 9° W.

Hence for ship's head by compass 035° (C) Deviation is 8° W.

Apply this Deviation (8° W) to Compass Course [035° (C)] to obtain the Magnetic Course, which will be 027° (M).

Now convert this Magnetic course 027° (M) to the true course by applying Variation (say 3° East), thus the true course in this case will be 030° (T).

It may be noted that the compass error, which is the resultant or the algebraic sum of Variation and Deviation, in this case is 5° West. This shall be the compass error which must be applied to all Compass bearings observed, before these bearings are laid on the chart, as long as the ship continues on 035° (C) course.

NOTE :

THE COMPASS ERROR IS ALWAYS FOR A PARTICULAR SHIP'S HEAD AND NOT FOR THE BEARING.

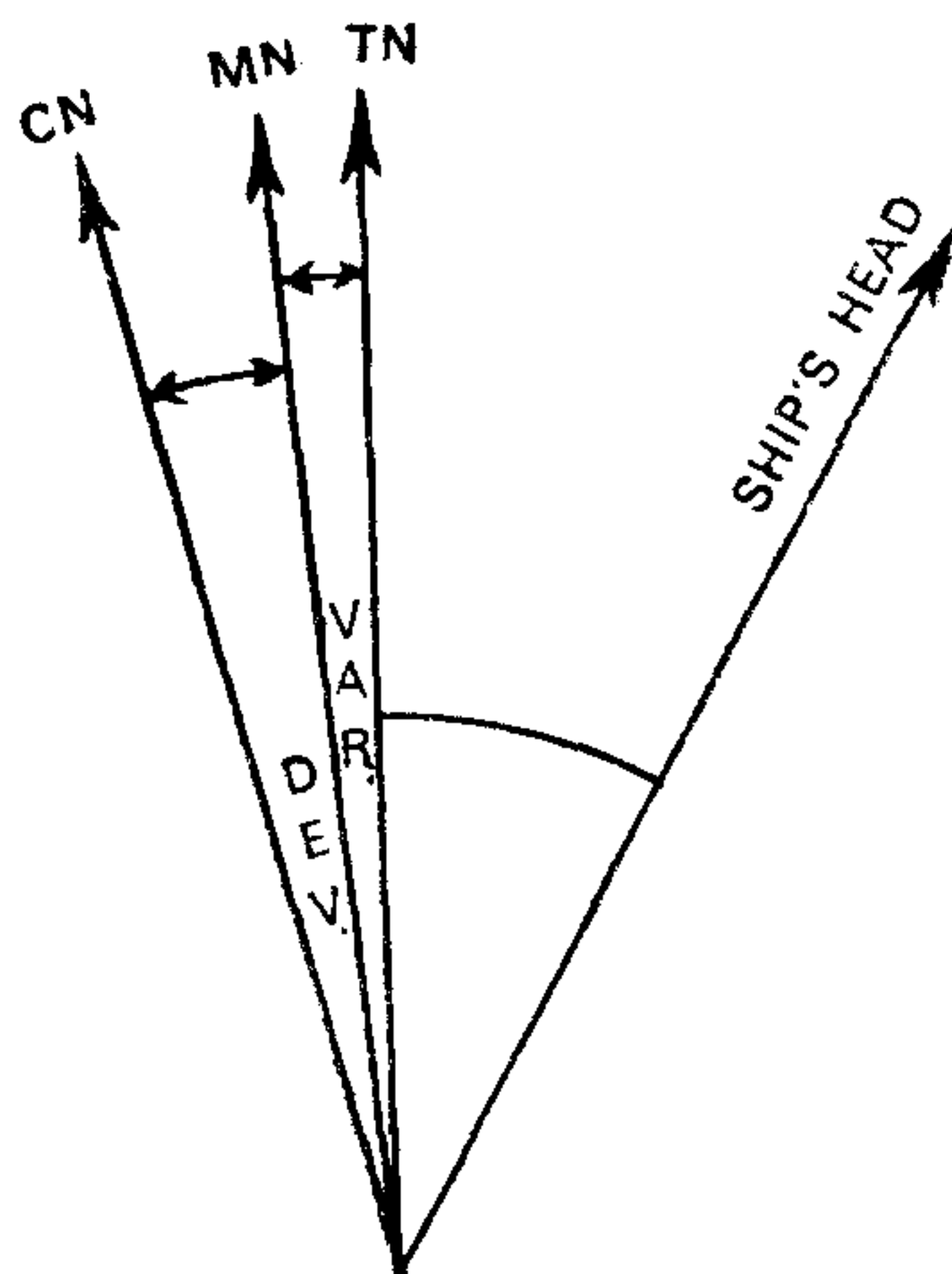
Example :

Given the ship's head by Compass 045° (C) find the true course if Variation is 5° W (Deviation Card I).

Compass Course 045° (C)
Deviation 9.5° W
(From card)

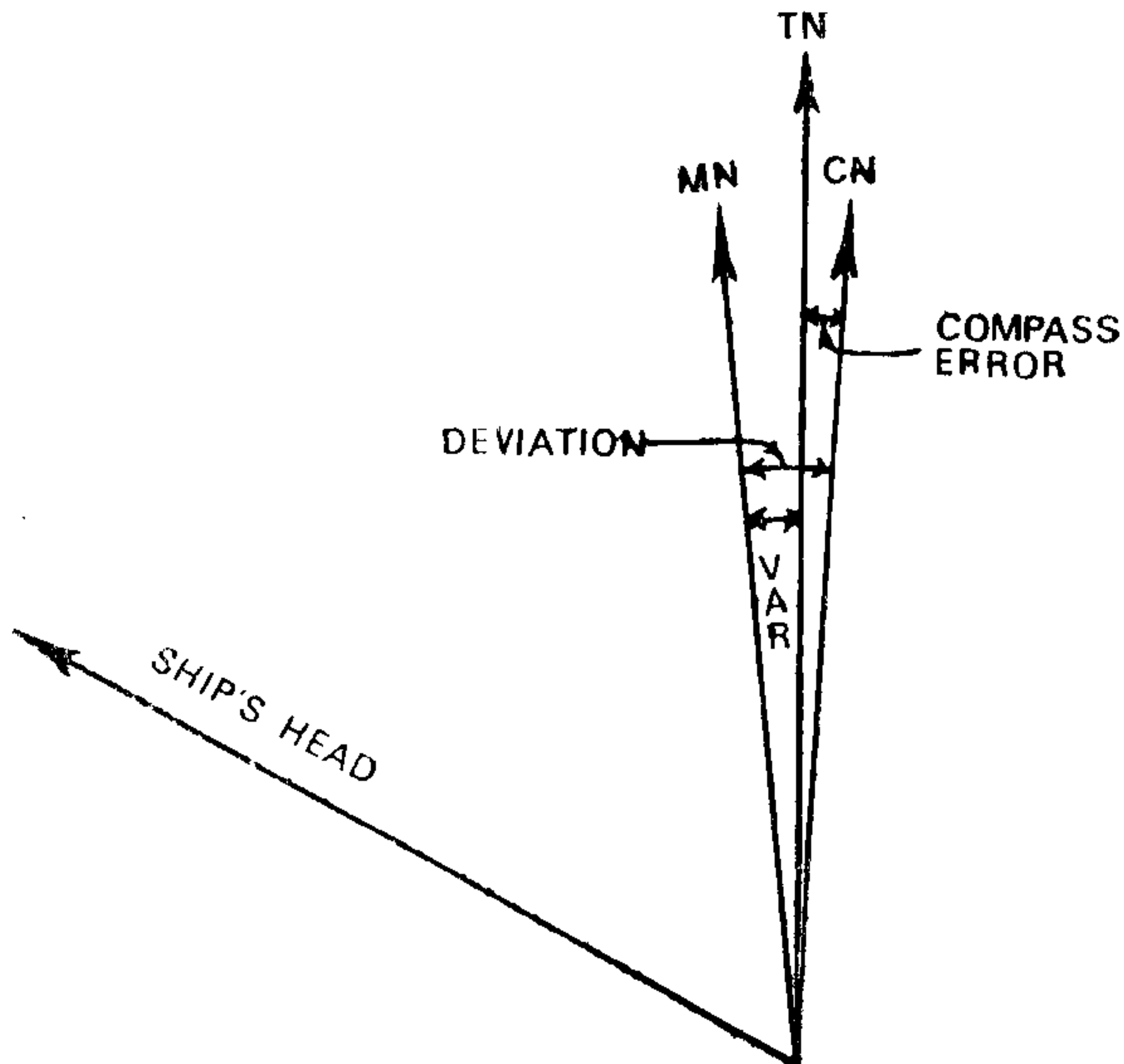
(interpolate between 040° and 050°)

Magnetic course 035.5° (M)
Variation 5° W
True course 030.5° (T)
Compass Error 14.5° W



Example :

Given the ship's head 295° (C), find the true course if Variation is 6° W (Deviation Card I)



Compass course	295° (C)
Deviation	9° E (from Deviation Card I)
Magnetic course	304° (M)
Variation	6° W
True course	298° (T)
Compass error	3° E

Exercise I.

If the ship was steering 124° by Compass, find the true course if Variation was 4° East. Deviation as per Deviation Card I.,

Answer :

Compass Course	124° (C)
Deviation	8.2° W
Magnetic course	115.8° (M)
Variation	4° E
True Course	119.8° (T)
Compass error	4.2° W

Exercise II.

If the ship's course by compass was 165° (C), find the true course? Variation 3° West. Deviation as per Deviation Card I. Also find the Compass error.

Answer :

Compass Course	165° (C)
Deviation	0.3° W
Magnetic course	164.7° (M)
Variation	3° West
True course	161.7° (T)
Compass Error	3.3° West.

Exercise III.

If the ship was steering 223° (C) find the true course if Variation was 5° West. Also find the compass error. (Deviation Card I)

Answer :

Compass course	223° (C)
Deviation	9.0° East
Magnetic course	232° (M)
Variation	5° West
True course	227° (T)
Compass error	4° East.

Exercise IV.

If the ship's head by compass was 055° (C) find the true course if Variation was 3° West (use Deviation Card II).

Answer :

Compass course	055° (C)
Deviation	4° E
Magnetic course	059° (M)
Variation	3° W
True course	056° (T)

Exercise V.

If the ship's head by compass is 133° (C) find the true course if Variation is 6° W (use Deviation Card II).

Answer :

Compass course	133° (C)
Deviation	9° W
Magnetic course	124° (M)
Variation	6° W
True course	118° (T)

Exercise VI.

If the ship's head by compass is 250° (C), find the true course if Variation is 6° East. (Use Deviation Card II).

Answer :

Compass course	250° (C)
Deviation	1° W
Magnetic course	249° (M)
Variation	6° E
True course	255° (T)

TO CONVERT TRUE COURSE TO COMPASS COURSE

To convert true course to compass course, the true course must first be converted to Magnetic course (by applying variation), and then the Magnetic course is converted into compass course by applying the Deviation.

TO CONVERT TRUE COURSE TO THE MAGNETIC COURSE

In order to convert True course to Magnetic course, as already explained, only variation is to be applied to the true course. The variation is given usually in the question itself.

TO CONVERT MAGNETIC COURSE TO COMPASS COURSE

The Deviation is shown on the Deviation Card for various *Compass courses*. Already, it has been explained earlier in this chapter, as to how Compass course is converted to Magnetic course.

Magnetic course is converted into Compass course by applying the necessary deviation. However, it is to be appreciated that the Deviation for Magnetic course cannot be

found from the Deviation Card by direct interpolation, as these Deviations on the Deviation Card are tabulated for the Compass courses only and not magnetic courses.

The method followed for finding deviation on the Magnetic course using the Deviation Card is as follows :—

From the Deviation Card, select two compass courses, which when their respective Deviations are applied, (as already explained in the previous paragraphs) will give two magnetic courses, one on each side of the Magnetic course, for which the deviation is required. The given Magnetic course now lies in between these two Magnetic courses just computed and for which the Deviations are known. Now the deviation for the given Magnetic course can easily be obtained by interpolation.

Apply the deviation, so obtained by interpolation, to the given Magnetic course, and you will get the Compass course.

Example :

Find the compass course to steer, if the true course is 030° (T) Variation 5.5° W, (Deviation as per Deviation Card I). Also find the compass error.

SOLUTION

Firstly convert the true course to Magnetic course by applying Variation.

True course 030° (T)

Variation 5.5° W

Magnetic course 035.5° (M)

Now to convert the above Magnetic course i.e. 035.5° (M) into Compass course, we have to find the Deviation for 035.5° (Magnetic) heading and for this proceed as follows :—

Referring to the Deviation Card No. I, we find that :—
For Ship's Head 040° (C), Deviation is 9° W and hence Magnetic course 031° (M).

Similarly for Ship's Head 050° (C), Deviation is 10° W and hence the Magnetic course 040° (M).

Thus, we have found two Magnetic courses Viz. $031^{\circ}(\text{M})$ and $040^{\circ}(\text{M})$, With corresponding Deviations of 9°W and 10°W respectively), between which lies the Magnetic course of $035.5^{\circ}(\text{M})$ of our question.

By simple interpolation, the required Deviation for the Magnetic course of $035.5^{\circ}(\text{M})$, can easily be obtained.

Thus the required Deviation (for Magnetic course 035.5°),

$$\begin{aligned} &= 9^{\circ} + \frac{1 \times 4.5}{9} \\ &= 9^{\circ} + 0.5^{\circ} \\ &= 9.5^{\circ}\text{W} \end{aligned}$$

Now Magnetic course $= 035.5^{\circ}(\text{M})$
 Deviation $= 9.5^{\circ}\text{W}$
 $\therefore$ Compass course $= 045.0^{\circ}(\text{C})$

Hence $045^{\circ}(\text{C})$ is the Compass course to steer in order to get 030° true course.

The compass error $= \text{Variation} \pm \text{Deviation}$
 Variation $= 5.5^{\circ}\text{W}$
 Deviation $= 9.5^{\circ}\text{W}$
 Compass error $= 15^{\circ}\text{West.}$

Exercise I.

Find the compass course to steer, if the true course is $135^{\circ}(\text{T})$ Variation 4°East . Deviation as per card I.

Answer :

True course $135^{\circ}(\text{T})$
 Variation 4°East
 Magnetic course $131^{\circ}(\text{M})$

Compass course	Deviation	Magnetic course
$130^{\circ}(\text{C})$	7.0°W	$123^{\circ}(\text{M})$
$140^{\circ}(\text{C})$	5.0°W	$135^{\circ}(\text{M})$

Hence by interpolation

if Magnetic course is $131^{\circ}(\text{M})$ then Deviation is 5.7°W

Now Magnetic course $131^{\circ}(\text{M})$

Deviation	5.7°W
Compass course	136.7° (C)

Exercise II.

If true course is 210° (T) Variation 3° West (Deviation as per card I), find the compass course.

Answer :

Magnetic course	213° (M)
Deviation	6.3° East
Compass course	206.7° (C)

Exercise III.

If true course is 285° (T) Variation is 7° East, Deviation as per card I, find the Compass course.

Answer :

Magnetic course	278° (M)
Deviation	12.7° E
Compass course	265.3° (C)

Exercise IV.

If the true course is 315° (T) Variation 5° West, Deviation as per card I, find the Compass course to steer.

Answer :

Magnetic course	320° (M)
Deviation	5.6° E
Compass course	314.4° (C)

Exercise V.

If the true course is 040° (T). Variation 4° West. (Deviation as per card II), find the Compass course.

Answer :

Magnetic course	044° (M)
Deviation	7.7° E
Compass course	036.3° (C)

Exercise VI.

Find the Compass course to steer, if the true course was 145° (T), Variation 3° E? (Deviation as per card II).

Answer :

Magnetic course	142° (M)
Deviation	11.3° W
Compass course	153.3° (C)

Exercise VII.

Find the Compass course to steer, if the true course was 245° (T) Variation 3° East (Deviation as per Card II).

Answer :

Magnetic course	242° (M)
Deviation	1.9° W
Compass course	243.9° (C)

Exercise VIII.

Find the Compass course to steer, if the true course is 308° (T) Variation 4° West (Deviation as per Deviation Card II).

Answer :

Magnetic course	312° (M)
Deviation	7.8° East
Compass course	304.2° (C)

GYRO ERROR

Now a days, most of the ships are equipped with gyro compass on board. When gyro compass reads higher than the true course, gyro error is termed "High" and if the gyro compass is less than the true course, gyro error is "Low". Hence when the gyro error is "High" subtract it from the gyro course in order to get the true course. Similarly, when the gyro error is "Low" add the gyro error to get the true course.

The above rule is reversed when converting true course to gyro course.

NOTE: It must be borne in mind that the gyro error is for particular ship's head, like the magnetic compass, and not for the bearings.

Example I — If the gyro course is 060° (G) and the gyro error is 1° (Low) find the true course.

Solution :—	Gyro Course	060° (G)
	Gyro Error	1° Low
	True Course	061° (T)

Example II — If the true course is 055° (T) and the gyro error is 1° (High) find the gyro course to steer.

Solution :—	True Course	055° (T)
	Gyro Error	1° High
	Gyro Course	056° (G)

Exercise I. Find the gyro course to steer, if true course is 252° (T) and the gyro error 2° (Low).

Answer: Gyro Course to steer 250° (G)

Exercise II. Find the gyro course to steer, if the true course is 115° (T), gyro error is 1° (High).

Answer: Gyro Course to steer 116° (G).

Exercise III. Find the true course, if the gyro course is 138° (G) and the gyro error is 2° (High).

Answer: True Course 136° (T).

Exercise IV. Find the true course if the gyro course is 260° (G) and the gyro error is 1° (Low).

Answer: True Course 261° (T).

Exercise V. Find the gyro course to steer if the true course is 308° (T) gyro error is 2° (Low).

Answer: Gyro Course 306° (G)

Exercise VI. Find the true course, if the gyro course is 265° (G) and the gyro error is 1° (High).

Answer: True Course 264° (T).



CHAPTER VII

RUNNING FIX

[English Channel (Eastern Portion) Chart B.A. No. 2675]

The position of a vessel can also be ascertained by taking a bearing of an object, and after an interval taking a second bearing of the same object or the bearing of another object, the course steered and the distance steamed between the two observations being known. This method of finding the ship's position, is said to be "Running Fix". This can best be explained with the help of an example :—

Example :

While steering a course of 070° (T) Start Point Lt. bore 009° (T) at 2200 hrs. and the same light bore 299° (T) at 2300 hrs. Find the ship's position at 2200 hrs. & 2300 hrs. (speed of the ship 12 knots).

SOLUTION :

(a) Lay off LD, the true bearing of Start Point Light at 2200 hrs. i.e. 009° (T). Take any point A on LD and lay true course steered i.e. 070° (T). Now mark off $AB = 12$ miles i.e. the distance steamed between 2200 hrs. and 2300 hrs.

Now through B, transfer the first bearing i.e. draw B F parallel to LD. The ship lies at 2300 hrs. somewhere on this line B'F, which is called the transferred position line.

To obtain the "Fix", now draw LE, the bearing taken at 2300 hrs. i.e. 299° (T). The point where this bearing cuts the transferred position line (i.e. C) is the Position of the ship at 2300 hrs.

Position at 2300 Hrs. :—

Latitude $50^{\circ} 08.3'N$ Longitude $03^{\circ} 23'W$

ANS :

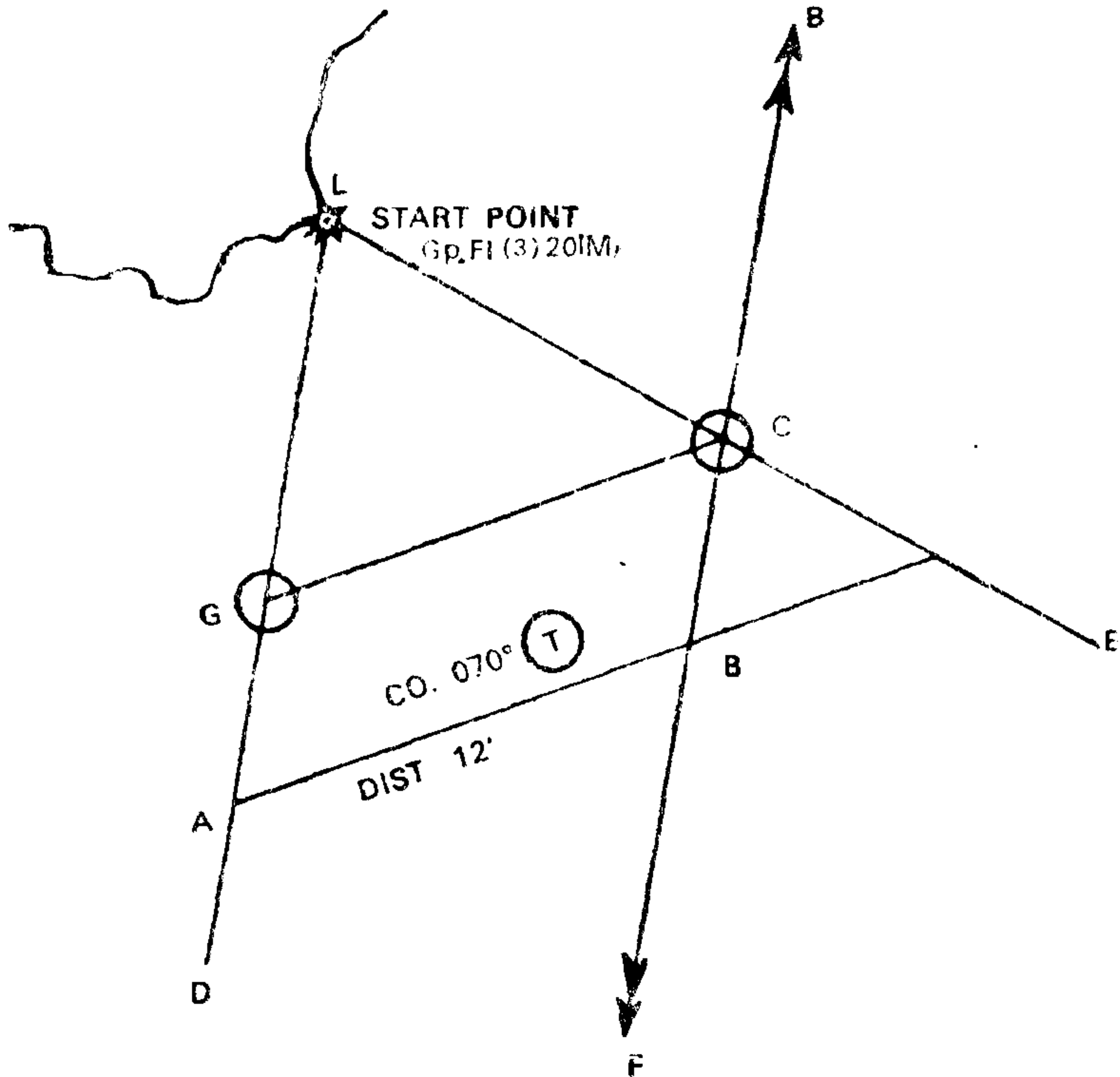
(b) To find the position at 2200 hrs. : —

From C, draw the reverse course steered i.e. C G parallel to A B cutting the first bearing LD at G. Then G is the position of the ship at 2200 hrs.

Position at 2200 hrs.:—

Latitude $50^{\circ} 04'N$ Longitude $03^{\circ} 41'W$

ANS :



NOTE :

The Point "A" on the first bearing may be taken at any convenient position, preferably near the Estimated Position of the ship. It may be pointed here that at whatever position the point "A" is taken on the first bearing, "the fix" (actual final position) will be the same.

Exercise I.

While steering a course of $184^{\circ} (C)$ Les Hanois Light, bore $150^{\circ} (C)$ at 2030 hours and at 2115 hours it bore $106^{\circ} (C)$. Find the vessel's position at 2030 hours and at 2115 hours. (Variation $3^{\circ}W$ Deviation $5^{\circ}E$ speed 16 knots)

Answer :

Compass course	184° (C)
Compass Error	2° E
True course	186° (T)
Compass bearing of Les Hanois Lt.	150° (C)
True bearing of Les Hanois Lt.	152° (T)
2nd Compass bearing of Les Hanois Lt.	106° (C)
2nd True bearing of Les Hanois Lt.	108° (T)
2030 hrs. Position Lat. 49° 40.6'N Long. 02° 55'W	
2115 hrs. Position Lat. 49° 28.9'N Long. 02° 56'W	

Exercise II.

While steering a course of 255° (C), Anvil Point Light bore 019° (C) at 0300 hrs. and after 1 hour, Bill of Portland Light bore 345° (C). Find the ship's position at 0300 hrs. and 0400 hrs. Ship's speed 15 knots. Variation 7.5° W. Deviation as per Card I.

Answer :

Compass course	255° (C)
Deviation	12.5° E
Variation	7.5° W
Compass error	5° E
True course	260° (T)
Compass bearing of Anvil Point Lt.	019° (C)
Compass Error	5° E
True bearing of Anvil Point Lt.	024° (T)
Compass bearing of Bill of Portland Lt.	345° (C)
Compass Error	5° E
True bearing of Bill of Portland Lt.	350° (T)

Ship's Position at 0300 hrs. Lat. 50° 28.5'N Long. 02° 02.7'W

Ship's Position at 0400 hrs. Lat. 50° 25.5'N Long. 02° 26'W

Exercise III.

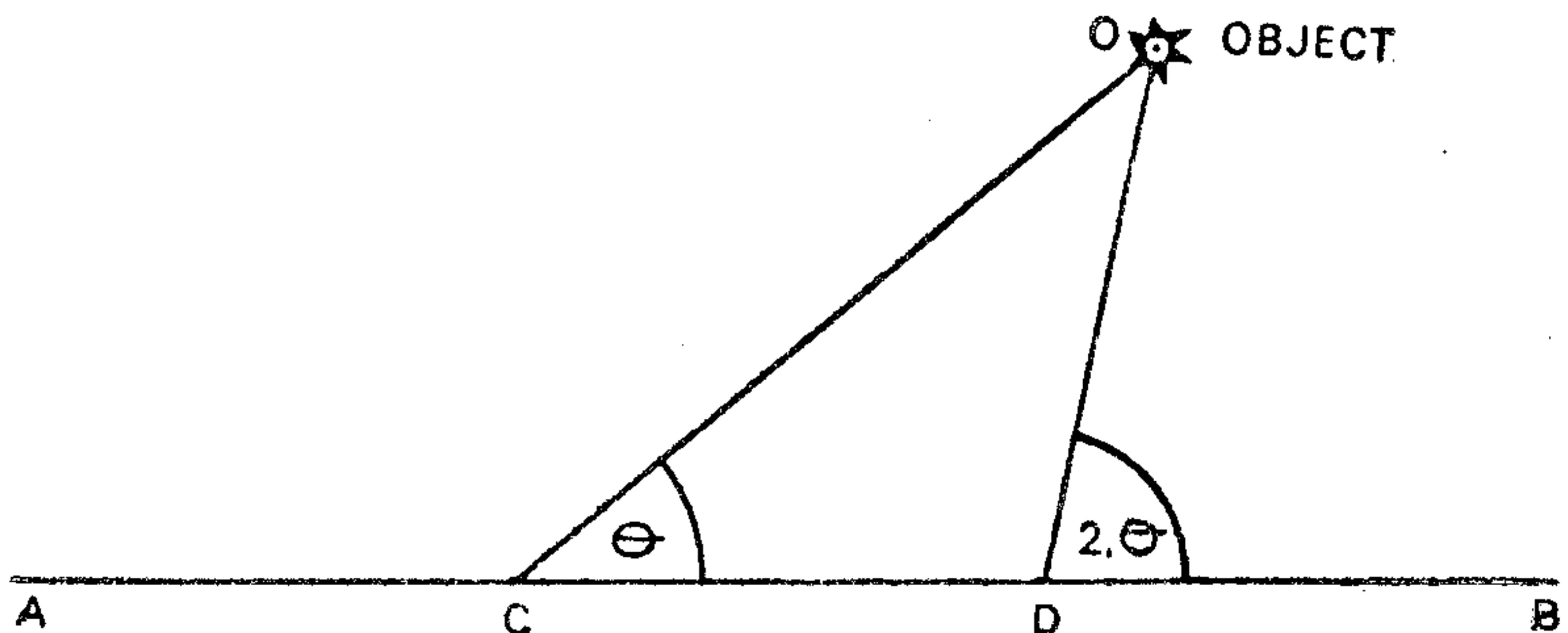
On a voyage from Le Havre to Antwerp, ship steering a course of 061° (C), C. de Antifer Lt. bore 201° (C) at 0440 hrs. and at 0600 hrs. Pte. d' Ailly Lt. bore 142° (C). Find the ship's position at 0600 hrs. Ship's speed 12 knots. Variation 6.5° East. Deviation Card I.

Answer :

Compass course	061° (C)
Deviation	11.5°W
Variation	6.5°E
Compass Error	5°W
True course	056° (T)
Compass bearing of C. de Antifer Lt.	201° (C)
Compass Error	5°W
True bearing of C. de Antifer Lt.	196° (T)
Compass bearing of Pte. D'Ailly Lt.	142° (C)
Compass Error	5°W
True bearing of Pte. D'Ailly Lt.	137° (T)
Ship's Position at 0600 hours :—	
Lat. 50° 08.2'N Long. 00° 38.7'E	

DOUBLE ANGLE ON THE BOW

Note the time and the patent log reading when the object is a certain number of degrees on the bow, and again when that object's angle on the bow is double of first angle, then the distance run during the interval is the distance off the object, at the instant of taking the second observation, provided there is no current.



In the above figure, A B is the course of the ship and O is the object at the bow.,

When the bearing is C O, the angle at the bow is θ and at D, when bearing is D O, the angle at the bow is 2θ .

In $\triangle OCD$, $\angle COD$ will also be θ , thereby making triangle OCD an isosceles triangle. Hence OD , which is the distance off at the time of second bearing will be equal to CD , the distance steamed between the two bearings.

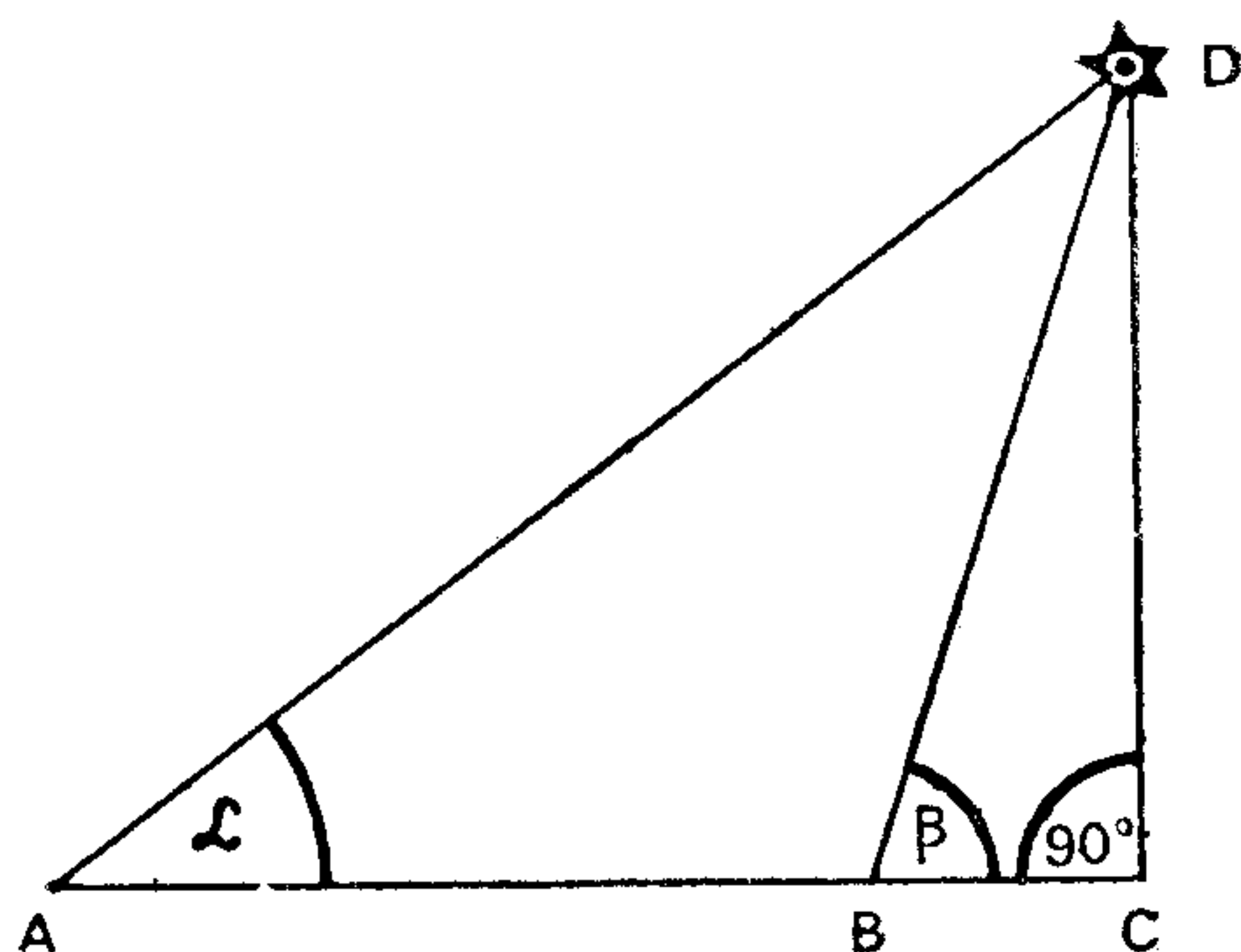
FOUR POINT BEARING

From the above, it will be seen that if light or a shore object bears 4 points on the bow and again after a certain lapse of time it is abeam, the distance run in the interval is the distance off the object, when abeam.

(NOTE : DISTANCE RUN IS THE DISTANCE SHIP WILL PASS OFF THE OBJECT WHEN ABEAM)

SELECTED BOW ANGLES

It is quite often desirable to know the distance off, a vessel will pass abeam of an object before it comes actually abeam, because that is the closest distance the ship will pass off that object. This can be accomplished by the use of certain selected pairs of "angles on the bow" whereby the distance traversed between the bearings, (i.e. selected bow angles) is actually the distance the ship will pass from the object, when abeam.



In the figure above, let D be the object, AD and BD the first and the second bearings respectively, AC is the ship's course and CD the beam bearing.

Let $\angle BAD = \alpha$ and $\angle CBD = \beta$

Given $AB = CD = \text{distance steamed} = \text{distance off abeam.}$

$$\text{In } \triangle DCA, \quad \frac{AB + BC}{CD} = \cot \alpha \dots\dots\dots (i)$$

$$\text{In } \triangle DCB, \quad \frac{BC}{CD} = \cot \beta \dots\dots\dots (ii)$$

Subtracting (ii) from (i) we get.

$$\therefore \frac{AB + BC}{CD} - \frac{BC}{CD} = \cot \alpha - \cot \beta$$

$$\frac{AB}{CD} = \cot \alpha - \cot \beta$$

but $AB = CD$.

$$\therefore 1 = \cot \alpha - \cot \beta$$

Hence, in order that distance run between the first and the second bearings will be equal to the distance off the object when abeam, the difference between the Cotangents of the first and the second angles on the bow must be UNITY

From the table of natural Cotangents it will be seen that many pairs of angles will comply with the above equation.

The most suitable angles are 35° and 67° , whose natural value of cotangents is 1.428 and 0.425 respectively. This is quite a suitable pair of angles for navigational purposes, as it will tell the navigator reasonable time before, as to how much distance off the object, the ship will pass when abeam.

Another suitable pair of such angles is 37° & 72° .

CHAPTER VIII

SOME WORKED EXAMPLES AND EXERCISES

[English Channel (Eastern Portion) Chart B.A. No. 2675]

Example I.

- (a) On a voyage from London to Liverpool, a ship heading 105° (C), Anvil Point Lt. Ho. bore 325° (C) and St. Catherine Point Lt. Ho. bore 048° (C). Find the ship's position.
- (b) From this position, course was set to pass Start Point Lt. Ho. 12 miles off, when abeam on the starboard side. Find the Compass course to steer.
- (c) While on this course, Bill of Portland Lt. Ho. bore 286° (C) and 30 minutes later, it bore 314° (C). Find the ship's position at the time of second bearing.

(Variation 13° E. Deviation as per Deviation Card I. Speed 16 knots).

SOLUTION

- (a) (i) To find the Compass error for the ship's head.

Ship's head by compass	105° (C)
Deviation	11° W
Magnetic course	094° (M)
Variation	13° E
True course	107° (T)

Hence find the Compass error on 105° (C) :—

Deviation	11° W
Variation	13° E
Compass Error	2° E

NOTE :

Compass error is also True course. $\sim$ Compass course (in this case $107^{\circ} \sim 105^{\circ} = 2^{\circ}$ East).

- (ii) To convert Compass Bearings to True Bearings :—

Compass bearing Anvil Pt. Lt. Ho.	325° (C)
Compass error	2°E (Easterly Error ADD)
True bearing of Anvil Pt. Lt. Ho.	327° (T)
Compass bearing of St. Catherine Pt. Lt. Ho.	
	048° (C)
Compass error	2°E
True bearing of St. Catherine Pt. Lt. Ho	050° (T)

Now plot the true bearing of Anvil Point Lt. Ho. and St. Catherine Point Lt. Ho. on the chart and thus obtain the ship's position by cross bearings.

From the Chart :—

Ship's position Lat. 50°21'N Long. 1°42.8'W.

- (b) (i) To find Course to Steer :—

Now with Start Point light as centre and 12 miles as a radius (Taken from the Latitude scale near to Start Point) draw a circle.

- (ii) From the Position obtained in (a), draw a tangent to the circle just drawn. This will be your true course to steer (Making sure not to make 180° error in the direction).

True Course 255° (T)

- (iii) To Convert True Course to Compass Course :—

True Course 255° (T)

Variation 13°E

Magnetic course 242° (M)

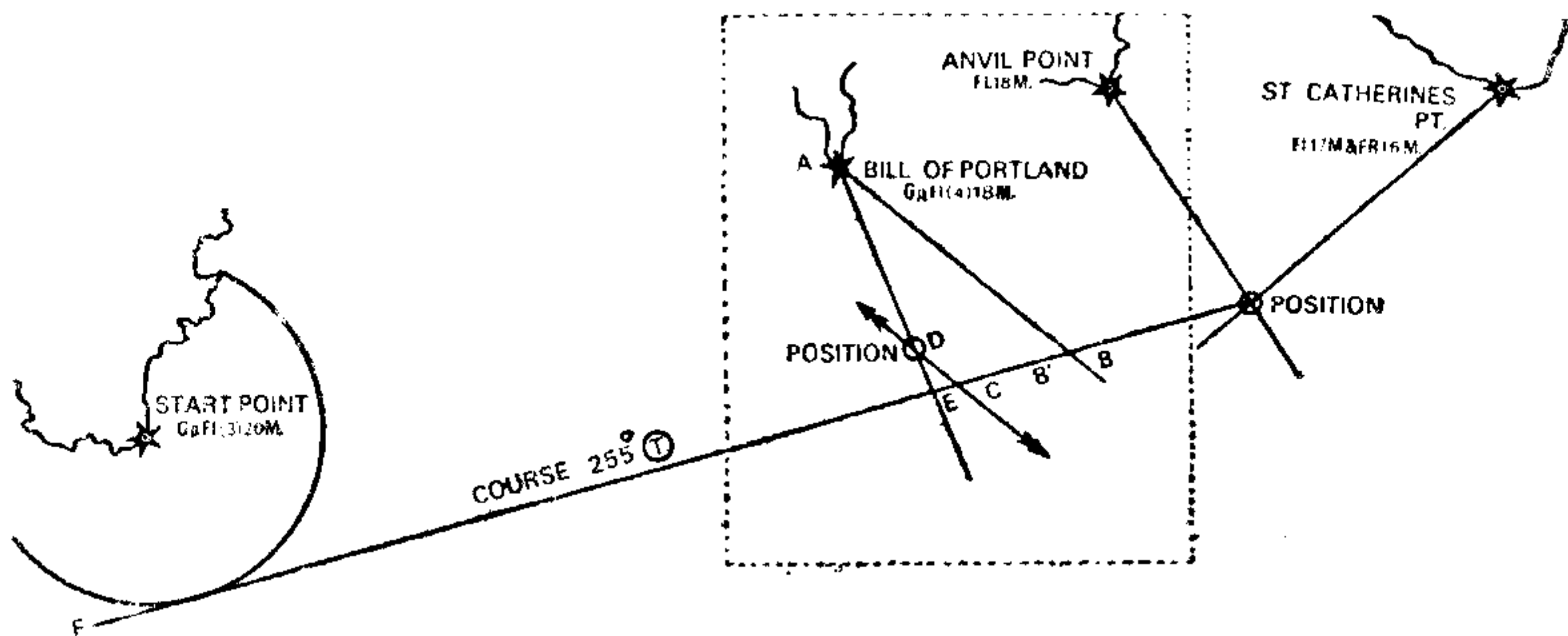
Using the Deviation Card I.

Ship's head by Compass	Deviation	Magnetic Course
230° (C)	10.0°E	240° (M)
240° (C)	11°E	251° (M)

So now for Magnetic Course 240° (M) Deviations is 10.0° E
and for Magnetic Course 251° (M) Deviation is 11.0° E
and interpolating for Magnetic Course 242° (M)
we get Deviation of 10.2° E
Now given Magnetic Course 242° (M)
Deviation 10.2° E
 $\therefore$ Compass course to steer 231.8° (C)

(iv) To find Compass error on this course

Variation	13°E
Deviation	10.2°E
Compass error	23.2°



(Enlarged plot given on page 57)

(c) (i) Find the True Bearings of Bill of Portland Lt.

First Compass bearing of Bill of Portland Lt.	286° (C)
Compass Error	23.2° E

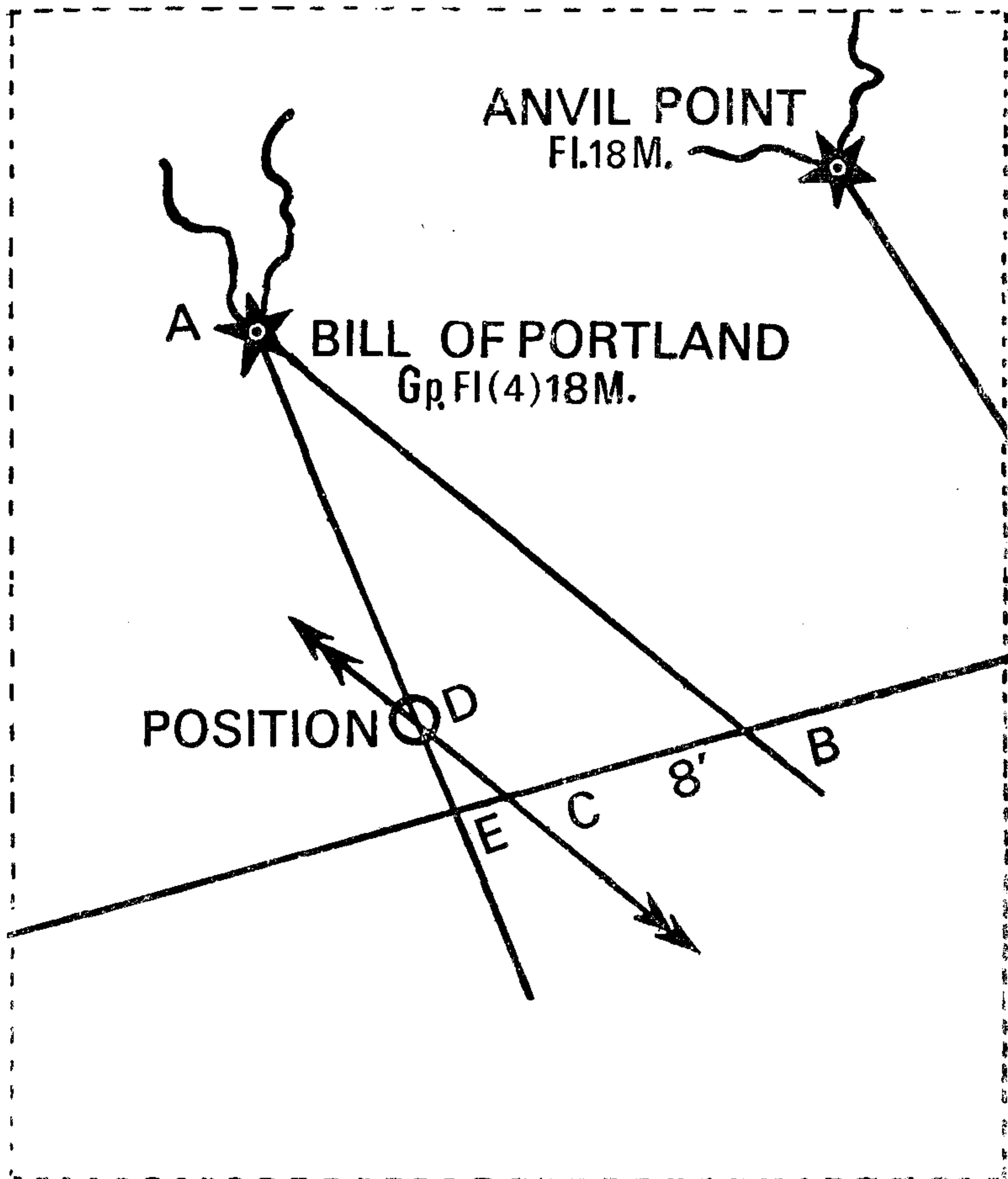
True bearing of Bill of Portland Lt. 309.2° (T)

Second Compass bearing of Bill of	
Portland Lt.	314° (C)
Compass Error	23.2° E

Second true bearing of Bill of Portland Lt. 337.2° (T)

Distance run between 1st and 2nd bearing in 30 minutes @ 16 knots = 8 Miles.

From Bill of Portland Lt. draw the 1st bearing AB
i.e. 309.2° (T) cutting the course steered at B.



(Enlarged plot)

From B, measure $BC = 8$ Miles i.e. distance steamed between the bearings.

Through C, transfer the first position line or the first bearing (in other words draw CD parallel to AB)

Plot the second bearing viz. 337.2° (T) as AE and where this cuts the transferred position line CD (i.e. at "D") is the position of the vessel at the time of second bearing.

Position of Ship. Lat. $50^\circ 18'N$ Long. $2^\circ 18.5'W$.

Example II.

On a voyage from London to Avonmouth,

- (a) A vessel steering 250° (C), at 1900 hrs. St. Catherine Point Lt. bore 302° (C) and Nab Tower bore 002° (C). Find the ship's position at 1900 hrs.
- (b) From this position, set a course by compass to pass Bill of Portland Lt. 10 miles off when abeam on the starboard side.
- (c) While on this course, at 2100 hrs. Anvil Point Lt. Ho. bore 4 points on the starboard bow and at 2145 hrs. Anvil Point Lt. was abeam on the starboard side. Find the ship's position at the time of beam bearing @ 2145 hrs?

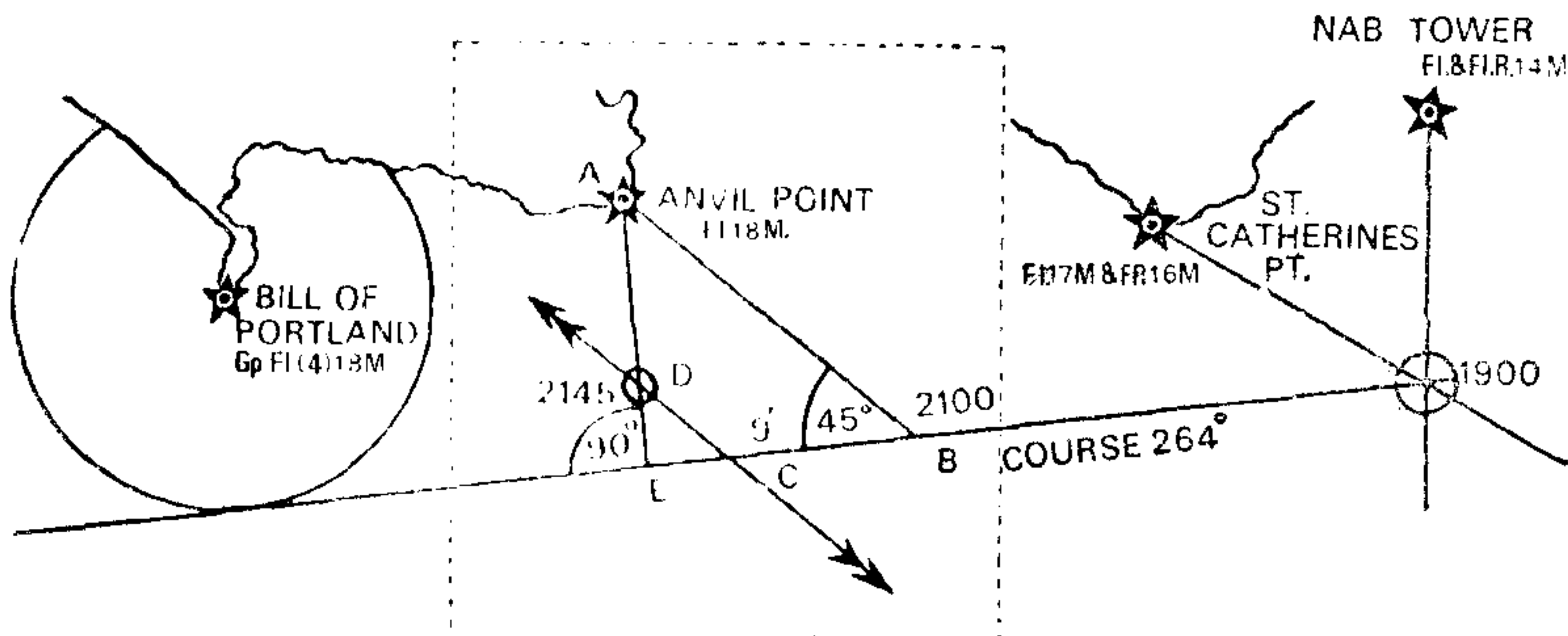
(Variation 14° W Ship's speed 12 Knots. Deviation Card I).

SOLUTION

- | | | |
|-----|--|---------------------------------------|
| (a) | Ship's head | 250° (C) |
| | Deviation | 12.0° E (From Deviation Card). |
| | Variation | 14° W |
| | Compass error | 2° W |
| | Compass bearing of St. Catherine Point Lt. | 302° (C) |
| | Compass Error | 2° W |
| | True bearing of St. Catherine Point Lt. | 300° (T) |
| | Compass bearing of Nab Tower | 002° (C) |
| | Compass Error | 2° W |
| | True bearing of Nab Tower | 000° (T) |

Plotting the true bearings of St. Catherine Pt. and Nab Tower, the ship's position at 1900 hrs. is :—

Lat. $50^\circ 27'N$ Long. $00^\circ 57.4'W$.



(Enlarged plot given on page 60)

(b) (i) With Bill of Portland Lt. as centre and 10 miles as a radius, draw a circle.

(ii) From the Position obtained in (a) draw a tangent to this circle. This tangent will be the true course to steer, viz 264° (T).

(iii) To Convert true course to compass course.

True course 264° (T)

Variation 14° W

Magnetic course 278° (M)

Using the Deviation Card :—

Ship's head by Compass	Deviation	Magnetic course
260° (C)	13.0° E	273.0° (M)
270° (C)	12.5° E	282.5° (M)

Now for 273.0° (M) Magnetic course Deviation is 13.0° E and for 282.5° (M) Magnetic course Deviation is 12.5° E.

Then by interpolation, for 278° (M) Magnetic course. Deviation is 12.7° E,

Now Magnetic course $= 278^{\circ}$ (M)

Deviation $= 12.7^{\circ}$ E

Compass course to steer 265.3° (C)

(c) True course steered $= 264^{\circ}$ (T)

2100 hrs. bearing. (4 Pts. on Stbd. bow)

$= 264^{\circ}$ (T) $+ 45^{\circ} = 309^{\circ}$ (T)

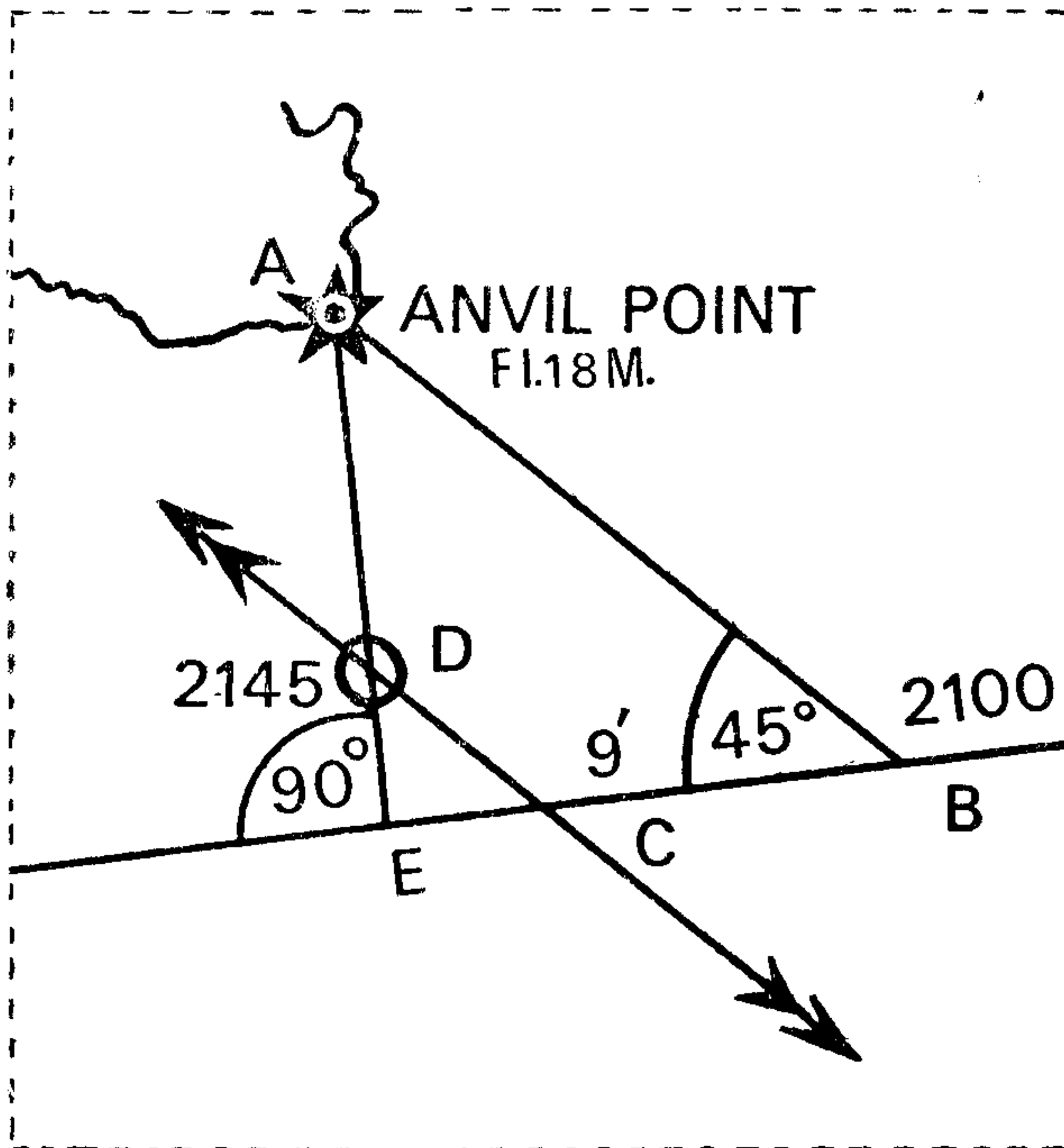
2145 hrs. beam bearing $= 264^{\circ}$ (T) $+ 90^{\circ} = 354^{\circ}$ (T)

Distance steamed between bow and the beam bearing is 9 miles (45 minutes @ 12 knots), which is also the distance off when abeam. Hence by plotting the beam bearing of 354° (T) and distance 9 miles off, we get a "Fix" at 2145 hours.

From the chart, the position at 2145 hours is :—

Lat. $50^{\circ} 26.5'N$ Long. $1^{\circ} 56'W$.

ANS.



(Enlarged plot)

NOTE :

This part of the question could also be done by "Running Fix" method as under :—

From Anvil Pt. Lt. draw the first true bearing AB i.e. 309° (T) and also the second bearing AE i.e. 354° (T).

With B as centre, measure $BC = 9$ miles i.e. the distance between the two bearings.

Now from C transfer the position line or 1st bearing, cutting AE, the second bearing at D.

Then "D" is the position of the ship when the Anvil Point light is abeam.

Ship's Position at 2145 hours :—

Lat. $50^\circ 26.5'N$ Long. $01^\circ 56'W$.

ANS.

NOTE :

Remember always in a 4 point bearings problem, the distance steamed between 4 point and the beam bearing of the light is equal to the distance the ship is off the light when abeam.

Exercise I.

- (a) At 0600 hrs. Les Hanois Lt. Ho. bore 106° (C) distance 7 miles. Ship's head 035° (C). Find the ship's position.
- (b) From this position, the ship then steered 045° (C) until 0848 hrs., when course was altered to 105° (C). This course was maintained until Pte. de Barfleur Lt. Ho. was abeam on the starboard side. Find the true course and the distance steamed and also the time when Pte. de Barfleur light will be abeam.
- (c) While on the second course at 0926 hrs. Alderney Lt. Ho. bore 4 points on the stbd. bow and at 1014 hrs. it was abeam. Find the ship's position at the time of beam bearing. (Variation 8° W, speed 10 knots throughout. Deviation Card I).

Answers :

- (a) Ship's position at 0600 hrs :—
Lat. $49^{\circ} 26'N$ Long. $02^{\circ} 53'W$
- (b) 1st Compass course $045^{\circ} (C)$
Compass Error $17.5^{\circ} W$
True course $027.5^{\circ} (T)$
Distance 28 Miles.
Course altered at 0848 hrs.
Second Compass Course $105^{\circ} (C)$
Compass Error $19^{\circ} W$
True course $086^{\circ} (T)$
Distance 49 Miles.
Pte. de Barfleur will be at abeam at 1342 hrs.
- (c) Ship's position at beam bearing :—
Lat. $49^{\circ} 51.7'N$ Long. $02^{\circ} 11'W$.

Exercise II.

- (a) A vessel steering 240° (C) at 2030 hrs. Needles Point Lt. bore 007° (C) and Anvil Point Lt. bore 308° (C). Find the ship's position at 2030 hrs.
- (b) From this position set a course by Compass to pass Start Point Lt. 10 miles off when abeam on the starboard side.
- (c) While on this course at 2200 hrs. Bill of Portland Light was 4 points on the bow and at 2300 hrs, the same light was abeam. Find the ship's position at 2300 hrs. (Variation 8° W. Ship's speed 10 knots Deviation Card I).

Answers :

- (a) Ship's position at 2030 hrs. :—
Lat. $50^{\circ} 25.8'N$ Long. $01^{\circ} 39'W$.
- (b) True course 253° (T)
Variation 8° (W)
Magnetic course 261° (M)
Deviation 11.9° E
Compass course to steer 249.1° (C)
- (c) Position at 2300 hrs :—
Lat. $50^{\circ} 21.2'N$ Long. $02^{\circ} 22'W$



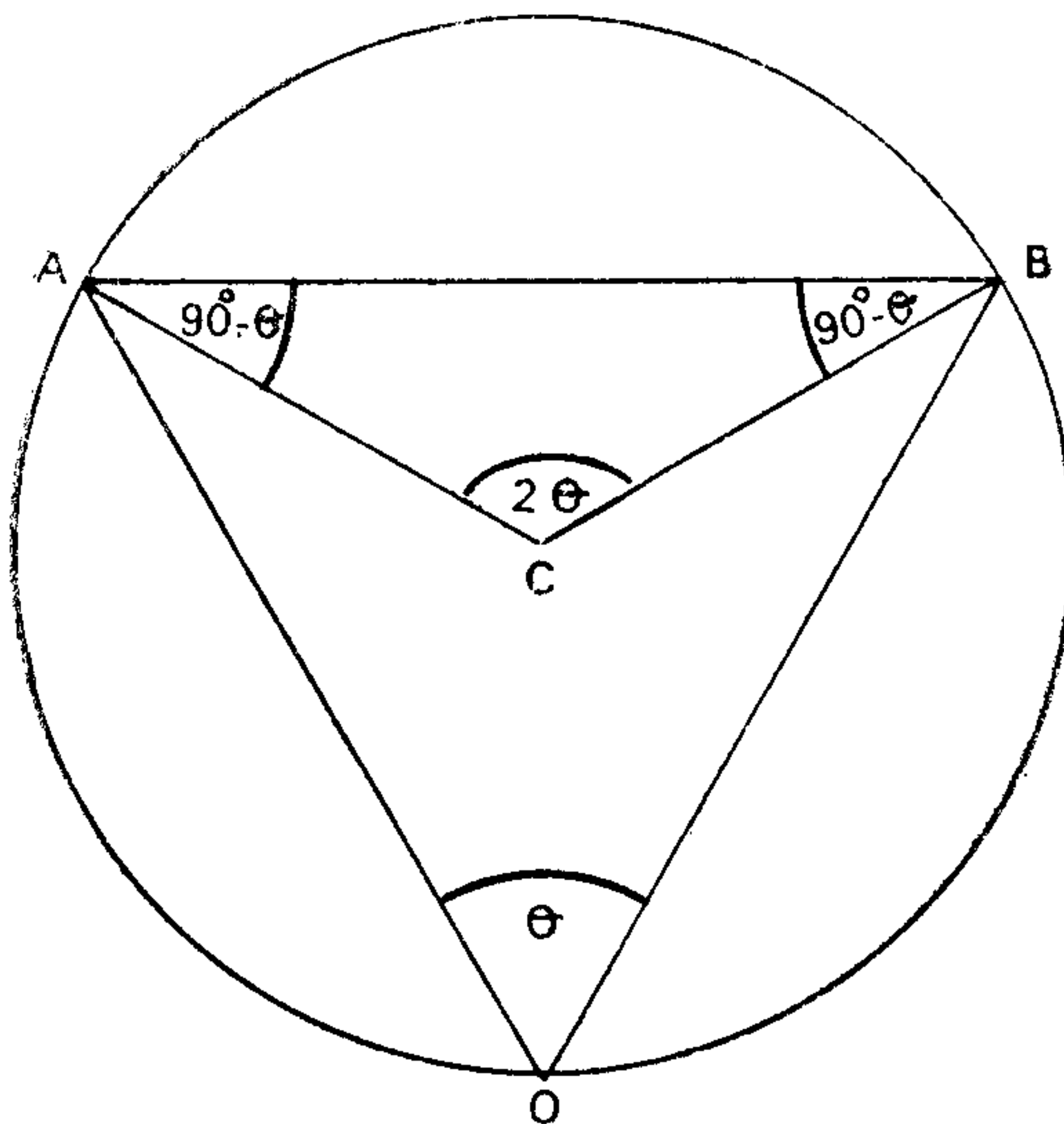
CHAPTER IX

HORIZONTAL ANGLES

[English Channel (Eastern Portion) Chart B.A. No. 2675]

Another accurate method of fixing a vessel's position is by means of observing horizontal angles subtended by shore objects at the observer.

When the horizontal angle subtended between two terrestrial objects is known, a circle of position can be obtained, which is drawn on the chart. The intersection of this circle of position with another similar position circle or a position line, will fix the position of the ship.



METHOD

If θ° is the horizontal sextant angle measured between the two light houses A and B, then A O B is the circle of position.

- (i) Join A and B by a straight line.
- (ii) At A and B lay off, on the same side as the observer, the complement of the horizontal angle (i.e. $90^\circ - \theta$).

- (iii) The point of intersection of these two arms of the angles is at C. Now with C as centre and CA or CB as a radius, draw the circle of position. i.e. AOB.

The ship will be anywhere on this circle of position.

NOTE :

- (i) This method is based on the Geometric Theorem that the angle at the centre is twice the angle at the circumference.
- (ii) When the horizontal sextant angle is greater than 90° , the centre of the position circle lies on the opposite side of the line joining the two objects, to that of the observer. For plotting, subtract 90° from the observed horizontal angle and proceed in the same manner as before. (However lay the required angles on the opposite side of observer in this case).

Normally three suitable objects are chosen from the chart, and the angles at the observer contained between the two pairs viz. the left hand and middle object and the right hand and middle object are measured with a sextant.

The two horizontal angles between the three objects give two circles of position and where these two circles intersect is the position of the ship.

Example I.

From a ship, the following horizontal sextant angles were obtained :—

Needles Pt. Lt. Ho. 33° St. Catherine Pt. Lt. Ho. and
St. Catherine Pt. Lt. Ho. 49° Nab Tower.

Find the ship's position.

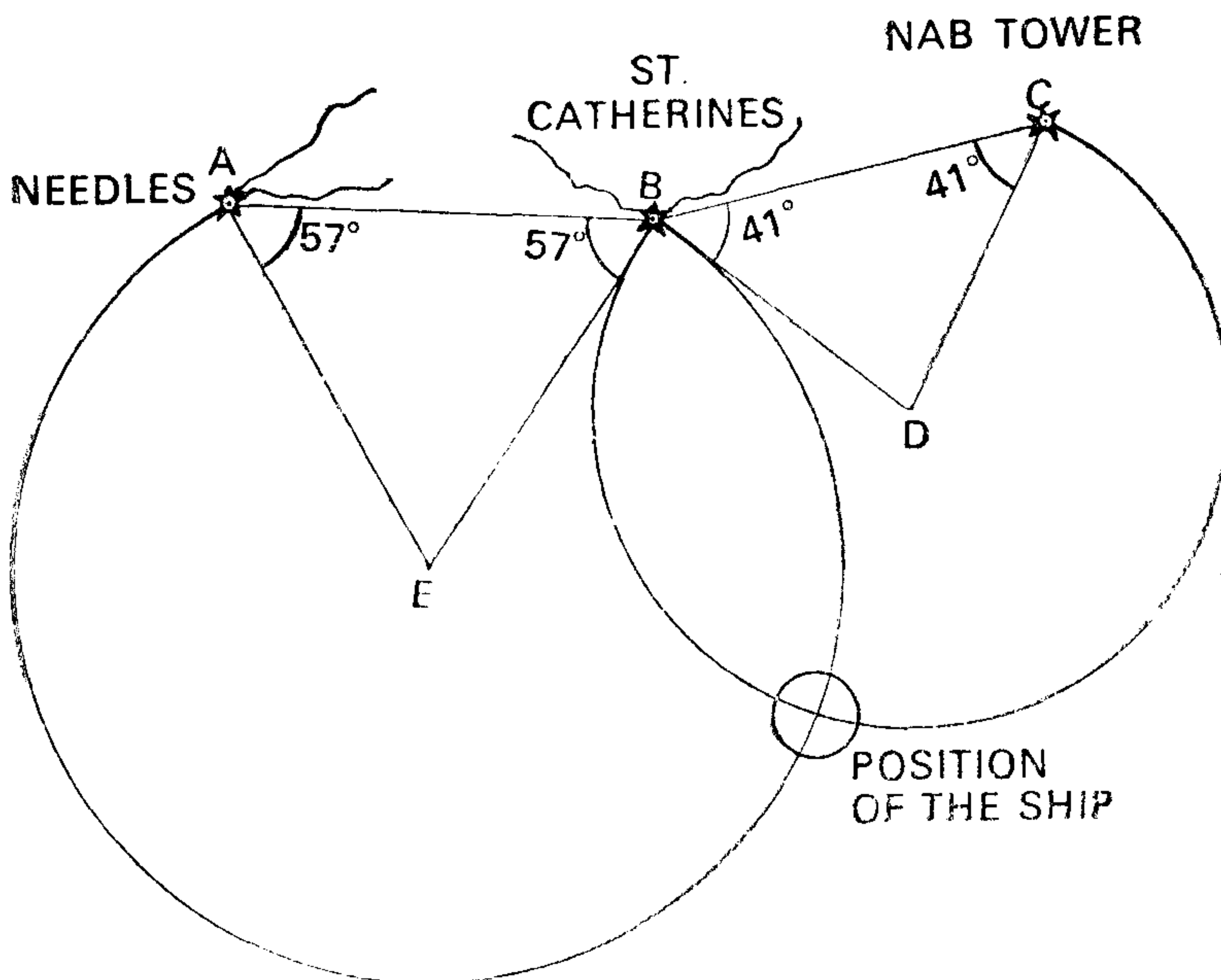
SOLUTION :

Complement of Needles & St. Catherine Pt. Lt. Ho.
 $= 90^\circ - 33^\circ = 57^\circ$

Complement of St. Catherine Pt. Lt. Ho. & Nab Tower
 $= 90^\circ - 49^\circ = 41^\circ$

- (1) Join Needles Point Lt. Ho. & St. Catherine Pt. Lt. Ho. and then draw $\angle EAB = 57^\circ$ & $\angle ABE = 57^\circ$

These two arms of the angles intersect at E. With E as a centre and EA or EB as a radius, draw a circle. The ship is somewhere on this position circle.



- (2) Join St. Catherine Pt. Lt. Ho. & Nab Tower and make $\angle CBD = \angle BCD = 41^\circ$. These two arms of the angles intersect at D. With D as a centre and DB or DC as radius draw the second position circle.

Where the two position circles cut each other, is the position of the ship.

Position of the Ship.

Lat. $50^\circ 25.5'N$ Long. $01^\circ 15'W$.

NOTE :

The two position circles will obviously, cut at two points, one at the middle object which can not be the position of the ship and the other point, is the Position of the Ship :—

Example II.

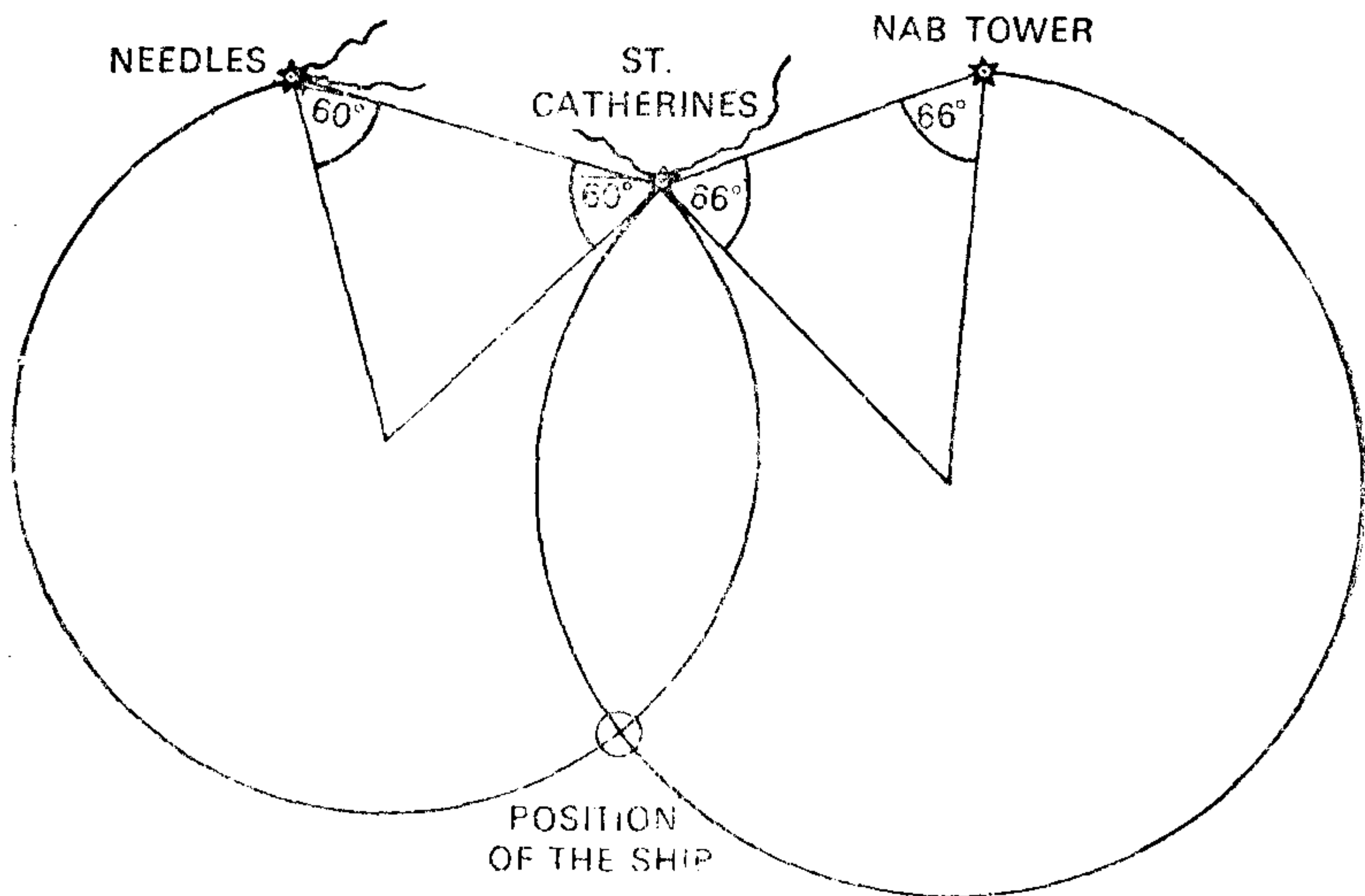
From a vessel at anchor, the following compass bearings were observed:—

Needles Pt. Lt. Ho. bore 345° (C)

St. Catherine Pt. Lt. Ho. bore 015° (C)

Nab Tower bore 039° (C)

Find the ship's position and the deviation of the compass for the ship's head, if Variation at that place was 7.5° W?



NOTE :

In a question of this nature, since deviations are not known, it is to be solved by "Horizontal angles" method.

METHOD

- (a) To draw the position circle through Needles Pt. Lt. Ho. and St. Catherine Pt. Lt. Ho.
 - (i) Join Needles Pt. Lt. Ho. and St. Catherine Pt. Lt. Ho.
 - (ii) Since Compass bearing of Needles Pt. Lt. Ho is 345° (C) and St. Catherine Pt. Lt. Ho is 015° (C), the horizontal sextant angle is $345^\circ \sim 015^\circ = 30^\circ$.
 - (iii) At each lighthouse, lay off, on the same side as the observer, the complement of the horizontal angle i.e. $90^\circ - 30^\circ = 60^\circ$.

- (iv) The point of intersection of these two arms of the angles is the centre of the required position circle, which passes through the two objects observed and the observer.
- (v) Draw in the required circle of position as explained previously.
- (b) Similarly, draw the circle of position through St. Catherine Pt. Lt. Ho. and Nab Tower and the observer. (The horizontal angle in this case is $039^\circ - 015^\circ = 24^\circ$)
- (c) The intersection of the two circles of position will give the position of the ship.

Position of the ship:—

Lat. $50^\circ 16.5'N$ Long. $1^\circ 23'W$ **ANS.**

- (d) To find the Deviation:—

The position of the ship having been ascertained, the true bearings of the light houses can be picked up from the chart. The difference between the true bearing and the compass bearing in each case will give the Compass Error.

True bearing of Needles Pt. Lt. Ho. (from the chart)	341° (T)
---	----------

Given Compass bearing of Needles Pt. Lt. Ho.	345° (C)
---	----------

∴ Compass Error	4°W
Variation	7.5°W
Deviation	3.5°E

NOTE

The result can be checked and confirmed with the bearings of St. Catherine Pt. Lt. Ho. and Nab Tower.

Exercise I.

On board a ship at 1100 hrs. the following horizontal sextant angles were obtained:—

Needles Point Lt. Ho. 40° St. Catherine Pt. Lt. Ho. and St. Catherine Pt. Lt. Ho. 51° Nab Tower. Find the ship's position at 1100 hrs.

Answer :

Complement of Needles Pt. Lt. and St. Catherine Pt.
 $= 90^\circ - 40^\circ = 50^\circ$

Complement of St. Catherine Pt. and Nab Tower
 $= 90^\circ - 51^\circ = 39^\circ$

Ship's position at 1100 hrs. :—

Lat. $50^\circ 28'N$ Long. $01^\circ 16.5'W$

Exercise II.

At 1400 hrs. the following Compass bearings were observed :—

Casquet's Light house	$061^\circ (C)$
Les Hanois Light house	$112^\circ (C)$
Roches Douvres Light house	$173^\circ (C)$

Find the ship's position and the deviation of the compass for the ship's head, if Variation was 2° East.

Answer :

Horizontal angle between Casquets Lt. Ho. and Les Hanois Lt. Ho. $= 51^\circ$

$\therefore$ Complement angle of Casquets Lt. Ho. and Les Hanois Lt. Ho. $= 39^\circ$

Horizontal angle between Les Hanois Lt. Ho. and Roches Douvres Lt. Ho. $= 61^\circ$

Complement angle of Les Hanois Lt. Ho. and Roches Douvres Lt. Ho. $= 29^\circ$

Ships position at 1400 hrs. :—

Lat. $49^\circ 28.8'N$ Long. $02^\circ 56'W$

True bearing of Casquets Lt. Ho. $057^\circ (T)$

Compass bearing of Casquets Lt. Ho. $061^\circ (C)$

Compass Error 4°West

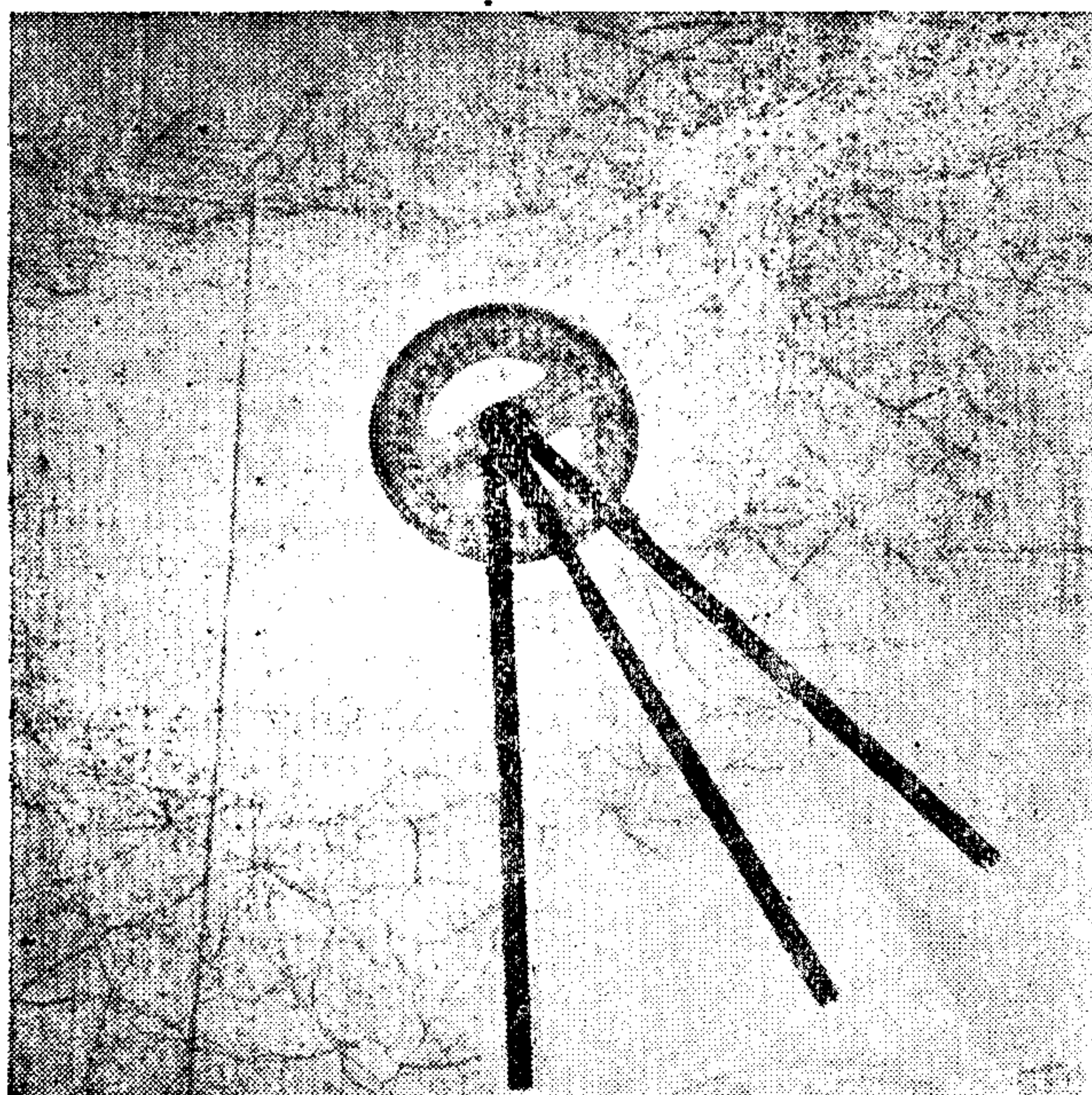
Variation 2°East

Deviation 6°West

STATION POINTER

A station pointer is an instrument which facilitates a quick plot of horizontal angles. It consists of a circular disc graduated in degrees from zero to 180° on either side of zero, with three legs, having bevelled edges radiating from the centre of the disc. One leg is fixed

with its bevelled edge at zero of the graduations and is known as the middle leg. The other two legs are called the right and left leg and they are free to revolve about the centre of the disc, one on either side of the fixed leg. These movable legs can be clamped by means of a small screw at any particular degree of graduations, which will show the inclination of the bevelled edge of the movable leg to the bevelled edge of fixed leg.



To use the Station Pointer

The fixed leg represents the middle object. Clamp the right leg at the observed angle between the middle and the right hand object and then clamp the left leg at the observed angle between the middle and left hand object. Place the "Station Pointer" on the chart, with the bevelled edges of two legs passing through the centres of their respective objects. Then carefully move it until the bevelled edge of the third leg passes through the centre of the third object. Then the centre of the disc will be the position of the observer, which should be marked with pencil.

CHAPTER X

CURRENT AND LEEWAY

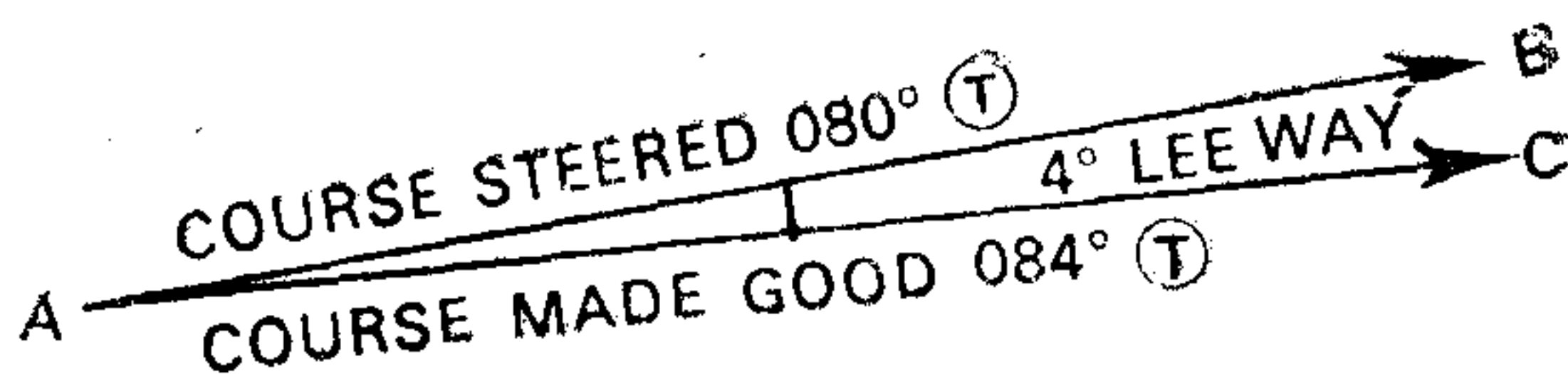
[English Channel (Eastern Portion) Chart B.A. No. 2675]

LEEWAY

The effect of wind on the course steered is called the "Leeway".

Leeway is the angle between the ship's fore and aft line and the line of the wake left behind her. In other words it is the angle between the course steered and the course made good. It is estimated approximately in number of degrees to the leeward side, according to the direction and the force of the prevailing wind.

In practice the leeway is estimated by the navigator as so many degrees to port or starboard and necessary allowance made for it in computing the course to steer.



EXPLANATION :—

If the ship steers a course of 080° (T) and the wind is from North (force 5) and she experiences a leeway of say 4° , then the course made good (after allowing for leeway) is ascertained as follows :—

In the Figure (on page 70) A B is the course steered viz. 080° (T). WW' is the direction of the wind from North, then $\angle$ BAC will be the leeway i.e. 4° (or 4° to stbd.) and the course made good will be 084° (T).

Note

In all questions dealing with leeway, it is advisable to draw a rough sketch.

Example :

A vessel wishes to make good a true course of 010° (T), find the true course to steer if the wind is from East-force 6. Leeway 5° .

True course to be made good	010° (T)
Leeway (Wind East)	$+5^{\circ}$
True course to steer counteracting leeway	015°

DEAD RECKONING (D.R.) POSITION

This is a position of the ship found by allowing for the courses steered and distance steamed through the water from a Fixed Position or any starting position. It is only an approximate position.

When a ship steers a certain course or courses, she does not necessarily arrive at her D. R. Position, obtained by allowing only for the courses steered and distances steamed. This is due to the effect of wind and current etc. on her hull and superstructure.

ESTIMATED POSITION (E.P.)

The calculated position, which a ship is expected to reach after allowing for her course and speed and estimated leeway and the current (set and drift) is called the Estimated Position.

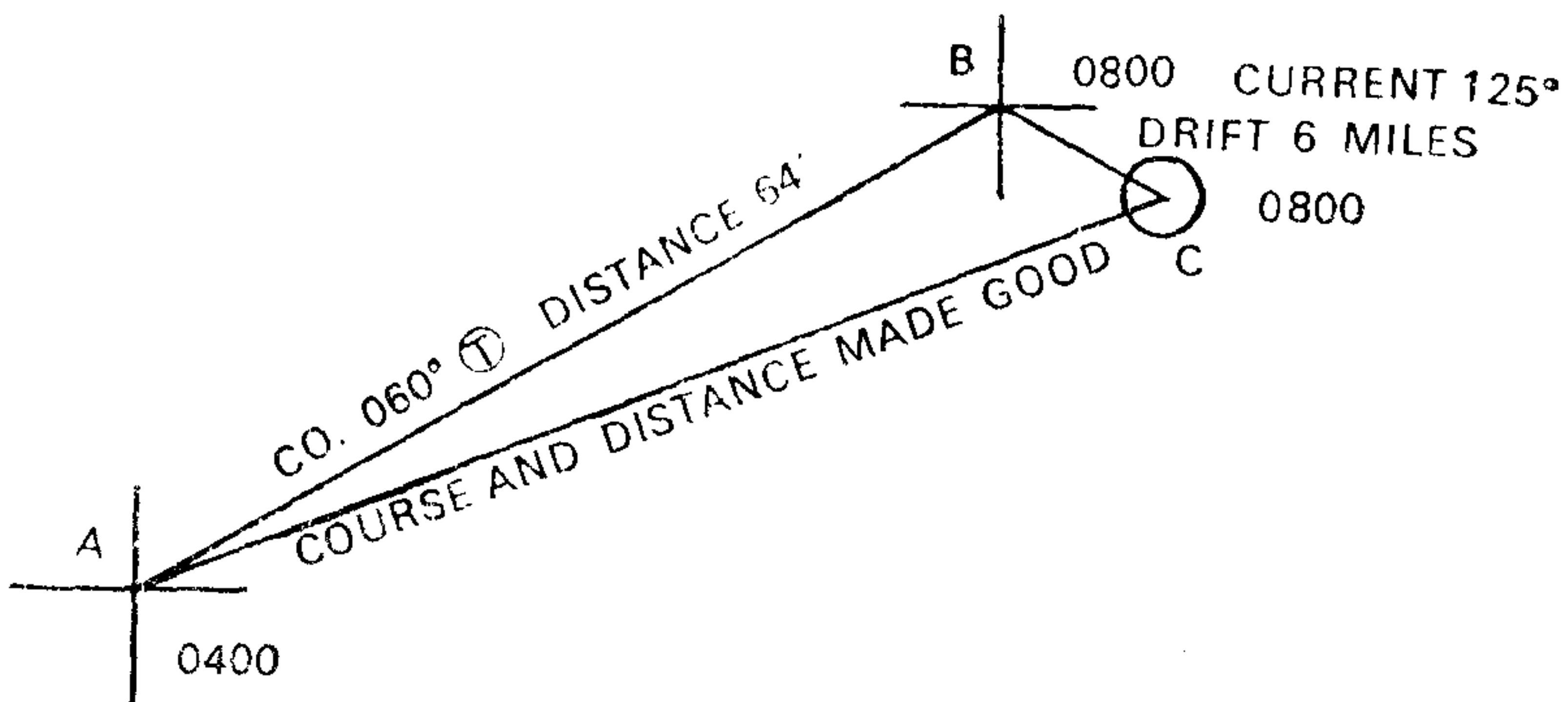
OBSERVED POSITION (OR FIX)

Observed Position on the other hand, is the actual true position of the ship, which may be ascertained by any means such as terrestrial bearings, astronomical observations, or the radio aids to navigation.

The Observed Position is the most accurate one, because it is based on the actual observations, whereas the accuracy of the Estimated Position will depend entirely on the estimates of the wind and current made by the navigator.

SET AND DRIFT OF THE CURRENT

The course and the distance between the D. R. Position and the observed position is the set and the drift of the current during the period under reference. (assuming there is no leeway).



Explanation :—

Suppose the ship starts from position A at 0400 hrs. and steers a course of 060° (T) for 64 miles and reaches D. R. Position B at 0800 hrs.

At 0800 hrs. observed position of the ship is obtained by terrestrial bearings i.e. at "C".

Then direction of BC i.e. 125° (T) is the set of current and the distance BC i.e. 6 miles, is the drift of the current from 0400 hrs. to 0800 hrs. Hence the rate of the current experienced is 1.5 knots.

AC represents the course and the distance made good.

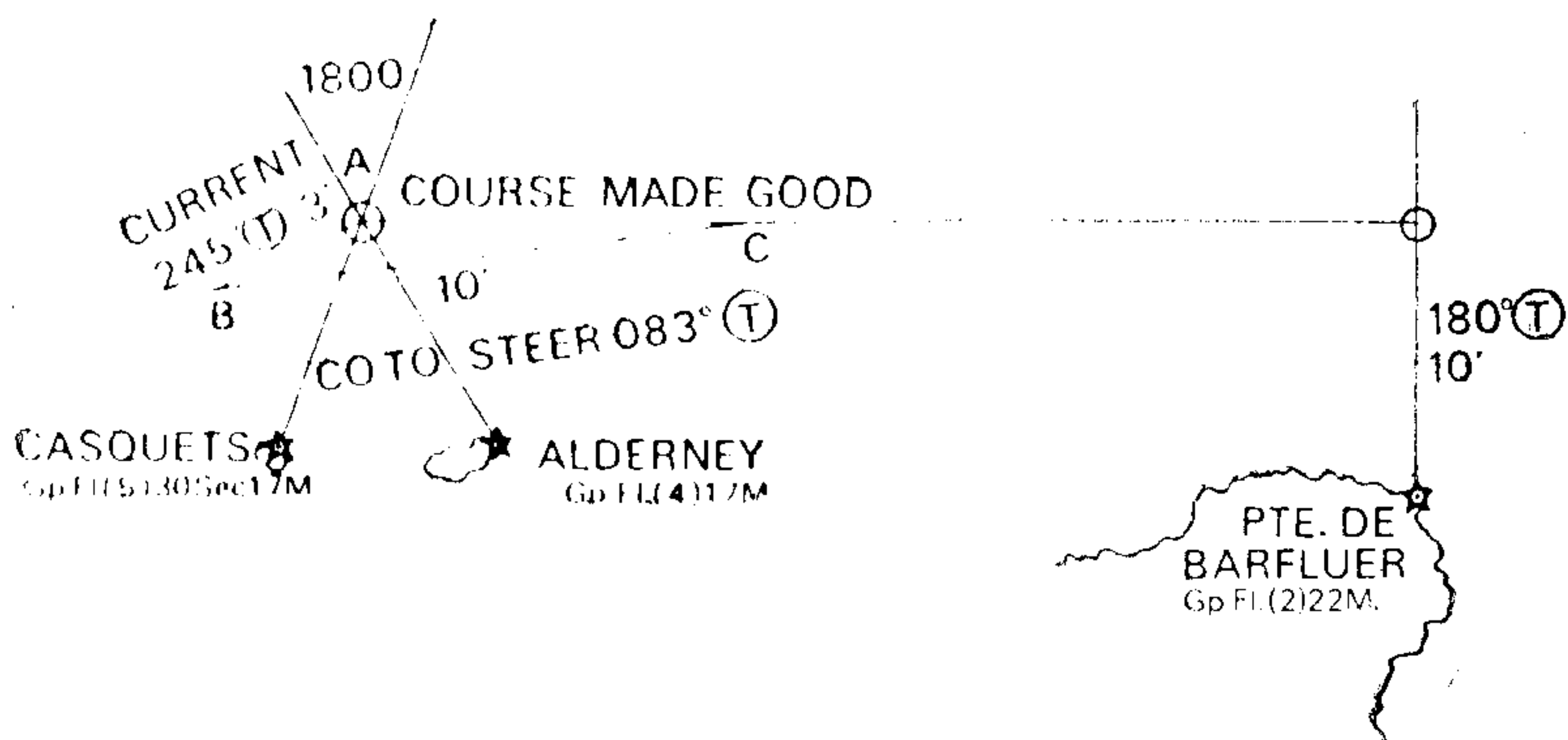
NOTE

It must always be remembered that the set and drift of the current is always from D. R. Position to the Observed Position.

TO FIND THE COURSE TO STEER TO COUNTERACT THE CURRENT

Example I.

- (a) At 1800 hours ship steering 050° (C), Casquets Lt. Ho. bore 200° (T) and Alderney Lt. Ho. bore 149° (T). Find the ship's position.
- (b) From the position at 1800 hours, find the true course, to a position with Pte. de Barfleur Lt. Ho. bearing 180° (T), distance 10 miles off.
- (c) From 1800 hrs. position, find the true course to steer so as to make good the course as found in section (b), counteracting the current which was known to be setting 245° (T) at 3 knots, ship's engine speed being 10 knots.

**SOLUTION**

- (a) Find the ship's position by laying the cross bearings of Casquets Lt. Ho. 200° (T) and Alderney Lt. Ho. bearing 149° (T). Ship's Position at 1800 hrs. :—
Lat. $49^\circ 52'N$ Long. $02^\circ 17.5'W$.

ANS.

- (b) Now lay off the position with Pte. de Barfleur Lt. Ho. bearing 180° (T) distance 10 miles off. Join 1800 hrs. position with the position just obtained. This will be

the required true course to make good so as to pass Pte. de Barfleur Lt. Ho. bearing 180° (T) distance 10 miles.

True course is 091° (T)

ANS.

(c) To find the true course to steer counteracting the current.

- (i) Call 1800 hrs. Position as A.
- (ii) Now from A lay off the current A B, known to be setting 245° (T).
- (iii) Mark off point B making A B = 3 miles i.e. current expected to set in one hour (Rate of the current).
- (iv) With B as a centre, and radius equal to 10 miles or the distance steamed in 1 hour, (speed of the ship) draw an arc cutting the course to be made good [i.e. 091° (T)] at C.
- (v) Then BC is the course to steer. Measure it with the parallel ruler.

Course to steer is 083° (T).

ANS.

It is to be noted that BC is the course that a vessel steaming at 10 knots must steer to make good the course AC, counteracting a current which is setting the ship in the direction AB.

NOTE

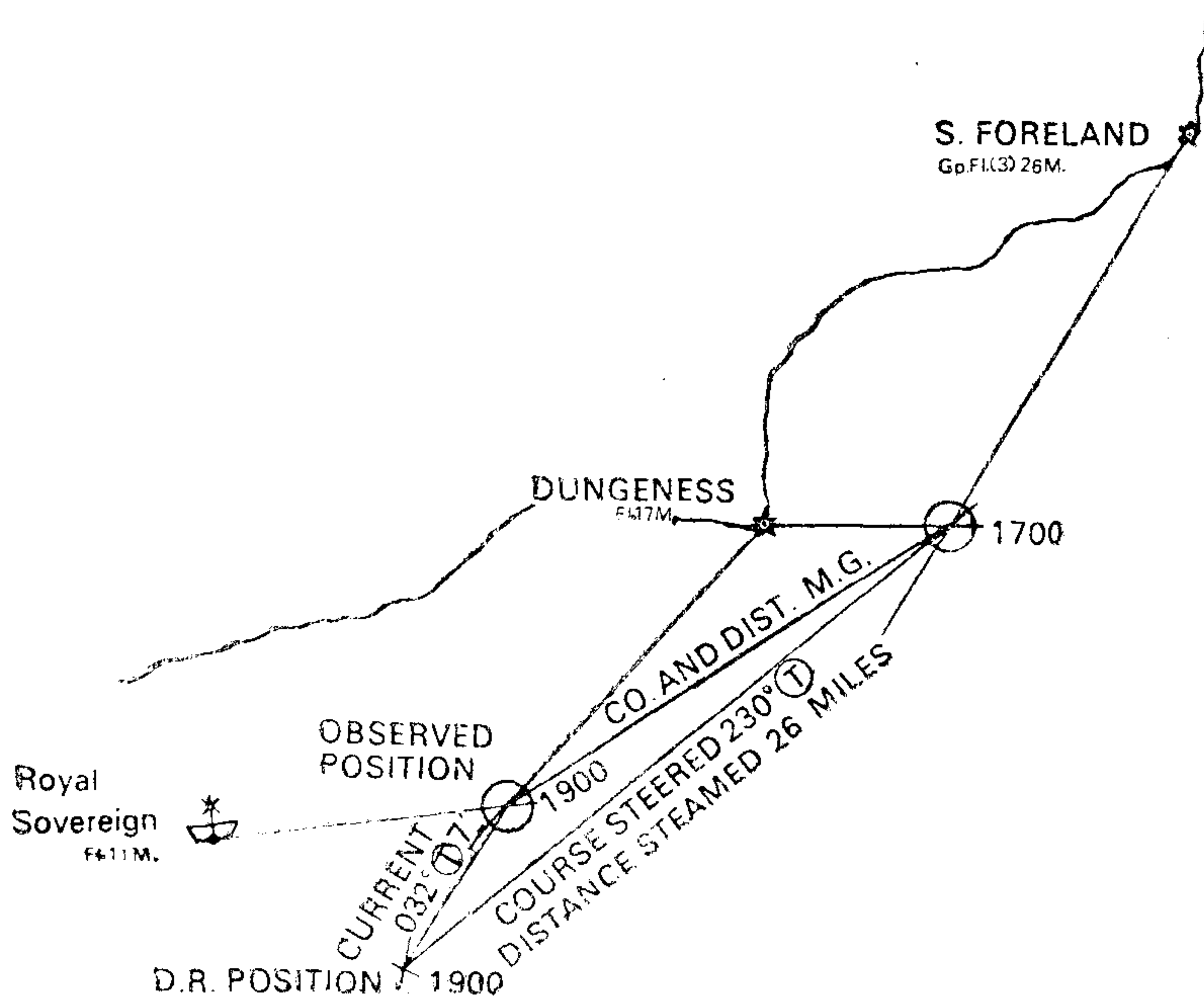
- (1) Remember that the current is always in the direction in which it sets the ship.
- (2) If you take the current for 1 hour then take the engine speed also for 1 hour and if you take the current for 2 hours then take the distance steamed also for 2 hours in the plot.
- (3) When the tide is from right ahead or right astern, the course made good is the same as the course steered. The speed made good will be equal to the ship's speed plus or minus the rate of current.

TO FIND THE COURSE AND DISTANCE (SPEED) MADE GOOD AND THE SET AND DRIFT OF CURRENT

Example II.

- At 1700 hrs. Dungeness Lt. Ho. bore 270° (T) and S. Foreland Lt. Ho. bore 031° (T). Find the ship's position.
- The vessel then steered 225° (C). At 1900 hrs. Royal Sovereign Lt. vessel bore 257° (C) and Dungeness Lt. bore 037° (C). Find the ship's position.
- Find the set and drift of the current, if the ship's speed was 13 knots.
- Also find the course and speed made good.

(Variation 4° W. Deviation Card I).



SOLUTION

- Lay off Dungeness Lt. Ho. bearing 270° (T) and S. Foreland Lt. Ho. bearing 031° (T) and where the two bearings intersect is the ship's position.

Ship's position at 1700 hrs. :—
 Lat. $50^{\circ} 55'N$ Long. $01^{\circ} 09.5'E$

(b)	Ship's head	$225^{\circ} (C)$
	Deviation	$9.25^{\circ} E$
	Magnetic course	$234.25^{\circ} (M)$
	Variation	$4^{\circ} W$
	True course	$230.25^{\circ} (T)$
	Deviation	$9.25^{\circ} E$
	Variation	$4^{\circ} W$
	Compass Error	$5.25^{\circ} E$
	From the position obtained in (a) lay true	
	course of	$230.25^{\circ} (T)$
	Compass bearing of Royal Sovereign	
	Lt. Vessel	$257^{\circ} (C)$
	Compass error	$5.25^{\circ} E$
	True bearing of Royal Sovereign Lt. Vessel	$262.25^{\circ} (T)$
	Compass bearing of Dungeness Lt.	$037^{\circ} (C)$
	Compass error	$5.25^{\circ} E$
	True bearing of Dungeness Lt.	$042.25^{\circ} (T)$

Plot the true bearings of Royal Sovereign Lt. Vessel
 and Dungeness Lt. Ho.

Ship's Position at 1900 hrs. :—
 Lat. $50^{\circ} 44.2'N$ Long. $00^{\circ} 43.2'E$

ANS.

- (c) (i) Now with position obtained in (a) measure 26 miles
 along the course line (230.25°) and mark off the
 D. R. Position at 1900 hrs.
- (ii) Join the D. R. Position obtained just above in
 (c) (i) with the observed position at 1900 hrs. in
 section (b).

Measure the course and distance from the D. R.
 Position at 1900 hrs. to the observed position at
 1900 hours. The course will be the set of the cur-
 rent and distance will be the drift of the current
 in 2 hours.

Set $032^{\circ} (T)$ Drift 7 Miles and the rate of the current
 is 3.5 knots.

ANS.

NOTE

Current is always from D. R. Position to the Observed Position.

- (d) Join 1700 hrs. and 1900 hrs. observed positions. This is the course and distance made good in 2 hours. From the Chart, Course made good 236.5° (T). Speed made good 9.6 knots.

Exercise I.

The ship's position at 1000 hrs. was found with Start Point Lt. Ho. bearing 298° (T) distance 8 miles. Find the compass course to steer so as to pass Shambles Lt. vessel 4 miles off when abeam to port, counter-acting a current known to be setting 285° (M) at 2 knots. Also find the speed made good.

(Variation 9° W, ship's engine speed 10 knots. Deviation Card I).

Answer :

True course to steer	074° (T)
Variation	9° W
Magnetic course to steer	083° (M)
Deviation	12° W
Compass course to steer	095° (C)
Speed made good	8.25 knots.

Exercise II.

At 0830 hours position was found with Pte. d'Ailly Lt. Ho. bearing 184° (T) 8.5 miles off. From this position, find the compass course to steer so as to pass C. d'Antifer Lt. Ho. 10 miles off when abeam. Whilst on this course, at 1130 hours. C. d'Antifer Lt. Ho. was in transit with C. De. La Heve Lt. Ho. and the distance from C. d'Antifer Lt. Ho. was 9 miles. Find the set and drift of the current experienced. (Variation 7.5° W, ship's engine speed 12 knots. Deviation Card I).

Answer :

True course to steer	249° (T)
Variation	7.5° W
Magnetic course to steer	256.5° (M)
Deviation	11.5° E
Compass course to steer	245° (C)
Current Set 103° (T). Drift 5.4 miles at 1.8 knots.	

Exercise III.

- (a) On the 4th November, at 1600 hrs. Start Point Lt. Ho. bore 256° (C) and Berry Head Lt. Ho. bore 328° (C). Variation 8° W Deviation 5° E, find the ship's position.
- (b) From the above position, find the compass course to steer to pass Pte. de Barfleur Lt. 10 miles off when abeam to starboard counteracting a current setting 220° (T) at 3 knots. (Variation 8° W and Deviation as per Card I. Speed 14 knots).
- (c) Find the time Pte. de Barfleur Lt. will be abeam.

Answer :

- (a) Compass Error 3° West
 True bearing of Start Point Lt. Ho. 253° (T)
 True bearing of Berry Head Lt. Ho. 325° (T)
 Ship's Position at 1600 hrs. :—
 Lat. 50° 16.3' N Long. 03° 21' W
- (b) True course to steer counteracting current 096° (T)
 Variation 8° W
 Magnetic course 104° (M)
 Deviation 10° W
 Compass course to steer to counteract the current 114° (C)
 Course made good 107° (T)
 Speed made good 12.5 knots.
- (c) True course steered 096° (T)
 For beam bearing + 90°

Beam bearing of Pte. de
Barfleur Lt. 186° (T)

Distance from 1600 hrs. Position
to beam bearing Position = 85.3 Miles

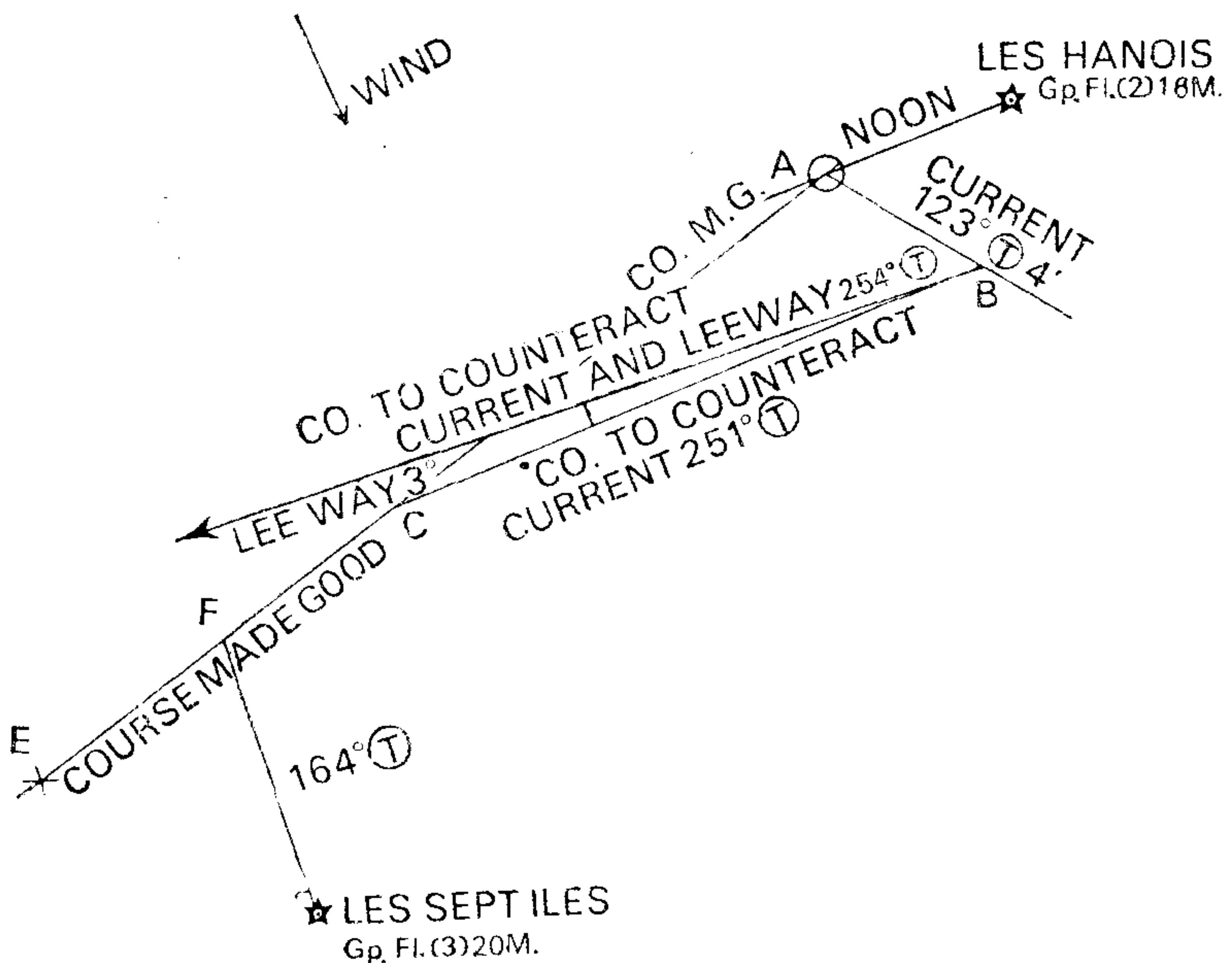
Time required $= \frac{85.3}{12.5} = 6\text{H } 50\text{M.}$

Pte. de Barfleur Lt. will be abeam at 2250 hrs.

ANS.

Example III.

- (a) On 29th June, noon position was found with Les Hanois Lt. Ho. bearing 070° (T) Distance 8 Miles. From noon position, set course by compass to make good a course of 235° (T) counteracting a current setting 123° (T) at 4 knots and Leeway of 3° (Wind NNW force 5).
- (b) Also calculate the time and the distance off Les Sept. Iles Lt. when abeam. (Speed 13.5 knots Variation NIL. Dev. as per Card I).



SOLUTION

- (a) (i) Find ship's position "A" with Les Hanois Lt. 070° (T) 8 miles off.
- (ii) Draw the required course to be made good i.e. 235° (T).
- (iii) Draw AB the current 123° (T) distance 4 Miles.
- (iv) With B as centre and BC as radius i.e. speed in 1 hour viz. 13.5 kts. draw an arc cutting AE (Course to be made good) at C.
- (v) Then BC is the course to steer counteracting the current viz. 251° (T).

To find the course to steer to counteract leeway.

- (vi) The wind is from NNW, leeway 3° , so the ship's head will have to be put to the windward by 3° i.e. $+ 3^{\circ}$.

Course to counteract current	251° (T)
Leeway	$+ 3^{\circ}$

$\therefore$ Course to counteract current and leeway	254° (T)
Variation	NIL

Magnetic course	254° (M)
Deviation	11.3° E

Compass course to steer counteracting the current and leeway	242.7° (C)
--	---------------------

Speed made good i.e. distance AC	11.2 knots.
----------------------------------	-------------

- (b) (i) To find the beam bearing of Les Sept. Iles :—

True course steered	254° (T)
For beam bearing	-90°

$\therefore$ Beam Bearing	164° (T)
---------------------------	-------------------

- (ii) To find the distance off when abeam of Les Sept. Iles. Draw the beam bearing 164° (T)

from Les Sept. Iles so that it cuts the course made good line i.e. AE at F. Distance from point F to the light house is the required beam distance of Les Sept. Iles Lt. i.e. 12.1 Miles. And AF is the distance to make good to have Les Sept. Iles Lt. abeam i.e. 32.5 Miles.

Distance to beam bearing 32.5 miles

Time taken to beam bearing 2 hrs. 55 minutes at 11.2 knots (speed made good)

Time when abeam 14 hrs. 55 minutes.

ANS.

NOTE

- (1) Always remember that beam bearing is on the course steered and never on the course made good.
- (2) Distance off when abeam is always on the course made good.

Example IV.

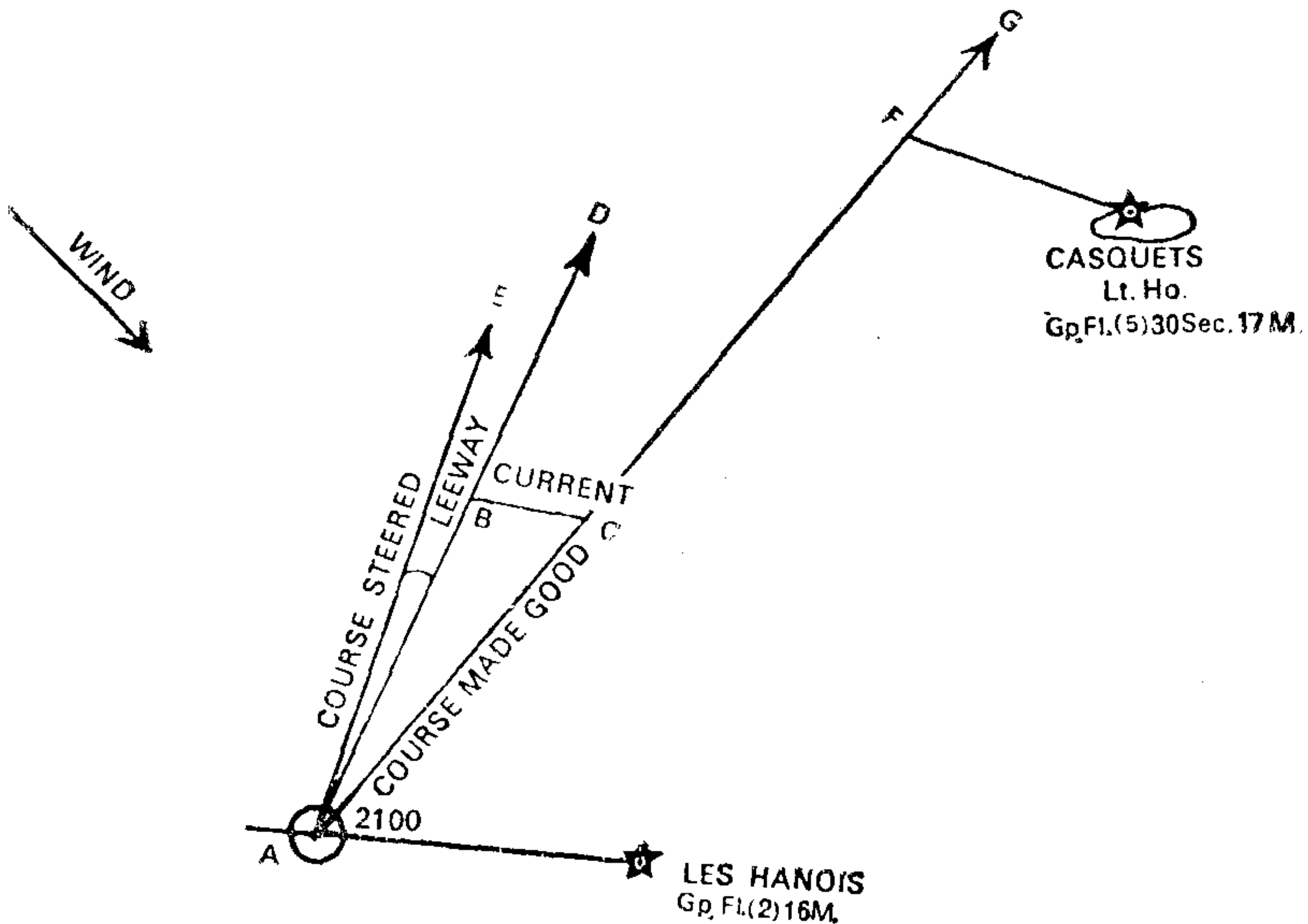
- (a) From a vessel steering 030° (C) at 10 knots, position at 2100 hrs. was found with Les Hanois Lt. bearing 104° (C) distance 9 miles off. Whilst steering 030° (C), the ship experienced a current known to be setting 100° (T) at 3 knots and wind NW. Leeway 5° . Find the course and speed made good.
- (b) Calculate the time when Casquets Lt. will be abeam and also find the beam distance off Casquets Lt.

(Variation 3° W Deviation Card I)

SOLUTION

- | | | | |
|-----|-----|---|-----------------|
| (a) | (1) | Compass course | 030° (C) |
| | | Deviation | 7° W |
| | | Variation | 3° W |
| | | Compass Error | 10° W |
| | | True course | 020° (T) |
| | | Compass bearing of Les Hanois Lt. | 104° (C) |
| | | Compass Error | 10° W |
| | | $\therefore$ True bearing of Les Hanois Lt. | 094° (T) |

- (2) Plot the position "A" with Les Hanois Lt. bearing 094° (T) 9 miles off.
- (3) From "A" lay the true course 020° (T) as AE.



- (4) To find the course made good:—
 Course steered 020° (T)
 Leeway Wind NW, (to the leeward) + 5°
 Hence course made good after allowing for
 leeway 025° (T)
 So draw Course AB, 025° (T) (course made
 good after allowing for leeway)
- (5) Mark AB = 10 miles i.e. speed of the ship in
 1 hour.
- (6) Lay off BC as current i.e. 100° (T) distance 3
 miles (drift for 1 hour only).
- (7) Join AC and extend it to F. Then AC is the
 course and speed made good after allowing for
 the leeway and current.
- Course made good 040° (T)
 Speed made good 11 knots.

ANS.

NOTE

Though the vessel is steering 020° (T), she will be actually moving along the line AC (i.e. 040°) over the ground.

- (b) To find beam bearing of Casquets Lt. Ho.:—
 True course steered 020° (T)
 For Beam bearing $+ 90^\circ$
 True beam bearing 110° (T)

Draw 110° (T) beam bearing of Casquets Light till it cuts the course made good AG at F.

Distance off when Casquets Light is abeam = 5.8 miles.

ANS.

Then AF is the distance to make good till Casquets Lt. Ho. is abeam. i.e. 24.5 miles.

Distance made good = 24.5 miles.

Speed made good = 11 knots.

$\therefore$ Time required to beam bearing = 2 hrs. 13 minutes
 (Calculated at 11 Knots)

Expected time when Casquets Lt. will be abeam = 2313 hours.

NOTE

The distance off the light in such problems is where the beam bearing (i.e. $\pm 90^\circ$ to the course steered) cuts the course made good line.

Exercise IV.

- (a) From a vessel steering 105° (C) at 12 knots, position @1930 hrs. was found by Alderney Lt. Ho. bearing 220° (C) and C. de La Hague bearing 165° (C). Whilst continuing on this course, the ship experienced a current known to be setting 064° (M) at 3 knots. Wind North. Leeway 5° .

Find the course and speed made good.

- (b) Also calculate the time when Pte. de Barfleur Lt. will be abeam and the distance off when abeam.

(Variation 4°W throughout. Deviation as per Card I).

Answer

(a)	Compass course	$105^{\circ}(\text{C})$
	Deviation	11°W
	Variation	4°W
	Compass Error	15°W
	True course	$090^{\circ}(\text{T})$
	Leeway (Wind North)	+ 5°
	Course after Leeway	$095^{\circ}(\text{T})$
	Current	$064^{\circ}(\text{M})$
	Variation	4°W
	True current	$060^{\circ}(\text{T})$ at 3 knots.

Course made good after allowing for leeway and current = $088.5^{\circ}(\text{T})$.

Speed made good 14.5 knots.

(b) Beam bearing of Pte. de Barfleur Lt. $180^{\circ}(\text{T})$.

Distance to be made good when Pte. de Barfleur Lt. will be abeam 31 Miles.

Time taken = 2 hours 10 minutes.

E.T.A. off Pte. de Barfleur Lt. = 2140 Hours.

Distance off when abeam = 10.2 Miles.

✓



CHAPTER XI

DIPPING AND RISING BEARING OF THE LIGHTS

[English Channel (Eastern Portion) Chart B.A. No. 2675]

A light is said to be “raised” when the light is first sighted on the Bridge of the ship. Similarly a light is “dipped” when the light is seen for the last time before it dips below the horizon. Hence “dipping or rising” distance will be the maximum range of that particular light.

The range of the light depends upon the height of the lighthouse above the sea level and also upon the height of the observer. The distance of visible horizon due to the height of light is fixed, while the observer’s distance of visible horizon changes because the height of eye is not constant (It depends upon the draft of the ship).

The distance of the visible horizon will depend on the height of the observer’s eye and also the height of the object. It may be calculated as follows :—

(a) If the height of eye is given in feet then

$$\text{Distance (d) of horizon} = 1.15 \sqrt{h}$$

where (d) = distance in miles.

and h = height of eye in feet.

(b) If the height of eye is given in metres then

$$\text{Distance (d) of horizon} = 2.08 \sqrt{h}$$

where (d) = distance in miles.

and h = height of eye in metres.

The two ranges of visible horizons, i.e. for the height of the object and that of the observer are calculated separately and when added together, will give the range of the light.

NOTE

It must be emphasized here that “Rising” and “Dipping” ranges calculated in the manner shown above are called the Geographical ranges and these are *theoretical* ranges only. A light will be seen at the “Rising” and “Dipping” range only if the luminosity of the light is sufficient for the range calculated.

The ‘List of lights’ now show the lower of the two ranges i.e. the lower of the geographical range (computed for the observer to be at height of 15 feet) and the “Nominal” luminous range depending upon the intensity of the light.

Example :

A shore light, height 144 feet, is observed to dip, height of eye 36 feet. Calculate the distance of the light from the observer.

$$\begin{aligned}
 \text{Distance of visible horizon of light} &= 1.15 \sqrt{144} \\
 &= 1.15 \times 12 = 13.8 \text{ Miles.} \\
 \text{Distance of visible horizon of the observer} &= 1.15 \times \sqrt{36} \\
 &= 1.15 \times 6 = 6.9 \text{ Miles} \\
 \text{Geographical range of the light} &= 13.8 + 6.9 = 20.7 \text{ Miles.}
 \end{aligned}$$

The distance of the visible sea horizon for various heights is given in Burton’s or Norie’s Nautical Tables.

NOTE

The range of visibility of lights presently shown on the chart is calculated for a height of the observer’s eye of 4.57 metres (15 feet). The light will be visible at the range of the light shown on the chart, provided it is a dark night with clear atmosphere, under normal conditions of refraction. For example, if range of light shown on the chart is 20 miles, then the light will be raised or dipped at 20 miles, provided the observer’s height of eye is 4.57 metres (15 feet).

Example I.

The range of Casquets Lt. given on the chart is 17 Miles, and height 36.58 Metres (120 feet). Find the raising distance of this light, if the observer's height of eye is 11 Metres (36 feet).

SOLUTION**First Method.**

Range of the light (from the chart)	=	17 Miles.
Sea horizon for 4.57 Metres (15 feet)	=	4.5 Miles
Range of the light at sea level	=	12.5 Miles.
Sea horizon for 11 Metres (36 feet)	=	7.0 Miles.
Raising distance of the light	=	19.5 Miles.

(Subject to the light having sufficient luminosity).

Second Method

Range for height of light 36.58 Metres (120 feet)	
(From Nautical Tables)	= 12.5 Miles.
Sea horizon for 11 Metres	= 7.0 Miles.
Raising distance of light	= 19.5 Miles.

(Subject to light having sufficient luminosity).

NOTE

- (1) Since the height of light house is given on the chart, the sea horizon for the same is obtained straight-away from the tables and then visible sea horizon for the height of eye is allowed.
- (2) When calculating the raising or dipping distance of the light, whose visibility is taken from the chart, the given range should first be reduced to sea level by subtracting the range of visible horizon for height of eye 4.57 Metres (15 feet) i.e. 4.5 Miles and then add the distance of visible horizon for the height of eye of the observer.

CAUTION

- (1) The range of lights is calculated for conditions of normal refraction, but when using dipping or rais-

ing distance of the light for navigating the ship, the possibility of abnormal refraction considerably vitiating the result should be constantly borne in mind.

- (2) As explained earlier, the rising and the dipping distance is only approximate and hence should be used with utmost Caution, when fixing ship's position.

Exercise I.

Find the dipping distance of Alderney Lt. (GP. Fl (4) 17 Miles) if the height of eye is 12 Metres (39.5 feet).

Answer :

Dipping distance = 19.9 Miles.

Exercise II.

Find the raising distance of C. de Antifer Lt. (Fl. 27 M) if the height of eye is 10 Metres (33 feet).

Answer :

Raising distance = 29.2 Miles.

VERTICAL SEXTANT ANGLES

Another method of finding the ship's position, is by means of taking a bearing of a light house or any terrestrial object and obtaining the distance off that object by means of a vertical sextant angle.

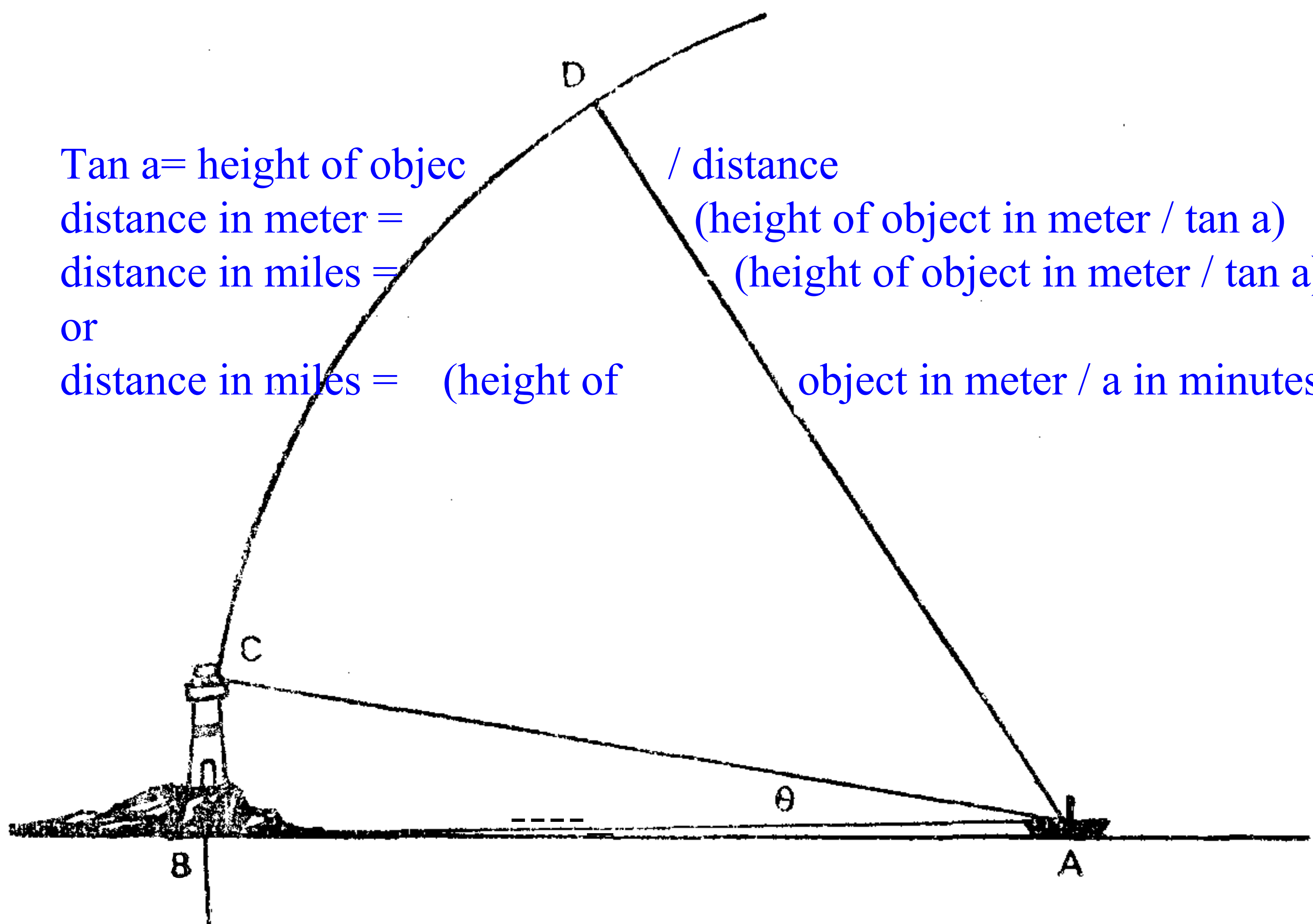
Ship's position can also be found by taking vertical sextant angles of two or more suitable objects; which in turn will give you the distance the vessel is off those objects. In other words each observation will give a position circle and where, the two position circles cut each other, will be the position of the ship.

The vertical sextant angle also proves very useful to a navigator, when a ship has to pass a certain safe distance off (say 2 miles off) a light house or an off lying danger.

In the figure below if BC is the height of the light house, A is the ship and AB is the distance of the ship from the light house then θ is the vertical sextant angle.

Let the arc BD be equal to the radius AB, then BAD is a radian. The value of a radian in sexagesimal measure is $57^\circ 18' 45''$

Radius AB $\approx$ arc BD $\approx 57^\circ 18' = 3438'$.



Tan a = height of object

distance in meter =

distance in miles =

or

distance in miles = (height of

/ distance

(height of object in meter / tan a)

(height of object in meter / tan a) / 1852

object in meter / a in minutes) x 1.852

$$\frac{\text{arc BD}}{\text{arc BC}} = \frac{\text{radius AB}}{\text{chord BE}} = \frac{\angle EAD}{\angle BAC} \text{ where } \theta \text{ is small}$$

$$\frac{AB}{BC} = \frac{57^\circ 18'}{\theta}$$

$$AB \text{ in feet} = \frac{BC \text{ in feet} \times 3438'}{\theta}$$

$$AB \text{ in Miles} = \frac{BC \text{ in feet} \times 3438'}{\theta \text{ in Minutes} \times 6080'}$$

$$\text{Distance off (in miles)} = \frac{\text{Height of object (in feet)}}{\text{Sextant altitude (in minutes)}} \times 0.565$$

or

If the height of object is given in metres then use the following formula :—

$$\text{Distance off (in miles)} = \frac{\text{Height of object (in metres)}}{\text{Sextant altitude (in minutes)}} \times 1.854$$

Example

The sextant altitude of a top of a light house 125 feet above the sea level is observed to be $00^{\circ} 35'$, find the distance the observer is off the light house.

$$\begin{aligned} \text{Distance off (in miles)} &= \frac{\text{Height of object (in feet)}}{\text{Sextant altitude (in minutes)}} \times 0.565 \\ &= \frac{125}{35} \times 0.565 = 2 \text{ Miles} \end{aligned}$$

AB = 2 Miles.

NOTE

The above distance can also be obtained easily from the Burton's Nautical Tables or Norie's Nautical Tables.

DISTANCE SAILED ROUND AN ARC

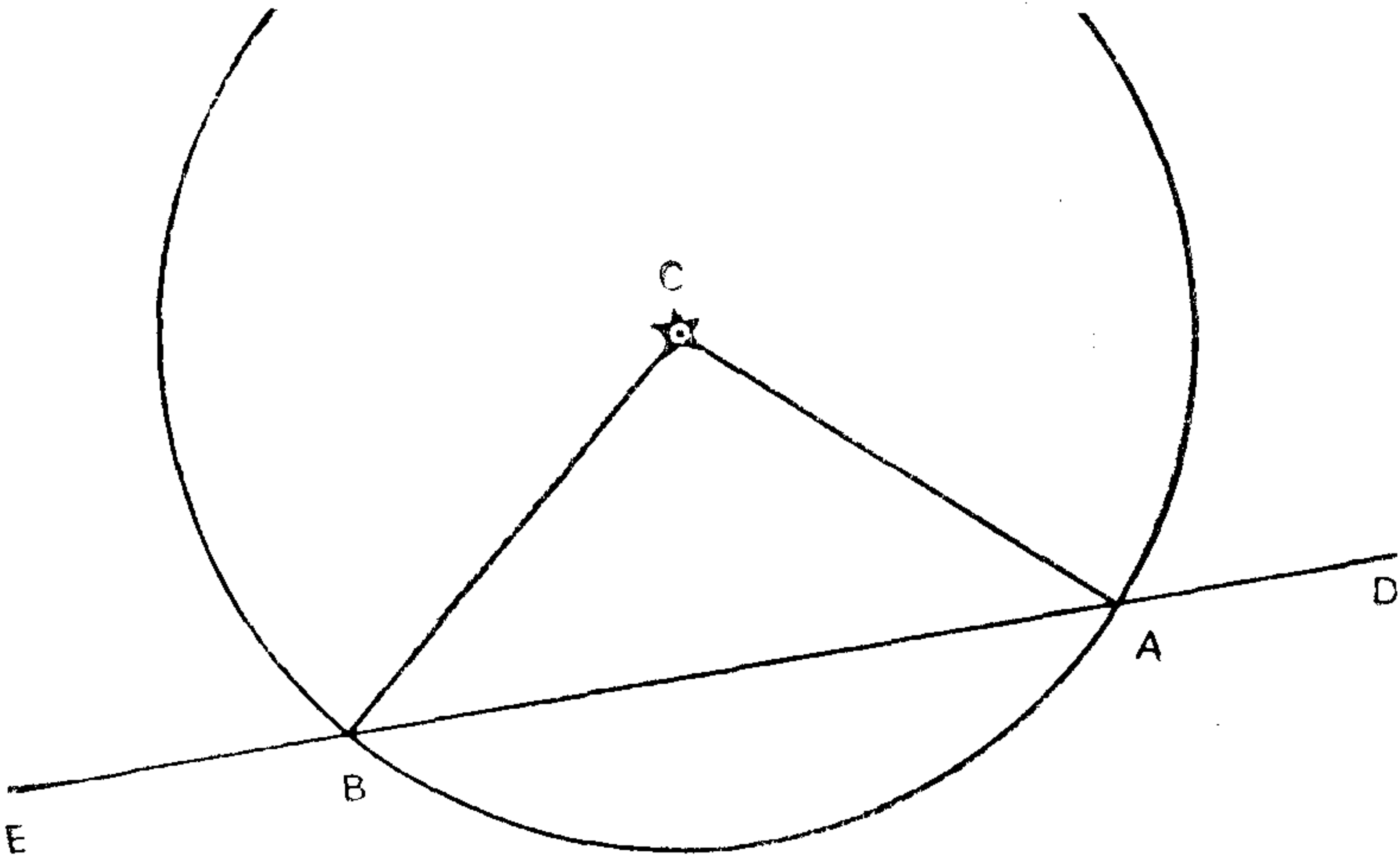
Sometimes, a ship may be required to sail round an arc, so as not to get closer than a certain distance to a danger or a rock, or a light house, whilst at the same time not deviating too much from the original course.

This is done by finding out the vertical sextant angle of the light house or a hill generally called a "Vertical Danger Angle" and then the sextant is set on that angle and this angle is maintained by altering the ship's course often, so that the ship can be made to sail round this arc, and at the same time not getting too far off the course line

laid on the chart. This distance sailed round the arc is easily found and is explained as below :—

Supposing a ship continuing on her course DE does not want to get closer than 5 Miles off C (a light house) (Figure below) and then with C as a centre and 5 Miles as radius, draw an arc cutting the original course DE at points A and B and the ship sails round the arc AB.

In order not to get closer than 5 Miles, as soon as the ship reaches point A, courses are altered as required, keeping the ship sailing round this arc AB, and distance off maintained with the help of a danger vertical sextant angle, until the ship reaches B, when the ship can resume back her old course.



The distance sailed round this arc is easily calculated by the formula :—

$$= \frac{\text{Distance sailed round the arc}}{\text{Angle subtended at the centre} \times \text{distance off}} \\ 57.3$$

Example II.

At 0430 hrs. Nab Tower Light dipped bearing 344° (T). From this position, course was set by compass

to pass Les Hanois Light house 14.0 Miles off when abeam to port. Find the compass course to steer. While on the above course it was decided not to get closer than 8 Miles off Casquets Lt. Ho., calculate the vertical danger angle to set on the sextant and also the E.T.A. (Expected time of arrival) when Les Hanois Light house will be abeam. No current, height of eye 12.19 Metres (40 feet). Index error 3' on the arc.

(Variation 7.5° W. Speed 13 knots. Deviation Card I).

Answer :

Visibility of Light	14 Miles.
Range for height of eye (4.57 mtrs. or 15 feet)	— 4.5'
Visibility of Light at sea level	9.5'
Range for 12.19 metres height of eye	+ 7.4'
Dipping distance	16.9 Miles.
True course to steer	240° (T)
Variation	7.5° W
Magnetic course	247.5° (M)
Deviation	10.7° E
Compass course to steer	236.8° (C)
	ANS.

Height of Casquets Lt. Ho. 120 feet.

Distance off = 8 Miles.

Height of object (in feet)

$$\text{Distance off} = \frac{\text{Sextant altitude (in minutes.)}}{\text{Height of object (in feet)}} \times 0.565$$

Height of object (in feet)

$$\text{Sextant altitude in minutes} = \frac{\text{Distance off (in miles.)}}{\text{Height of object (in feet)}} \times 0.565$$

$$= \frac{120 \times 0.565}{8} = 8.5'$$

Sextant altitude (Observed)	8.5'
Index Error	3' on the arc
Sextant altitude	11.5'

Angle subtended at the centre = 96°

Distance off or radius = 8 Miles

Distance sailed round the arc

$$= \frac{\text{Angle subtended at centre} \times \text{distance off}}{57.3}$$

$$= \frac{96^\circ \times 8}{57.3} = 13.4 \text{ Miles}$$

Beam bearing of Les Hanois Lt. Ho. 150° (T)

Total distance = $66.2' + 13.4' + 13.8' = 93.4$ Miles

Speed = 13 knots.

Time taken = 7 hours 11 minutes.

E.T.A. at the beam bearing = 1141 hrs.

ANS :

Exercise 1.

From a vessel steering 310° (C) the following
Compass bearings were observed at 1930 hrs.

C. d' Antifer Lt. bearing	108° (C)
C. de La Heve Lt. bearing	165° (C)
Le Havre Lt. Vessel bearing	205° (C)

Find the ship's position. The vessel continued on her course and at 2054 hrs. Pte. de Barfleur Lt. was raised bearing 256° (C), find the ship's position and the set and drift of the current experienced. Find also the course and speed made good. (Use Variation 12.5° W. Deviation as per Card I. Speed 15 knots. Height of eye 10 Metres (33 feet)).

Answer :

Ship's head	310° (C)
Deviation	6.5° E
Variation	12.5° W
Compass Error	6° W
True course	304° (T)

True bearing of C. d'Antifer Lt.	102° (T)
True bearing of C. de La Heve Lt.	159° (T)
True bearing of Le Havre Lt. Vessel	199° (T)
Ship's position at 1930 hrs :—	
Lat. 49°42.7'N Long. 00°03.3'W	
Range of Pte. de Barfleur Lt.	= 22 Miles.
Range for height of eye 15 feet	= — 4.5 Miles.
Visibility of Pte. de Barfleur Lt. at sea level.	= 17.5 Miles
Range for height of eye 10 metres. (33 feet)	= + 6.7 Miles.
Visibility at Height of Eye 10 Metres.	24.2 Miles.
Compass bearing of Pte. de Barfleur Lt.	256° (C)
Compass Error	6°W
True bearing of Pte. de Barfleur Lt.	250° (T)
Obs. position at 2054 hrs :—	
Lat 49° 50.2'N Long. 00° 40.2'W	
Distance steamed for 1H. 24M.	= 21 Miles.
Current	= 239° (T)
Drift	7.7 Miles in 1 hour 24 minutes
Rate of current	5.5 knots.
Course made good	288° (T)
Distance made good	24.6 Miles
Speed made good	17.5 Knots.

Exercise II.

On a voyage from London to Portsmouth, a vessel steering 275° (C), speed 14 knots. At 1910 hrs. Beachy Head Light dipped bearing. 025° (C) and at 2104 hours Nab Tower Lt. was raised bearing 318° (C). Variation 9°W. Height of eye 11 metres (36 feet).

Find the ship's position at 1910 hours and at 2104 hours, the set and drift of the current experienced and the course and speed made good.

(Deviation Card I)

Answer :

Course steered	275° (C)
Deviation	12°E Variation 9°W

Compass error	3°E	
True course Steered	278° (T)	
	Beachy Head Lt.	Nab Tower
Compass bearing	025° (C)	318° (C)
Compass error	3°E	3°E
True bearing	028° (T)	321° (T)
Range of light	16.0'	14.0'
Range for 4.57 metres (15 feet)	— 4.5'	— 4.5'
Visibility @ Sea level	11.5'	9.5'
Range for 11 metres (36 feet)	+ 7.0'	+ 7.0'
Dipping or raising distance	18.5'	16.5'
Position @ 1910 hrs. Lat. 50°27'N Long. 00°01.0'E		
Position @ 2104 hrs. Lat. 50°28'N Long. 00°41.0'W		
Set 181° (T) Drift 4 Miles @ 2.2 knots.		
Course made good 270° (T)		
Distance made good 26 Miles.		
Speed made good 13.7 knots.		

Exercise III.

On a voyage from Bristol to Antwerp, a vessel steering 145° (C) at 15 knots, position at 1500 hrs. was found with Bill of Portland Lt. Ho. bearing 318° (C) and Anvil Point Lt. Ho. bearing 034° (C). Find the ship's position. The vessel continued on her course through an estimated current setting 281° (M) at 1.5 knots. Find how close did the ship pass Pte. de Barfleur Lt. Ho. and also the estimated time when the light house was abeam.
(Variation 11°W Deviation Card I.)

Answer :

Ship's head	145° (C)
Deviation	4°W
Variation	11°W
Compass Error	15°W
True course	130° (T)
Current	281° (M)
Variation	11°W
Current	270° (T)

	Bill of Portland Lt.	Anvil Point Lt.
Compass bearing	318° (C)	034° (C)
Compass Error	15°W	15°W
True bearing	303° (T)	019° (T)
Position at 1500 hrs. Lat. 50°21.5'N Long. 2°05'W		
Nearest distance off Pte. de Barfleur Lt. Ho. 7.6 Miles.		
Distance to make to beam bearing		50.0 Miles
Speed made good		13.75 knots
Time taken		3 Hours 38 Minutes
E. T. A. for beam bearing		1838 hours.

Exercise IV.

- At 1700 hrs. vertical sextant angle of Hardy monument (772 feet) was 1° 03' and that of Bill of Portland Lt. Ho. (145 feet) was 00° 10'. Find the ship's position.
- From this position, course was set for Les Hanois Light counteracting a current setting 289° (M) at 2.5 knots. Wind East, force 6. Leeway 3°. Find the compass course to steer, and the speed made good.
- Calculate the time Casquets Light was raised.
- Find the time and the distance off when Casquets Light will be abeam. (H.E. 9.5 metres (31 feet) Variation 11° W. Ship's speed 12.5 knots. Deviation Card I).

Answer :

$$\begin{aligned}
 \text{(a) Hardy Monument} &= 772 \text{ feet.} \\
 \text{Vertical Sextant angle} &= 1^\circ 03' = 63' \\
 &\quad \text{Height of object (in feet)} \\
 \text{Distance off (in miles)} &= \frac{\text{Sextant altitude (in minutes.)}}{\text{Height of object (in feet)}} \times .565 \\
 &= \frac{772}{63} \times .565 = 7.0 \text{ miles.} \\
 \text{Bill of Portland Lt. Ho. height} &= 145 \text{ feet.} \\
 \text{Vertical Sextant angle} &= 10' \\
 &\quad \text{Height of object (in feet)} \\
 \text{Distance off (in miles)} &= \frac{\text{Sextant altitude (in minutes)}}{\text{Height of object (in feet)}} \times .565 \\
 &= \frac{145 \times .565}{10} = 8.0 \text{ miles off.}
 \end{aligned}$$

Ship's position at 1700hrs. :—

Lat. $50^{\circ} 35'N$ Long. $02^{\circ} 38'W$

(b)	Current	$289^{\circ} (M)$
	Variation	$11^{\circ}W$
	True Current	$278^{\circ} (T)$ at 2.5 knots.
	True course to steer to counteract the current	$171^{\circ} (T)$
	Leeway (Wind East)	— 3°
	True course to counteract the current and leeway	$168^{\circ} (T)$
	Variation	$11^{\circ}W$
	Magnetic course	$179^{\circ} (M)$
	Deviation	$1.7^{\circ}E$
	Compass course to steer Counteracting current and leeway	$177.3^{\circ} (C)$
	Speed made good	12 knots
(c)	Range of Casquets Light	17.0 Miles
	Distance for H. E. 4.57 metres (15 feet)	— 4.5'
	Range at Sea level	12.5'
	Distance for H. E. 9.5 metres (31 feet)	+ 6.5'
	Raising distance of Casquets Lt.	19.0'
	Distance to raising light position	37 Miles
	Speed made good	12 Knots.
	Time taken to raise the light	3H. 05M
	E. T. A. when light is raised.	2005 hrs.
(d)	True course steered	$168^{\circ} (T)$
	For beam bearing	— 90°
	Beam bearing of Casquets Lt.	$078^{\circ} (T)$
	Distance from 1700 hrs. Position to beam bearing	54 miles
	Speed made good	12 knots.
	Time taken	4 Hrs. 30 Minutes.
	Hence Casquets Light will be abeam at	2130 hours.
	Distance off when Casquets Light is abeam	12 miles.

Exercise V.

- (a) At 0800 hrs. horizontal sextant angle between St. Catherine Pt. Lt. Ho. and Nab Tower was 63° and the vertical sextant angle of Nab Tower was $00^\circ 11'$ (Height 41.15 metres or 135 feet). Find the ship's position.
- (b) From this position find compass course to steer to pass 8 miles due south of Start Point Lt. Ho. counteracting a current setting $116^\circ (M)$ at 4 knots. Wind North. Leeway 3° . Find the speed made good and the E.T.A. off Start Point Lt.
- (c) Find the time when Anvil Point Lt. Ho. will be abeam. (Ship's speed 15 knots. Variation $9^\circ W$. Deviation Card I. Index Error NIL)

Answer :

- (a) Complement of horizontal angle 27°
 Vertical sextant angle of Nab Tower $00^\circ 11'$
 Distance off Nab Tower 7.0 Miles
 Position at 0800 hrs. Lat. $50^\circ 34' N$ Long. $00^\circ 53' W$
- (b) True course to steer counteracting current $263^\circ (T)$
 Leeway (Wind North) $+ 3^\circ$
 True course counteracting Current and Leeway $266^\circ (T)$
 Variation $9^\circ W$
 Magnetic course $275^\circ (M)$
 Deviation $12.9^\circ E$
 Compass course to steer to counteract Current and Leeway $262.1^\circ (C)$
 Speed made good 11.5 knots.
 Distance to the position 8 Miles due South of Start Point 109 Miles
 Time taken @ 11.5 knots. 9 Hrs. 29 Mins.
 E.T.A. off Start Point Lt. 1729 hrs.
- (c) True course steered $266^\circ (T)$
 Beam bearing $356^\circ (T)$
 Distance off Anvil Pt. Lt. $\perp$ 41.8 Miles
 Time taken @ 11.5 knots. 3 H 38 M.
 E.T.A. when Anvil Pt. Lt. $\perp$ 1138 hours.

Exercise VI.

- (a) On 20th Jan. Position at 2200 hrs. was found with Berry Head Lt. bearing 332° (T) and Start Point Lt. bearing 245° (T), when course was set to pass St. Catherine Point Lt. 8 miles off to port. Find the Compass course to steer.

At 2330 hrs. Bill of Portland Lt. (Gp. Fl. (4) 18 M) was raised bearing 076° (C). Find also the set and drift of the current experienced.

- (b) At 2330 hrs. on 20th January, course was reset to pass St. Catherine Lt. 10 miles off to port, counteracting the current experienced from 2200 hrs. to 2330 hrs. Find the compass course to steer. Also find the time and the distance off when Anvil Point Lt. will be abeam.

(Variation 6.5° E. Ship's speed 14 knots. Height of eye 12 metres (39.1 feet) Deviation Card I).

Answer :

- | | | |
|-----|--|---------------------|
| (a) | True course to steer | 083.5° (T) |
| | Variation | 6.5° E |
| | Magnetic course | 077° (M) |
| | Deviation | 12.5° W |
| | Compass course to steer | 089.5° (C) |
| | Compass error | 6° W |
| | Range of Bill of Portland Light | 18 Miles |
| | Reduction for 4.57 metres (15 feet) | -4.5 Miles |
| | Range at sea level | 13.5 Miles |
| | Visible horizon for 12 metres | $+7.4$ Miles |
| | Visibility of the light (H.E. 12 Mts.) | 20.9 Miles |
| | Compass bearing of Bill of Portland Lt. | 076° (C) |
| | Compass error | 6° W |
| | True bearing of Bill of Portland Lt. | 070° (T) |
| | Distance steamed in $1\frac{1}{2}$ hrs. | 21 Miles |
| | Current Set 305° (T) drift 6.5 Miles
at 4.3 knots. | |
| (b) | True course to steer counteracting
the current experienced | 098° (T) |
| | Variation | 6.5° E |

Magnetic course	091.5° (M)
Deviation	11.3° W
Compass course to steer	102.8° (C)
Course made good	089° (T)
Speed made good	10.75 knots
Beam bearing of Anvil Point Lt.	008° (T)
Distance off when abeam	11.8 Miles
Distance from 2330 hrs. position to beam bearing	36.5 Miles
Speed made good	10.7 knots
Time taken	3H. 23M.
E.T.A. when Anvil Point Lt. will be abeam 0253 hrs. on 21st January.	

Exercise VII.

- (a) From a vessel steering 252° (C) at 0800 hrs. Nab Tower bore 020° (C) and St. Catherine Pt. Lt. Ho. bore 308° (C). Find the ship's position.
- (b) From this position, set a course by compass to counter-act current setting 158° (M) at 4 knots, Wind North. Leeway 2° so as to reach 8' due south of Start Pt. Lt. Ho.
- (c) Find the time when the vessel will be abeam off the Shambles Lt. Vessel (Variation 8° W Deviation as per Card I. Ship's speed 12 knots).

Answer :

(a) Compass Course	252° (C)
Deviation	12.2° E
Variation	8° W
Compass Error	4.2° E
True course	256.2° (T)
True bearing of Nab Tower	024.2° (T)
True bearing of St. Catherine Pt. Lt. Ho.	312.2° (T)
Ship's position at 0800 hrs. :—	
Lat. 50° 28' N Long. 01° 06' W	

- (b) Current 150° (T) @ 4 knots.
 True course to steer to counteract
 the current 275° (T)
 Leeway (Wind N'y) $+ 2^{\circ}$
 True course to steer counteracting
 Current and Leeway 277° (T)
 Variation 8° W
 Magnetic course 285° (M)
 Deviation 12.2° E
 Compass course to steer 272.8° (C)
- (c) Beam bearing of Shambles Lt. Vessel 007° (T)
 Distance from 0800 hrs. Position to
 Shambles Lt. Vessel abeam 50.4 Miles
 Speed made good 10.2 Knots
 E.T.A. when Shambles Lt. Vessel is abeam 1254 hrs.



CHAPTER XII

POSITION LINES BY ASTRONOMICAL OBSERVATIONS

[English Channel (Eastern Portion) Chart B.A. No. 2675]

We have so far in the previous chapters found the ship's position by position lines obtained from various terrestrial observations. However, it may be appreciated that a position line can also be obtained and calculated from astronomical observations.

An astronomical position line is really a small arc of a circle of position, whose centre is the object observed and the radius is the angular distance of the observer's zenith from the object (Zenith distance).

The practical method of laying down a position line is to plot a small part of the circle of position, as a straight line. The position line from a celestial observation is thus found by adding and subtracting 90° to the Azimuth of a heavenly body.

It is not proposed to discuss in this chapter the theory of how a position of the ship is obtained by celestial observations but a brief description of the two methods, which give a position from where to draw a position line are enumerated below very briefly :—

(a) LONGITUDE BY CHRONOMETER METHOD

With D. R. Latitude and Declination and true altitude of the heavenly body known, calculate the local hour angle (L.H.A.) and thence the observed Longitude. With the help of ABC tables, calculate the Azimuth of that heavenly body and thus obtain the position line (P.L), which is always at right angles to the Azimuth of the body.

Plot the D. R. Latitude and the observed Longitude and through this position draw the position line. The ship at the time of observation lies somewhere on this position line.

(b) MARCQ ST. HILAIRE METHOD

In this method, the true Zenith distance of a celestial object is obtained by observing its altitude. Using the D. R. Lat. and D. R. Long., the Zenith distance of the body is calculated with reference to this D. R. Position. The difference between the true and calculated Zenith distance is called the Intercept. The Azimuth of the heavenly body is calculated by ABC Tables and thus the P.L., which is at right angles to the Azimuth.

The D. R. Position is plotted on the chart and the intercept laid off along the true bearing of the object (either Towards or Away) at the time of observation. This is called Inter Terminal Position. A line drawn at right angles to the Azimuth through this position is the required position line, and the ship lies somewhere on this position line.

In both the above stated methods, the position of the ship is not found, but it is only a means of finding the position through which to draw the position line. However, the position line so obtained can be used in finding the ship's position by intersecting it with another position line, found by the same or any other method.

For instance, if simultaneously with the observation of the heavenly body, a bearing of a terrestrial object is taken, or a D.F. bearing of a D.F. station is obtained, the intersection of the bearing (D.F. or terrestrial) and the position line obtained from the observation of a heavenly body, will give the position of the ship.

If a Position Line is obtained by a celestial observation and after a known lapse of time, a terrestrial bearing is observed, then the position of the vessel can also be obtained by the "Running Fix" method. In this case, the position through which the position line passes is laid on the chart and then the course steered and the distance steamed in the interval is laid off. From the position so arrived draw the transferred position line and where it cuts the terrestrial bearing is the position of the ship.

If, however, a current is experienced during the interval, then from the position through which to draw the position line, lay off the course and distance steamed and then apply the set and drift of the current during that interval and from this position, draw the transferred position line and where it cuts the terrestrial bearing, is the actual position of the ship at the time of taking the terrestrial bearing.

It may be noted that the second position line may be obtained by any suitable method including a second observation of a celestial body. The second celestial observation must, of course, make a "good cut" with the first (or the transferred) position line to give an accurate "Fix".

In practice a ship's position is found at sea by taking an observation of a celestial body (say sun in the morning) and thus finding a position through which the position line passes (either by Longitude by Chronometer method or Intercept method) and then applying the course and distance steamed i.e. the run, till the heavenly body (Sun) is at or near the meridian. A second observation of the heavenly body (Sun) is then taken when at or near the meridian and the second position line obtained. Position of the ship is now obtained by crossing the transferred position line with the position line computed from the second observation.

It may be appreciated that whatever be the D. R. position of the ship, at the time of first observation, the Fix i.e. resultant observed position at the time of second observation, will always be the same.

NOTE : It must be remembered in this type of Chart Work problems, that at NOON (when sun is on the observer's meridian) the sun bears North or South, the position line runs EAST & WEST i.e. a parallel of Latitude. Similarly again if an observation of a heavenly body is taken when it is on the prime vertical, it bears EAST or WEST and consequently the position line will run due North and South i.e. the meridian. Thus the meridian altitude observation gives the navigator the true Latitude and the prime vertical observation gives the true Longitude.

THE USE OF A SINGLE POSITION LINE

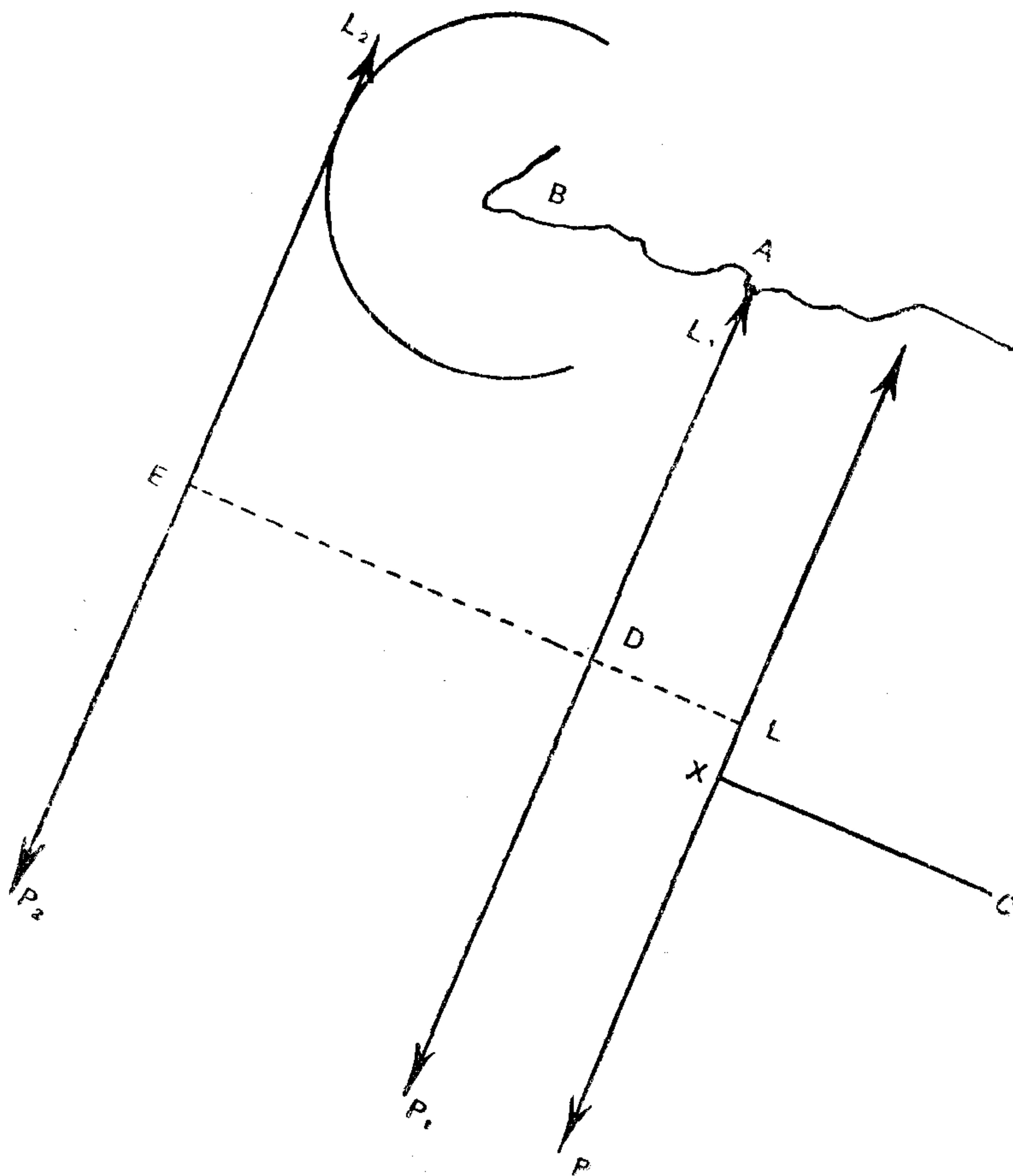
A single position line, as obtained from the observation of a heavenly body, does not give a fix, but it merely shows that the vessel is somewhere on that position line. The other main advantage of this position line is, that it may ensure steering a safe course to pass a certain distance off a light house or to arrive at a certain point or position. This can best be explained by an example.

Let C represent the D.R. Position (See Figure on Page 105) and X represent a position through which the position line PL passes. It must be remembered that PL gives only

the position line and the ship may not be at this "X" position, but will be somewhere on the position line PL.

In the vicinity of land, when the position line obtained may be succeeded by low visibility, then safe course to reach a certain position or to pass a head land at a safe distance or to clear a danger will be to take this position line as a COURSE, which will be safest, as explained below:—

(1) Suppose PL is the position line, obtained from a reliable sight and immediately thereafter visibility deteriorates and it is desired to reach the position A. Through A draw $P_1 L_1$ parallel to PL. Choose any point 'L' on PL and draw LD perpendicular to $P_1 L_1$. Then LD will be the first course and the distance to steam and $P_1 L_1$, the final



course to steer to reach A. The distance ship will have to sail along P_1DL_1 will depend upon how much the ship is away from the position X.

(2) Similarly PL is again the position line obtained from a sight and it is required to pass a point B at a distance of say 5 miles, visibility being poor due to fog.

With B as a centre and 5 miles as a radius draw an arc. Then draw P_2EL_2 as a tangent to this arc and also parallel to PL. Draw LE as perpendicular to P_2L_2 . Then LE will be the first course to steer and distance to steam, and P_2L_2 will be the second course to steer and by proceeding on this course P_2L_2 , the ship will pass 5 miles off the point B and the distance steamed along P_2L_2 again will depend upon how much the ship is away, from the position X

The above two cases assume that there is no wind or current affecting the ship during the period.

But should the effect of current be there, it will have to be taken into account. In that case, find the course to steer to counteract the current to make good LE as the course and distance. Again at the appropriate time, find the second course to steer to counteract the current to make good the course of P_2L_2 . The vessel will now pass the required distance off B.

Here it is advised that the navigator when using position line to clear a head land at a safe distance or to make a certain point, should make frequent and intelligent use of soundings and especially of crossing different "fathom lines" or depth contours.

The line of sounding, when used in conjunction with the position line or transferred position line may also be helpful to the navigator.

Similarly the navigator should also make use of all other navigational aids at his disposal, when using position line as a course to clear a head land at a safe distance.

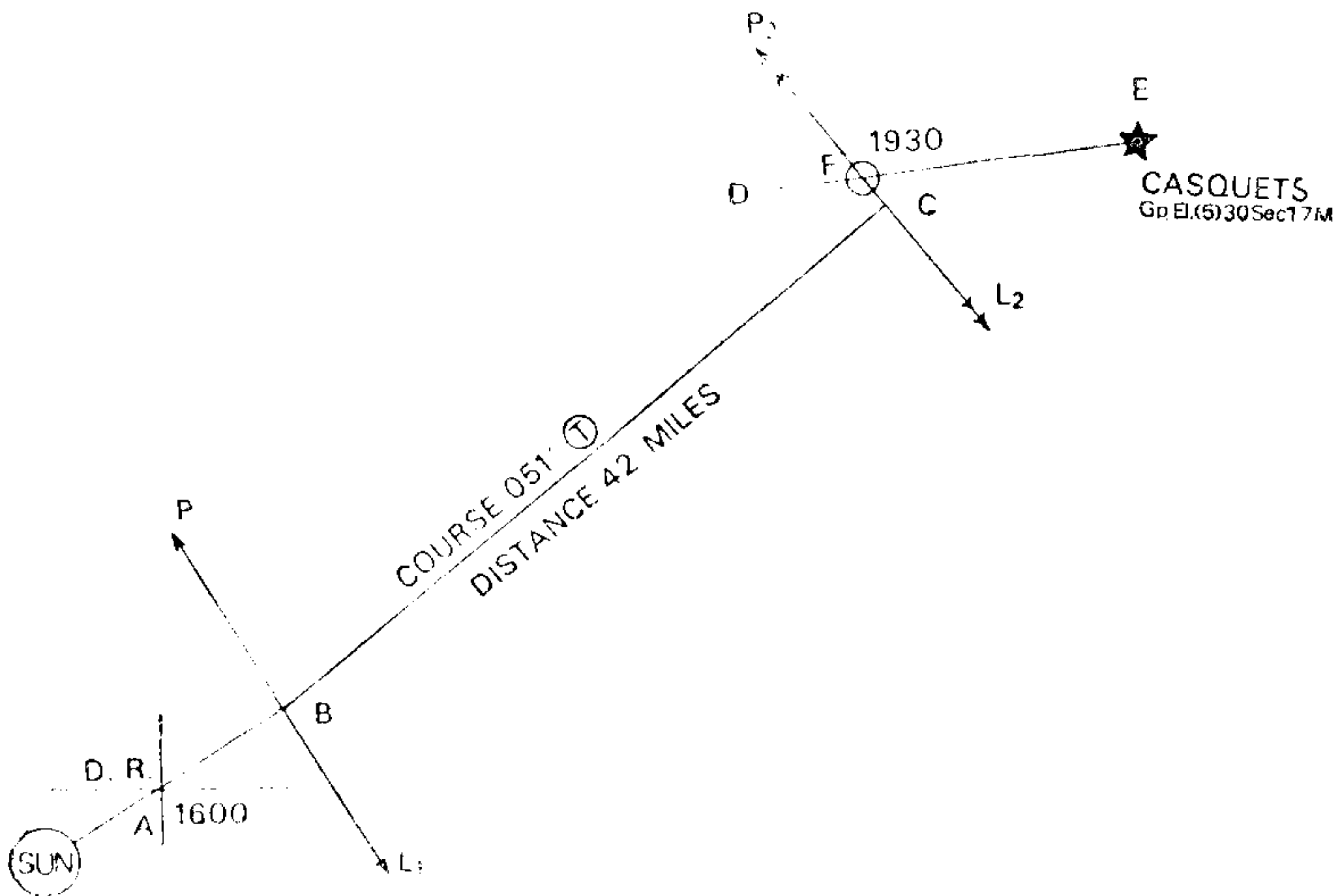
Example I.

From a vessel steering 071° (C) an observation of the sun at 1600 hours, gave the following results :—
D.R. Position Latitude $49^\circ 09'N$ Longitude $03^\circ 44'W$. True Azimuth 238° (T). Intercept 8' AWAY.

The vessel continued on her course and at 1930 hrs. Casquets Lt. was observed bearing 103° (C). The ship's speed was 12 knots and Variation 8° W, find the vessel's position at 1930 hours. (Deviation Card I).

SOLUTION

Compass course	071° (C)
Deviation	12° W
Variation	8° W
Compass Error	20° W
True course	051° (T)
True bearing of Casquets Lt.	083° (T)

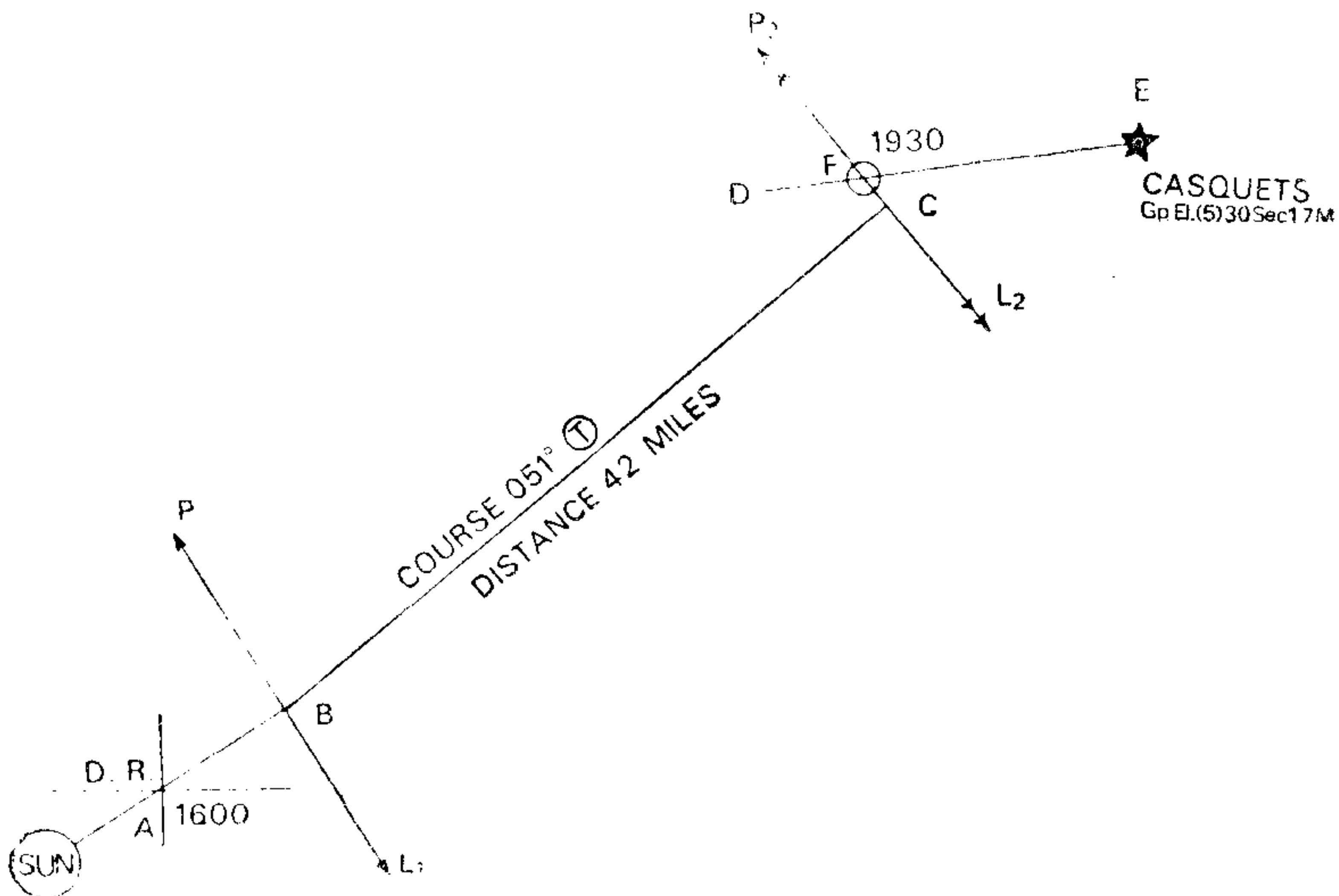


- (1) Plot the D.R. Position i.e. $49^\circ 09'N$ $03^\circ 44'W$ on the chart and from it draw the Azimuth i.e. 238° (T).
- (2) Since the Intercept is 8' AWAY, mark off position B in the direction 180° away from the Azimuth (i.e. in 058° direction) and distance 8 Miles. This is I.T.P.
- (3) From B draw $P_1 L_1$ (the position line) at right angles to the Azimuth. The ship is somewhere on this position line at the time of observation.
- (4) Now lay true course BC i.e. 051° (T) making $BC = 3\frac{1}{2}$ hrs. steaming = 42 miles.

The vessel continued on her course and at 1930 hrs. Casquets Lt. was observed bearing 103° (C). The ship's speed was 12 knots and Variation 8° W, find the vessel's position at 1930 hours. (Deviation Card I).

SOLUTION

Compass course	071° (C)
Deviation	12° W
Variation	8° W
Compass Error	20° W
True course	051° (T)
True bearing of Casquets Lt.	083° (T)



- (1) Plot the D.R. Position i.e. $49^\circ 09'N$ $03^\circ 44'W$ on the chart and from it draw the Azimuth i.e. 238° (T).
- (2) Since the Intercept is 8' AWAY, mark off position B in the direction 180° away from the Azimuth (i.e. in 058° direction) and distance 8 Miles. This is I.T.P.
- (3) From B draw $P_1 L_1$ (the position line) at right angles to the Azimuth. The ship is somewhere on this position line at the time of observation.
- (4) Now lay true course BC i.e. 051° (T) making $BC = 3\frac{1}{2}$ hrs. steaming = 42 miles.

- (5) Through C draw the transferred position line, $P_2 L_2$.
- (6) Draw the true bearing of Casquets Lt. Ho. at 1930 hrs. i.e. 083° (T).
- (7) Where this true bearing 083° (T) cuts the transferred position line or $P_2 L_2$, is the position of the ship at 1930 hrs.
1930 hrs. Position. Lat. $49^\circ 41.8'N$ Long. $02^\circ 44.7'W$.

ANS.

Exercise I.

At 0900 hrs. a vessel in D.R. Lat. $50^\circ 04'N$ Long. $01^\circ 15'W$, a sun's sight gave observed Longitude $01^\circ 08'W$ and the Azimuth 035° (T). The vessel then steered 100° (C) at 12 knots until 1200 hrs. when C. d'Antifer Lt. Ho. bore 167° (C). Find the ship's position at 1200 hrs. (Variation $4.5^\circ E$ Deviation Card I).

Answer :

Compass course	100° (C)
Deviation	$11.5^\circ W$
Variation	$4.5^\circ E$
Compass error	$7^\circ W$
True course	093° (T)
True bearing of C. d'Antifer Lt. Ho.	160° (T)
Position at 1200 hrs. :—	
Latitude $49^\circ 55.8'N$ Longitude $00^\circ 02'E$	



CHAPTER XIII

RUNNING FIX WITH CURRENT

[English Channel (Eastern Portion) Chart B.A. No. 2675]

In Chapter VII the procedure for finding the position of the ship by running fix method was explained. However, it was assumed that no current was affecting the ship during the period. This is hardly the case in practice, as some current is always present, which naturally effects the course and speed and thus the position of the ship.

The method of finding ship's position by running fix, when the current is affecting the ship, is therefore, explained here by a worked example :—

Example

From a vessel steering 119° (C) at 0100 hrs. Pte. de Barfleur Lt. bore 168° (C). One hour later i.e. at 0200 hrs. the same light bore 259° (C). During that time the current was known to be setting 080° (T) at 3 knots. Find the ship's position at 0200 hrs. and at 0100 hours (Variation 8° W. Speed 12 knots. Deviation Card I).

SOLUTION

Compass course	119° (C)
Deviation	9.1° W
Variation	8° W
Compass error	17.1° W
True course	101.9° (T)
1st Compass bearing of Pte. de Barfleur Lt.	168° (C)
Compass Error	17.1° W
1st True bearing of Pte. Barfleur Lt.	150.9° (T)
2nd Compass bearing of Pte. de Barfleur Lt.	259° (C)
Compass Error	17.1° W
2nd True bearing of Pte. de Barfleur Lt.	241.9° (T)

Course made good 098° (T) and the speed made good is 14.8 knots.

Now from C transfer the position line i.e. draw a line parallel to the first bearing. Then plot the second bearing of Pte. de Barfleur Lt. i.e. 241.9° (T) and where the transferred position line and the second bearing intersect (i.e. at D) is the position of the ship at the time of second bearing.

Ship's position at 0200 hrs. Lat. $49^{\circ}48'N$ Long. $01^{\circ}00'W$
ANS.

To find the position at the time of taking the first bearing :—

From D lay a course parallel to AC, cutting the first bearing at E. Then E is the required position of the ship at the time of 1st bearing.

Ship's Position at 0100 hrs. :—

Lat. $49^{\circ}49.2'N$ Long. $01^{\circ}22.7'W$

ANS.

NOTE

The point "A" on the first bearing may be taken at any convenient position, preferably near the Estimated Position of the ship. It may be pointed here that at whatever position the point "A" is taken on the first bearing, the "FIX" (actual final position) will be the same.

Exercise I.

At 1800 hrs. a vessel steering $030^{\circ}(C)$, observed Casquets Lt. bearing $083^{\circ}(C)$, and again at 1900 hours it bore $131^{\circ}(C)$, The current was known to be setting $342^{\circ}(M)$ at 2 knots throughout. Required the ship's position at 1900 hours and also estimate the ship's position at 2100 hours. (Ship's speed 12 knots. Variation $4^{\circ}E$ Deviation Card I).

Compass Course $030^{\circ}(C)$

Deviation $7^{\circ}W$

Variation $4^{\circ}E$

Compass Error $3^{\circ}W$

True course $027^{\circ}(T)$

1800 hrs. Casquets Lt. true bearing $080^{\circ}(T)$

1900 hrs. Casquets Lt. true bearing $128^{\circ}(T)$

True current $346^{\circ}(T)$ at 2 knots

Ship's position at 1900 hrs. :—

Lat. $49^{\circ}53'N$ Long. $02^{\circ}41.2'W$

Speed made good = 13.6 knots.

Estimated ship's position at 2100 hrs. :—

Lat. $50^{\circ}18.2'N$ Long. $02^{\circ}25.8'W$.

Exercise II.

A ship steering 115° (C) at 12 knots, at 1930 hrs. Pte. de Barfleur Lt. bore 174° (C) and at 2030 hrs. Pte de Barfleur Lt. bore 238° (C). During this time the current was setting 208° (T) at 2.5 knots. Wind North. Leeway 3° . Find the ship's position at 2030 hrs. (Variation 8° W. Deviation Card I).

Answer :

Compass course	115° (C)
Deviation	9.7° W
Variation	8° W
Compass error	17.7° W
True course	097.3° (T)
Leeway	$+ 3^{\circ}$
True course made good after Leeway	100.3° (T)
1930 hrs. True bearing of Pte. de Barfleur	156.3° (T)
2030 hrs. True bearing of Pte. de Barfleur	220.3° (T)
2030 hrs. Position Lat.	$49^{\circ} 48.2'N$ Long. $01^{\circ} 07.2'W$

Exercise III.

On a voyage from Southampton to Avonmouth, a vessel steering 260° (C), at 2000 hrs. St. Catherine Pt. Lt. bore 295° (C) and at 2100 hrs. it bore 027° (C). During this time the current was setting 209° (T) at 3 knots. Wind. South Force 6 Leeway 3° . Find the ship's position at 2100 hrs. and also at 2000 hrs. and the course and the speed made good (Variation 10° W. Engine speed 14 knots. Deviation Card I).

Answer :

Compass course	260° (C)
Deviation	13° E
Variation	10° W
Compass error	3° E
True course	263° (T)
Leeway (Wind South)	$+ 3^{\circ}$
True course made good after allowing for	
	leeway 266° (T)
Position at 2100 hrs. Lat.	$50^{\circ} 25'N$ Long. $01^{\circ} 26'W$
Position at 2000 hrs. Lat.	$50^{\circ} 29'N$ Long. $01^{\circ} 01.5'W$

Course made good 257° (T)
 Speed made good 16.3 knots.

Exercise IV.

On a voyage from Cherbourg to Boulogne, at 0835 hrs. a sun's sight worked with D. R. Lat. $49^{\circ} 55'N$ Long. $00^{\circ} 50'W$ gave observed Long. $00^{\circ} 44'W$ and Azimuth 111° (T). The vessel then steered 081° (C) at 12 knots until Noon when Pte. d'Ailly Lt. Ho. bore 134° (C). If the current during this time was estimated to be setting 120° (M) at 3 knots, find NOON position. (Variation $6.5^{\circ}W$. Deviation Card I).

Answer :

Ship's Head	081° (C)
Deviation	$12.5^{\circ}W$
Variation	$6.5^{\circ}W$
Compass Error	$19^{\circ}W$
True course	062° (T) speed @ 12 knots.
True current	113.5° (T) @ 3 knots.
Time taken	3H. 25M.
Distance steamed in 3H. 25M. @ 12 knots.	= 41 miles.
Drift in 3H. 25M. @ 3 knots	= 10.25 miles.
Compass bearing of Pte d' Ailly Lt.	134° (C)
Compass error	$19^{\circ}W$
True bearing of Pte. d'Ailly Lt.	115° (T)
NOON position Lat. $50^{\circ} 05'N$ Long. $00^{\circ} 24.3'E$	



CHAPTER XIV

WIRELESS BEARINGS

[English Channel (Eastern Portion) Chart B.A. No. 2675]

Direction Finder sets are required to be carried by all ships of 1600 ton gross or more. In fact almost all sea going ships now are equipped with this useful aid to navigation. In this chapter, it is not proposed to deal with the principle or operation of the D. F. Set, but merely with the information which a navigator acquires from it and its use in finding ship's position.

At various places throughout the world are established Wireless Direction Finding Stations (W/T. D. F. Station). These stations transmit radio signals at certain frequencies, at specified times, the particulars and details of which are enumerated in the Admiralty List of Radio Signals Vol. II. The bearing of these Radio Signals and thus the bearing of the D. F. Station, is obtained on board the ship by the use of the ship borne D. F. receiver set. As these bearings are "Relative bearings", the true course of the ship should be applied to it (Relative bearing) to obtain the true bearings. Now a days, many D. F. Sets are Gyro stabilised and thus the navigator can obtain directly the Gyro bearing. In fact, the latest D. F. receivers are automatic in operation, thus removing the source of personal error.

It is important to remember that there can be an ambiguity of 180° in the D. F. bearing so obtained, but this 180° ambiguity can easily be removed by the use of "SENSE" check. In practice however, navigator is seldom in doubt of this 180° ambiguity, because he can easily remove it by consulting the chart.

In all cases, the observed D. F. bearings are however, to be corrected for calibration error from the "Calibration Curve" available on the ship and for convergency before plotting them on the charts.

CONVERGENCY

Radio wave travels by the shortest distance and since the shortest distance between two points on the earth's surface is the arc of a great circle, it necessarily follows that the D. F. bearings are great circle bearings.

On the surface of the earth the meridians converge and meet at the poles, while on a Mercator's Chart, meridian is represented by a straight line, parallel to each other and at right angles to the Equator. A great circle will, therefore, make a varying angle as it crosses each meridian and the difference in angle which it makes with any two meridians is known as CONVERGENCY.

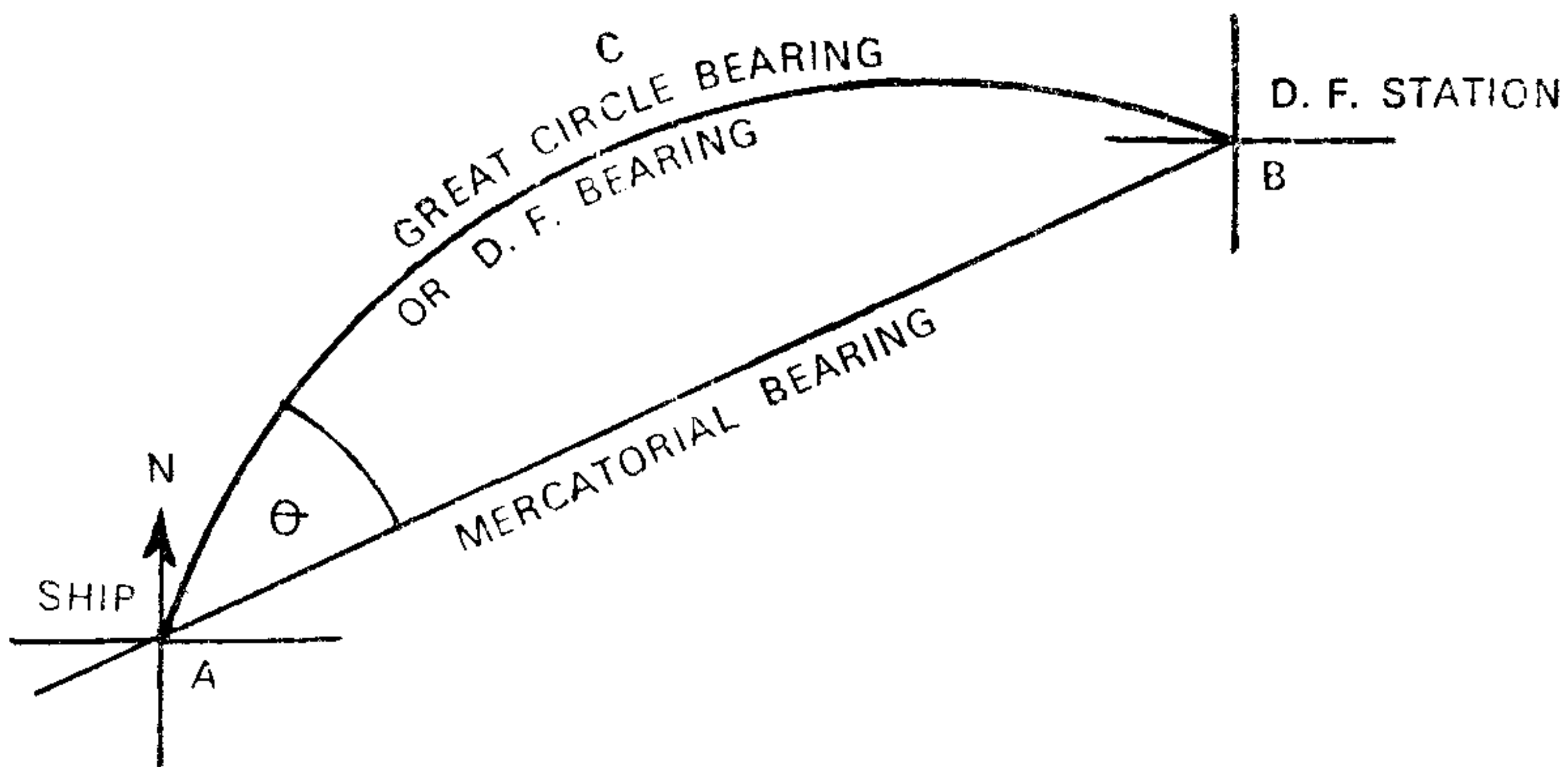
The angle of convergency varies with Latitude and the difference of Longitude between the points of intersection of the great circle, and it is calculated by the following formula :—

Convergency = D'Long. X Sine of Middle Latitude.

MEAN MERCATORIAL BEARING

Normally Mercator's charts are used in navigating the ships and thus the bearings of W/T.D.F. Stations which can be plotted on the chart should be mercatorial bearings only. But as W/T.D.F. bearings are great circle bearings, Half Convergency has to be applied to them, in order to obtain mean mercatorial bearings, for plotting on Mercators' chart.

Thus Mean Mercatorial bearing = True great circle bearing $\pm \frac{1}{2}$ convergency.



Suppose the ship A is in northern hemisphere and the relative position of the D. F. station B is marked. Then ACB is the great circle bearing of the D. F. station from the ship A and AB is the Mercatorial bearing of the station. θ is the half convergency which should be applied in order to get Mercator's bearing from D. F. bearing.

Assuming, for illustration that the D. F. bearing of the station from the ship is 040° and the half convergency is 1° , then the mercatorial bearing will be 041° (T).

The difference between the bearing i.e. half convergency, increases with the Latitude and the ship's distance from the W/T station. It is greatest when their relative position is East and West of each other and it is nil when the ship and the station are on the same meridian.

NOTE

Always remember that the mercatorial bearing always lies on the Equatorial side of the Great Circle bearing.

RULES FOR CONVERTING W/T BEARING INTO A MERCATORIAL BEARING

A rough sketch should be drawn as shown in the figure earlier, so that the relative positions of the ship and the shore station with a great circle joining them, is easily visualised.

RULE

IN NORTH HEMISPHERE

ADD the half convergency when W/T bearing is less than 180° and SUBTRACT when it is more than 180° .

IN SOUTH HEMISPHERE

The above rule is reversed.

Example I.

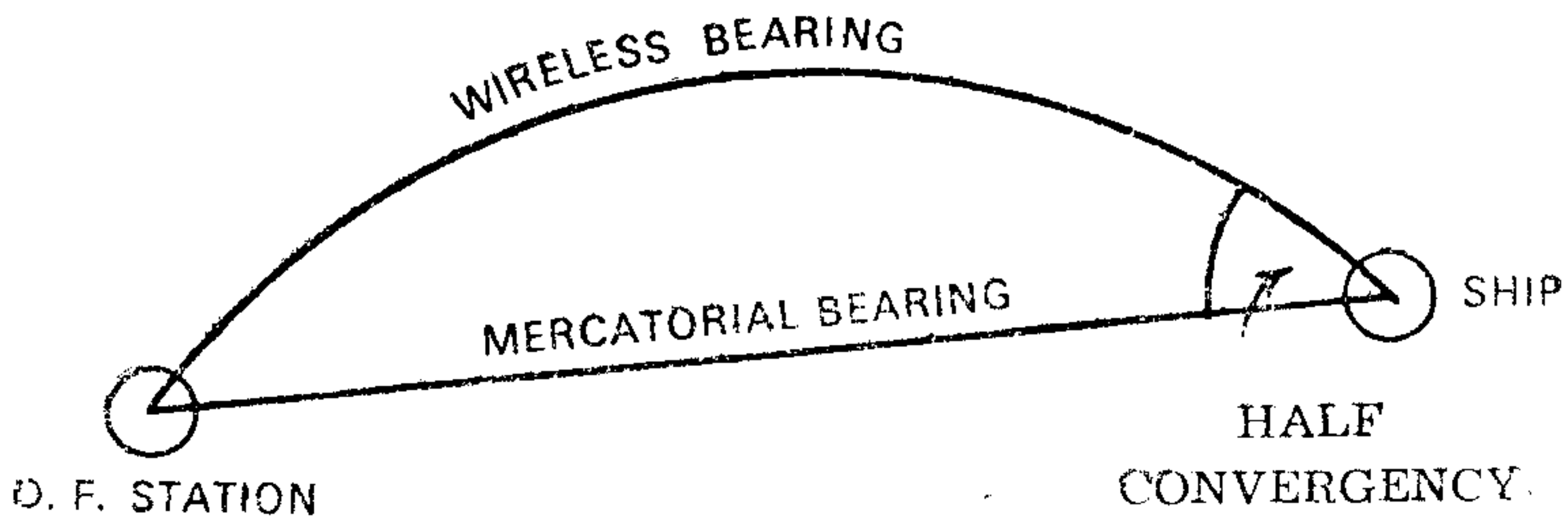
A ship in D. R. Position Lat. $23^\circ 00'N$ Long. $123^\circ E$ observes the D. F. bearing of Hong Kong D/F station in Lat. $22^\circ 13'N$ Long. $114^\circ 16'E$ to be 266° . Required the mercatorial bearing for laying off on a chart.

Lat. of Wireless Station	$22^\circ 13'N$
Lat. of the ship	$23^\circ 00'N$
Mean Lat.	$22^\circ 36.5'$ North
Long. of Wireless Station	$114^\circ 16'E$
Long. of the ship	$123^\circ 00'E$

Difference of the Long	=	8° 44'W
	=	524'
Half convergency	=	$\frac{D'Long \times \text{Sine Mean Lat.}}{2}$
		$\frac{524 \times \text{Sine } 22^\circ 36.5'}{2}$
524		2.71933
Sine 22° 36.5'		1.58482

201.44		2.30415
Half convergency	=	201.44

		2
	=	100.72
	=	1° 40.7'



From the above figure and the rule quoted earlier it will be seen that Half convergency is **SUBTRACTIVE**.

Wireless Bearing 266°

$\frac{1}{2}$ Convergency 1° 40.7'

Mercatorial Bearing 264° 19.3'

Hence 264° 19.3' will be the mercatorial bearing which can be laid off on the chart.

(Because of Northern hemisphere and the W/T bearing being more than 180°, the correction is subtracted).

NOTE

- (1) Half convergency correction Tables are given in **BURTON'S OR NORIE'S NAUTICAL TABLES**.

- (2) The convergency can also be found by inspection from the Traverse Tables. Enter the tables with Mean Latitude as COURSE, the difference in Longitude (in minutes) as DISTANCE and the convergency is found in the DEPARTURE column.

By Inspection Method :- (Using Traverse Tables)

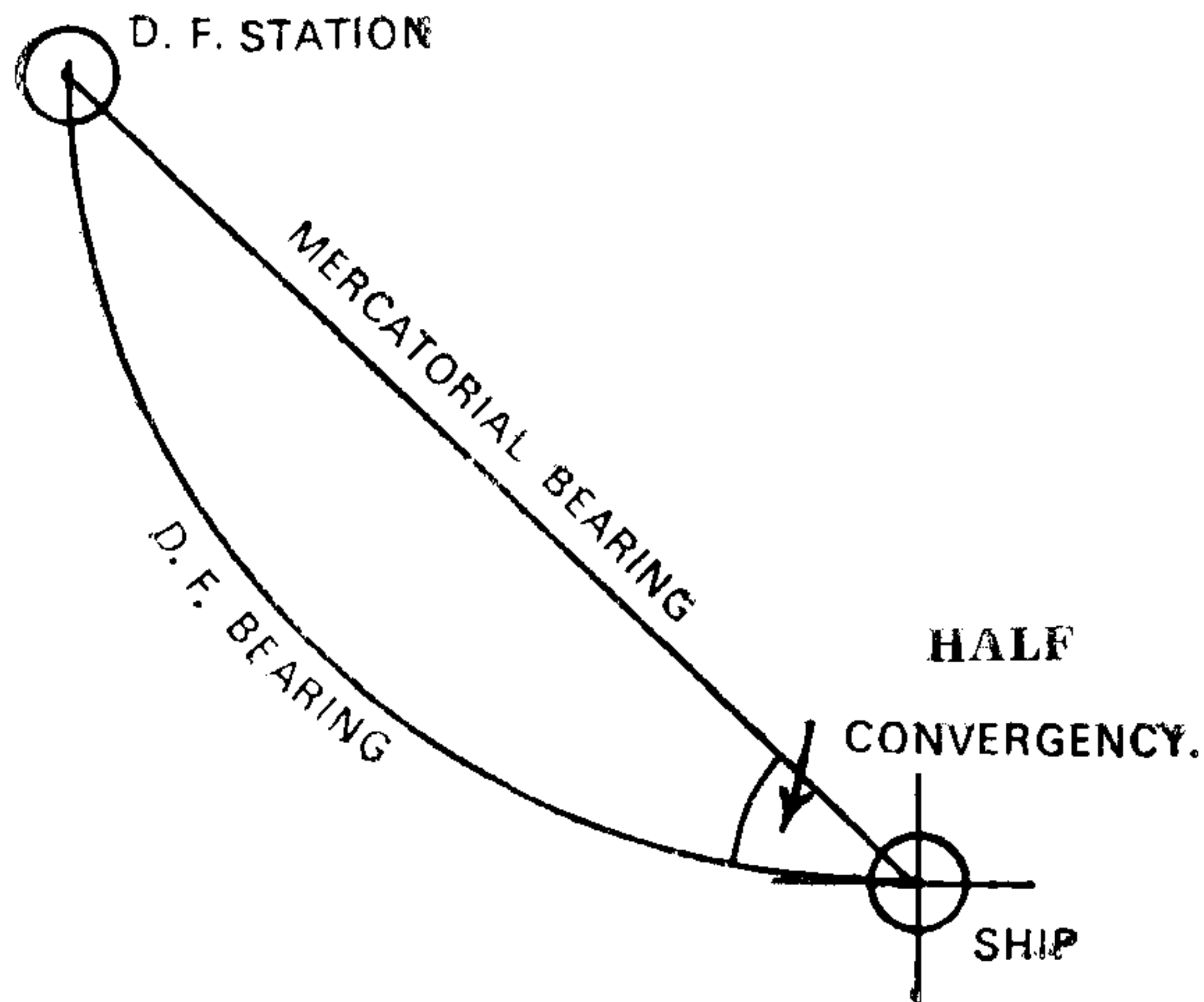
Mean Latitude $22^{\circ} 36'$ in the Course column and D'Long $524'$ in the Distance Column gives convergency $200.5'$ in the Departure column.

$$\begin{array}{rcl} \text{Hence } \frac{1}{2} \text{ convergency} & \frac{200.5}{2} & = 100.25' \\ & & = 1^{\circ} 40.25' \end{array}$$

Example II.

A ship in D. R. Lat. $20^{\circ} 00'S$ Long. $50^{\circ} E$ observes the D. F. bearing of Madagascar D. F. station in Lat. $15^{\circ} 43'S$ Long. $46^{\circ} 20'E$ to be 320° . Required the mercatorial bearing for laying on the chart.

Lat. of ship	$20^{\circ} 00'S$
Lat. of D. F. Station	$15^{\circ} 43'S$
Mean Lat.	$17^{\circ} 51.5'S$
Long. of ship	$50^{\circ} 00'E$
Long. of D. F. Station	$46^{\circ} 20'E$
D'Long	$3^{\circ} 40'$
D'Long	$= 220'$
Convergency	$= \text{D'Long} \times \text{Sine Mean Lat.}$
	$= 220 \times \text{Sine } 17^{\circ} 51.5'$
220	2.34242
Sine $17^{\circ} 51.5'$	1.48666
67.465	1.82908
Half convergency	$= \frac{67.46'}{2}$
	$= 33.73'$



D. F. Bearing = 320°

Half Convergency = $33.7'$

Mercatorial Bearing = $320^\circ 33.7'$

ANS.

NOTE

The ship and station are in Southern hemisphere and since D. F. bearing is more than 180° , the half convergence correction is added.

Exercise I.

A ship in D. R. Position Lat. $41^\circ 03'N$ Long. $50^\circ 19'W$ takes D. F. bearing of Halifax D. F. station in Lat. $44^\circ 40'N$ Long. $63^\circ 35'W$ and observes it to be 286° . Required the true bearing so that it can be laid off on a Mercator's chart.

Answer :

Half Convergency = $270.7' = 4^\circ 30.7'$.

Mercatorial Bearing = $281^\circ 29.3'$

Exercise II.

A ship in D. R. Lat. $50^\circ 25'N$ Long. $01^\circ 50'W$ observed the relative bearing of Start Point D. F. station in

Lat. $50^{\circ} 13'N$ Long. $03^{\circ} 38'W$ to be 012° . The ship was steering 250° (T). Find the Mercatorial Bearing.

Answer :

$$\text{Half Convergency} = 41.5'$$

$$\text{Mercatorial Bearing} = 261^{\circ} 18.5'$$

Exercise III.

A ship in D. R. position Lat. $2^{\circ} 00'N$ Long. $53^{\circ} 46'E$ receives bearing of 017° from Diege Suarez D. F. station in Lat. $12^{\circ} 15'S$ Long. $49^{\circ} 23'E$. Required the Mercatorial bearing.

Answer :

$$\text{Half Convergency} = 16.3'$$

$$\text{True Mercatorial Bearing} = 016^{\circ} 43.7'$$

Exercise IV.

A ship in D. R. Position Lat. $49^{\circ} 29'N$ Long. $03^{\circ} 52'W$ found that La Corbiere D. F. station in Lat. $49^{\circ} 11'N$ Long. $02^{\circ} 16'W$ was bearing 108° on the D.F. set. Find the mercatorial bearing to lay on the chart.

Answer :

$$\text{Half Convergency} = 0^{\circ} 36.4'$$

$$\text{True Mercatorial Bearing} = 108^{\circ} 36.4'$$

Exercise V.

At 0930 hrs. in D.R. position $49^{\circ} 50'N$ $00^{\circ} 39'W$, the ship's speed was reduced due to thick fog and ship's head was kept steady at 255° (C). The following D/F bearings were taken with D.F. set :—

Start Point D. F. beacon bore 021° (Relative).
Bassurelle Lt. vessel D.F. beacon bore 167° (Relative).
Find the ship's position at 0930 hrs.

(Deviation Card I. Variation $7^{\circ}W$).

Answer :

Ship's Head 255° (C)

Deviation 12.5° E

Variation 7° W

Compass Error 5.5° E

True ship's head 260.5° (T)

D. F. Bearing of Start Point 021° (Relative)

True D. F. Bearing 281.5° (T).

D. F. bearing of Bassurelle Lt. vessel $= 167^{\circ}$ (Relative)

True D. F. Bearing $= 067.5^{\circ}$ (T)

To find the Half Convergency on Start Point Bearing :—

Start Point D.F. Station $50^{\circ} 13.3'N \quad 03^{\circ} 38'W$

D. R. Position $49^{\circ} 50'N \quad 00^{\circ} 39'W$

Mean Lat. $50^{\circ} 01.7'N$

D'Long. $02^{\circ} 59'$

Half Convergency $\frac{1}{2}$ D'Long $\times$ Sine Mean Lat.

68.6 $\frac{1}{2}$ (179 $\times$ Sine $50^{\circ} 1.7'$)

Half Convergency $= 1' 03.6'$

Bassurelle Lt. Vessel D.F. station $50^{\circ} 33.8'N \quad 00^{\circ} 58'E$

D.R. Ship $49^{\circ} 50'N \quad 00^{\circ} 39'W$

Mean Lat. $50^{\circ} 11.9'N$

D'Long. $1^{\circ} 37'$ or $97'$

Half Convergency $= \frac{1}{2}$ (Sine M Lat. $\times$ D' Long.)

$= 36.49'$

$= 0.6^{\circ}$

	Start Point	Bassurelle Lt. Vsl.
D.F. Bearing.	281.5° (T)	067.5° (T)
Half Convergency	$- 1.1^{\circ}$	$+ 0.6^{\circ}$

Mercator's Bearing 280.4° (T) 068.1° (T)

0930 hrs. Ship's Position $49^{\circ} 57.8'N \quad 01^{\circ} 21.8'W$

ANS.

Exercise VI.

A vessel in D.R. Position $50^{\circ} 10'N \quad 00^{\circ} 15'E$, a Sun's sight gave Azimuth of 225° (T) Intercept $5'$ AWAY and at the same time D.F. bearing of Bassurelle Lt. Vessel was 036° (T). Find the ship's position.

Answer :

I.T.P. Position Lat. $50^{\circ} 13'N$ Long. $00^{\circ} 20'E$

Position of Bassurelle Lt. Vsl. Lat. $50^{\circ} 33.5'N$

Long. $00^{\circ} 57.5'E$

Mean Latitude $= 50^{\circ} 23'North$

D'Long. $= 37.5'E$

Half Convergency $= + 14.4' = 0.2^{\circ}$

D.F. Bearing of Bassurelle Lt. Vessel $= 036^{\circ}(T)$

Half Convergency $= + 0.2^{\circ}$

Mercator's bearing of Bassurelle Lt.

Vessel $= 036.2^{\circ}(T)$

Ship's Position Lat. $50^{\circ} 08.4'N$ Long. $00^{\circ} 28.7'E$



CHAPTER XV

THREE POINT BEARINGS

[English Channel (Eastern Portion) Chart B.A. No. 2675]

If three bearings of a suitable shore object are taken at intervals of time, whilst the ship continues on her course, then the course made good and the ship's position can be found by what is commonly known as "Three Point Bearing Method."

"Three bearing problem" thus represents a convenient and accurate method of obtaining the course a vessel is making good over the ground provided the vessel steers the same course at a uniform speed, and the other factors like the Wind and Current which affect the course made good, remain constant.

This problem is easily solved by laying three true bearings of the same object on the chart. Then a line at right angles to the middle bearing is drawn passing through the shore object. The distance steamed between the first and the centre bearing and the distance steamed between 2nd and 3rd bearing is marked on this perpendicular line drawn. Now draw lines parallel to the middle bearing through the points just obtained on the perpendicular line to cut the first and third bearing. By joining the points where they cut first and third bearings, the course made good is obtained.

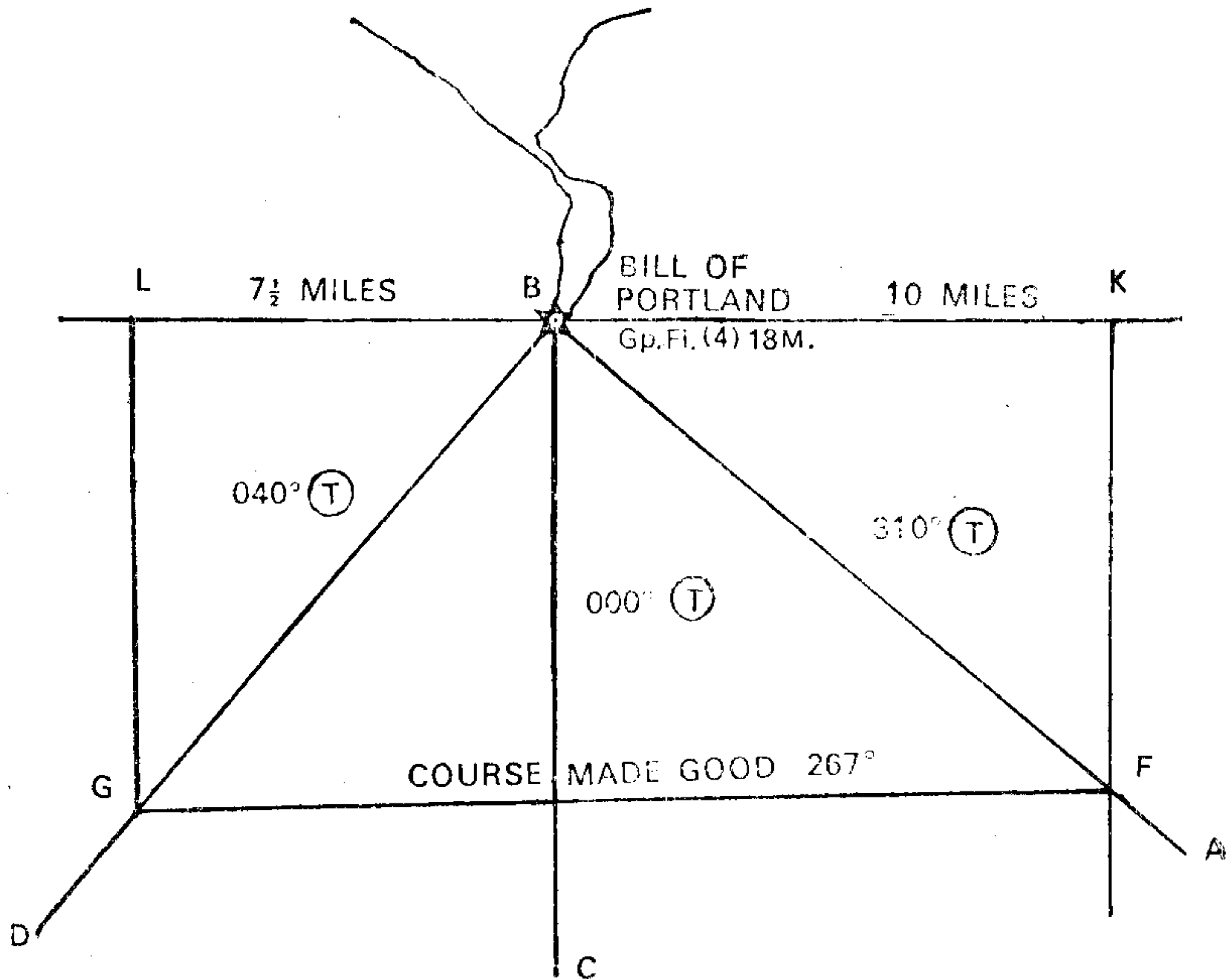
NOTE

It is not necessary that the actual distance steamed between the 1st and 2nd, and 2nd and 3rd bearing should be taken. Any radii may be taken to describe the arcs provided the ratio existing between intervals of time elapsing between the bearings is maintained.

Example I.

At 1000 hrs. Bill of Portland Lt. Ho. bore 310° (T) and at 1040 hrs. it bore 000° (T) and at 1110 hrs. the same light house bore 040° (T). The vessel during the time

steamed at a uniform speed of 15 knots. Find the course made good by the ship.



SOLUTION

- (1) Draw the three bearings BA, BC & BD equal to 310° (T), 000° (T) and 040° (T) taken at 1000 hrs. 1040 hrs. and 1110 hrs. respectively.
- (2) Draw a line KL perpendicular to BC.
- (3) Mark off BK = 10 miles (distance steamed in 40 minutes) and
Mark off BL = $7\frac{1}{2}$ miles (distance steamed in 30 minutes).
- (4) Draw KF and LG parallel to BC cutting BA and BD at F and G respectively.
- (5) Join FG. Then GF is the course made good by the ship which is 267° (T).

Hence course made good 267° (T).
Hence course made good 267° (T).

ANS.

SOLUTION

- (1) Draw BA, BC and BD the true bearings of the Bill of Portland Lt. House i.e. 310° (T) 000° (T), and 040° (T).
- (2) Draw KL perpendicular to BC and mark off BK = 10 miles and BL = $7\frac{1}{2}$ miles.
- (3) Draw KF and LG parallel to BC.
- (4) Then FG is the course made good which is 267° (T).
ANS.
- (5) From F draw FS, the course steered i.e. 260° (T) making FS = $17\frac{1}{2}$ miles i.e. distance steamed in 1H. 10M.
- (6) Then lay off the current SP i.e. 055° (T) till it meets the course made good line GF at P. Then SP must be drift of the current in 1H. 10M. in order that FP may be the actual course and distance made good.

The position at 3rd bearing can now be found as by "Running Fix." method.

- (7) From P draw a line parallel to first bearing i.e. AB cutting the third bearing at M.
Then M is the position of the ship at 3rd bearing.
3rd Bearing Position. Lat. $50^\circ 23.8'N$ Long $02^\circ 37'W$
ANS.
- (8) Through position M, lay off in the reverse direction, the course made good i.e. parallel to FG cutting the 2nd bearing and 1st bearing at N and O respectively.
Then N and O are the positions of the ship at 2nd and 1st bearing respectively.

Position at 1st Bearing. Lat. $50^\circ 24.1'N$ Long. $02^\circ 15'W$
ANS.

Drift of the current is 4.6 miles in 1H. 10M.

ANS.

Exercise I.

A ship steering 035° (C) at 12 knots, at 2000 hrs. observed C. d'Antifer light bearing 294° (C). After 30 minutes steaming the same light bore 327° (C) and after another 45 minutes at 2115 hrs. it bore 007° (C). Find the course made good and the ship's position

at 2115 hrs. and 2000 hrs. and the drift of the current, which was known to be setting 151° (T) (Deviation Card I. Variation 3° E)

Answer :

Compass Course	035° (C)
Deviation	8° W
Variation	3° E
Compass Error	5° W
True Course	030° (T)
1st true bearing of C. d'Antifer Lt.=	289° (T)
2nd true bearing of C. d'Antifer Lt.=	322° (T)
3rd true bearing of C. d'Antifer Lt.=	002° (C)
Distance steamed between 1st and 2nd bearing=	6 Miles.
Distance steamed between 2nd and 3rd bearing=	9 Miles.
Course made good	045° (T)
Position at 2115 hrs. Lat. $49^{\circ}53.5'N$ Long. $00^{\circ}10.7'E$	
Position at 2000 hrs. Lat. $49^{\circ}44'N$ Long. $00^{\circ}04'W$	
Drift of the Current	4.25 Miles.
$\therefore$ Rate of Current	3.4 Knots.



CHAPTER XVI

PICKING UP A LINE OF SOUNDING

[English Channel (Eastern Portion) Chart B.A. No. 2675]

During thick weather, when the visibility is poor and the ship's position is uncertain, the navigator may be unable to find the vessel's position by normal visual observations. Under such conditions, the position of the vessel may be ascertained with reasonable accuracy by running "A line of soundings" (provided the vessel is in soundings).

A series of soundings are taken at fixed time intervals, and the soundings are corrected for the height of tide thereby reducing the soundings to the chart datum (and the ship is kept steaming on a steady course and at a uniform speed). These soundings are then compared with the soundings printed on the chart (near the D.R. Position) and the position of the ship is estimated by comparison of soundings. The nature of the bottom, whenever possible should also be ascertained, as this knowledge is of considerable help while comparing them with the chart soundings. However, it may be pointed out that position so found may not always be reliable and thus such position should be used with utmost caution.

The actual method of running a "line of sounding" is to take a slip of paper, mark off the distance steamed or made good on this paper for the time intervals, between the soundings and alongwith it write the corrected soundings at the time given intervals (and the nature of bottom, wherever available). Then keeping the parallel ruler in the direction of the course made good alongwith the paper marked with soundings near the D.R. Position, move it until the soundings marked on this paper coincide with the soundings on the chart. This will give the position of the ship.

The finding of the position is comparatively easier, if there is no current during the time of "line of soundings". But it is not always the case and therefore the effect of current must also be taken into account. This is done by moving the paper marked with the sounding over the direction of the course made good and not the course steered.

Similarly, the distance made good and not the distance steamed during the intervals of soundings should only be marked on this extra paper. This can easily be done by

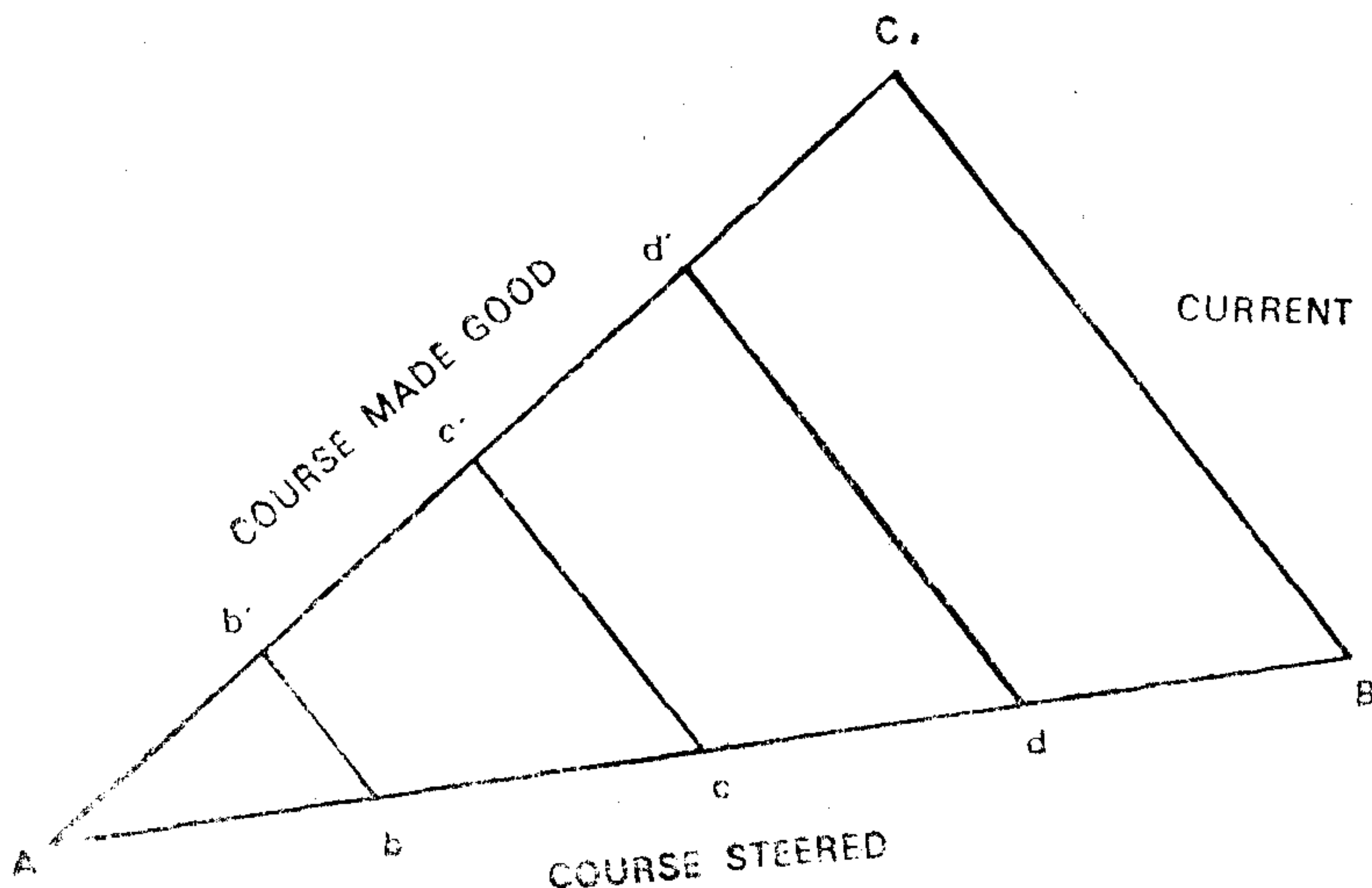
finding out the course and the speed made good. The set and the drift of the current, if being experienced, should be either known or estimated.

The method used can easily be explained with the help of an example:—

Suppose a vessel is steering 060° (T) at 5 knots, through a current known to be setting 330° (T) at 3 knots, the following soundings reduced to chart datum were observed:—

Time	1100 hrs.	1124 hrs.	1148 hrs.	1212 hrs.	1236 hrs.
Soundings	30 fms.	26 fms.	24 fms.	24 fms.	28 fms.

From the above it will be seen that from the first to the last soundings, time elapsed is 1H. 36M. and the ship steamed 8 miles and the drift of the current during this interval is 4.8 miles.



To find the course and distance made good:—

Lay off AB course steered anywhere on the chart i.e. 060° (T) and distance steamed for 1H. 36M. i.e. 8 miles. Then from B lay off BC as set and drift of current i.e. 330° for 4.8 miles.

AC is then the course and distance made good. Now mark off Ab, bc, cd and dB as distances steamed during the intervals at 1124, 1148, 1212 and 1236 hrs.

Draw dd' , cc' , bb' parallel to BC .

Then Ab' , $b'c'$, $c'd'$ and $d'C$ are the distances made good during the given intervals.

The parallel ruler is kept along AC and the points A , b' , c' , d' and C are transferred to the paper laid along the edge, and the parallel ruler is moved until the soundings marked, agree with those printed on the chart.

A reasonably good D. R. Position and the knowledge of the nature of the bottom at the time of soundings will be of great assistance in determining the position of the vessel.

Furthermore if, however, a sight had been taken previously or a bearing of terrestrial object was obtained before the "line of sounding", then the transferred position line or bearing can be laid off on the chart from the course made good.

Then the "line of sounding" and nature of bottom, when compared with the chart soundings along, the transferred position line, can be combined to enhance the accuracy of the position found by the line of sounding.

EXAMPLE :—

At 0600 hrs. in D.R. Lat. $50^{\circ} 14'N$ Long, $02^{\circ} 09'W$, a Star sight gave Azimuth $246^{\circ} (T)$ Intercept $4'$ Towards. The vessel was bound for Southampton and was steering $080^{\circ} (C)$ at 16 knots.

At 0715 hrs. the ship entered a fog bank, when the ship's speed was reduced to 8 knots and the sounding of 23 fathoms, reduced to chart datum was obtained. Thereafter, casts with hand lead, all reduced to chart datum, were as follows :—

Time	0805	0832	0911	0942
Soundings	20 fms.	20 fms.	20 fms.	18 fms.
Nature of Bottom.	(Shells Shingle)			chalk
Time	1023	1129	1158	1235
Sounding	18 fms.	15 fms.	14 fms.	12 fms.
Nature of Bottom.	Gravel			Sand
Find the ship's position at 1235 hours (Deviation Card I Variation 7.5° E)				

Answer :

Ship's Course	080° (C)
Deviation	12.5° W
Variation	7.5° E
Compass Error	5° W
True Course	075° (T)

I.T.P. Lat. 50° 12.1'N Long 02° 14.9'W

Position Line 156° (T) and 336° (T)

Time	0715	0805	0832	0911	0942	1023	1129	1158	1235
------	------	------	------	------	------	------	------	------	------

Distance

Steamed	2.0'	6.7'	3.6'	5.2'	4.1'	5.5'	8.8'	3.9'	4.9'
---------	------	------	------	------	------	------	------	------	------

1235 hrs. Position Lat. 50° 32.1'N Long 00° 43.8'W

NOTE

Now a days, since the radio navigational aids like Radar and Decca are easily available, the mariner rarely runs a formal "line of soundings" in the manner described above. However, the importance of taking soundings at regular intervals and checking them with the "Chart Soundings" cannot be over emphasised, regardless of the deployment of the modern aids to navigation.



CHAPTER XVII

TIDES

Periodical rise and fall of the tide increases and decreases the depth of water throughout the day at any one place. The soundings printed on the navigational charts cannot, therefore, represent the actual depths of water at any given time.

The chart soundings are depths below a selected level of the sea called “Chart Datum” which is generally the lowest level to which the tide falls viz. Lowest Astronomical Tide (L.A.T.). Thus the actual depth of water at any place at any give time is the sum of the charted depth plus the height of the tide at the time.

SOME DEFINITIONS AND ABBREVIATIONS ABOUT TIDES

1. **The height of Tide** at any given time is the height of water level above “chart datum” i.e. Actual depth minus the charted depth of water.
2. **High Water (H.W):—** It normally refers to the time of high water. It is also used to express the rise of the tide i.e. height of the “High Water level” above the chart datum.
3. **Low Water (L.W.):—** Similarly, low water refers to the time of low water level as well as height of tide at low water time.
4. **Range of Tide:—** It is the difference between high water and low water heights. Low water tidal level may, on rare occasions, fall below the chart datum. In such a case, the low water height would naturally be a negative (—) quantity and the range of the tide will be the arithmetic sum of the high water and low water heights.

Duration of Rise of Tide:— It is time the tide takes to rise from low water level to high water level i.e. the interval between low water time and the next high water time or simply the direction of the tide.

Duration of the Fall of Tide:— Similarly the time interval between the high water and the next low water is called

the duration of the fall of the tide or simply the duration of the tide.

M.H.W. represents the Mean High water.

M.L.W. represents the Mean Low water.

M.H.W.S. represents the height of Mean of High water Spring Tides.

M.L.W.S. represents the height of Mean of L.W. Spring Tides.

M.H.W.N. represents the height of Mean of H.W. Neap Tides.

M.L.W.N. represents the height of Mean of L.W. Neap Tides.

M.H.H.W. represents the height of Mean Higher High water.

M.L.H.W. represents the height of Mean Lower High water.

M.H.L.W. represents the height of Mean Higher Low water.

M.L.L.W. represents the height of Mean Lower Low water.

STANDARD PORTS :—

A List of “Standard Ports” arranged alphabetically is given on the back of the cover page of each of the three volumes of “Admiralty Tide Tables”.

Data concerning daily predictions of times and heights of high water and low water for standard ports are given in the main body of the Tide Tables.

Predictions for standard ports are generally based on continuous observations of the tide over a period of at least one year and average meteorological conditions.

METEOROLOGICAL EFFECTS ON TIDES : Meteorological conditions, which differ from the average will cause corresponding differences between the predicted and actual tides, particularly in high water and low water heights. Variations in heights are mainly caused by strong or prolonged winds and or extreme variations in atmospheric pressure. Wind also affects the times of high and low water.

Shallow Water Corrections : At some ports where shallow water effects are noticeable and can reasonably be represented by a table of shallow water correction, then the corrections for the same are included in Part II of the Admiralty Tide Tables. Shallow water corrections are given only in Volumes II & III of Admiralty Tide Tables.

Seasonal Changes in Mean Sea Levels

If the maximum variation in the monthly variations of the mean sea levels is greater than 0.1 metre from the mean values, the same are also tabulated in Part II alongwith the data on secondary ports. These corrections are also valid and are thus given only for ports covered in Vol. II and III of Admiralty Tide Tables.

Time and Time Differences in the Predictions

The time of standard port predictions are given in the normal standard (zone) time kept by the port and is given at the head of each page. Thus if a ship is keeping different time, then the predicted times must be corrected for Longitude in the normal manner.

To Find Times, Heights of High and Low Water

Times and Heights of high and low water for standard ports are tabulated for every day of the year in the main body of the Tide Tables.

Necessary time corrections for variations from the tabulated zone time must, of course, be made to obtain true predictions.

To convert Standard Time into Local Time

Rule :- "When the ship's meridian is to the East of the Zone time meridian, ADD the difference in time and if to the West SUBTRACT." This rule is to be reversed, when converting ship's (Local) time into zone time. It must always be borne in mind that the ship's clocks are advanced as she sails East and clocks are retarded as she sails West.

Example I.

Find the local mean time of high water and low water at Colombo, on Jan. 16th given the following extracts from Admiralty Tide Tables :—

Extracts from A.T.T.	
Zone Time	-0530
H.W.....	0231
L.W.....	0846
H.W.....	1456
L.W.....	2010

Solution :

Mean Long. of the Zone Time	=	82° 30'E			
Long. of Colombo	=	79° 51'E			
D'Long.	=	2° 39'W			
		× 4			
	=	10m 36s			
	=	11m (approximately)			
Colombo Jan. 16th	H.W.	L.W.	H.W.	L.W.	
Zone time	0231	0846	1456	2010	
Long. Correction	—0011	—0011	—0011	—0011	
Local Mean Times	0220	0835	1445	1959	
					Ans.

Example II.

Find the Local Mean times of high water & low water on board a ship at Singapore, on 19th May, given the following extracts from Admiralty Tide Tables :—

Extracts from A.T.T.	
Zone Time	-0730
H.W.....	0218
L.W.....	0930
H.W.....	1632
L.W.....	2137

Solution :

Long. of the Zone Time	112° 30'E			
Long. of Singapore	103° 51'E			
D'Long.	8° 39'W			
	× 4			
Correction for Long.	34m 36s	=	35m (approx.)	
	H.W.	L.W.	H.W.	L.W.
Singapore May 19th				
Zone times	0218	0930	1632	2137
Correction for Long.	—0035	—0035	—0035	—0035
Local Mean Times	0143	0855	1557	2102
				Ans.

Example

Find the local mean times of H.W. and L.W. on board a ship at Belfast on 10th October given the following extracts from the Adm. Tide Tables:—

Extracts from A.T.T.	
Zone Time	-0100
H.W.....	0110
10 L.W.....	0703
W H.W.....	1328
L.W.....	1931

Solution :

Long. of Zone Time	= 15° E
Long. of Belfast	= 5° 55' W
D'Long,	<u>20° 55' W</u>
	× 4

Correction for Long. -1h 23m 40s = -1h 24m (approx.)

The correction is minus because Belfast meridian is WEST of the Zone time meridian.

	H.W.	L.W.	H.W.	L.W.
Belfast Oct. 10th				
Zone times	0110	0703	1328	1931
Correction for Long.	—0124	—0124	—0124	—0124
Local Mean Times	9th2336	10th0539	10th1204	10th1807

Ans.

NOTE :

It must be borne in mind that a tide occurring just after midnight with minus correction for Long. may be turned into a tide of the previous day if expressed in local mean time or if occurring just before midnight, it may be turned into a tide on the following day should a plus correction have to be applied to turn into local mean time.

FOR FINDING THE HEIGHT OF THE TIDE AT TIMES BETWEEN HIGH AND LOW WATER

HOURLY INTERVAL FROM NEAREST HIGH WATER

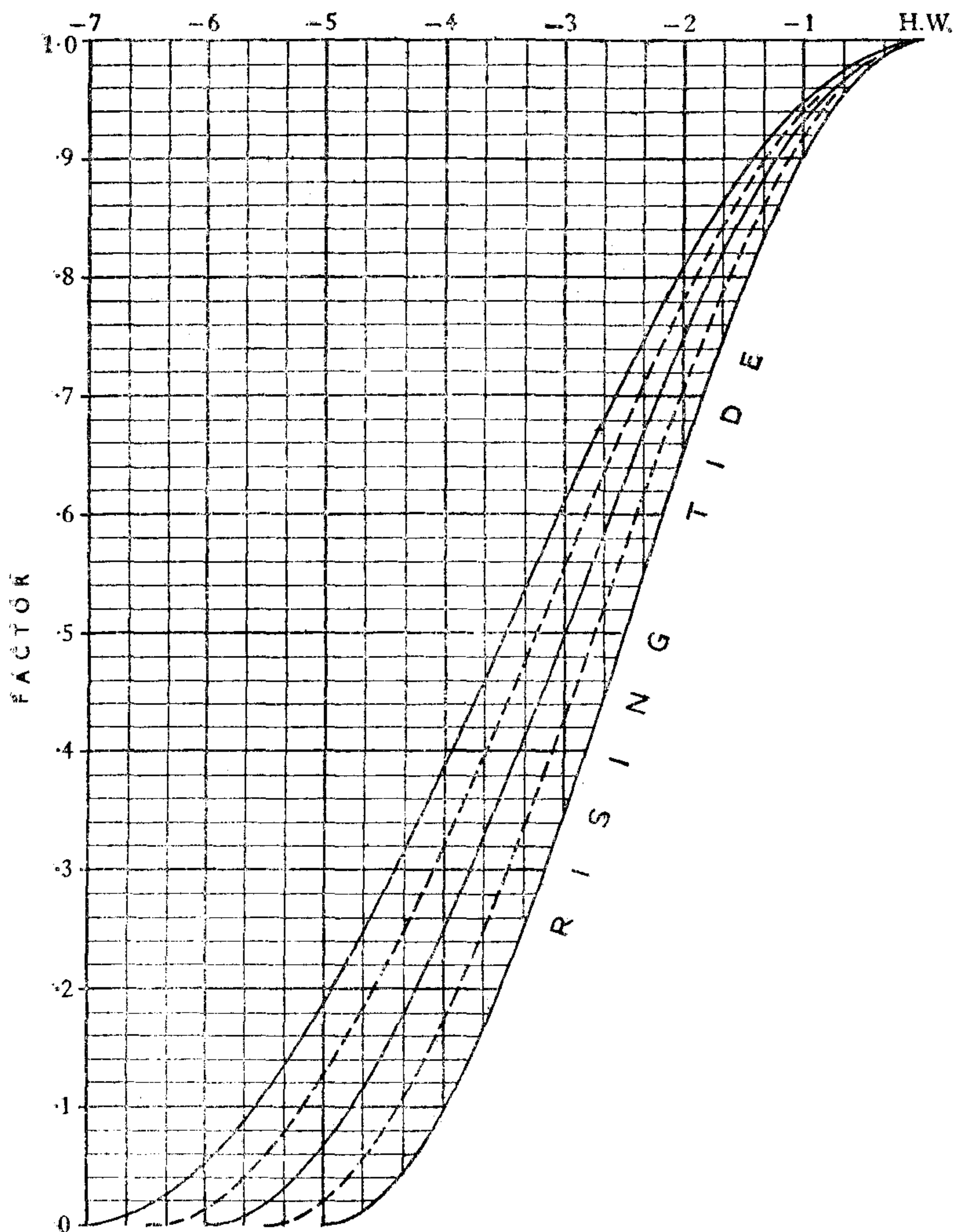


Diagram for use with Admiralty Tide Tables Volumes
II and III

FOR FINDING THE HEIGHT OF THE TIDE AT TIMES BETWEEN HIGH AND LOW WATER
 HOURLY INTERVAL FROM NEAREST HIGH WATER

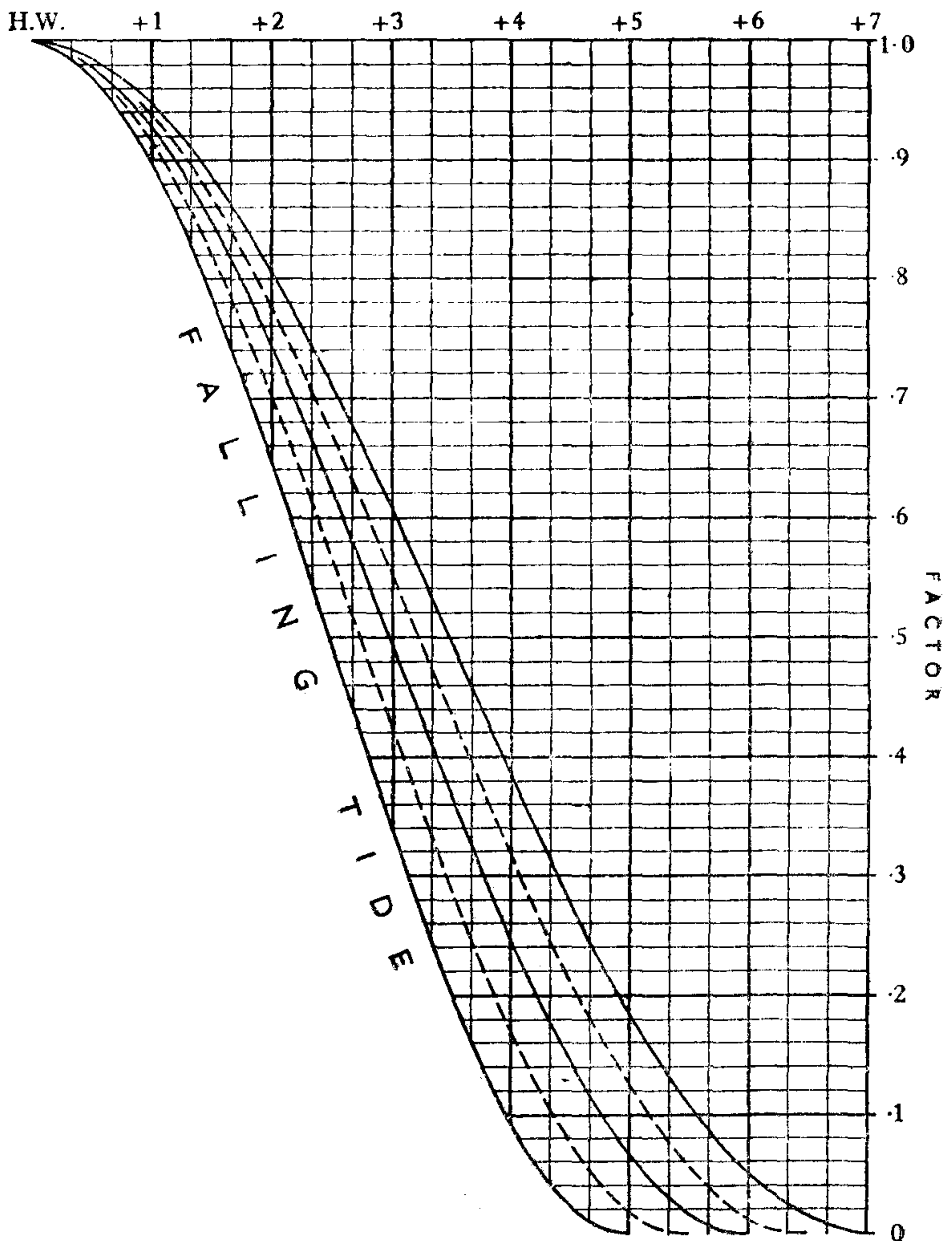


Diagram for use with Admiralty Tide Tables Volumes
 II and III

To find the height of tide at times between high and low water for Ports outside British and European water (i.e. Volumes II & III).

Volumes II & III of Admiralty Tide Tables carry a "Standard Tidal Diagram" for computing the height of tide at the time between high water and low water. This standard diagram is based on the assumption that the rise and fall of tide takes the shape of a simple cosine curve.

In practice, the tidal curve at many places may easily differ from the above assumed cosine curve, when the intermediate heights so computed would be considerably in error. (As in the case of British and European ports — Volume I).

However, the standard diagram does give satisfactory results for the ports covered in Volume II & III of the Admiralty Tide Tables. This diagram should, however, be used only when the rise and fall of tide is within the limits of the Diagram. No extrapolation should be attempted. Standard Diagram for Volumes II and III of the Admiralty Tables is given on page No. 137 and 138.

The principle of this table is to multiply the "range" by a factor depending on the length of time before or after high water; the result being added to the height of low water to give the required height of tide.

In actual fact, a series of curves at half hourly intervals of the duration of rise or fall between 5 to 7 hours, are given for ease in computation. For intermediate durations, interpolation should be employed. But as stated earlier "No extrapolation" is to be attempted. (It will be observed that the factor at L.W. is always zero and unity at H.W.).

METHOD for finding height of tide at time between high and low water.

Step I: From the relevant predictions for the standard port, obtain the times and heights of high and low water before and after the times for which the height is required. (Be careful about the date and month in the question.)

Step II: Find the duration of the rise or fall of the tide as the case may be, from the predicted time of high water and low water.

Step III: Similarly, compute the predicted range of the tide.

Step IV : Determine the interval from the high water for the time in the question.

Step V : From the “Diagram” on page 137 or 138 using the interval from the high water and the duration of rise or fall, read off the “FACTOR”.

Step VI : Multiply the “Factor” so obtained with the predicted range.

Step VII : The result so obtained in step VI, when added to the height of low water, would give the height of tide at the time under reference.

Note : While picking up the “Factor” from the Tide curve, care must be taken to ensure that correct sign of the interval from H.W. is used. In this connection interval before H.W. i.e. on rising tide, is termed “minus” e.g. -2h20m means 2h20m before H.W. Similarly interval after H.W. i.e. on falling tide is “positive” e.g. +3h30m implies 3h30m after High water time.

Example I.

Find the height of tide off Singapore harbour at 1100 hours. (S.T.) On 3rd February. The following extracts from the tide tables for the date under reference are given below :—

Extract from A.T.T.	
.....	
Zone Time	-0730
.....	
TIME	HEIGHT
0123.....	2.7m
0703.....	0.9m
1302.....	2.9m
1930.....	0.5m

Solution :

Time in question = 1100 hrs.

Low Water Time = 0703 hrs.

High Water Time = 1302 hrs.

Step IV : Determine the interval from the high water for the time in the question.

Step V : From the "Diagram" on page 137 or 138 using the interval from the high water and the duration of rise or fall, read off the "FACTOR".

Step VI : Multiply the "Factor" so obtained with the predicted range.

Step VII : The result so obtained in step VI, when added to the height of low water, would give the height of tide at the time under reference.

Note : While picking up the "Factor" from the Tide curve, care must be taken to ensure that correct sign of the interval from H.W. is used. In this connection interval before H.W. i.e. on rising tide, is termed "minus" e.g. -2h20m means 2h20m before H.W. Similarly interval after H.W. i.e. on falling tide is "positive" e.g. +3h30m implies 3h30m after High water time.

Example I.

Find the height of tide off Singapore harbour at 1100 hours. (S.T.) On 3rd February. The following extracts from the tide tables for the date under reference are given below :—

Extract from A.T.T.	

Zone Time	-0730

TIME	HEIGHT
0123.....	2.7m
0703.....	0.9m
1302.....	2.9m
1930.....	0.5m

Solution :

Time in question = 1100 hrs.

Low Water Time = 0703 hrs.

High Water Time = 1302 hrs.

Duration of tide = 1302 - 0703 = 05h 59m
(Rise)

Interval before High Water = 1302 - 1100 = 2h 02m

Predicted height of Low Water = 0.9 m.

Predicted height of High Water = 2.9 m.

Range of tide = 2.0 m.

From the diagram, using the duration of rise of 5h 59m and interval before High Water as 2 hrs. 02 mins. the factor is found to be 0.75.

Height of tide above Low Water = Range x Factor
= 2 x 0.75 = 1.5 m.

Height of low Water = 0.9 m.

Required Height of tide at 1100 hrs. = 1.50 + 0.9 = 2.4 m.

Ans.

Example II.

Find the height of tide and depth of water at 1430 hrs. on March 2nd, at a position off Singapore, where charted depth is 4 metres. Extracts from the Tide Tables for the day under reference are given below :-

Extracts from A.T.T.	
Zone Time	-0730
TIME	HEIGHT
0014.....	2.7m
0603.....	0.8m
1209.....	2.9m
1830.....	0.6m

Solution :

	Time	Height
High Water	1209	2.9M
Low Water	1830	0.6M
Duration of fall	0621	Range of tide = 2.3M
High Water time	1209	
Tide time required	1430	(as per question)
Interval from High Water	= 2H 21M	

From the diagram, using the duration of fall 6h 21m and interval from high water as 2h 21m, the factor obtained is 0.70.

$$\begin{aligned}\text{Height above Low water} &= \text{Range} \times \text{Factor} \\ &= 2.3 \times 0.70 = 1.61 \text{ M.}\end{aligned}$$

$$\text{Height of Low water} = 0.6 \text{ M}$$

$$\text{Height of tide at 1430 hrs.} = 1.61 + 0.60 = 2.21 \text{ M.}$$

$$\text{Charted depth} = 4 \text{ M.}$$

$$\text{Total depth of Water at 1430 hrs.} = 6.21 \text{ Metres.}$$

Ans.

Example III.

Given the following extracts from the Tide Tables, find the standard time during the afternoon on 28th February at which there will be 5 Metres of water over a shoal patch where the chart shows 2 Metres sounding, off the Port of Darwin (Australia).

Extracts from A.T.T.	
TIME	HEIGHT
0018.....	2.7 M.
28 0557.....	6.2 M.
M 1223.....	1.5 M.
1832.....	7.0 M.

Solution :

	Time	Height
High Water	1223	1.5 M.
Low Water	1832	7.0 M.

Duration of rise 06H 09M Range = 5.5 Metres.

Height of tide required = $5.0 - 2.0 = 3.0 \text{ M.}$

Height of Low Water = 1.5 Metres.

Required Height above Water = $3.0 - 1.5 = 1.5 \text{ M.}$

$$\text{Required Factor} = \frac{\text{Height above Low Water}}{\text{Range}} = \frac{1.5}{5.5} = 0.27$$

∴ (Height above Low Water = Range x Factor.)

From the diagram, using the duration of tide as 06h 09m and factor as 0.27, we get interval from high water as 3h 57m.

Hence the required time when there will be 5 m sounding over the shoal in question = 1832 — 0357.

= 1435 hours (Darwin Time)

Note:— In practice the Standard time may be converted into the ship's time if the Standard time kept on the ship was different from the Darwin Standard Time.

Exercise I.

Find the height of tide at Darwin (Australia) at 1805 hrs. Standard time on 20th January. The extracts from the Tide Tables are given below:—

Extracts from A.T.T.	
TIME	HEIGHT
0250.....	2.0 M
20 0830.....	6.6 M
Thu. 1436.....	1.2 M
2105.....	7.5 M

Solution :

	Time	Height
Low Water	1436	1.2 M
High Water	2105	7.5 M
Duration of rise	6h 29m	Range 6.3 M
Interval from High Water	= 2105 — 1805	= 3 H 00 M
Factor (from the Diagram)	= 0.56	
Now height above Low Water	= Range × Factor	
	= 6.3 × 0.56	= 3.52 Metres.
Height of Low Water	= 1.2 M.	
Height of tide at 1805 hrs.	= 3.52 + 1.20	= 4.72 Metres.

Ans.

Exercise II.

Find the height of tide at 1930 hrs. Standard time on 4th February at DARWIN. Extracts from the tide tables for the day under reference are as under:—

Extracts From A.T.T.	
TIME	HEIGHT
0315.....	1.7 M
4 0904.....	6.5 M
Fri. 1502.....	1.9 M
2112.....	6.9 M

Order of Working:—

	Time	Height
Low Water	1502	1.9
High Water	2112	6.9

Duration of rise = 6H00M Range = 5.0 Metres,

High Water 2112

Time required 1930

Interval from H.W. = 2112 — 1930 = 1H42M

(From the Diagram) Factor = 0.82.

Height above Low Water = Range × Factor

= 5.0 × 0.82 = 4.10 M

Height of Low Water = 1.90 M

Height of tide = 6.0 Metres

Ans.

Exercise III.

Find the time at which there will be 7 Metres of water in the afternoon of 27th April on a shoal patch, off Darwin where the chart shows 3 Metres sounding.

Extracts from the Adm. Tide Tables for the day are as follows:-

Extracts from A.T.T.		
TIME		HEIGHT
	0550.....	6.6 M
27	1157.....	2.5 M
Thu.	1743.....	6.3 M.

Solution :

	Time	Height
Low Water	1157	2.5

High Water	1743	6.3
------------	------	-----

Duration of rise 05H46M Range 3.8 M

Height of tide required = 7.0 -- 3.0 = 4.0 M.

Given Height of Low Water = 2.5 Metres.

∴ Required height above Low Water = 4.0 — 2.5 = 1.5 M

Hence Factor = $\frac{\text{Height above Low Water}}{\text{Range}} = \frac{1.5}{3.8} = 0.39$

From the Diagram, Interval from High Water = 3H15M

High Water Time = 1743

∴ Required Time = 1428 hrs.

Hence at 1428 hrs. there will be 7 metres of water on the Shoal patch.

Ans.

Exercise IV

Find the height of tide at 1800 hours G.M.T. on 2nd August 1972 at Prince Rupert (B.C.) The extract from the A.T.T. for the day under reference are given below:

Extract from A.T.T.	
Time Zone + 0800	
TIME	HEIGHT
0025.....	1.6
2 0625.....	5.0
W 1210.....	2.3
1840.....	5.9

Solution :

G.M.T.	1800 hrs.	
Zone Time	0800	
Standard Time	1000 hrs.	
High Water	0625	Height 5.0 m
Low Water	1210	Height 2.3 m
	H M	
Duration of fall	5 45	Range 2.7 m
Time in question		1000 hours
Interval after highwater	= 1000 hours — 0625 hours	
	= 3H 35M	

From the diagram, using during of fall of 5H 45M and the interval after highwater as 3H 35M, factor obtained is 0.31.

Height of tide above Low water	= Range x Factor
	= 2.7 x 0.31 = 0.837
Height Low Water	= 2.3 M
Height of Tide	= 3.137 M

Ans.

Exercise V

Find the height of tide at 0920 hours S.M.T. off Golden Gate on 23rd June 1972. The extracts from A.T.T. for the day under reference are given below:—

Extract from A.T.T.	
Lat 37° 48'N	
Long 122° 27'W	
Time Zone + 0800	
TIME	HEIGHT
0336...	— 0.1
23 1042.....	1.2
F 1428.....	0.9
2101.....	1.8

Solution :

S.M.T.	09H 20M
L.I.T.	18H 10M (West)
G.M.T.	17H 30M
Time Zone	08H 00M
Standard Time	09H 30M

Thus we must find the height of tide at 0930 hours Standard Time.

Low Water	03H 36M	Height — 0.1 m
High Water	10H 42M	Height 1.2 m
Duration of rise	7H 06M	Range 1.3 m
Time in question	09H 30M	
Interval before highwater	= 1042 hours — 0930 hours	
	= 1H 12M	

From the diagram, using the duration of fall of 7H 06M and interval before highwater at 1H 12M, the factor is found to be 0.93.

Height of Tide above Low Water

	= Range x Factor
	= 1.3 x 0.93
	= 1.209
Height of Low Water	= — 0.1
Height of Tide	= 1.109 m

Ans.

Exercise VI

Find the earliest time on 17th June 1972, a vessel off BOSTON, drawing 3.4 meters will be able to cross a bar marked 2 meters, with a clearance of 1 metre under her keel. The extract from A.T.T. are given below:

Extract from A.T.T.		
	TIME	HEIGHT
16 F	0229.....	3.1
	0848..	— 0.1
	1508.....	2.9
	2109.....	0.2
17 Sa	0325.....	3.0
	0939.....	0.0
	1601.....	2.8
	2205.....	0.3

Solution :

Draft of ship = 3.4 m

Clearance required under the keel = 1.0 m

Total depth of water required $3.4 + 1.0 = 4.4$ m

Depth over the bar = 2.0 m

Height of tide required = $4.4 \text{ m} - 2.0 \text{ m} = 2.4 \text{ m}$

On 17th, earliest height highwater = 0325 hrs. Height 3.0 m

On 16th previous low water = 2109 hrs. Height 0.2 m

Duration of rise = 6H 16M Range = 2.8 m

Height of tide = Height of low water + height above low water.

∴ Height above low water = Height of tide — Height of low water
 $= 2.4 - 0.2 = 2.2\text{M}$

Height above Low water = Range x Factor

∴ Factor = $\frac{\text{Height above Low Water}}{\text{Range}} = \frac{2.2}{2.8} = 0.78$

From the diagram, using duration of tide as 6H 16M and factor as 0.78, we get interval from high water as 1H 56M.

High Water on 17th 0325

Interval from high water —156

Hence time (when height of tide is 2.4M) = 0129 hours

The earliest time, the vessel will be able to cross the bar on 17th June will be 0129 hours. **Ans.**

Exercise VII

Find the error to be applied to the sounding after taking a cast of lead off Bombay at 1451 hours L.M.T. on the 1st March 1972, before comparing it with the chart. The extract from the A.T.T. for the day under reference are given below:

Extract from A.T.T.	
Lat 18° 55'N Long 72° 50'E	
Time Zone — 5H 30M	
TIME	HEIGHT
0049.....	4.4
1 0700.....	0.9
W 1300.....	4.2
1851.....	1.0

Solution :

L.M.T.	1451
L.I.T.	— 451 (East Long.)
G.M.T.	1000
Zone	530
Standard Time	1530 hours

Hence we must find the height of tide at 1530 Hours

High Water	1300	Height 4.2 m
Low Water	1851	Height 1.0 m
Duration of fall	5H 51M	Range 3.2 m

High water	=	1300 hours
Time in question	=	1530 hours
Interval after highwater	=	2H 30M

From the diagram, using the duration of fall of 5H 51M and the interval after high water as 2H 30M, the factor is found to be 0.62.

Height of Tide above Low Water	=	Range x Factor
	=	3.2 x 0.62
	=	1.98 m
Height of Low Water	=	1.0 m
Height of Tide	=	1.98 + 1.0 = 2.98 m

Hence 2.98 meters is the correction to be applied to the sounding before comparing it with the chart at 1451 hours L.M.T.

Ans.

Exercise VIII

Find the depth of water a vessel drawing 6.4 meters will have under her keel when crossing 5.4 meters patch at Vancouver Harbour on 12th May 1972 at 1400 hours. Standard Time. The extract from the A.T.T. for the day under reference are given below:—

Extract from A.T.T.	
Lat. 49° 17'N	
Long 123° 07'W	
Time Zone + 0800	
TIME	HEIGHT
0345.....	4.4
12 1105.....	0.3
F 1810.....	4.3
2315.....	3.0

Solution :

Lower Water	1105	Height 0.3 meters
High Water	1810	Height 4.3 meters
Duration of rise	7H 05M	Range 4.0 meters.

Time in question	1400 hours
Interval from high water	= 1810 — 1400
	= 4H 10M

From the diagram, using the duration of rise of 7H 05M, and the interval from high water as 4H 10M the factor is found to be 0.35.

Height of Tide above Low Water	
	= Range x Factor
	= 4 x 0.35 = 1.40 m

Height of Tide =	Height above Low Water
	+ Height of Low water
	= 1.40 + 0.3 = 1.70

Total depth of water above shoal	
	= 5.4 + 1.70
	= 7.10 m

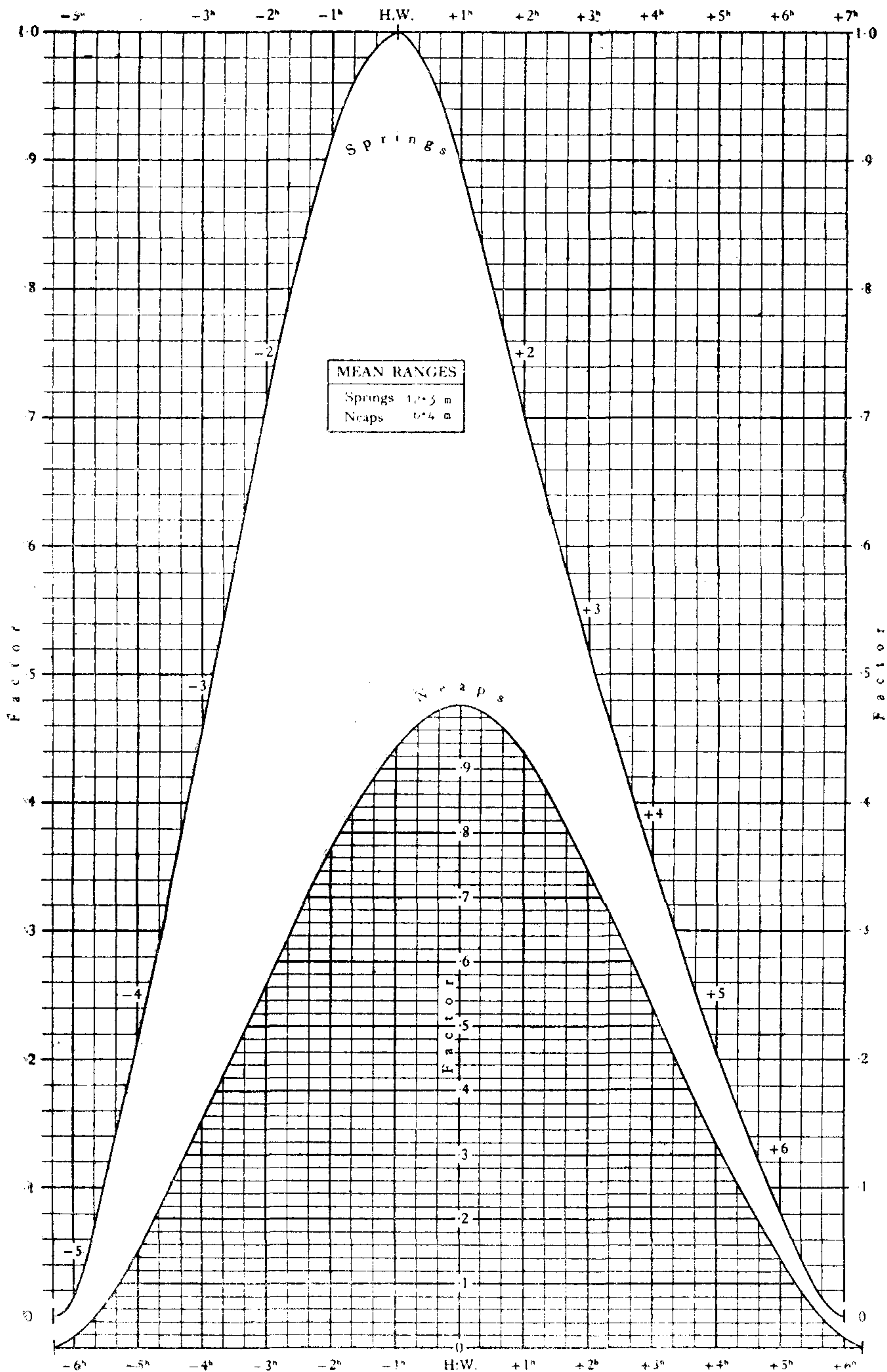
Draft of the ship	= 6.4 m
-------------------	---------

Clearance under the keel	= 0.70 metres.
--------------------------	----------------

Ans.

AVONMOUTH

MEAN SPRING AND NEAP CURVES



To find the height of tide at times between high and low water for British and European Ports. (Admiralty Tide Tables Volume I).

The standard "Diagram/Table", as explained earlier, is based on the assumption that the rise and fall of the tide takes the shape of a simple cosine curve. As such an assumption is not valid for ports covered by Volume I of Admiralty Tide Tables viz. British and other European ports, a separate diagram showing the mean tidal curves at both "Spring" and "Neaps" is given for each port for greater accuracy.

A specimen diagram for a port, Avonmouth in the British Isles is shown in page No. 151. The two curves, viz. Spring and Neap curves, refer to range of tide of 12.3 M and 6.4 M respectively.

The "Factor" obtained from the relevant 'curve' when multiplied by the range, gives the height of tide above low water. (The "factor" at low water being 'zero' and 'one' at high water.)

For a day at Avonmouth, when the range of tide is 12.3 M or close to 12.3 M, it would be sufficient to find the factor, using the Spring curve only. Similarly, when the range is close to 6.4 M, the Neap curve is used.

However, when the range of tide is between the mean Spring and Neap ranges (i.e. between 6.4 M and 12.3 M) it is necessary to work out the "Factor" on both the curves and then to interpolate for the range of tide on the day in question.

It is to be appreciated that the interpolation between the Spring and Neap curves can also be carried out in the end i.e. by first working out the two results (one from each curve) independently.

Note:— For ranges higher than the Spring range, Spring curve can be used. Similarly, Neap curve is used when range of tide is less than neap range.

Order of working :

- (1) From the predictions of the day, write down the predicted heights of high and low water and by subtraction, compute the predicted range.

- (2) Compare the predicted range with the mean ranges given on the "Diagram" and select the appropriate curve. (in doubtful cases, use both the curves and interpolate later for greater accuracy)
- (3) Determine the interval from the high water for the time for which height is required.
- (4) Refer to the Tidal Diagram for the port and read off the "factor" for the interval from the high water.
- (5) Multiply the factor by the predicted range found in (1) above.
- (6) Add the answer obtained in (5) to the predicted height of low water in order to obtain height of tide at time required.

Example

Find the height of tide at Avonmouth at 1700 hrs. on 27th March. The extracts from the Admiralty Tide Tables for the day under reference are given below:—

Extracts from A.T.T.	
TIME	HEIGHT
0111.....	1.7 M
27 0653.....	11.6 M
M 1351.....	1.2 M
1917.....	11.8 M

Solution :

High Water Time = 1917
 Time for which height
 of tide is required = 1700

Interval from High water	= 2H 17M
Highwater height	= 11.8 M
Lowwater height	= 1.2 M
Range of tide	= 10.6 M
Mean spring range at Avonmouth	= 12.3 M (from the Diagram)
Mean Neap range at Avonmouth	= 6.4 M (from the Diagram)
Predicted range for the day	= 10.6 M

As the range for day is not close to either mean spring or neap range, we have to use both the curves and then interpolate between the two.

From Spring curve	From Neap curve
Factor .62	Factor 0.7
Range 10.6	Range 10.6
Height of tide above L.W. = Range $\times$ Factor = $10.6 \times 0.62 = 6.57$ M	Height of tide above L.W. = Range $\times$ Factor = $10.6 \times 0.7 = 7.42$ M
Height of Low Water = 1.2 M	Height of Low Water = 1.2 M
Predicted height at 1700 hrs. = 7.77 Mtrs.	Predicted height at 1700 hrs. = 8.62 Mtrs.

Interpolating between Mean Spring range (12.3 M) and Mean Neap range (6.4 M) for the given range of 10.6 M, predicted height at Avonmouth at 1700 hrs.

$$\begin{aligned}
 &= 7.77 + \frac{(8.62 - 7.77) \times (12.3 - 10.6)}{(12.3 - 6.4)} \\
 &= 7.77 + \frac{0.85 \times 1.7}{5.9} = 7.77 + 0.24 = 8.01 \text{ M} \\
 &= 8.01 \text{ Metres}
 \end{aligned}$$

Ans.

Exercise

Find the height of tide at Avonmouth at 1430 hrs. on 7th February. The extracts from the Tide Tables for the day are as under:—

Extract from A.T.T.	
TIME	HEIGHT
0013.....	10.4 M
7 0635.....	2.4 M
M 1227.....	10.1 M
1845.....	2.8 M

Solution :

High water time	1227
Time required	1430
Interval from H.W.	2H03M
High water height	10.1 M
Low water height	2.8 M
Predicted range	7.3 M
Mean spring range at Avonmouth = 12.3 M	
Mean Neaps range at Avonmouth = 6.4 M	

Spring curve		Neap curve	
Factor	= 0.7	Factor	= 0.74
Range	= 7.3	Range	= 7.3
Ht. above L.W.		Ht. above L.W.	
= Range × Factor		= Range × Factor	
= 7.3 × .7 = 5.1 M.		= 7.3 × 0.74 = 5.4 M.	
Ht. at L.W.	= 2.8	Ht. at L.W.	= 2.8
Height of tide	= 7.9 Mtrs.	Ht. of tide	= 8.2 Mtrs.

By Interpolation, required height of tide at 1430 hrs. at Avonmouth = 8.16 Metres.

Ans.

Exercise

Find the height of tide at Avonmouth at 0900 hrs. on 5th January, given the following extracts from Admiralty Tide Tables.

Extract from A.T.T.	
TIME	HEIGHT
0536.....	1.3
5 1102.....	12.2
Wed 1758.....	1.5
2325.....	11.6

Solution :

High Water time	1102
Time required	0900
Interval from H.W.	= 2H02M
High Water height	= 12.2 M
Low Water height	= 1.3 M
Range predicted	= 10.9 M
Mean spring range at Avonmouth	= 12.3 M
Mean neaps range at Avonmouth	= 6.4 M

From Spring curve
Factor = 0.72
Range = 10.9
Ht. above Low Water
= Range × Factor
= 10.9 × 0.72 = 7.8 M
Ht at Low Water = 1.3 M
Height of tide at 0900 hrs.
= 9.1 Metres.

From Neap curve
Factor = 0.76
Range = 10.9
Height above Low Water
= Range × Factor
= 10.9 × 0.76 = 8.3 M
Ht at Low Water = 1.3 M
Height of tide at 0900 hrs.
= 9.6 Metres.

∴ Required Height of tide at 0900 hrs. at Avonmouth (By Interpolation) = 9.2 Metres.

Ans.

SECONDARY PORTS

The names of the secondary ports and their serial number are given in the alphabetical order under the "Geographical Index" at the end of the Admiralty Tide Tables. The "Secondary ports" are arranged numerically in Part II of the Tide Tables.

Predictions for secondary ports are made by applying time and height differences to predictions at a selected standard port. These are tabulated in Part II of the Admiralty Tide Tables.

The data on which these differences are based are extremely variable but generally, they rely on at least one month's observations.

The term "secondary port" hence does not necessarily imply that the place concerned must necessarily be of lesser importance than the standard port.

The standard port chosen in Part II is such that it has tidal characteristics similar to those of the "Secondary port". Hence in some cases the secondary port may be seen to be some distance away from the standard port.

To find times and heights of high and low water

The times of high and low water are obtained by applying the time difference tabulated in Part II.

Time and Time difference in Predictions

In the secondary ports, it must be noted that time differences given in Part II, when applied to times of high water and low water at standard ports will give the times of high and low waters at secondary ports "IN THE ZONE TIME TABULATED FOR THE SECONDARY PORT". (The zone time of the secondary port is given in Part II printed directly above the respective secondary port).

Hence any change in the zone time at the standard port or any difference between the zone times at standard and secondary ports has no significance on the predicted value.

However if the zone time at the secondary port is different from those tabulated, the same must be corrected for. In other words should a ship be keeping different zone time, from the zone time listed for the secondary port in

Part II of A.T.T; Longitude correction must be applied in the usual manner.

Height difference in Predictions

The heights of high and low water are obtained by using the height difference tabulated in Part II.

These differences are given for mean spring and mean neap levels at the standard port. It is normally assumed that there is a linear variation between spring and neaps. Hence the differences for other heights are obtained by simple interpolation or extrapolation. The height of tide so obtained will obviously be with reference to the chart datum of the secondary port.

Seasonal Variations.

It is to be noted that predictions for standard ports in Volumes II & III of the Admiralty Tables include the "seasonal variations" for those ports. These variations may differ from seasonal variations for the secondary ports.

Hence the first step is, therefore, to SUBTRACT algebraically the seasonal variation for the standard port from the predicted heights obtained from Part I. Height differences for the secondary ports are then applied to them in the usual manner. The final step is to apply i.e. add algebraically the seasonal variation for the secondary port.

Whilst applying the seasonal variation, one must, of course be careful to ensure that the signs of the seasonal variations are correctly applied. Where no seasonal variations are given or they are less than 0.1 M, they can be ignored.

Example V.

Find the times and heights of high and low waters at Mangalore port, on March 10. The extract from Admiralty Tide Tables is given below:

Extracts from Part II of Adm. Tide Tables.

Place	Position		Time difference		Height Differences			
	Lat.	Long	MHW	LLW	MHHW	MLHW	MHLW	MLLW
Standard Port 4322 KARACHI	N	E	—	—	2.7	2.4	1.1	0.4
Secondary Port 4385 Mangalore	12°51'	74°50'	+0035	+0025	—1.2	—1.1	—0.2	—0.0

SEASONAL CHANGES IN MEAN LEVEL

Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Standard Port:—											
0.0	0.0	—0.1	0.0	+0.1	+0.1	+0.1	0.0	—0.0	—0.1	0.0	0.0
Secondary Port:—											
+0.1	+0.1	+0.1	0.0	0.0	0.0	0.0	—0.1	—0.1	—0.1	0.0	+0.1

Extract from Part-I	
STANDARD PORT	
TIME	HEIGHT
0016.....	1.8 M
10 0420.....	2.0 M
F 1226.....	0.8 M
2013.....	2.3 M

Solution :

	HW	HW	LW	LW
Predicted times at standard port	0420	2013	0016	1226
Time difference at Secondary Port	+0035	+0035	+0025	+0025
Predicted times at Secondary Port	0455	2048	0041	1251
Predicted height at standard Port	2.0	2.3	1.8	0.8
Seasonal change of M.L. Standard Port	—0.1	—0.1	—0.1	—0.1
Predicted height less seasonal change (corrected heights at Standard Port)	2.1	2.4	1.9	0.9
Interpolated height difference at Secondary ports.	—1.1	—1.1	—0.2	—0.1
Uncorrected heights at Secondary Port	1.0	1.3	1.7	0.8
Seasonal change of M.L. at Secondary Port	+0.1	+0.1	+0.1	+0.1

	HW	HW	LW	LW
Predicted heights at Secondary Port	1.1	1.4	1.8	0.9

NOTE : (1) Computation of high water is done from the two values of high water tabulated. Similarly, low water is computed from the two tabulated values of low water.

(2) It may be noted in the above question that the zone time at the standard port is -5h00m whilst the zone time at the secondary port is -5h30m. However, as stated earlier, the time difference given in Part II, when applied to times of H.W. & L.W. at standard ports will give the times of high & low waters at Secondary Ports in the zone time tabulated for secondary port (i.e. 5h30m time zone in this case).

Exercise

Using the extracts of Part II A.T.T. given in Example I, and the following extracts of Standard port, find the heights of high water and low water at Secondary Port on 20th March.

EXTRACTS FROM PART-I
STANDARD PORT
Month March

Extracts from A.T.T.	
TIME	HEIGHT
0113.....	2.8
0759.....	0.0
1441.....	2.5
2019.....	1.3

Solution :

	H.W.	H.W.	L.W.	L.W.
Predicted times at Standard Port	0113	1441	0759	2019
Times difference at secondary Port	+0035	+0035	+0025	+0025
Predicted height at Secondary port	0148	1516	0824	2044

	HW	HW	LW	LW
Predicted height at Standard port	2.8	2.5	0.0	1.3
Seasonal change of M.L. at standard port	—0.1	—0.1	—0.1	—0.1
Corrected height at standard port	2.9	2.6	0.1	1.4
Interpolated height difference at Secondary Port	—1.2	—1.2	—0.0	—0.3
Uncorrected height at Secondary Port	1.7	1.4	0.1	1.1
Seasonal changes of M.L. at secondary port	+0.1	+0.1	+0.1	+0.1
Predicted heights at secondary port	1.8	1.5	0.2	1.2



TEST PAPER I

[English Channel (Eastern Position) B.A. Chart No. 2675]

(DEVIATION CARD II)

- I (a) At 1530 hrs., while heading 200° (C) St. Catherine Point Lt. Ho. bore 315° (C) and Nab Tower bore 027° (C).
Find the ship's position.
- (b) From the position obtained at 1530 hrs. find a compass course to steer to pass Start Point Lt. Ho. 7 Miles off when abeam to starboard, counteracting a current setting 155° (M) at 4 knots. Wind North. Leeway 3° .
- (c) Find the time when Bill of Portland Light will be abeam. (Engine speed 13 knots. Variation 5° E).
- II At 1100 hrs. the following compass bearings were obtained :—
Casquets Lt. Ho. bore 234° (C)
Alderney Lt. Ho. bore 179° (C)
C. de La Hague Lt. Ho. (Fl. 18 M) bore 131° (C).
Find the ship's position at 1100 hrs. and also the Deviation of the compass, if Variation was 2° East.
- III At 0900 hrs., a ship in D.R. Lat. $49^{\circ}45'N$ Long. $3^{\circ}00'W$ a sun's sight gave Azimuth 235° (T) Intercept 4' AWAY and at the same time D.F. bearing of Casquet's Radio Beacon was 36° (Relative) on the starboard bow. The ship was steering 058° (T). Find the ship's position at 0900 hrs. Calibration Error NIL.
- IV In fog, at 1400 hrs., the following D.F. bearings corrected for calibration were observed :—
- | | |
|-----------------------------|-------------------|
| Casquets D.F. Station | 077° (T) |
| Guernsey D.F. Station | 106° (T) |
| Roches Douvres D.F. Station | 140° (T) |
- Find the ship's position at 1400 hrs.

ANSWERS — TEST PAPER I.

- I (a) Ship's Head $200^{\circ}(\text{C})$
 Deviation 10°W
 Variation 5°E
 Compass Error 5°W
 Compass bearing of St. Catherine
 Pt. Lt. Ho $315^{\circ}(\text{C})$
 Compass Error 5°W
 True bearing of St. Catherine
 Pt. Lt. Ho. $310^{\circ}(\text{T})$
 Compass bearing of Nab Tower $027^{\circ}(\text{C})$
 Compass Error 5°W
 True bearing of Nab Tower $022^{\circ}(\text{T})$
 Ship's Position at 1530 hrs.:—
 Lat. $50^{\circ}28'\text{N}$ Long D $1^{\circ}05.5'\text{W}$
- (b) Current $155^{\circ}(\text{M})$
 Variation 5°E
 True current $160^{\circ}(\text{T})$
 True course to steer to counteract
 current $275^{\circ}(\text{T})$
 Leeway (Wind North) $+ 3^{\circ}$
 True course to steer to counteract
 current and leeway $278^{\circ}(\text{T})$
 Variation 5°E
 Magnetic course $273^{\circ}(\text{M})$
 Deviation 2.1°E
 Compass course to steer to counteract
 current and leeway $270.9^{\circ}(\text{C})$
 Course made good $257^{\circ}(\text{T})$
 Speed made good 12 knots
- (c) Beam bearing of Bill of
 Portland Lt. $= 278^{\circ} + 90^{\circ}$
 $= 008^{\circ}(\text{T})$
 Distance from 1530 hrs. Position to beam bearing
 $= 55.8$ Miles.
 Speed made good $= 12$ knots.
 Time taken $= \frac{55.8}{12} = 4\text{H}.39\text{M}.$
 Bill of Portland Lt. will be abeam at 2009 hrs.

- II Horizontal angle between Casquets Lt. Ho. and Alderney Lt. Ho. = 55° -
 Complement = $90^{\circ} - 55^{\circ} = 35^{\circ}$
 Horizontal angle between Alderney Lt. Ho. and C. de La Hague Lt. Ho. = 48°
 Complement = $90^{\circ} - 48^{\circ} = 42^{\circ}$
 Ship's position at 1100 hrs.:—
 Lat. $49^{\circ}49.5'N$ Long. $02^{\circ}11'W$
 (From the Chart) True bearing of Casquets Lt. Ho. = 230° (T)
 Compass bearing of Casquets Lt. Ho. = 234° (C)
 Compass Error $4^{\circ}W$
 Variation $2^{\circ}E$
 Deviation $6^{\circ}W$
- III Ship's Head 058° (T)
 D. F. Relative bearing of Casquets
 D.F. Station 036°
 D. F. Bearing of Casquets D.F. Station 094° (T)
 To find Half Convergency :—
 Casquets D.F. Station $49^{\circ} 43'N$ $02^{\circ} 23'W$
 D. R. Position $49^{\circ} 46.5'N$ $02^{\circ} 55'W$
 D'Long. X Sine Mean Lat.
 Half Convergency = $\frac{\quad}{2}$
 = 0.2°
 True Mercator's bearing of Casquets D.F. Station 094.2° (T)
- Ship's position at 0900 hrs.:—
 Lat. $49^{\circ}45'N$ Long. $02^{\circ}53'W$
- IV D. R. Position Lat. $49^{\circ} 34'N$ Long. $3^{\circ} 25'W$
 Casquets Radio D.F. Station:—
 Lat. $49^{\circ}43'N$ Long. $02^{\circ}23'W$
 Mean Lat. $49^{\circ} 38.5'N$
 D'Long. $62'$
 Half Convergency $+ 0.4^{\circ}$
 True bearing of Casquets D.F. Station 077.4° (T)
 Guernsey D.F. Station Lat. $49^{\circ}26'N$ Long. $02^{\circ}39'W$
 D. R. Position Lat. $49^{\circ} 34'N$ Long. $3^{\circ} 25'W$
 Half Convergency $+0.3^{\circ}$
 True bearing of Guernsey D.F. Station 106.3° (T)
 Roches Douvres D.F. Station
 Lat. $49^{\circ}06.5'N$ Long. $02^{\circ}49'W$
 D. R. Position Lat. $49^{\circ} 34'N$ Long. $3^{\circ} 25'W$
 Half Convergency $+0.2^{\circ}$
 True bearing of Roches Douvres D.F. station 140.2° (T)
 Ship's Position at 1400 hrs :—
 Lat. $40^{\circ}34.5'N$ Long. $03^{\circ}25'W$

TEST PAPER II

[English Channel (Eastern Position) B.A. Chart No. 2675]

DEVIATION CARD II.

- I (a) At 0600 hrs. a vessel steering 245° (C), Royal Sovereign Lt. Vsl. bore 028° (C) and Beachy Head Lt. bore 328° (C), find the ship's position.
- (b) From 0600 hrs. position, find the compass course to steer to pass Cosquets Lt. Ho. 9 Miles off when abeam, counteracting a current setting 274° (T) at 2.5 knots. Wind North. Leeway 4° . Find also the course and speed made good.
- (c) Find the time and the distance off when Alderney Lt. Ho. will be abeam.
- (Ship's speed 15 knots. Variation 6° W)
- II The following D.F. bearings corrected for calibration, were observed :—
- | | |
|-------------------------------|-------------------|
| St. Catherine D.F. Station | 316° (T) |
| Pte. de Barfleur D.F. Station | 200° (T) |
| Pte. d'Ailly D.F. Station | 108° (T) |
- Find ship's position.
- III On a voyage from Southampton to Bristol, a vessel steering 250° (C), at 2100 hrs. Bill of Portland Lt. bore 303° (C) and at 2200 hrs. the same light bore 033° (C). During this time, the current was known to be setting 016° (M) at 3 knots. Find the ship's position at 2100 hrs. and also at 2200 hrs.
- (Ship's engine speed 11 knots. Variation 6° W)
- IV From a ship, the following horizontal sextant angles were observed. St. Catherine Lt. Ho. 41° Needles Lt. Ho. 50° Anvil Point Lt. Ho. Find the ship's position.

ANSWERS — TEST PAPER II

- I
- | | | |
|-----|---------------|----------|
| (a) | Ship's Head | 245° (C) |
| | Deviation | 1.7° W |
| | Variation | 6° W |
| | Compass Error | 7.7° W |
- True bearing of Royal Sovereign Lt. Vessel 020.3° (T)
- True bearing of Beachy Head Lt. 320.3° (T)
- 0600 hrs. Ship's Position.
Lat. 50°37.2'N Long. 00°24'E
- (b) True course to steer to counteract current 243° (T)
- Leeway (Wind North) + 4°
- True course to steer to counteract Current and Leeway 247° (T)
- Variation 6° W
- Magnetic course 253° (M)
- Deviation 0.6° W
- Compass course to steer to counteract Current and Leeway 253.6° (C)
- Course made good 247° (T)
- Speed made good 17.3 knots.
- (c) Beam bearing of Alderney Lt. 157° (T)
- Distance from 0600 hrs. to bearing Position 111 Miles.
- Time when Alderney Lt. Ho. abeam 1225 hrs.
- Distance off when Alderney Lt. Ho. is abeam 11.8 Miles.
- II
- D. R. Position Lat. 50° 18.2'N Long. 00° 54'W
- Position of St. Catherine D.F. Station :—
Lat. 50° 34.5'N Long. 1° 18'W
- Half Convergency = 0.15°
- Position of Pte. de Barfleur D.F. Station :—
Lat. 49° 42'N Long. 1° 16'W
- Half Convergency = 0.15°
- Position of Pte. d'Ailly D.F. Station :—
Lat. 40° 54.5'N Long. 00°57'E
- Half Convergency = 0.75°

St. Catherine D.F. Station Mercator bearing
 315.85° (T)

Pte. de Barfleur D.F. Station Mercator bearing
 199.85° (T)

Pte. d'Ailly D.F. Station Mercator bearing
 108.75° (T)

Ship's position Lat. $50^{\circ} 19.5'N$ Long. $00^{\circ} 54.5'W$

- III Compass course 250° (C)
 Deviation $1^{\circ}W$
 Variation $6^{\circ}W$
 Compass Error $7^{\circ}W$
 True course 243° (T)
 At 2100 hrs. True bearing of Bill of Portland Lt.
 296° (T)
 At 2200 hrs. True bearing of Bill of Portland Lt.
 026° (T)
 True current 010° (T) at 3 knots.
 Ship's position at 2200 hrs.:—
 Lat. $50^{\circ}25.5'N$ Long. $02^{\circ}31.5'W$
 Ship's position at 2100 hrs.:—
 Lat. $50^{\circ}27.7'N$ Long $02^{\circ}17'W$

- IV Complement of St. Catherine Pt. &
 Needles Lt. Ho. = $90^{\circ} - 41^{\circ} = 49^{\circ}$
 Complement of Needles Lt. Ho. &
 Anvil Point Lt. Ho. = $90^{\circ} - 50^{\circ} = 40^{\circ}$
 Ship's Position Lat. $50^{\circ} 22.4'N$ Long. $1^{\circ} 41'W$



- IV. On a voyage from London to Le Havre, at 1845 hrs. in D. R. Lat. $50^{\circ} 30.5'N$ Long. $00^{\circ} 16'W$, a Star Sight gave observed Longitude $00^{\circ} 12'W$ and Azimuth $249^{\circ}(T)$. Find the safe true courses to steer, so as to pick up Le Havre light vessel right ahead. Also find the distance to steam on the first course. What is the principle involved in your courses ?

ANSWERS — TEST PAPER III

- | | | | |
|----|-----|---|----------------|
| I | (a) | Vertical sextant angle | 0°20' |
| | | Index Error | 3' on the arc. |
| | | Observed Vertical Sextant angle | 0°17' |
| | | Distance off Bill of Portland Light House | 4.8' |
| | | 1600 hrs. Ship's position:— | |
| | | Lat. 50°26'N Long. 2°27.2'W | |
| | (b) | True course to steer counteracting | |
| | | current | 260° (T) |
| | | Leeway (Wind North) | +3° |
| | | True course to steer counteracting | |
| | | Current & Leeway | 263° (T) |
| | | Variation | 2°E |
| | | Magnetic course | 261° (M) |
| | | Deviation | 0.5°E |
| | | Compass course to steer counteracting | |
| | | Current & Leeway | 260.5° (C) |
| | (c) | Course made good | 247° (T) |
| | | Speed made good | 8.9 knots. |
| | | Beam bearing of Berry Hd. Light | 353° (T) |
| | | Distance from 1600 hrs. Position to | |
| | | beam bearing position of Berry. Head = | 41' |
| | | Time taken at 8.9 knots = | 4H 36M |
| | | Time when Berry Head light will be | |
| | | abeam | 2036 hrs. |
| | | Distance off when Berry Head Light | |
| | | is abeam | 14 Miles |
| II | (a) | Compass course | 105° (C) |
| | | Deviation | 4.2°W |
| | | Variation | 2°W |
| | | Compass Error | 6.2°W |
| | | True Course | 098.8° (T) |
| | | Leeway (Wind North) | +3° |
| | | True course after Leeway | 101.8 (T) |

At 2100 hrs. Compass bearing of
Pte. de Barfleur Lt. 156° (C)
At 2100 hrs. True bearing of
Pte. de Barfleur Lt. 149.8° (T)
At 2200 hrs. Compass bearing of
Pte. de Barfleur Lt. 221° (C)
At 2200 hrs. true bearing of
Pte. de Barfleur Lt. 214.8° (T)
Current 042° (T) at 3 knots.

Ship's position at 2200 hrs.:—

Lat. $49^{\circ}52'N$ Long. $1^{\circ}04'W$

Ship's position at 2100 hrs.

Lat. $49^{\circ} 52.8'N$ Long. $1^{\circ} 25.6'W$

- (b) Beam bearing of C. d'Antifer Lt. 188.8° (T)
Distance from 2200 hrs. Position to beam bearing
of C. d'Antifer Lt. = 49. Miles.
Speed made good = 14.2 Knots.
Time taken = 3 hours 27 minutes.
Estimated time when C. d'Antifer Lt. will be abeam
= 0127 hrs. on 21st January.

III Horizontal angle between Needles Lt. Ho. and
St. Catherine Pt. Lt. Ho. = 32°
Complement angle = $90^{\circ} - 32^{\circ} = 58^{\circ}$
Horizontal angle between St. Catherine Pt. Lt. Ho.
and Nab Tower = 40°
Complement angle = $90^{\circ} - 40^{\circ} = 50^{\circ}$
Ship's position Lat. $50^{\circ} 23.5'N$ Long. $1^{\circ} 16.8'W$
True bearing of Needles Lt. Ho. 324° (T)
Compass bearing of Needles Lt. Ho. 329° (C)
Compass error $5^{\circ}W$
Variation $2^{\circ}E$
Deviation $7^{\circ}W$

IV Azimuth = 249° (T)
Position line = 159° (T) and 339° (T)
1st course = 249° (T) for 20 Miles.
2nd course to pickup Le Havre Lt. Vessel right
ahead. = 159° (T)

TEST PAPER IV

[English Channel (Eastern Position) B.A. Chart No. 2675]

(DEVIATION CARD II)

- I (a) At 1600 hrs. a ship steering 250° (C) St. Catherine Point Light house bore 323° (C) and Nab Tower bore 022° (C) find the ship's position.
- (b) From the position at 1600 hours, find the compass course to steer so as to raise Start Point Light (Gp. Fl. (3) 20M) 20° on the Starboard bow. Find the position at which Start Point Light, (as stated above) will be raised and at what distance do you expect to pass the same light when abeam, while on the above course.
- (c) Also find the time when Start Point Light will be abeam. (Ship's speed 13 knots. H.E. 10.67 Metres or 35 feet. Variation 6° East).
- II (a) At 2000 hrs. Les Sept. Iles Light dipped bearing 175° (T). From this position find Compass course to steer to pass Casquets Lt. 5 Miles off when abeam counteracting a current setting 114° (M) at 3 knots. Wind North West, gale force. Leeway 3° .
- (b) Find the course and speed made good and also the time when Casquets light will be abeam. (Ship's speed 15 knots. H.E. 12.19 Metres or 40 feet. Variation 6° East).
- III (a) At 0900 hrs. a ship steering 092° (C) at 13 knots engine speed, Alderney Light house bore 226° (C) and at 1100 hrs. Pte. de Barfleur Lt. Ho. was abeam. A current was known to be setting 334° (M) at 2 knots throughout. Find the ship's position at 0900 hrs. and at 1100 hrs.
- (b) At 1100 hrs. while steering the same course, engine speed was reduced to 10 knots due to Engine trouble. The current continued to be the same as before in (a). Find the time when C. d'Antifer Lt. Ho. will be abeam and also the distance of this Lt. Ho. when abeam. (Variation 6° East).

ANSWERS — TEST PAPER IV

- I (a) Ship's Head 250° (C)
 Deviation 1° W
 Variation 6° E
 Compass Error 5° E
 True bearing of St. Catherine Point Lt. Ho. 328° (T)
 True bearing of Nab Tower 027° (T)
 Ship's Position at 1600 hrs :—
 Lat. $50^{\circ} 26'N$ Long. $01^{\circ} 09.2'W$
- (b) Visibility of Start Point Lt. 20 Miles.
 For H. E. 4.57 Metres (15 feet) —4.4'
 Visibility of Lt. at sea level 15.6'
 For 10.67 Metres +6.8
 Raising distance of Start Point Lt. 22.4
 By Traverse Tables, in order to raise the light 20° on the Starboard bow at 22.4', the beam distance off the light will be 7.66 Miles. Hence find a course from 1600 hrs. position, so as to pass Start Point Lt. when abeam at 7.66 Miles.
 True course to steer 258° (T)
 Variation 6° E
 Magnetic course 252° (M)
 Deviation 0.6° W
 Compass course to steer 252.6° (C)
 Position when Start Point Light will be raised :—
 Lat. $50^{\circ} 10.4'N$ Long. $03^{\circ} 03.2'W$
- (c) Distance from 1600 hrs. to beam position of Start Point Light = 95 Miles.
 Time required to cover this distance

$$= \frac{95}{13} = 7H. 18M.$$
- Hence Start Point Light will be abeam at 2318 hrs.
- II (a) Visibility of Les Sept. Iles Lt. 20 Miles.
 For H. E. 4.57 Mtrs. (15 feet) —4.4 Miles.
 Visibility of the Les Sept Iles Lt. at sea level 15.6 Miles.
 For H. E. 12.19 Metres. (40 feet) +7.4 Miles.
 Dipping distance of Light 23.0 Miles.
 Current 120° (T)

True course to steer to counteract		
Current		042° (T)
Leeway (Wind NW)		— 3°
True course to steer counteracting		
Current & Leeway		039° (T)
Variation		6°E
Magnetic course		033° (M)
Deviation		10.1°E
Compass Course to steer counteracting		
Current & Leeway.		022.9° (C)
II (b) Course made good		
		052.5° (T)
Speed made good		16.0 knots.
Beam bearing of Casquets Lt.		129° (T)
Distance till Casquets Lt. abeam		51.5 Miles.
Time taken to cover 51.5 Miles @ 16 knots.		
		= 3 hours 13 minutes.
Casquets Lt. will be abeam at		2313 Hrs.
III (a)		
Compass course		092° (C)
Deviation		2.3°W
Variation		6°E
Compass Error		3.7°E
True course		095.7° (T)
True bearing of Alderney Lt. Ho.		229.7° (T)
Beam bearing of Pte. de Barfleur Lt.		185.7° (T)
True Current		340° (T)
Position at 1100 hrs. Lat. 49° 55'N Long.		1°14.5'W
Position at 0900 hrs. Lat. 49° 53.2'N Long.		1°53'W
Course made good		086° (T)
Speed made good		12.6 Knots.
III (b) Course made good after 1100 hrs.		
Position		083° (T)
Speed made good after 1100 hrs.		
Position		9.4 Knots
Beam bearing of C. d'Antifer Lt.		185.7° (T)
Distance to C. d'Antifer Lt. abeam		56.0 Miles.
ETA when C. d'Antifer Lt. is abeam		1657 Hrs.
Distance off when C. d'Antifer Lt.		
is abeam		= 19.8 Miles.

TEST PAPER V

[English Channel (Eastern Position) B.A. Chart No. 2675]

- I A ship steering 074° (G) in the English Channel, Pte. de Barfleur light bore 117° (G). After 1 hour's steaming at 15 knots, the same light bore 188° (G). Find the ship's position at the time of taking first and the second bearing, if the current during the period was setting 035° (T) at 3 knots. (Gyro Error 1° Low).
- II (a) At 2000 hours, C. de Le Heve Light bore 143° (G) and C. d'Antifer Light bore 103° (G). Find the ship's position. From the position obtained at 2000 hours, find the gyro course to steer so as to pass Bassurelle Light Vessel 7.2 Miles off when 30° on the port bow.
- (b) Find the course and the speed made good by the above vessel, if the current was setting 180° (T) at 2.5 knots and a strong wind was blowing from a North Westerly direction. Leeway 5° .
- (c) Find the time and the distance off when Pte. d'Ailly Light will be abeam. (Engine speed 15 knots. Gyro Error 1° Low).
- III (a) Find the gyro compass course to steer from a position at 1900 hours with Beachy Head light bearing 000° (T) at 10 Miles to a position 12 miles off St. Catherine Point light when abeam, allowing for the current setting 315° (T) at 2 knots and leeway of 3° . Wind South.
- (b) Whilst on the above course Nab Tower light is expected to be raised at a distance of 19 Miles. Find the time and the relative bearing when the light is raised.
- (Ship's speed 12 knots. Gyro Error 2° High).
- IV At 0600 hours, a ship in D. R. Lat. $49^{\circ} 50'N$ Long. $3^{\circ} 40'W$, a star sight gave an intercept of 6.1' AWAY and Azimuth of 050° (T). The ship then continued on her course 065° (T) at 12 knots until 1000 hrs. when "The Shambles" D.F. Beacon. gave a relative D. F. bearing as 15° (Red). Find the ship's position at 1000 hours.

ANSWERS — TEST PAPER V

- | | | |
|-----|--|-----------------------|
| I | Gyro Course steered | 074° (G) |
| | Gyro Error | 1° Low |
| | True course steered | 075° (T) |
| | Current | 035° (T) at 3 knots. |
| | 1st True bearing of Pte. de Barfleur Lt. | 118° (T) |
| | 2nd True bearing of Pte. de Barfleur Lt. | 189° (T) |
| | Ship's Position at 2nd bearing:— | |
| | Lat. 49° 55.8' N | Long. 1° 12.5' W |
| | Ship's position at 1st bearing:— | |
| | Lat. 49° 49.5' N | Long. 1° 38' W |
| II | (a) True bearing of C. de Le Heve Light | 144° (T) |
| | True bearing of C. d'Antifer light | 104° (T) |
| | Ship's Position at 2000 hours:— | |
| | Lat. 49° 44.5' N | Long. 00° 10.8' W |
| | When Bassurelle Lt. Vessel is 30° on the bow at | |
| | | 7.2 Miles. |
| | .. Distance off when abeam | = 3.6 Miles. |
| | True course to steer | 045° (T) |
| | Gyro Error | 1° Low |
| | Gyro course to steer | 044° (G) |
| | (b) True course made good after allowing for | |
| | | Leeway 050° (T) |
| | Current | 180° (T) at 2.5 knots |
| | Course made good | 058° (T) |
| | Speed made good | 13.65 knots. |
| | (c) Beam bearing of Pte. d'Ailly | |
| | Light | 135° (T) |
| | Distance from 2000 hrs. Position to beam bearing | |
| | | = 40 Miles. |
| | Speed made good = | 13.6 knots. |
| | Time when Pte. d'Ailly light will be abeam | |
| | | 2257 hours. |
| | Distance off when Pte. d'Ailly light is abeam | |
| | | 14.4 Miles. |
| III | (a) True course to steer to counteract current | |
| | | 250° (T) |
| | Leeway (Wind South) | — 3° |
| | True course to steer counteracting current and | |
| | | Leeway = 247° (T) |

Gyro Error 2° High
 Gyro course to steer counteracting.
 Current and Leeway = 249° (G)

- (b) Speed made good 13 knots.
 Distance made good when Nab Tower is raised
31.2 Miles.
 Time required = 2 hours 24 minutes.
 Hence Nab Tower light will be raised at
2124 hours.
 True bearing when light is raised 311° (T)
 Gyro bearing when light is raised 313° (G)
 Gyro course 249° (G)
 Relative bearing 64° (Green)

- IV Azimuth of the star = 050° (T)
 ∴ Position line = 140° (T) and 320° (T)
 D. R. Position at 1000 hrs.:—
Lat 50° 06'N Long. 2° 39'W
 Position of "The Shambles":—
Lat. 50° 31'N Long. 2° 20'W

Mean Lat. 50° 18.5'N
 D'Long. = 19'W
 Half Convergency = NIL
 True D. F. bearing = 050° (T)
 Ship's Position at 1000 hrs.:—
Lat. 50° 15'N Long. 2° 51'W



TEST PAPER VI

[English Channel (Eastern Position) B.A. Chart No. 2675]

DEVIATION CARD II

- I From a position, at 1800 hrs. with Pte. de Barfleur Lt. bearing 180° (T) distance 10 miles, find the compass course to steer to a position 180° (M) 4 Miles off from Le Havre light vessel, counteracting a current setting 160° (M) at $2\frac{1}{2}$ knots and adjusting the engine speed so as to arrive at her destination at 2200 hours. (Variation 6° W).
- II At 0800 hours, a ship in D.R. Position Lat $50^{\circ} 08'N$ Long $00^{\circ}04'W$, an observation of the Sun gave an intercept of 4' TOWARDS and P.L. was 050° (T) and 230° (T). The ship then steered 118° (C), through a current setting 220° (M) at 4 knots. Ship's speed through the water 15 knots. Wind North. Leeway 5° . At 0900 hours, Pt. d'Ailly Lt. Ho. bore 135° (T). Find the ship's position at 0800 hours and 0900. (Variation 6° W).
- III A ship steering 260° (C) at 12 knots, at 0900 hours St Catherine Point Light bore $333\frac{1}{2}^{\circ}$ (C) and at 0930 hours it bore $005\frac{1}{2}^{\circ}$ (C) and at 1010 hours it bore $031\frac{1}{2}^{\circ}$ (C). At the time of taking the third bearing Anvil Point light bore $305\frac{1}{2}^{\circ}$ (C). Find the course made good, position at the time of second bearing and the set and drift of the current between 0900 hrs. and 1010 hours. (Variation 6° W).
- IV (a) On 20th December, a ship steering 230° (C) at 11 knots at 2000 hours Anvil Point Lt. bore 052.5° (C) and Bill of Portland light bore 326.5° (C). Find the ship's position, and from this position find the compass course to steer so as to pass Start Point light 10 miles off when 30° on the starboard bow.
- (b) Find the course and speed made good if she experienced a current setting 200° (T) at 2 knots.

(c) Find the time and distance off when Berry Head light will be abeam (Variation 6° West).

ANSWERS—TEST PAPER VI

- | | | |
|-----|---|-----------------------|
| I | Magnetic bearing of Le Havre
Lt. Vsl | 180° (M) |
| | Variation | 6°W |
| | True bearing of Le Havre Lt. Vsl | 174° (T) |
| | Magnetic current | 160° (M) |
| | True current | 154° (T) at 2½ knots. |
| | Total distance required to be covered in 4 hrs. | 45 Miles. |
| | Therefore speed made good required :- | 11¼ knots. |
| | True course to steer counteracting the
current | 101° (T) |
| | Variation | 6°W |
| | Magnetic course to steer | 107° (M) |
| | Deviation | 5.5°W |
| | Compass course to steer counteracting
current | 112.5° (C) |
| | Engine speed to be adjusted to | 9.7 knots. |
| II | P.L. = 050° (T) & 230° (T) | |
| | ∴ Azimuth | = 140° (T) |
| | Compass course | 118° (C) |
| | Deviation | 6.6°W |
| | Variation | 6°W |
| | Compass error | 12.6°W |
| | True course | 105.4° (T) |
| | Leeway (Wind North) | + 5° |
| | True course after allowing for Leeway | 110.4° (T) |
| | True current | 214° (T) at 4 knots |
| | Engine speed | 15 knots. |
| | Ship's Position at 0900 hrs.:— | |
| | Lat. 50°07.2'N Long. 00°39.0'E | |
| | Ship's Position at 0800 hrs.:— | |
| | Lat. 50°15.8'N Long. 00°21'E | |
| III | Compass course | 260° (C) |
| | Deviation | 0.5°E |
| | Variation | 6°W |
| | Compass error | 5.5°W |
| | True course | 254.5° (T) |

1st True bearing of St. Catherine Pt. Lt. 328° (T)
2nd true bearing of St. Catherine Pt. Lt. 000° (T)
3rd True bearing of St. Catherine Pt. Lt. 026° (T)
Anvil Point Lt. True bearing 300° (T)
Distance steamed between 1st and 2nd bearing 6 Miles.
Distance steamed between 2nd and 3rd bearing 8 Miles.
Course made good 245° (T)
Ship's Position at 0930 hrs.:—
Lat. 50°27'N Long. 01°17.4'W
Current set 097½° (T)
Drift of the current 4.6 Miles in 1 hr. 10 min.

IV	(a) Compass course	230° (C)
	Deviation	4.5°W
	Variation	6°W
	Compass error	10.5°W

True bearing of Anvil Point light.	042° (T)
True bearing of Bill of Portland light	316° (T)

Ship's Position at 2000 hrs.:—

Lat. 50°23'N Long. 02°15.5'W

When Start Point light will be 30° on the Stbd. bow
at 10 miles, it will be abeam at 5 Miles

True course to steer 254° (T)

Variation 6°W Magnetic course 260° (M)Deviation 0.5°E

Compass course to steer 259.5° (C)

(b) Current 200° (T) at 2 knots.

Course made good $246\frac{1}{2}^{\circ}$ (T)

Speed made good 12.2 knots.

(c) Beam bearing of Berry Hd. Lt. 344° (T).

Distance off when Berry Hd. light abeam
19.8 Miles

Distance from 2000 hrs. to beam bearing Posn.
= 45.6 Miles

Speed made good 12.2 knots

Time when Berry Hd. light will be abeam
= 2345 hrs.

TEST PAPER VII

[Ceylon South Part (South of $7^{\circ}20'N$) B.A. Chart No. 813]

DEVIATION CARD III

- I (a) At 2030 hours, position was found with Colombo light bearing $100^{\circ}(T)$ distance 7 Miles. From this position at 2030 hours find the compass course to steer so as to pass Point de Galle light 12 Miles off when abeam.
- (b) Whilst steering the above course, the ship experienced the current setting $218^{\circ}(M)$ at 3 Knots. Wind Easterly. Leeway 3° . Find the course and and speed made good.
- (c) Also find the time and the distance off when Barberyn light will be abeam. (Variation 3° East, speed 11 knots).
- II (a) At 1900 hours, whilst steering $110^{\circ}(C)$. Point de Galle light bore $323^{\circ}(C)$ and Dondra Head light bore $059^{\circ}(C)$, find the ship's position.
- (b) From the position as 1900 hours, find the compass course to steer, so as to raise Great Basses Reef Light at a distance of 19 Miles, when 20° on the port bow. Find the position at which Great Basses Reef Light, as stated above, will be raised and at what distance off do you expect to pass the same light when abeam, whilst on the above course.
- (c) Find the time when Great Basses Reef light will be abeam. (Speed 15 knots. Variation 3° E).
- III At 0530 hours, a ship in D.R. Position Lat. $6^{\circ}51'N$ Long. $82^{\circ}06'E$, a star sight gave an observed Longitude $82^{\circ}11'E$ and Azimuth $070^{\circ}(T)$. The ship then continued on her course $211^{\circ}(C)$ at 12 knots until 0800 hours when little Basses Reef light was sighted bearing $243^{\circ}(C)$. Find the ship's position at 0800 hours. (Variation 3° East).
- IV A ship was anchored for engine repairs and the following compass bearings were observed :

Sangama Kanda Point Lt. Ho.	348° (C)
Nilagalahela Peak (655)	273° (C)
Kudumbegala (Rugged Ridge) Peak (372)	231° (C)

Find the ship's position and also the deviation of the compass if the variation is 3° East.

ANSWERS — TEST PAPER VII

- I
- | | |
|--------------------------|------------|
| (a) True course to steer | 163° (T) |
| Variation | 3° East |
| Magnetic course | 160° (M) |
| Deviation | 4.6° W |
| Compass course to steer | 164.6° (C) |
- (b)
- | | |
|------------------------------------|----------------------|
| True course steered | 163° (T) |
| Leeway (Wind Easterly) | 3° |
| True course made good after leeway | 166° (T) |
| Current | 221° (T) at 3 knots. |
| Course made good | 177° (T) |
| Speed made good | 13 knots. |
- (c)
- | | |
|---|----------------------|
| Beam bearing of Barberyn Light | 073° (T) |
| Distance off when Barberyn light is abeam | = 13.4 Miles. |
| Distance from 2030 hrs. to beam bearing | = 33.4 Miles. |
| Speed made good | = 13 knots. |
| Time taken to beam bearing | = 2 hours 34 minutes |
| Barberyn light will be abeam at | 2304 hrs. |
- II
- | | |
|------------------------------------|------------|
| (a) Compass course | 110° (C) |
| Deviation | 2.9° W |
| Variation | 3° E |
| Compass Error | 0.1° E |
| True bearing of Point de Galle Lt. | 323.1° (T) |
| True bearing of Dondra Head Lt. | 059.1° (T) |
| Position at 1900 hrs.:— | |
| Lat. 5°47.5'N Long. 80°23'E | |
- (b)
- | | |
|---|-----------|
| Raising distance of the light | 19 Miles. |
| By Traverse Tables, in order to raise the light | |
| 20° on the port bow at 19 Miles the beam | |
| distance of the light will be 6.5 Miles. Hence | |

find the course to steer so as to pass Great Basses Lt. at 6.5 Miles, when abeam.

True Course to steer	076° (T)
Variation	3° E
Magnetic course	073° (M)
Deviation	0.2° East
Compass course to steer	072.8° (C)
Position when Great Basses Light will be raised:—	
Lat. 05° 59.8' N Long. 81° 13' E	

- (c) Distance from 1900 hrs. Position to beam bearing
= 69 Miles
Time required = 4H 36M
Great Basses Lt. will be abeam at 2336 hours.

III	Azimuth of the star	070° (T)
	Position Line	160° (T) and 340° (T)
	Compass Course	211° (C)
	Deviation	4° W
	Variation	3° E
	Compass Error	1° W
	True Course	210° (T)
	True bearing of Little Basses Light	242° (T)
	Position at 0800 hrs. Lat. 06° 29.5' N Long. 81° 54' E	

IV	Horizontal angle between Sangama Kanda Pt. Lt. and Nilagalahela Peak	= 75°
	Horizontal angle between Nilagalahela Peak and Kudumbegala Peak	= 42°
	Ship's Position Lat. 06° 50.2' N Long. 81° 55.6' E	
	True bearing of Nilagalahela Peak	269° (T)
	Compass bearing of Nilagalahela Peak	273° (C)
	Compass Error	4° W.
	Variation	3° E.
	Deviation	7° West.



TEST PAPER VIII

[Ceylon South Part (South of $7^{\circ}20'N$) B.A. Chart No. 813]

(DEVIATION CARD III)

- I (a) At 1730 hours, position was found with Colombo light bearing 120° (T) distance 13 Miles. From this position find the compass course to steer so as to pass Point de Galle Light 12 Miles off when abeam.
- (b) At 1930 hours, Colombo light bore 029° (C) and Barberyn light bore 139° (C), find the set and drift of the current.
- (c) From the position obtained at 1930 hours, find the compass course to steer so as to pass Point de Galle light 12 Miles off when abeam counteracting the current experienced in (b).
- (d) Find the time and distance off when Barberyn light will be abeam. (Variation 3.5° West. Speed 10.5 knots).
- II (a) At 2100 hours, a ship steering 104° (C) at 16 knots, Dondra Head light bore 071° (C) and at 2200 hours, the same light bore 307° (C). During this time the ship experienced a current setting 040° (T) at 2.5 Knots. Wind North. Leeway 2° . Find the ship's position at 2100 hours and at 2200 hours. (Variation 3.5° West).
- (b) At 2200 hours, while steering the same course engine speed was reduced to 12 knots due to Engine trouble. The current and leeway continued to be the same as before in (a). Find the time and the distance off when Hambantota light will be abeam.
- III From a position with Great Basses light house bearing 023.5° (M) and its vertical sextant angle was $00^{\circ}20'$ (the tide having fallen 10 feet below the level of M.H.W.O.S.) vessel sailed round an arc maintaining the distance as obtained by verti-

cal sextant angle, till Great Basses light house bore 288.5° (M). Find the final ship's position and the distance sailed round the arc. (Variation 3.5° W. Index Error $3'$ on the arc).

ANSWERS — TEST PAPER VIII

- I
- | | | |
|-----|---|------------------------|
| (a) | True course to steer | 161° (T) |
| | Variation | 3.5° W |
| | Magnetic course | 164.5° (M) |
| | Deviation | 4.6° W |
| | Compass course to steer | 169.1° (C) |
| | Compass error | 8.1° W |
| (b) | True bearing of Colombo light | 020.9° (T) |
| | True bearing of Barberyn Light | 130.9° (T) |
| | Current | 210° (T) |
| | Drift | 3.5 Miles @ 1.7 knots. |
| (c) | True course to steer counteracting current | 150° (T) |
| | Variation | 3.5° W |
| | Magnetic course | 153.5° (M) |
| | Deviation | 4.5° W |
| | Compass course to steer counteracting current | 158° (C) |
| (d) | Beam bearing of Barberyn Light. | 060° (T) |
| | Distance from 1930 hrs. to beam bearing of Barberyn Lt. | 17.4 Miles. |
| | Speed made good | 11.5 Knots |
| | Time taken | 1 hour 31 minutes. |
| | Time when Barberyn Light will be abeam | 2101 hrs. |
| | Distance off when Barberyn light is abeam | 8.2 Miles. |
- II
- | | | |
|-----|---|-------------------|
| (a) | Compass course | 104° (C) |
| | Deviation | 2.5° W |
| | Variation | 3.5° W |
| | Compass error | 6.0° W |
| | True course steered | 098° (T) |
| | 2100 hrs. True bearing of Dondra Head light | 065° (T) |

2200 hrs. True bearing of Dondra
 Head light 301° (T)
 True course steered 098° (T)
 Leeway (Wind North) $+2^{\circ}$
 Course made good after Leeway 100° (T)
 Current 040° (T) at 2.5 knots.
 Position at 2200 hrs. Lat. $05^{\circ}50'N$ Long. $80^{\circ}44.5'E$
 Position at 2100 hrs. Lat. $05^{\circ}51'N$ Long. $80^{\circ}26.8'E$

II (b) Course steered 098° (T)
 Leeway (Wind North) 2°
 Course made good after leeway 100° (T)
 Current 040° (T) at 2.5 knots.
 Course made good after leeway and
 current 091° (T)
 Speed made good 13.5 knots.
 Beam bearing of Hambantota Lt. 008° (T)
 Distance off when Hambantota
 Lt. abeam 17.8 Miles.
 Distance from 2200 hrs. to beam
 bearing position 20.8 Miles.
 Speed made good 13.5 knots.
 Time when Hambantota Lt. will
 be abeam 2329 hrs.

III Height of the object (when tide has
 fallen 10') 120 feet
 Distance off Lighthouse 4 Miles.
 1st True bearing of the lighthouse 020° (T)
 2nd True bearing of the lighthouse 285° (T)
 Angle at the centre 93°

Distance sailed round the arc
$$= \frac{r \times \theta}{57.3} = \frac{4 \times 93^{\circ}}{57.3}$$

$$= 6.49 \text{ Miles.}$$

Final Position. Lat. $06^{\circ}09.25'N$ Long. $81^{\circ}32.7'E$



TEST PAPER IX

[Ceylon South Part (South of $7^{\circ}20'N$) B.A. Chart No. 813]

- I (a) At 1900 hours Colombo light bore $013^{\circ}(G)$ and Barberyn light bore $141^{\circ}(G)$. Find the ship's position.
- (b) From the position obtained in (a) find a course to steer by Gyro so as to pass Point de Galle light 10 Miles off when abeam counteracting a current setting $230^{\circ}(T)$ at 2.5 knots. Wind WSW. Leeway 3° .
- (c) Find the time and distance off when Barberyn light is abeam. (Gyro Error 1° High. Speed 11 knots.)
- II A ship steaming at 12 knots, while steering $080^{\circ}(G)$ at 0900 hours Hambantota light house bore $040^{\circ}(G)$ and at 0935 hours it bore $357^{\circ}(G)$ and at 1000 hours it bore $309^{\circ}(G)$. At the time of taking the third bearing Dorava Point bore $026^{\circ}(G)$. Find the course made good, position at the time of second bearing and the set and drift between 0900 hours and 1000 hours. (Gyro Error 1° High)
- III (a) From the position found at 0200 hours with Great Basses Reef Lt. bearing $006^{\circ}(G)$ distance 9 Miles off, find the gyro course to steer so as to pass Little Basses Reef Light 8 Miles off when 30° on the port bow.
- (b) Find the course and the speed made good if the current on the above course was setting $110^{\circ}(T)$ at 2 knots.
- (c) Find the time and distance off when Great Basses Reef Light will be abeam (Gyro Error 1° High. Engine speed 10 knots.)
- IV At 0500 hours a ship in D.R. $06^{\circ}57'N$, $82^{\circ}06'E$, a star sight gave intercept of 4' AWAY and Azimuth of $234^{\circ}(T)$. The ship then continued on her

course of 206° (G) at 12 knots until 0730 hours when Little Basses Reef Light bore 070° (G). Find the ship's position at 0730 hours. (Gyro Error 1° High)

ANSWERS — TEST PAPER IX

- I (a) Ship's position at 1900 hours:—
Lat. $06^{\circ}40.5'N$ Long. $79^{\circ}47.25'E$
- (b) True course to steer counteracting current 147° (T)
Leeway (Wind W S W) 3°
True course to steer counteracting Current and Leeway 150° (T)
Gyro Error 1° High
Gyro Course to steer 151° (G)
- (c) Beam bearing of Barberyn Lt. 060° (T)
Distance off when Barberyn Lt. is abeam 5.6 Miles.
Distance from 1900 hrs. to beam bearing position 16.7 Miles.
Speed made good 11.6 knots
Time taken 1 hour 27 minutes
Barberyn Light will be abeam at 2027 hrs.
- II Course steered 073° (T)
Distance steamed between 0900 hrs. and 0935 hrs. = 7 Miles.
Distance steamed between 0935 hrs. and 1000 hrs. = 5 Miles.
Course made good 072° (T)
Set 052° (T)
Drift 4.6 Miles
Position at 2nd bearing:—
Lat. $05^{\circ}59.25'N$ Long. $81^{\circ}08.25'E$
- III If Little Basses light is 8 Miles when 30° on the bow, then distance off when abeam = 4 Miles.
True course to steer so as to pass Little Basses Lt. 4 Miles off when abeam 043° (T)
Gyro Error 1° High
Gyro course to steer 044° (G)

(b) Course made good after current	052.5° (T)
Speed made good	10.9 knots.
Beam bearing of Great Basses Lt.	313° (T)
Distance off when abeam	6.8 Miles.
Distance from 0200 hrs to beam bearing position	7.3 Miles
Speed made good	10.9 knots.
Great Basses Reef light when abeam	0240 hours.

IV Azimuth	234° (T)
Position lines	144° (T) and 324° (T)
True course steered	205° (T)
Distance covered in 2½ hrs.	30 Miles.
True bearing of Little Basses Lt.	069° (T)
Ship's position at 0730 hours :—	
Lat. 06° 29.5'N Long. 81° 58.3'E	



TEST PAPER X

[Ceylon South Part (South of $7^{\circ}20'N$) B.A. Chart No. 813]

- I On a voyage from Bombay to Madras, a vessel was steering $098^{\circ}(T)$ at 12 knots. At 0800 hours, Dondra Head light house bore $041^{\circ}(T)$ and at 0830 hours it bore $000^{\circ}(T)$. and at 0910 hours it bore $310^{\circ}(T)$. Find the course made good and the position of the ship at 0800 hours and at 0910 hours and the drift of the current which was known to be setting $317^{\circ}(T)$.
- II A ship steering $289^{\circ}(G)$, at 2100 hours Point De Galle light bore $334^{\circ}(G)$ and after steaming for 1 hour at 15 knots the same light bore $045^{\circ}(G)$. During the interval, the ship experienced a current setting $200^{\circ}(T)$ at 3 knots. Wind South. Leeway 2° . Find the ship's position at 2200 hours and 2100 hours. (Gyro Error 1° Low)
- III (a) From a position at 0800 hours with Point De Galle light house bearing $079^{\circ}(G)$ distance 11 Miles off, find the Gyro course to steer so as to pass Colombo light 8 Miles off when abeam, counteracting a current setting $285^{\circ}(T)$ at 2.5 knots. Wind WSW. Leeway 4° .
- (b) Find the time and distance off when Barberyn lighthouse will be abeam. (Gyro Error 1° Low. Speed 13 knots).
- IV (a) At 1900 hours Great Basses Reef light bore $009^{\circ}(G)$ distance 6 Miles. The ship then steered $049^{\circ}(G)$ at 13 knots and was experiencing a current setting $090^{\circ}(T)$ at 2.5 knots. Wind NW. Leeway 3° . Find the course and speed made good.
- (b) Find the time and distance when Little Basses light will be abeam.
- (c) When Little Basses light was abeam course was altered to $025^{\circ}(G)$. Find the ship's position at 2200 hours. The current, leeway and speed continued to be the same as in (a). (Gyro Error 1° Low)

ANSWERS — TEST PAPER X

- | | | |
|-----|---|--------------------------------|
| I | Distance steamed between 1st and 2nd bearing | 6 Miles. |
| | Distance steamed between 2nd and 3rd bearing | 8 Miles. |
| | Course made good | 089° (T) |
| | Position of the ship at 0910 hours. | |
| | | Lat. 05°49.2'N Long. 80°42.6'E |
| | Position of the ship at 0800 hours. | |
| | | Lat. 05°49.1'N Long. 80°30.6'E |
| | Drift of the current 2.9 Miles in 1 hour 10 minutes | |
| II | True course steered | 290° (T) |
| | Leeway (Wind South) | 2° |
| | Course after leeway | 292° (T) |
| | 1st true bearing of Point de Galle Lt. | 335° (T) |
| | 2nd true bearing of Point de Galle Lt. | 046° (T) |
| | Position at 2200 hours | Lat. 05°51.8'N Long. 80°03.5'E |
| | Position at 2100 hours. | Lat. 05°49.2'N Long. 80°18.5'E |
| III | (a) True course to steer to counteract current | 349.5° (T) |
| | Leeway (Wind WSW) | 4° |
| | True course to steer counteracting current and leeway | 345.5° (T) |
| | Gyro Error | 1° Low. |
| | Gyro course to steer | 344.5° (G) |
| | (b) Beam bearing of Barberyn light | 075.5° (T) |
| | Distance off when light is abeam | 5.75 Miles. |
| | Speed made good | 14.25 knots. |
| | Distance from 0800 hours to beam bearing | 28.5 Miles. |
| | Time Barberyn Lt. Ho. will be abeam | 1000 hours. |
| IV | (a) True course steered | 050° (T) |
| | Leeway (Wind NW) | 3° |
| | Course made good after allowing for leeway | 053° (T) |
| | Current 090° (T) at 2.5 knots. | |

Course made good	059° (T)
Speed made good	15 knots.

IV (b) Beam bearing of Little Basses Reef Lt.	320° (T)
Distance off the light when abeam	8.8 Miles.
Distance from 1900 hours position to beam bearing position	25.1 Miles.
Speed made good	15 knots.
Time when Little Basses Reef light will be abeam 2040 hours	

(c) Next true course	026° (T)
Leeway (Wind NW)	3°
Course after allowing for leeway	029° (T)
Current 090° (T) at 2.5 knots.	
Speed made good	14.4 knots.
2200 hours Position Lat. 06°32.6'N Long. 82°01.2'E.	



DEVIATION CARD I

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	2.0°W	180°	2.0°E
010°	3.5°W	190°	3.5°E
020°	5.5°W	200°	5.0°E
030°	7.0°W	210°	7.0°E
040°	9.0°W	220°	8.5°E
050°	10.0°W	230°	10.0°E
060°	11.5°W	240°	11.0°E
070°	12°W	250°	12.0°E
080°	12.5°W	260°	13.0°E
090°	12.5°W	270°	12.5°E
100°	11.5°W	280°	11.5°E
110°	10.5°W	290°	10°E
120°	9.0°W	300°	8°E
130°	7°W	310°	6.5°E
140°	5°W	320°	4.5°E
150°	3°W	330°	2.5°E
160°	1°W	340°	1.0°E
170°	0.5°E	350°	0.5°W
180°	2.0°E	360°	2.0°W

DEVIATION CARD II

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	12.5°E	180°	12.5°W
010°	11.5°E	190°	11.5°W
020°	10.5°E	200°	10.0°W
030°	9.0°E	210°	8.0°W
040°	7.0°E	220°	6.5°W
050°	5.0°E	230°	4.5°W
060°	3.0°E	240°	2.5°W
070°	1.0°E	250°	1.0°W
080°	0.5°W	260°	0.5°E
090°	2.0°W	270°	2.0°E
100°	3.5°W	280°	3.5°E
110°	5.0°W	290°	5.5°E
120°	7.0°W	300°	7.0°E
130°	8.5°W	310°	9.0°E
140°	10.0°W	320°	10.0°E
150°	11.0°W	330°	11.5°E
160°	12.0°W	340°	12.0°E
170°	13.0°W	350°	12.5°E
180°	12.5°W	360°	12.5°E

(DEVIATION CARD III)

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	4.6° E	180°	4.5° W
010°	4.4° E	190°	4.4° W
020°	4.1° E	200°	4.3° W
030°	3.7° E	210°	4.0° W
040°	3.1° E	220°	3.7° W
050°	2.8° E	230°	3.4° W
060°	1.6° E	240°	2.0° W
070°	0.6° E	250°	2.5° W
080°	0.6° W	260°	1.9° W
090°	1.6° W	270°	1.2° W
100°	2.3° W	280°	0.4° W
110°	2.9° W	290°	0.5° E
120°	3.4° W	300°	1.3° E
130°	3.9° W	310°	2.1° E
140°	4.1° W	320°	2.8° E
150°	4.4° W	330°	3.4° E
160°	4.6° W	340°	3.9° E
170°	4.6° W	350°	4.3° E
180°	4.5° W	360°	4.6° E

Merchant Shipping Notice No. 854**NAVIGATION SAFETY**

Notice to shipowners, Master and Deck Officers in the Merchant Navy and Skippers and Second Hands of Fishing Vessels.

1. Research into recent accidents occurring to ships has shown that by far most important contributory cause of navigational accidents is human error, and in many cases information which could have prevented the accident was available to those responsible for the navigation of the ships concerned.

2. There is no evidence to show serious deficiency on the part of deck officers with respect either to basic training in navigation skills or ability to use navigational instruments and equipment; but accidents happen because one person makes the sort of mistake to which all human beings are prone in a situation where there is no navigational regime constantly in use which might enable the mistake to be detected before an accident occurs.

3. To assist masters and deck officers to appreciate the risks to which they are exposed and to provide help in reducing those risks it is recommended that steps are taken to :

- (a) ensure that all the ship's navigation is planned in adequate detail with contingency plans where appropriate;
- (b) ensure that there is a systematic bridge organisation that provides for
 - (i) comprehensive briefing of all concerned with the navigation of the ship;
 - (ii) close and continuous monitoring of the ship's position ensuring as far as possible that different means of determining position are used to check against error in any one system;
 - (iii) cross-checking of individual human decisions so that errors can be detected and corrected as early as possible;
 - (iv) information available from plots of other traffic to be used carefully to ensure against over-confidence, bearing in mind that other ships may alter course and speed.

- (c) ensure that optimum and systematic use is made of all information that becomes available to the navigational staff;
 - (d) ensure that the intentions of a pilot are fully understood and acceptable to the ship's navigational staff.
4. The Annex to this Notice provides information on the planning and conduct of passages which may prove useful to mariners.

Department of Trade,
Marine Division
London WC1V 6LP
August 1978.

ANNEX
GUIDE TO THE PLANNING AND CONDUCT
OF PASSAGES
PILOTAGE

1. The contribution which pilots make to the safety of navigation in confined waters and port approaches, of which they have up-to-date knowledge, requires no emphasis; but it should be stressed that the responsibilities of the ship's navigational team do not transfer to the pilot and the duties of the officer of the watch remain with that officer.
2. After his arrival on board, in addition to being advised by the master of the manoeuvring characteristics and basic details of the vessel for its present condition of loading, the pilot should be clearly consulted on the passage plan to be followed. The general aim of the master should be to ensure that the expertise of the pilot is fully supported by the ship's bridge team. (See also paragraph 16).
3. Attention is drawn to the following extract from IMCO Resolution A 285 (VII),

"Despite the duties and obligations of a pilot, his presence on board does not relieve the officer of the watch from his duties and obligations for the safety of the ship. He should co-operate closely with the pilot and maintain an accurate check on the vessel's position and movements. If he is in any doubt as to the pilot's actions or intentions, he should seek clarification from the pilot and if doubt still exists he should notify the master immediately and take whatever actions necessary before the master arrives".

Responsibility for Passage Planning

4. In most deep-sea ships it is customary for the master to delegate the initial responsibility for preparing the plan for a passage to the officer responsible for navigational equipment and publications, usually the second officer. For the purposes of this guide the officer concerned will be referred to as the navigating Officer.

5. It will be evident that in small ships, including fishing vessels, the master or skipper may himself need to exercise the responsibility of the navigating officer for passage planning purposes.

6. The navigating officer has the task of preparing the detailed passage plan to the master's requirements prior to departure. In those cases when the port of destination is not known or is subsequently altered, it will be necessary for the navigating officer to extend or amend the original plan as appropriate.

Principles of Passage Planning

7. There are four distinct stages in the planning and achievement of a safe passage:

- (1) Appraisal
- (2) Planning
- (3) Execution
- (4) Monitoring

8. These stage must of necessity follow each other in the order set out above. An appraisal of information available must be made before detailed plans can be drawn up and a plan must be in existence before tactics for its execution can be decided upon. Once the plan and the manner in which it is to be executed have been decided, monitoring must be carried out to ensure that the plan is followed.

Appraisal

9. This is the process of gathering together all information relevant to the contemplated passage. It will of course be concerned with navigational information shown on charts and in publications such as Sailing Directions, List of Lights Current Atlas, Tidal Atlas, Tide Tables, Notices of Mariners, publications detailing Traffic Separation and other Routing Schemes, and radio aids to navigation. Reference should also

be made to climatic data and other appropriate meteorological information which may have a bearing upon the availability for use of navigational aids in the area under consideration such as, for example, those areas subject to periods of reduced visibility.

10. A check list should be available for the use of the navigating officer to assist him to gather all the information necessary for a full passage appraisal and the circumstances under up-to-date information, for example, radio navigational warnings meteorological forecasts, may be received after the initial appraisal.

11. In addition to the obvious requirement for charts to cover the area or areas through which the ship will proceed, which should be checked to see that they are corrected up to date in respect of both permanent and temporary Notices to Mariners and existing radio navigational warnings, the information necessary to make an appraisal of the intended passage will include details of :

- (a) Currents (direction and rate of set)
- (b) Tides (times, heights and direction of rate of set)
- (c) Draught of ship during the various stages of the intended passage
- (d) Advice and recommendations given in Sailing Directions
- (e) Navigational lights (characteristics, range arc of visibility and anticipated raising range)
- (f) Navigational marks (anticipating range or which objects will show on radar and/or will be visible to the eye)
- (g) Traffic Separation and Routing Schemes
- (h) Radio aids to navigation (availability and coverage of Decca, Omega, Loran and D/F and degree of accuracy of each in that locality)
- (i) Navigational Warnings affecting the area
- (j) Climatological data affecting the area
- (k) Ship's manoeuvring data.

12. An overall assessment of the intended passage should be made by the master, in consultation with the navigating officer and other deck officers who will be involved, when

all relevant information has been gathered. This appraisal will provide the master and his bridge team with a clear and precise indication of all areas of danger, and delineate the areas in which it will be possible to navigate safely taking into account the calculated draught of the ship and planned under-keel clearance. Bearing in mind the condition of the ship, her equipment and any other circumstances, a balanced judgement of the margin of safety which must be allowed in the various sections of the intended passage can now be made, agreed and understood by all concerned.

Planning

13. Having made the fullest possible appraisal using all the available information on board relating to the intended passage, the navigating officer can now act upon the master's instructions to prepare a detailed plan of the passage. The detailed plan should embrace the whole passage, from berth to berth, and include all waters where a pilot will be on board.

14. The formulation of the plan will involve completion of the following tasks :

- (a) Plot the intended passage on the appropriate charts and mark clearly, on the largest scale charts applicable, all areas of danger and the intended track taking into account the margins of allowable error. Where appropriate, due regard should be paid to the need for advance warning to be given on one chart of the existence of a navigational hazard immediately on transfer to the next. The planned track should be plotted to clear hazards at as safe a distance as circumstances allow. A LONGER DISTANCE SHOULD ALWAYS BE ACCEPTED in preference to a shorter more hazardous route. The possibility of main engine or steering gear breakdown at a critical moment must not be overlooked.
- (b) Indicate clearly in 360 degree notation the true direction of the planned track marked on the charts.
- (c) Mark on the chart those radar-conspicuous objects, marks or recons, which may be used in position fixing.
- (d) Mark on the charts any transit marks, clearing bearings or clearing ranges (radar) which

may be used to advantage. It is sometime possible to use two conspicuous clearing marks where a line drawn through them runs clear of natural dangers with the appropriate margin of safety; if the ship proceeds on the safe side of this transit she will be clear of the danger. If no clearing marks are available, a line or lines of bearings from a single object may be drawn at a desired safe distance from the danger; provided the ship remains in the safe segment, she will be clear of the danger.

(e) Decide upon the key elements of the navigational plan. These should include but not be limited to :

- (i) Safe speed having regard to the manoeuvring characteristics of the ship and in ships restricted by draught, due allowance for reduction of draught due to squat and heel effect when turning;
- (ii) Speed alterations necessary to achieve desired ETA's on route, e.g. where there may be limitations on night passage, tidal restrictions etc.;
- (iii) positions where a change in machinery status is required;
- (iv) course alteration points, with wheel-over positions; where appropriate on large scale charts taking into account the ship's turning circle at the planned speed and the effect of any tidal stream or current on the ship's movement during the turn;
- (v) Minimum clearance required under the keel in critical areas (having allowed for height of tide);
- (vi) points where accuracy of position fixing is critical, and the primary and secondary methods by which such positions must be obtained for maximum reliability;
- (vii) contingency plans for alternative action to place the ship in deep water or proceed to an anchorage in the event of any emergency necessitating abandonment of the plan.

15. Depending on circumstances, the main details of the plan referred to in paragraph 14 above should be marked in appropriate and prominent places on the charts to be used during passage. These main details of the passage plan should in any case be recorded in a bridge notebook used specially for this purpose to allow reference to details of the plan at the conning position without the need to consult the chart. Supporting information relative to the passage such as times of high and low water, or of sunrise or sunset, should also be recorded in this notebook.

16. It is unlikely that every detail of a passage will have been anticipated, particularly in pilotage waters. Much of what will have been planned may have to be changed after embarking the pilot. This in no way detracts from the real value of the plan, which is to mark out in advance where the ship must not go and the precautions which must be taken to achieve that end, or to give initial warning that the ship is standing in danger.

Execution

17. Having finalised the passage plan, and as soon as estimated times of arrival can be made with reasonable accuracy, the tactics to be used in the execution of the plan should be decided. The factors to be taken into account will include;

- (a) the reliability and condition of the ship's navigational equipment;
- (b) estimated times of arrival at critical points for tide heights and flow;
- (c) meteorological conditions, particularly in areas known to be affected by frequent periods of low visibility;
- (d) day time versus night time passing of danger points, and any effect this may have upon position fixing accuracy;
- (e) traffic conditions, especially at navigational focal points.

18. It will be important for the master to consider whether any particular circumstance, such as the forecast of restricted visibility in an area where position fixing by visual means at a critical point is an essential feature of the navigation plan, introduces an unacceptable hazard to the safe

conduct of the passage; and thus whether that section of the passage should be attempted under the conditions prevailing, or likely to prevail. He should also consider at which specific points of the passage he may need to utilise additional deck or engine room personnel.

Monitoring

19. The close and continuous monitoring of the ship's progress along the pre-planned track is essential for the safe conduct of the passage. If the officer of the watch is ever in any doubt as to the position of the ship or the manner in which the passage is proceeding he should immediately call the master and, if necessary, take whatever action he may think necessary for the safety of the ship.

20. The performance of navigational equipment should be checked prior to sailing, prior to entering restricted or hazardous waters and at regular and frequent intervals at other times throughout the passage.

21. Advantage should be taken of all the navigational equipment with which the ship is fitted for position monitoring, bearing in mind the following points :

- (a) Visual bearings are usually the most accurate means of position fixing;
- (b) every fix should, if possible, be based on at least three position lines;
- (c) Transit marks, clearing bearings and clearing ranges (radar) can be of great assistance;
- (d) when checking use systems which are based on different data;
- (e) positions obtained by navigational aids should be checked where practical by visual means;
- (f) the value of the echo sounder as a navigational aid;
- (g) buoys should not be used for fixing but may be used for guidance when shore marks are difficult to distinguish visually; in these circumstances their positions should first be checked by other means;
- (h) the functioning and correct reading of the instruments used should be checked;

- (i) an informed decision in advance as to the frequency with which the position is to be fixed should be made for each section of the passage.

22. On every occasion when the ship's position is fixed and marked on the chart in use, the estimated position at a convenient interval of time in advance should be projected and plotted.

23. Radar can be used to advantage in monitoring the position of the ship by the use of parallel indexing techniques. Parallel indexing, as a simple and most effective way of continuously monitoring a ship's progress in restricted conspicuous waters, can be used in any situation where a radar navigation mark is available and it is practicable to monitor continuously the ship's position relative to such an object.

