In addition the route is checked with respect to the following considerations.

I. Limitations on account of Charter party.
II. Limitations on account of Load line zones.
III. Possible encounter with ice. Whether the ship is strengthened for ice or not? The latest ice report etc.
IV. Special cargo on board, e.g. a cargo too sensitive to bad & inclement weather
V. Probable frequency of encountering gale force winds.
VI. Probability of encountering fog & status of navigational equipments viz. Radar.
VII. Possibility of carrying out maintenance & routine work during the voyage.

Best route is selected processing an equation comprising of

a. Economic speed,
b. chartrer's requirements,
c. owners commitment &
d. limitation of the vessel.

Saving of the distance is argued versus saving of the ship from adverse weather.

OCEAN PASSAGES OF THE WORLD

OP.W Contains information based on available hydrographic experience relating to planning & conduct of voyage through the oceans. The recommended passage through the non oceanic areas is also discussed. Admiralty sailing direction must be thoroughly consulted for a coastal passage though..

The route obtained through the OPW is based on 'long term statistical data'. Weather contrary to the one that is stated in O.P.W. is possible on account of short term variation.

The ocean passage may comprise of;

a. One or more R.L. courses,
b. A great circle passage,
c. Great circle passage in combination with a course along a parallel of latitudes.

Suppose a navigating officer wants to plan an ocean passage from Halifax to Lisbon he can go to the index at the back of OPW & find the paragraph number from the general index. Following is the information obtained from relevant paragraph.

Halifax <> Vigo, Lisbon & Strait of Gibralter.
From 15th February to 10th April, E-bound & W bound routes pass respectively 60 & 40 miles S of Sable Island & through 42°00'N & 43°00'N on meridian of 50°00'W, & by Great circle E of there positions. Distances: Vigo 2420 miles, Lisbon 2460 miles Strait of Gibraltar 2690 miles.

From 11th April to 14th February routes are direct between Halifax & 45°25'N, 50°00'W, E-bound, & 45°55'N, 50°W, W-bound, E of these positions, they are as the Cabot strait routes namely by great circle for Cabo de Sao Vicente, Vigo tracks joining the great circle in 30°W & Lisbon tracks in 15°W. Distances: Vigo 2370 miles; Lisbon 2420 miles; Strait of Gibraltar 2640 miles.

Low powered vessels, W-bound from the straits of Gibraltar should proceed by rhumb line S of Arquipelago dos Acores to 36°00'N 45°00'W, thence to Halifax.

Elsewhere in the chapter one may also obtain the information regarding currents, wind; swell, ice limits, ice reporting services & other navigation related cautions.

Example

Ocean passage is to be planned from Halifax to Gibraltar on 15th July of a certain year.
List the information & courses available from

1. Ocean passage of the world
2. Routing chart

Halifax direct to 45°25'N, 50°00'W & there after by great circle courses, distance to Gibraltar = 2640 miles. (Note: - the passage recommendation between 15th Feb & 10th April in earlier paragraphs)

From 45°25'N 50°00'W
To 36°00'N 006°00'W

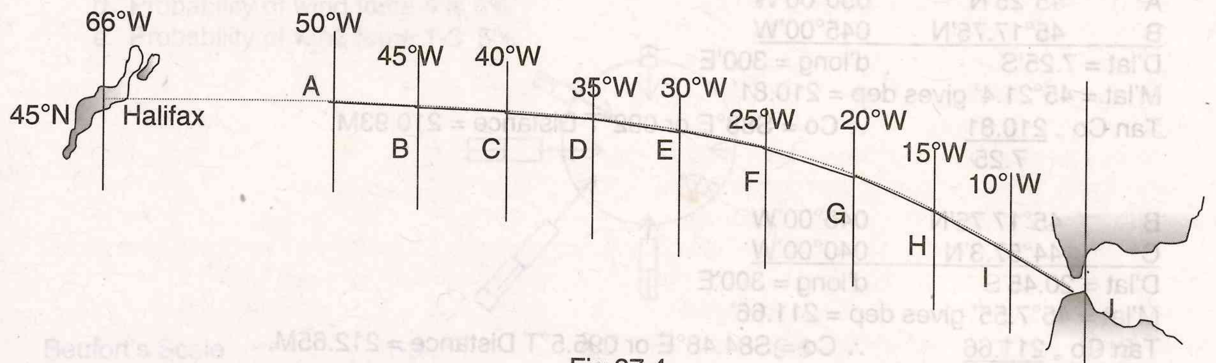


Fig 27.4

The great circle course coordinates or way points may be calculated say at every 5° of longitude. Let the waypoints be A, B, C........ J.

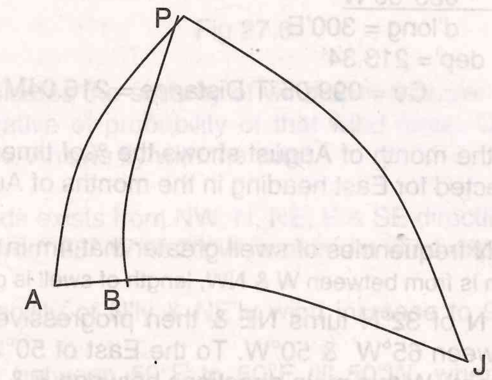


Fig 27.5

$$\frac{\text{Sin } 44°35'}{\text{Tan } 54°} = \frac{\text{Sin } 44}{\text{tan Co}} + \text{Cos } 44°35' \text{ Cos } 44°$$

$$\frac{\text{Sin } 44°}{\text{Tan Co}} = \frac{\text{Sin } 44°\,35'}{\text{tan } 54°} - \text{Cos } 44°35' \text{ Cos } 44°$$

$$\text{Tan Co} = \frac{\text{Sin } 44°}{-0.16998} = -296.046. \quad \therefore \text{Co} = 90.194°$$

Once initial course is known the latitudes of intermediate meridians can be found as follows.

$$\text{Tan lat, B} = \frac{1}{\text{Cos lat, A}} \left[\frac{\sin 5°}{\tan \text{I/Co}} + \text{Sin lat, A Cos } 5° \right] \quad \text{d'long between A \& B} = 5°$$

$$\text{Tan lat, B} = \frac{1}{\text{Cos } 45°25'} \left[\frac{\sin 5°}{\tan 90.19°} + \text{Sin } 45°25' \text{ Cos } 5° \right]$$

$$\text{B} = 45.29° = 45°17.75'\text{N}$$

$$\text{Tan lat, C} = \frac{1}{\text{Cos lat, A}} \left[\frac{\text{Sin } 10°}{\tan \text{I/Co}} + \text{Sin lat, A Cos } 10° \right]$$

Lat B ≡ 45° 17.75'N   LAT C ≡ 44°57.3'N Lat, D ≡ 44°23.3'N..........

Now that position of A,B,C - - - - J are found they are each plotted on navigational charts adjacent points are joined by straight lines or rhumb line course.
Thus rhumb line courses AB, BC, CD & so on are found as follows:

A	45°25'N	050°00'W
B	45°17.75'N	045°00'W
D'lat = 7.25'S		d'long = 300'E

M'lat = 45°21.4' gives dep = 210.81'

Tan Co = $\frac{210.81}{7.25}$ ∴ Co = S88°E or 092°T Distance = 210.93M.

B	45°17.75'N	045°00'W
C	44°57.3'N	040°00'W
D'lat = 20.45'S		d'long = 300'E

M'lat = 45°7.55' gives dep = 211.66'

Tan Co = $\frac{211.66}{20.45}$ ∴ Co = S84.48°E or 095.5°T Distance = 212.65M.

C	44°57.3'N	040°00'W
D	44°23.3'N	035°00'W
D'lat = 34.0'S		d'long = 300'E

M'lat = 44°40.3' gives dep = 213.34'

Tan Co = $\frac{213.34}{34}$ ∴ Co = 099.05°T Distance = 216.04M.

Wave Chart :Wave Chart for the month of August shows the %of time during which a reduction of speed due to high seas may be expected for East heading in the months of August.

Swell: Between 30°N & 40°N frequencies of swell greater that 4m in heights are 5% to 10% during May to August. Predominant duration is from between W & NW, length of swell is generally short (less than 90m).

Current: Gulf stream to the N of 32°N turns NE & then progressively E so that the main direction of current N of 36°N is E'ly, between 65°W & 50°W. To the East of 50°W Gulf stream spreads & weakens out to become 'N Atlantic current'. Within main directions between E & NE.
Off Halifax the currents are as follows:
Labrador current after passing 'E' coast of Newfoundland affects the entire area of Grand Banks. A large branch follows the East edge of the bank. This part of current carries ice South to reach trans-Atlantic routes. Currents generally to be experienced in this region are SW.

Current during the end of trans Atlantic passage are as follows:
South part of N Atlantic current gradually turns clock wise to SE'ly & the SW'ly direction over the whole ocean E of 40°W to 45°W. The branch turning S is called 'Azores Current' & S'ly current off West coast of Portugal & Spain is called 'Portugal Current'.

ROUTING CHART

Routing Chart is one of the most useful reference material through out the passage. The routing chart provides following information:

1. *Recommended Course:* A course may be plotted via South of Sable Is till position 43° N 50° W & there after via great circle to entrance to Gibraltor.
2. *Currents:* Till sable Is weak current of ½ kn is met setting nearly to starboard Beam
   From Sable Is till 50° W initially an adverse current of ½ kn & thereafter the favorable current is met.
   - Between 50° W & 20°W a favourable current up to ½ kn is available. There after, till the entrance to Gibraltar starboard setting (S X W) 'Portugal Current' is met.
3. *Traffic:* 50° W meridian appears to be a meeting point of trans-Atlantic traffic.
4. *Iceberg limit:* 43°N, 50° W appears within range of maximum iceberg limit.

5. *Wind rose:* Till 35°W the wind rose appears as follows
   The wind rose indicates that
   a. Generally a SW'ly wind up to 'Beaufort Scale' of up to 7 only is expected,
   b. Probability of force 7 though is 2%,
   c. Probability of wind force 5 to 6 is 5%,
   d. Probability of wind force 4 is 6%'
   e. Probability of wind force 1-3 5%

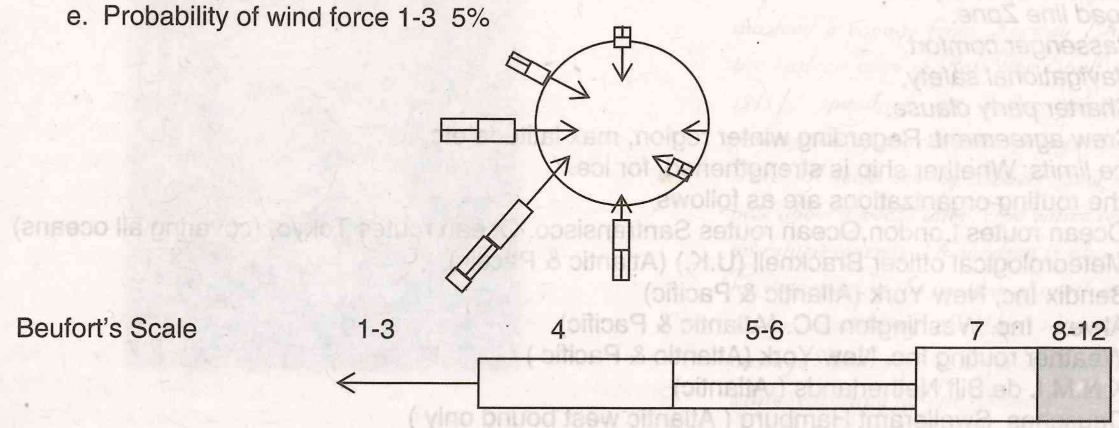


Fig 27.6

The thickness of the arrow indicates the severity of wind speed as per Beufort's scale. Length of the respective arrow segment is indicative of probability of that wind force. On the BA chart a length of 2 inches means a probability of 100%. Arrows fly with the wind.

A very small probability of light winds exists from NW, N, NE, E & SE directions.
Wind will generally be favourable from 35° W till 20°W, maximum wind expected is not more than 5/6 on Beaufort's scale.
From 20°W till entrance the probability of N'ly & NE'ly wind increase to 90 % initially & then to 70 %, closer to coast.

6. *Mean air temp* expected is between 50°F to 60°F till 50°W, where after temp will increase to gradually to 70°F & remain steady there after
7. *Mean air pressure at sea level*, initially 1014 & then gradually rise to 1020 & later may be even high up to 1024mb, falls gradually to 1016mb near the entrance. Gradient is steeper near 50° W.
8. *Probability of visibility less than 5 miles* is 25% till 50°W & thereafter probability is 10% till 10°W, where after the probability is 20%
9. *Probability of fog* (visibility < 1M) Between 50°W & 40°W the probability of fog is 10%, there is about 2% probability of fog even at entrance to Gibraltar.
10. *Load Line zone*: Vessel through out is in summer zone.
11. *Past track of storms:* From Halifax till 30°W, Hurricanes moving E have been experienced in the month of July.
12. Probability of wind force more than 7 in this month, during the voyage is just 2%
13. *Mean sea temperature:* Mean sea temperature during the voyage will vary from 55°F to 68° or so.
14. *Dew point temp* Dew point temp will vary from 54° F till 62°F.

COMMERCIAL ROUTING

The routes provided by ocean passages of the world or Routing Charts take in to account the probability of the weather, current etc. Data being obtained from past records, assisted by past experience. Knowledge of wind/current pattern further improves prediction.

A tailor made route for precise conditions, which presently prevail can be obtained from certain routing organization ashore. They have meteorologists & experienced seafarers. They would compute the best route based on one or more of the following factors.

a. *Ship's characteristics & limitations.* (Speed, beam, draft, length, Block coefficient, metacentric height etc), limitations wrt equipments,
b. *Cargo type:* Deck load, cargo requiring ventilation, cargo sensitive to heat, cargo sensitive to water, containers on deck, cargo susceptible to damage in bad weather.
c. *Chartrer's requirement:* Speed & ETA requirements from owners/chartrer,
d. *Economic Speed & fuel consumption,*
e. *Load line Zone,*
f. *Passenger comfort,*
g. *Navigational safety,*
h. *Charter party clause,*
i. *Crew agreement:* Regarding winter region, max latitude etc,
j. *Ice limits:* Whether ship is strengthened for ice.

Some of the routing organizations are as follows

1. Ocean routes London,Ocean routes Sanfransisco, Ocean routes Tokyo, (covering all oceans)
2. Meteorological officer Bracknell (U.K.) (Atlantic & Pacific)
3. Bendix Inc, New York (Atlantic & Pacific)
4. Alwex Inc. Washington DC. (Atlantic & Pacific)
5. Weather routing Inc. New York (Atlantic & Pacific)
6. K.N.M.I. de Bilt Netherlands (Atlantic)
7. Deusches Swelleramt Hamburg (Atlantic west bound only)

Now a days most 'Time Chartrers' include a charter party clause saying that the ship would be weather routed with 'Mss ....'. Weather Routing Organizations ships are closely informed of positions & progress of voyage at regular interval. Routing Organizations with the data from weather satellites, meteorological equipments, other sources & experienced faculty provide route & directions based on short / medium / long term weather forecast. A ship, which is 'weather routed' as above, proceeds along the prescribed route. Extra distance if any, world not be considered as route-deviation, so long as ship satisfies the fair weather criteria of speed.

Prior to departure the required particulars are sent to routing organization & there after immediately upon sailing the departure GMT along with commencing time of sea voyage is indicated to the organization.

In addition to the way points or the specific route to be followed, the 'Routing Organization' also provides the following:

1. Position of Lows, depressions etc across the Ocean,
2. Wind force, swell etc expected along the Ship's route &
3. Movement expected of Lows for at last 5 days,
4. Long term forecast up to about 15 days.

Master must provide the Routing Organization with required information. A sudden change of pressure & weather must be reported. A weather different from predicted is also reported.

Commercial Routing Organizations generally have reputation of predicting precise weather for the ship's route. The advice is not free & a charge must be paid. Subsequent savings however (direct and indirect) viz. voyage time, fuel, cargo claims, wear & tear make up quite adequately for the money spent. There is no doubt that shore based, Weather Routing is a profitable option.

The Ship's staff is happier to

1. Find more comfortable passage,
2. Do more routine maintenance work
3. Relax better in rest periods & perform better in work hours.

Chartrers & Insurers prefer the ship to be weather routed because then they know the precise weather experienced by the ship during the voyage. The weather recorded in the log book some times is found exaggerated. Weather reported by ship is crucial at times in deciding the liability on account of inappropriate ventilation and voyage delay.

Amundsen Ronald: *[1872-1928] was a Norwegian explorer. He led the first expedition to reach South pole on 14-12-11. The expedition involved a voyage from Norway [June 1910] to the eastern edge of Ross Ice Shelf in [January 1911], spending an entire winter here & resumption of journey in springs till the South Pole. A team led by Robert Scot reached 'S' pole about 5 weeks later. The entire team perished on return journey. Amundsen is also remembered for determining the position of north magnetic pole & for completing the first trip through NW passage Amundsen & his crew vanished in Arctic while searching for one 'Nobile'*

[Pic. Ronald Amundsen]

Chapter 28 Navigation in Special Circumstance [High Latitude / Ice]

Polar Navigation

High latitude navigation or the polar navigation may be considered as the most challanging form of navigation requiring most basic abilities of a mariner as a navigator. Navigation in the other regions is tending to become more & more automatic & simple, with tremendous support from modern navigational aids. Almost every aspect of navigation has a different look. There is a different method of measurement of distance between two points, plotting of a course, plotting of a terrestrial bearing, plotting of an astronomical PL and identifying the land features on radar. Normally a mariner in navigable latitudes is used to placing a near total reliance on the chart. In high latitudes however one must be very cautious in using the information that is provided by the chart. To sum it up, the high latitude navigation can be called more of a test of true navigation. It is indeed an expedition rather than mere navigation.

General drawbacks in polar charts:

The charts of polar region have following drawbacks

1. Lack of details

a) Charts are not surveyed for the details those are provided on normal navigational charts.
b) Soundings are for a few locations only.
c) Coastal features are shown by their general outlines only. Accurate features are not detectable due to heavy cover of ice.

2. Inaccuracy

a) Charts are based on incomplete surveys and reports sent by those who went there.
b) Icebergs are sometimes mistaken for landmass.

3. Coverage

a) Less number of charts available.
b) Chart boundaries are not convenient for the user.
c) A total absence of large-scale charts for certain area.

The other problems with Polar charts

1) Meridians tend to be radial lines, thus the true direction of an oblique line tends to vary considerably over small area.
2) Compass roses are not customarily shown on such a chart. If they do appear, each one applies only to the meridian on which it is located.
3) If a course is to be measured, the mid meridian of each leg should be used.

Performance of magnetic compass in Polar Regions.

1) Horizontal intensity tends to become weaker towards poles. A constant check on deviation is required.
2) Magnetic poles participate in diurnal, annual, secular changes.
3) Several secondary magnetic poles exist.
4) Closely spaced isogonic lines cause rapid change of variation over a small distance.
5) Decrease in horizontal intensity affects deviation.
6) Greater influence of frictional forces.
7) Deviation up to 45° reported during magnetic storms
8) Despite limitations instrument is valuable, as even gyro is of reduced reliability.
9) The magnetic compass is of reduced reliability if horizontal magnetic field intensity is less than 0.09 Oersted. It is found erratic if horizontal magnetic field intensity is less than 0.06 Oersted. Compass becomes useless if horizontal intensity goes down less than 0.03 Oersted.

A Navigator may consider Polar Regions as extending from geographic poles of earth to a parallel of 70° of same name.

Performance of gyrocompass in polar region

1. For its operation gyro depends on earth rotation. Thus maximum directive force is at equator.
2. Generally gyro is reliable up to 70° beyond which the disturbing effects and effect of imperfections is magnified.
3. At high latitudes the latitude adjustment is critical;
   a. Speed error increases relatively due to decrease in rotational speed of earth.
   b. Ballistic deflection error becomes large.
   c. Compass is slow to respond to corrective forces
4. Compass becomes useless at 85°
   a. Course/speed/latitude error is inversely proportional to the Cos of latitude. ($\delta \alpha$ 1/cos Lat), Cos of high latitude tends to 0 & therefore error tends to become very high.
   b. If ballistic deflection is made equal to the change of course/speed error then the undamped period of a gyro compass is found to be inversely proportional to the square root of Cosine of the latitude (α 1/$\sqrt{}$ Coslat). It makes it more difficult for the axle to come back to meridian. More over the ballistic deflection is independent of latitude where as the change of course speed error is dependent on the latitude.
   c. Damping error is directly proportional to Tangent of the latitude, (α tan lat).

Certain gyros viz Arma Brown may be used as directional gyro in the high latitudes.

Principle: Any where on the horizon at azimuth say α°, simultaneous corrections for drift & tilt are applied at opposite rates.

Procedure: Keeping the slew rate switch on the panel in vertical position, the main control is set to free flow sector. This is to enable the gyro to preset to required heading & to remove the tilt if any. A suitable slow rate of precessional slew is selected & upon operating appropriate push button the compass processes to the required heading & removes any existing tilt.

The compass now maintains the meridian with a reduced damping factor. The main control is retained in free slew mode & the pendulum signal is disconnected from the tilt amplifier but is still connected to the azimuth amplifier. The instrument no longer acts as a north-seeking compass but assumes the character of a directional gyro. When using the gyro in this fashion some limit must be placed on the initial azimuth chosen. The error should be checked frequently using astronomical bodies to check if any wander & there after the gyro should be re-slewed. Thus a directional gyro as above provides stablised azimuth indication in very high latitudes.

Selection of a polar projection:

The different features one would want to have on a polar chart are:

a. *Conformality* which basically will help the angles to be represented correctly.
b. *Representation of great circle:* Representation of great circle as straight line or as close to a straight line as possible.
c. *Scale variation:* Over the area covered by the chart the scale variation must be as low as possible.
d. *Straight meridians:* It is expected that the meridians are straight lines & not curvilinear.
e. *Limits of utility:* The boundaries of the charts must consider navigationally crucial areas. Thus certain navigational appropriate regions may be charted in greater details than those areas which are navigationally less important. The adjacent charts must duely overlap at the boundaries.

Projections commonly used in polar regions:

The preferred projections, having most of the above stated features are:

a. Transverse Mercator.
b. Modified Lambert Conformal
c. Stereographic

Gnomonic projection is also available for certain areas.

Polar Charts using the perpendicular grids: A chart having the vertical & horizontal grids in addition to the meridians & parallels of latitudes may be found. And when a course is laid on such chart the course will be found at a constant angle wrt the grid meridian & at a drastically changing angle wrt radiating geographic meridians. If the grid meridians are made parallel to the Greenwich meridian (which is made to run vertically) then a simple relation ship can be established between the:

a. Longitude in use,
b. The true course,
c. The grid course'
d. The constant used on the chart.

Other Considerations:

1. Prior undertaking a high latitude navigation appropriate sailing direction, code, latest information pertaining to that area etc must be consulted & thoroughly understood.
2. Fog & ice are closely related. The ship must be prepared for both as both these hazards are present in high latitudes.
3. Mirage may be observed due to drastic variation in the temperature in the layers of atmosphere. Unusual refraction may cause an error in appearance & apparent change of distance of land.
4. Plotting of bearings on chart is difficult as the meridians are not parallel to each other.
5. For measurement of distance one may be restricted to the use of an additional scale provided or a scale, which is true only for a certain portion of the chart & for other areas on has to be satisfied with a reduced accuracy.
6. An extreme high latitude would be the pole itself. At pole the stars would maintain the altitude & make a circle around the zenith of an observer in a sidereal day.
7. The sun on the other hand will be visible during 6 months of summer & vanish below the horizon for another 6 months. Thus the path gradually spirals towards the horizon or away from the horizon.
8. The azimuth of heavenly bodies would change rapidly as compared to the altitude. But sights taken over a small interval also can give a reasonably good angle of cut by running the PLs.
9. Astronomical sights are difficult during the period when sun is just below the horizon to cause a twilight, which would not allow the visibility of stars.
10. The refraction caused may be large & unpredictable. The correction for temperature & barometric pressure must be allowed.
11. A bubble sextant that is used on aircraft or the sextant with bubble attachment can be used when the horizon is a problem. The bubble sextant however will require the mounted deck to be tranquil. It may be required to stop the ship & go ashore on the ice, mount a theodolite & take a sight & come back on the ship to resume the voyage.
12. Loran C may be available for some regions. GPS must calculate a precise fix but the problem lies with the discrepancy between the position datum of the chart in use & the one used by GPS.
13. All the meridians & hence the time zones meet at the pole & therefore the local time has little significance.
14. Radar & the echo sounder are probably the most important instruments. An intelligent interpretation of the data given by them may be required at most times.

15. The land features (visual as well as the radar outline) may be drastically modified & found different than charted outline, due to the ice accumulation.
16. Physical fitness of watch keepers, lookouts, workers, their work cloths & gears, ship being able to withstand the frigid climate, the water, provision, relevant charter party clauses & commercial expectations etc are some of the other aspects to look at.

Navigation in Ice

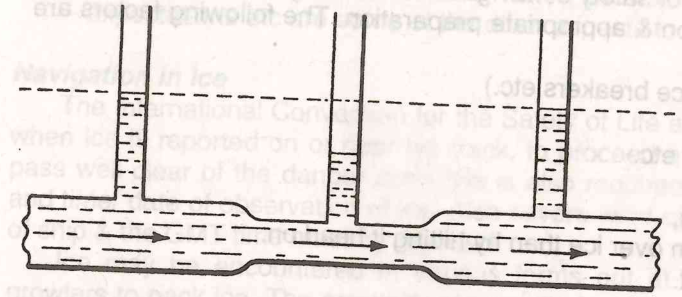
The International Convention for the Safety of Life at Sea (SOLAS) requires the master of every ship, when ice is reported on or near his track, to proceed at a moderate speed at night or to alter course to pass well clear of the danger zone. He is also required to make the report regarding the type, position, and time/ date of observation of ice. Also severe wind causing ice accumulation on deck with the position of ship & the GMT time must be reported.

Ice may be encountered in various forms out at sea. Right from drifting icebergs, bergy bits & growlers to pack ice. The proximity of ice calls for a special attention in navigation. Additional cautionary measures are essential in the navigation, management & the seamanship procedures.

We are not going to discuss the formation or origin, types of icebergs & sea ice. Chapter 7 of Mariner's Handbook, on ice must be read. Various ice pictures & description of different ice terms can be found there. Following description is more of a checklist, which may be used by a mariner within or in the proximity of an ice zone.

a. *Information regarding the possibility of ice:* Information must be gathered from:
   1. Routing charts,
   2. Admiralty sailing direction,
   3. Ice weather reports &
   4. Safety massages.
b. Watch keeper must report any signs of presence of ice viz. ice blink, isolated fog patch with supporting signs etc to master.
c. Erect or inverted image of an iceberg may be seen due to super refraction. Such an image of ice is likely to be of a magnified size.
d. Seawater temperature must be recorded more frequently than normal. The frequency will depend upon the possibility of proximity of ice. Steep fall of temperature must be taken seriously, as an indication of possibility of presence of ice. A surface temperature of –0.5°C normally should imply the proximity as less than 50 miles.
e. The calving of icebergs or cracks & falls into sea a thunderous roar can be heard. The echo of ship's whistle may or may not be heard.
f. A sudden drop in strength of sea state associated with a drop in air temperature & visibility may also indicate presence of ice especially to side from where swell was coming & strength of which is damped now.
g. Icebergs are some time not detected over long range owing to smooth, sloping surface, poor reflecting material etc. Some of navigationally dangerous bergy bits may not be detected over more then 3 miles from the ship. A sharp look out visually & on radar must be maintained.
h. In fog or dense mist an iceberg may shine like a luminous object, if sunlight falls on it. On the other hand on a clear night no iceberg may be sighted at more than 1 or 2 miles. On a moonlit night iceberg is more easily seen if moonlight falls on it from behind the observer.
i. On a clear day, with sky mostly blue, iceblink appears as a luminous yellow haze on the horizon in the direction of the iceberg. The height of the blink depends on the proximity of the ice field. Iceblink is exhibited by consolidated & extensive ice field.
j. Close to land, the topographical features may be modified due to ice stuck to the land. The mariner must therefore cross check radar's position-fixing by other means also.
k. If two radars are on, then one of them must be kept on 6 miles range scale, tuned for detecting ice. The other radar must be on a suitable higher range. Large icebergs may be detected 20miles off. Bergy bits smaller but still dangerous to ship may not be detected till about one mile off. A clutter caused by choppy sea can eclipse dangerous bergy bits, which can cause substantial damage to the ship.
l. In the Antarctic, the Antarctic Petrel & Snow Petrel are said to indicate the proximity of ice.
m. Speed of the ship must be moderate only, especially at night in the ice area.

n. Ice fields in general must be avoided but some ports in winter may have pack ice or pancake ice of varying thickness for miles around the entrance & thus ice encounter may be inevitable.
o. When ice field entry is inevitable the master must consult owners & correspond with chartrers & consult the charter party & act in the interest of safety of navigation & owners.
p. The ice field must be entered only with caution & appropriate preparation. The following factors are considered.
   1. Routes if maintained by shore authorities (ice breakers etc.)
   2. Thick ness of cake ice.
   3. Type of ice field, closed pack or open pack etc.
   4. Trim of ship: Extra trim world help:
      a. Positive immersion of propeller blades,
      b. Break ice by gradually landing the stem over ice than by hitting it head on.
   5. Waiting period & the stay period in the port.
   6. Possibility of alternative load, discharge port.
   7. Power of ships, type of engines, draft & manoeuvrability of ship. A ship of less than 12kn, not strengthened for ice is likely to become firmly beset in the ice.
   8. Extension of ice field & its status, whether the growth of ice is on the incline or is on the decline.
   9. Reliability of navigational & communication equipment is of a great importance.
q. While manoeuvring in ice field, cake ice may be in separate clusters. A new cluster must be approached as slowly as possible & once in contact with cake ice, full power may be required to continue the headway.
r. Allowance must be made to normal collision avoiding principles. Intermediate ice often acts as fender between two ships in close proximity. On the other hand a low powered ship while crossing from one side to other side may suddenly stop ahead of your ship in want of sufficient engine power.
s. Continuous lookouts are maintained & the lookout person is briefed about the kind of reporting that is expected of him.
t. While the Ship advance through pan-cake ice, a large amount of ice is broken fine with the body of ship. These broken pieces are driven on either side of propeller at stern. Many pieces travel from under the ship's keel & then rise to surface just abaft the propeller. This is one of the reasons that sudden astern propulsion may damage the propeller & must be avoided.
u. Fairway buoy & channel-marking buoys may be removed or adrift due to tidal movement of ice.
v. There are numerous incidents of losing anchor, broken propeller blades etc. While waiting in a bay or an anchorage area of tidal stream with pancake ice, it may be a good idea not to anchor at all. During change of tide, entire caked surface tends to move out of the harbour & then towards the harbour on next tide.
w. Stability related precautions: Effect of ice accretion on exposed deck is considered. (refer to Resolution no. A–769, Intact stability Criteria, of 18th Assembly.
x. Seamanship related precautions: Cold climate precautions regarding ballast tanks (keep more than 10% space for expansion), fuel oil tanks, fresh water tanks (ease to about 90%), deck water line, life boat's FW containers, deck ice, windlass, winches, hydraulic lines, safety at work place & warming of living place etc are all attended to. Good searchlights are required for night navigation. Gale forces in combination with –2°C & below would require an alteration of course to the warmer area. Leads through the ice are very useful but the one leading ashore must be avoided. The ship's propeller & rudder must be operational all the time. Once the ship is beset in ice ship may have to move with the ice. Serious pressures may be caused by ice on the ship's hull or bottom. Sometimes change of trim / list may be tried out to release the ship from the ice.
y. Performance of navigational aids such as coloured lights, sector lights etc may be affected by ice on the screen.
z. When navigating under the assistance of icebreaker the procedure to be followed by escorted vessel, communication methods between the ships etc must be understood well & duly followed. Towing gear is kept ready and rigged.



Bernoulli: *Was family name for 3 Swiss mathematicians. Jakob & Johann were brothers. Danniel was Johann's son. Both the brothers were professors of mathematics at university of Basel. Johann has contribution in the tides where as Daniel Bernoulli laid down hydrodynamic principles by which flow of fluids could be calculated. Famous Bernoulli's principal was named after Daniel [1700- 1782]*

[Pic Bernoulli's Experiment: Flow rate increases in constriction]

Chapter 29: Calculations in Shallow & Restricted Areas & Sailing round the arc with controlled rate of turn

Shallow & Restricted Areas:

In shallow water the manoeuvring characteristics change. An experienced navigator is aware of these changes & may use them to his advantage. A watch keeper must be aware of shallow water signs. He must make a report to relevant hydrographic department if he finds positive shallow water signs in apparent deep water with details as precise as practicable.

Some of the shallow water signs are:

1. Increased wave making,
2. More sluggishness,
3. Increased draft in draft indicators'
4. 15% to 20% drop in RPM,
5. 30% to 60% drop in ship's speed,
6. Vibrations,
7. Reduction in rolling, pitching & heaving,
8. Muddy water
9. Increased turning circle diameter,
10. Increased stopping distance & time.

Draft of the ship while sailing, increases some times due to a special condition viz grounding, underwater damage, change of density of water in which she is floating etc. Draft may at some other times also increase due to change of pressure fields in surrounding waters. This increase of draft in a way may be considered virtual as the increase is with displacement remaining constant.

A ship making way through water appears to be at a draft deeper than the static & a trim different than the static trim. This is due to the squat.

Squat was always there but the analytical study of squat & advance calculations have become more important owing to;

a. Plying of much bigger ships,
b. Speed of ships much faster than yester years,

Cause of Squat:

With the ship advancing ahead & the water remaining behind, it may be said that the bulk of water relatively moves backwards at the speed of ship. This bulk of water when has to pass through restricted passage, moves at a speed higher than relative speed of ship. This gives rise to virtual vacuum in the restricted area. If this vacuum is on the bank sides, bank suction is created. And if the vacuum is under the keel, squat is experienced by ship..

Different factors, which affect the squat, are as follows:

a. Speed: Squat α speed^2
b. Block coefficient C_b: Squat α C_b
c. Ratio of Depth of channel (D_p) & static draft (D_r).
d. Blockage factor B, which is the ratio of the transverse area of under water part of hull & the cross-sectional area of the canal.
e. Presence of another vessel in the canal.

In general the course must be plotted as far as away from shoals & bank as is practicable. Shoals, which are passed at a close distance, may give rise to sudden & rapid sheer, for which the corrective action should be equally bold.

There are various simple formulae for calculation of increase in draft as follows:

1. Squat = $0.01 \times C_b \times V^2$................[When $D_p > 1.1\ D_r$ upto $1.4D_r$]
2. Squat = $0.02 \times C_b \times V^2$................[When $D_p < 1.1\ D_r$]
3. Squat = $0.05 \times C_b \times V^{2.08} \times B_f^{\ 0.81}$......[$B_f$ is the blockage factor]
   Breadth for a narrow canal is found by the formula stated in sub para. d above. For a wide shallow channel the artificial breadth is found by the following formula:
   Breadth = $[7.7 + 20\,(1-C_b)^2]$ b
4. Alternately the artificial canal width may be taken as 8.35b for loaded tankers, 9.5b for a general cargo ship & 11.75b for container ships.

Examples:

1. Calculate the squat for a ship proceeding at 16 kn, C_b = 0.7 using formula (1).

Sol.

Squat $= 0.01 \times C_b \times V^2$
$= 0.01 \times 0.7 \times 16^2$
= 1.792m.

2. What should be the speed so as to control squat to just 1 metre in enclosed channel conditions(formula no 2)?

Sol.

Squat $= 0.02 \times C_b \times V^2 = 1$
$\therefore V^2 = 71.42$
$\therefore V = 8.45$ kn

3. Breadth & depth of a canal is 65m x 17m. A ship transits the canal at 12kn. Average crossectional area of ship is 22m x 14m. If C_b of the ship is 0.76. Calculate squat using formula(3)

Sol

$B_f = 0.279$
Squat $= 0.05 \times C_b \times V^{2.08} \times B_f^{\ 0.81}$
$= 0.05 \times 0.76 \times 12^{2.08} \times 0.279^{\ 0.81}$
= 2.374m

4. A ship at draft 10m is transiting River Plate (shallow wide channel) at 7 kn. Average depth of channel 12m. If C_b of ship is 0.55 & breadth of ship is 23m. Calculate the maximum squat that the ship may experience at this speed. What would be the squat at 12kn?

Sol

Artificial width $= [7.7 + 20\,(1-C_b)^2]$ b = 270.25m
$B_f = 0.07092$
Squat $= 0.05 \times C_b \times V^{2.08} \times B_f^{\ 0.81}$
$= 0.05 \times 0.55 \times 7^{2.08} \times 0.07092^{\ 0.81}$
= 0.185m
Squat at 12kn = 0.566m

A graph showing maximum squat at bow or stern against ship's speed in knots may be provided for different confined water situations or $D_p:D_r$ as shown in fig:

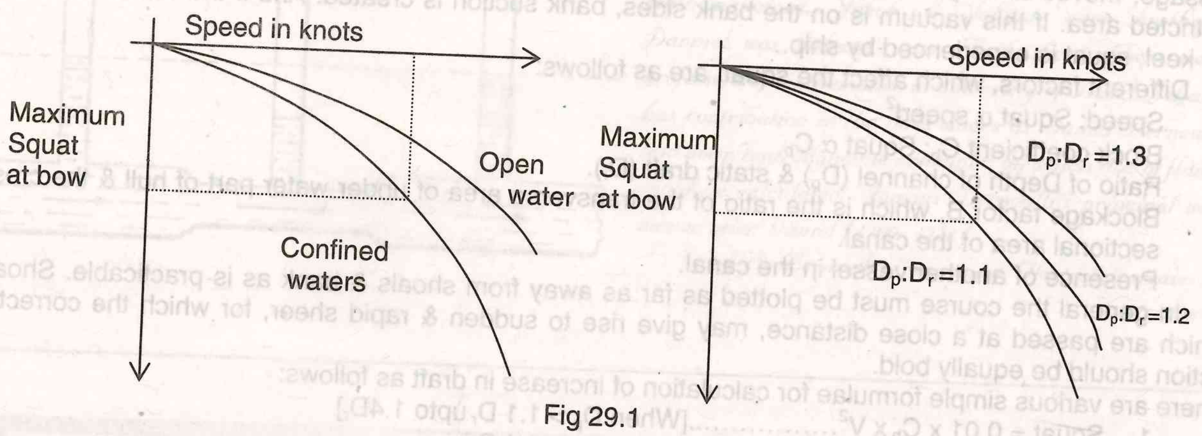
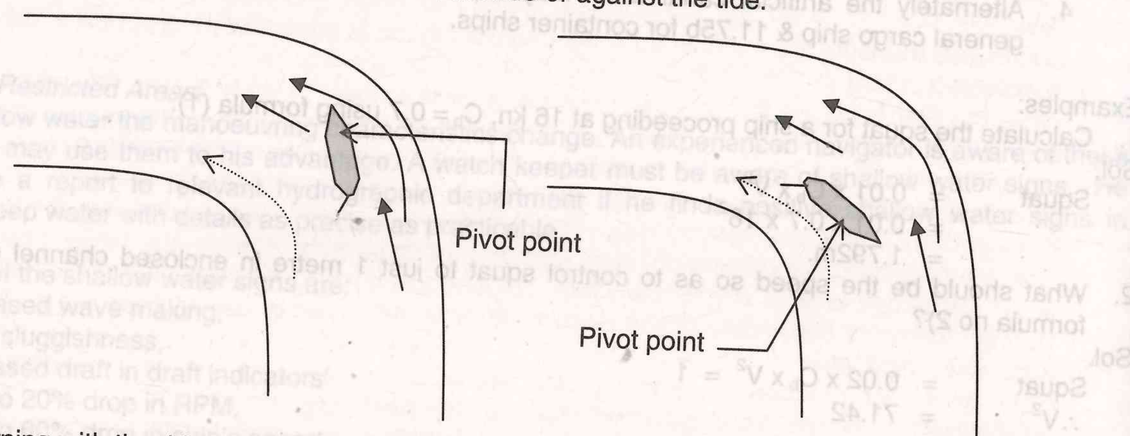


Fig 29.1

Ploting of the ship's course through bends: When ploting a course through restricted bends the following points must be considered:

a. Giving helm at appropriate time is of utmost importance.
b. The strength & direction of tidal streams, whether more than one stream.
c. Whether ship has to manoeuver with the tide or against the tide.



Turning with the tide keep in the main stream — Against the tide, keep her closer to weak stream if practicable

Fig 29.2

Mathematically an equation between the following is made :

a. Turning moment caused to stern by outside stream,
b. Turning moment caused to stem by outside stream &
c. Turning moment caused by rudder.

All the moments being taken about the pivot point.

Sailing round the arc with controlled rate of turn:

An alteration of course in restricted water must be executed by master or an officer who is experienced in such operations. A prudent & experienced master would take over the conning from a new third mate & hand him over again only when ship is steady & safe on the next course.

An inexperienced watch keeper might start altering when the ship actually is on position marked for alteration. A ship advancing through water will tend to continue in the original direction due to momentum

(M x V), while the course is being altered. Generally it may be said that the ship continues in the original direction for little over a ship's length & then starts to go along an arc.

Radius of the turn circle is related to linear momentum & the turning moment. For a given ship some of the parameters to decide the turn circle are ship's speed, present displacement & the 'rudder angle'. Shallow water also causes a change in size of turn circle.

After the helm is given at 'A/Co' position, ship takes an outer route as compared to the plotted course line & finally would follow a course line // to the plotted one.

If there was a ship making good a course of 000°T proceeding at 12kn & if she had to turn by 90°, the effect of giving helm at A/Co position would be as follows:

She appears to respond after about 200m, then drift radially outwards by an amount equal to radius of the turn circle. The cross track error on the new course would be equal to the advance of the ship. The advance may be about 2 cables at full ahead to about 5 cables at 10° helm.

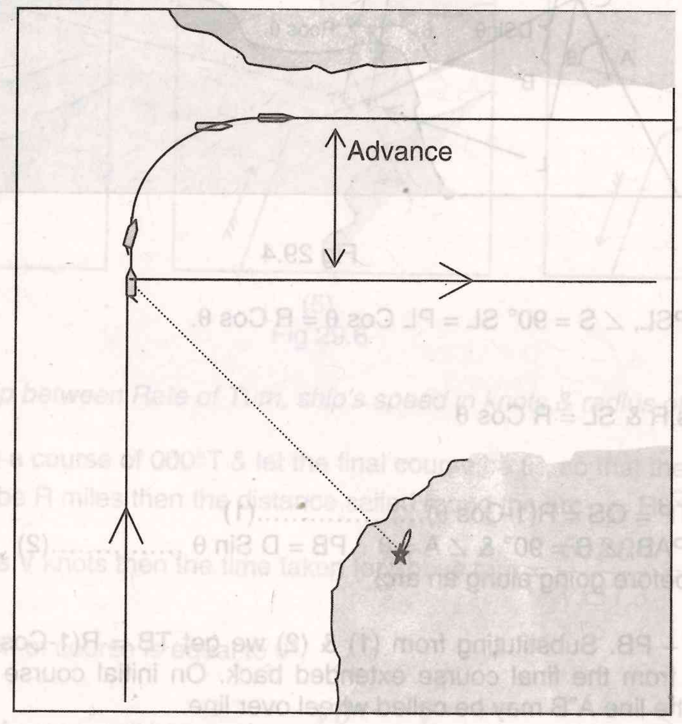


Fig 29.3

Problem could be more grave if the ship is a loaded tanker or a bulk carrier & more so when all of a sudden the position is transferred from a normal navigational chart to a large scale chart where the ship moves at a different speed on paper chart. The problem could be further aggravated when there is a following current on the first course.

Senior mariners have experienced all that is stated above through their past observations, or some times the hard way. It is now recommended that even the junior officers understand the dangers involved in undertaking a turn, which is taken too late or too early. A pre calculated helm is given before reaching the marked position. The position at which this must be done is called wheel over position.

Let us now take a case where the ship's initial course is 030°T & final course is 070°T. The alteration of course involved is 40°. It has been decided that the radius of the turn is 5 miles.(R). The ship will traverse on an arced path through 40°. The centre of this arc is found as follows:

Draw pecked lines // to & to the inwards of both the course lines at a distance of R miles. Where the pecked lines meet is the centre of R miles arc. P & Q are tangent on this arc by the two courses.

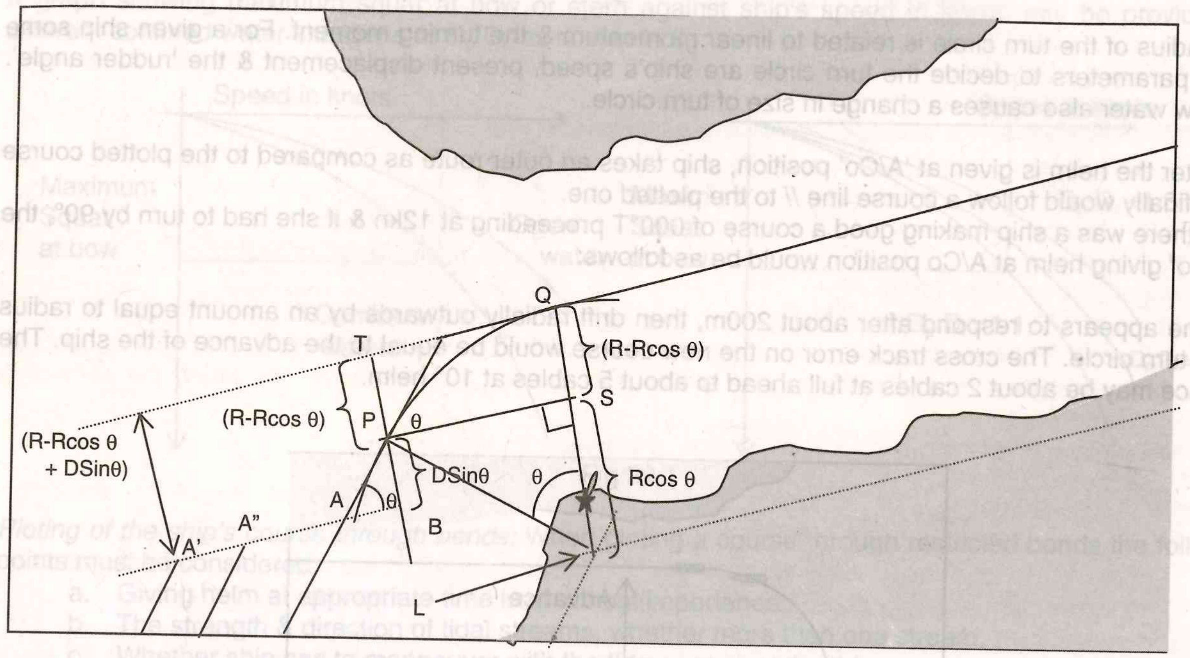


Fig 29.4

In right angled triangle PSL, $\angle S = 90°$ SL = PL Cos θ = R Cos θ.
QS = QL – SL.

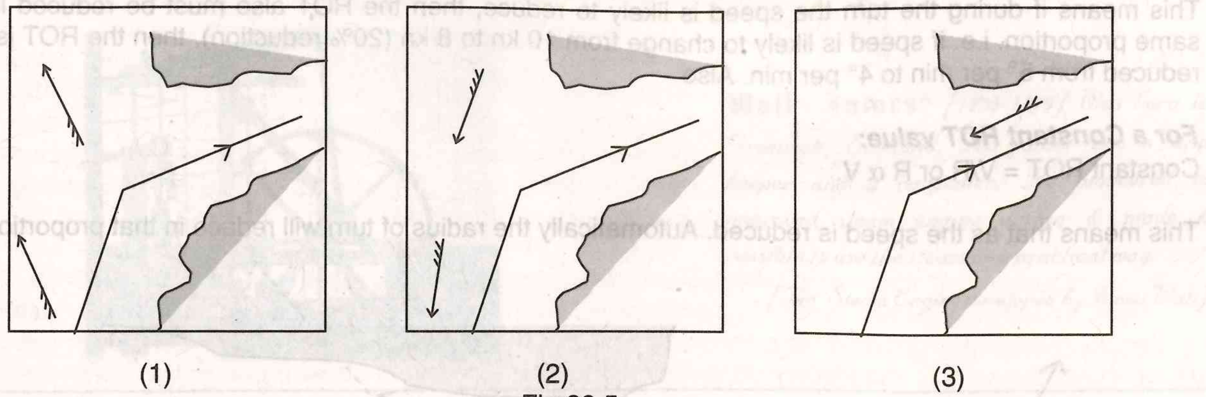
Substituting QL = radius,R & SL = R Cos θ
QS = R(1-Cos θ).

PSQT is a rectangle ∴TP = QS = R(1-Cos θ)......................(1)
In right angled triangle PAB, $\angle B = 90°$ & $\angle A = \theta$ ∴PB = D Sin θ ....(2)
(D is distance traveled before going along an arc)

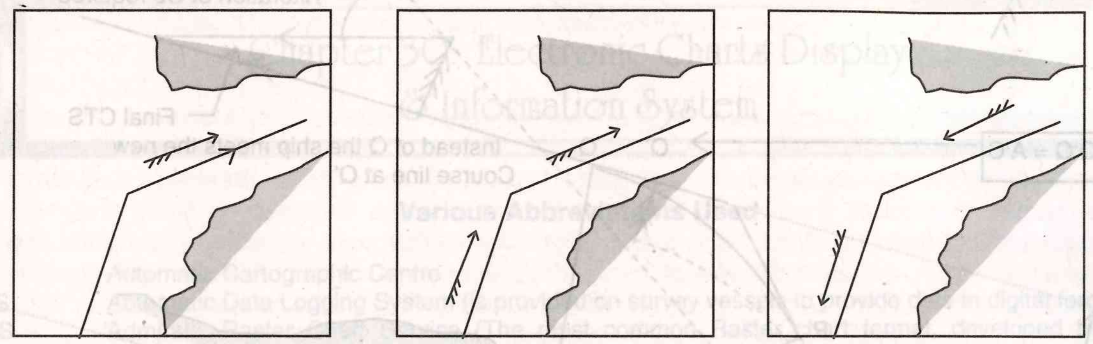
In the fig TB = TP + PB. Substituting from (1) & (2) we get TB = R(1-Cos θ) + D Sinθ. This is the perpendicular distance from the final course extended back. On initial course the ship may give helm when at A or A' or A". The line A"B may be called wheel over line.

Speed made good, rudder angle & radius of turn are interrelated. While turning the instantaneous SMG may be changing all the times. We may have one of the following situations.

In situations (5) & (6) SMG may be used for calculation purpose, but in situation (1) to (4) master must give due allowance to the effect of tidal stream / current during the initial / final part of the turn by actual line drawing. In case (1) the helm order will have to be preponed according to the amount of drift expected for the period of turn (see example at the end of this explanation)& in case (2) the helm order will have to be postponed according to the amount of drift which is expected during the period of manoeuver. Above is not a standard rule. Master must add his experience to the home work that is done to decide the wheel over position. He must also watch for any counter stream or weaker stream present in addition to the main stream. Risk of sudden sheer & bank suction must be considered right through.



(1) (2) (3)
Fig 29.5



(4) (5) (6)
Fig 29.6

Approximate relation ship between Rate of Turn, ship's speed in knots & radius of turn.

Let the ship be steaming a course of 000°T & let the final course be θ°, so that the alteration of course = θ°.
If the radius of turn is to be R miles then the distance sailed round the arc $= R\theta^C$ or Rθ°/57.3.

If speed during the turn is V knots then the time taken for above turn $= \dfrac{60R\theta°}{Vx57.3} = \dfrac{R\theta° \min}{V}$

In $\dfrac{R\theta°}{V}$ minutes alteration of course is equal to θ°,

∴In 1 minute alteration of course will be equal to $\dfrac{V\theta°}{R\theta°} = \dfrac{V°}{R}$

Thus rate of turn per minute in degrees is approximately equal to V/R, where V is the speed in knots & R is the radius of turn in nautical miles. Thus if a ship's speed during the turn is 10 kn & a radius of turn = 5M has been decided then the vessel must be turned @ 10/5 = 2° per min. For a tighter turn viz R = 2.5M the rate of turn must be 10/2.5 = 4° per min. It would be a fine idea to train the helmsmen in open sea to give a helm to maintain a certain rate of turn. A helmsman who is trained in this fashion will be a great asset in carrying out the scheduled turns.

Consider the relationship ROT = V/R
Out of the three parameters any one may be considered fixed or constant. The other two will vary accordingly to maintain the relationship. Thus,
For a Constant Radius Turn:
ROT = V x Constant or ROT α V.

This means if during the turn the speed is likely to reduce, then the ROT also must be reduced in the same proportion. i.e. if speed is likely to change from 10 kn to 8 kn (20% reduction), then the ROT is also reduced from 5° per min to 4° per min. Also

For a Constant ROT value:
Constant ROT = V/R or $R \propto V$.

This means that as the speed is reduced. Automatically the radius of turn will reduce in that proportion.

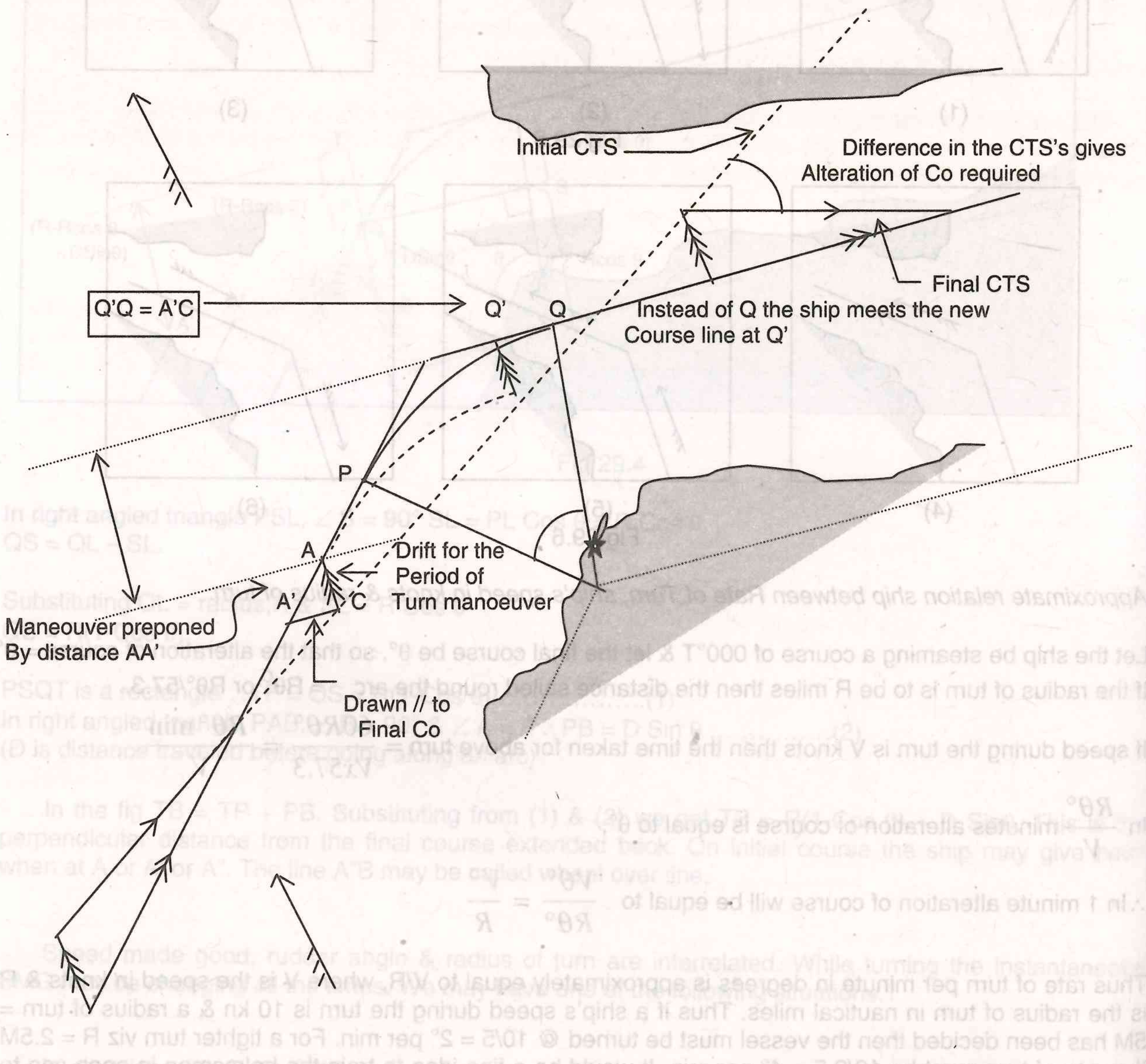
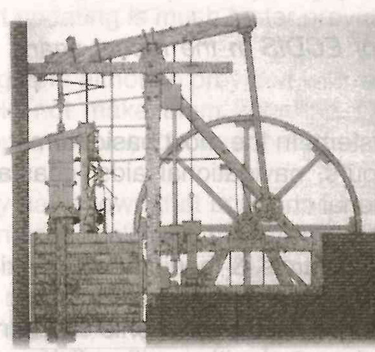


Fig 29.7

'To find initial CTS, find CTS & Wheelover Positions during a turn where a steady current sets throughout'



Watt James: *[1736-1819] Was born in Greenock, Scotland. His father was a ship keeper and a carpenter. He pioneered & improved steam engine design & made it possible to use the steam in a practical way.*

[Pic. Steam Engine developed by James Watt]

Chapter 30: Electronic Charts Display & Information System

Various Abbreviations Used

ACS	Automatic Cartographic Centre
ADLS	Automatic Data Logging System (is provided on survey vessels to provide data in digital form)
ARCS	Admiralty Raster Chart Service (The most common Raster chart format, developed by the UK Hydrographic Office)
CATZOC	Category of Zone of Confidence (while using ENC, operator should also check the reliability of Source Data indicated in CATZOC)
CD-ROM	Compact Disk - Read Only Memory
DGPS	Differential Global Positioning System
DNC	Digital Nautical Chart
EBL/M	Electronic Bearing Line / Marker
EC	Electronic Chart
ECS	Electronic Chart System
ENC	Electronic Navigational Chart
ENCDB	Electronic Navigational Chart Database
EPS	IMO Performance Standard for ECDIS (Resolution A.817(19)) adopted on 23.11.95
GIS	Geographical Information System
HGE	Harmonization Group on ECDIS (experts from IMO & IHO)
HO	Hydrographic Office
IEC	International Electronic Committee
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INS	Integrated Navigation System
MDC	Marine Data Centre (stores hydrographic parameters including bathymetric data)
MSC	Maritime Safety Committee (IMO body)
NECSA	National Electronic Chart System Association
NHO	Naval Hydrographic Office (at Dehradun)
NHSC	North Sea Hyrographic Commission
NMEA	National Marine Electronic Association
RCDS	Raster Chart Display System
RENC	Regional Electronic Navigational Chart Coordinating Centre (IHO Has recommended setting up of a set of RENCs which will be linked together to form WEND. Each RENC Will, in addition to maintaining own region's database of ENCs, collect, regulate, distribute the ENCs with their updates. They will also advise & assist the respective HO in the production of ENCs.)
RTCM	Radio Technical Commission for technical Service
SENC	System Electronic Navigational Chart
WEND	Worldwide Electronic Navigational Chart Database (its a common worldwide network of ENC data sets. [see RENC])

Meaning of ECDIS & its advantages

Q. 30.1 What is ECDIS? Discuss regarding the rapid growth of ECDIS in the recent years. Explain its advantages in brief.

Ans.

ECDIS stands for Electronic Chart Display & Information System. In the most basic form it consists of electronic chart itself. The chart shows coastline, depth contours, navigational aids, coastal features, buoyage, traffic lanes & other information provided on a navigational chart.

In more advanced form, it is integrated with navigational controls & equipment on bridge. Such integrated system is referred to as Integrated Navigating System (INS) or Integrated Bridge System. A typical INS would have provision of position fixing & route monitoring on the electronic chart. In fact there will be continuous route monitoring if the electronic chart is integrated with position fixing system like Decca, Radar, GPS etc. Controls like steering, autopilot, telegraph etc. may be included into system.

ECDIS has rightly been described as "a quantum leap" with the "potential to change navigation practices forever ... a process involving enhanced information management techniques to support improved navigation & decision making."

Electronic charting & Display System being a newer concept has tremendous scope for innovation & research work. Navigational safety & quality of navigation can get more & more enhanced with development of technology. It already has & going to have more & more numbers of customers & worldwide market for product. People not only from marine but also from outside fields are involved & concerned for varying reasons. From time to time, since the inception of electronic charts, the research work has been going on, onboard different ships. Various aspects like safety, government infrastructure, future upgrading of the system, ECDIS as aid to save groundings & collision, provisional colour & symbol, display of chart scale, display of screen cursor functions have been considered, evaluated & analysed from time to time.

Mariners, the end users were asked to comment on the trial results & their opinion regarding the performance & improvement almost in all the cases was considered. The same made the basis of further improvement over existing equipment.

Some of the bodies who conducted the tests were:

USA & Canada under their joint test programme conducted several tests & trials. Likewise USA, Canada, Germany, Japan with BANET (Baltic & North Sea ECDIS Testbed project) carried out variety of trials at sea in different areas & on simulators reviewing various aspects of ECDIS. ULS Corporation, a Canadian company, completed extensive trials of ECDIS units from six different manufacturers. Evaluations were completed by

Masters & Mates among others, who contributed to the decision. In addition to criteria such as 'user friendliness' and reliability the factors that the Master wanted to emphasize were the 'awareness of safety' & 'accuracy and skills for close quarter navigation'. The SHARED Project, (Singapore Hong Kong - British Admiralty Raster ENC Demonstration), was carried out using the Voyage Management System (VMS), fitted into the ship's bridge system.

ECDIS has following advantages over conventional paper charts.

01. Continuous monitoring may be provided on the chart display. Progress of the vessel may be seen on the chart wrt shore features & traffic lanes without the OOD having to plot the ship's position at that frequent an interval. OOD does not waste time in going to & coming from chart room, every now & then, nor does he have to wait to get used to the light conditions. He must however cross-check the ship's position by alternative means.
02. In addition to the position monitoring, different navigational controls may be integrated with electronic chart. It means one man can do the work of two or three persons, thus needing less number of people.
03. Navigator may have guard ring working as efficient lookout & depth contour alarm acting as echosounder giving shallow water warning. Various alarms ensure more safety, more efficiency & less fatigue.

04. OOD may be able to view the ship on large scale chart or different presentation almost instantly.
05. Chart updating is much faster provided corrections are made available.
06. Navigators although provided with whole lot of information available almost at the touch of fingers, it should not make them lethargic. On the contrary they will be on their toes, alert at all the time because the voyage is recorded & reproduction will reveal any negligence exercised by any of the parties.
07. Study has shown that Integrated Navigation System, using electronic charts can prevent majority of groundings, collision, though not all. In most cases of collisions, groundings etc. an audio visual warning will be given by INS. An avoiding action can be taken in time. All the accidents however may not be avoidable especially those complicated due to steering & engine failures. This may eventually add to the shipowner's profits by cutting down on expenses due to litigation, liabilities, laid up phases, repairs, workshop deployments & additional drydockings.
08. Vessel traffic services will be tremendously benefited with ECDIS used in conjunction with digital reporting. In harbour monitoring, traffic control in harbour & overall safety of navigation can be better achieved using ECDIS. Coastguards, harbour patrols, port control stations, pilot stations, VTMS stations will positively benefit from it.

In respect of overlaying of radar information or superimposition of information from different navigational equipment on ECDIS, care must be taken so that neither ECDIS nor the superimposed information from say radar / ARPA displays or any sensor fitted are degraded by each other.

An ECDIS using positional information from DGPS can be extremely beneficial in restricted waters, even in restricted visibility. The precession & efficient navigation has resulted from real time charted positions & computer assisted intelligent information contributing to better decision making,.

Standardization & uniformity in making of ECDIS

Q. 30.2 Why the standardization & uniformity is a must in making ECDIS? How is the same acquired?

Ans.

In spite of efforts made from time to time, hydrographic offices of different countries still use different symbols on paper charts. Also the datum used may not be common. Positions obtained by today's navigator may not be compatible with the topography provided by the hydrographers. Its required that all the electronic charts are printed or converted to a common datum. This is to ensure that the ENC is compatible with Satellite based positioning system today.

Paper charts have been in circulation for years now. Now that different parties have started feeling that ECDIS is capable of replacing the conventional paper chart, we are going to experience a chart transition age where in ECDIS is going to be installed on more & more ships. ECDIS is going to be accepted with great pleasure, though also with some anxiety, fear & suspicion. This would mean that ECDIS users must be provided with replacement & updating facility in different parts of the world. To accomplish this task lot of hard work of dedicated people & cooperation of different countries is required. It is better to make a joint, all nation effort to make ECDIS 'globally uniform', than to let different countries make their own different electronic charts.

Different measures taken in the direction of standardization are as follows.

(1) Efforts are made towards standardization of survey methods from time to time.
(2) IMO has, with the cooperation of IHO adopted a performance standard for ECDIS. IHO has set standards & specifications through the publication S-52, which is "specifications for chart contents & display aspects of ECDIS".
(3) S-57 is "IHO transfer standard for digital hydrographic data". At present edition 3 of S-57 is in force & is not going to change for a period of 4 years. It contains exchange format, DX-90 & ENC product specifications. IHO member states have accepted DX-90 as international format for exchange.
(4) It is required that ECDIS should provide the standard display at the largest scale available. It should not be possible to alter the contents. Requirement regarding updating the charts is also standardized. Thus not only the chart but equipment also must follow the minimum criteria. Thus;
(5) Standards have been laid down for display size & type.

(6) Requirement regarding the voyage recording has been laid down.
(7) Minimum requirement regarding performance test, different alarms, power supply & power back up are provided for ECDIS.

Different countries have to cooperate in globalization of ECDIS. They may have to offer more cooperation to let their coastlines surveyed.

Thus it can be seen that hydrographers have a marathon task ahead. Private bodies have to be involved. Piracy of ENCs, use of substandard & non standard electronic charts should be prevented. Copyright violations have to be strictly guarded against. To achieve all this there has to be uniformity in surveying, understanding in data exchanging, appointment of coordination centres. Thus different hydrogrphic offices have to speak & write the same chart to make the project successful.

Legal status of ECDIS as compared with paper chart. Requirements that an ECDIS must fulfill

Q. 30.3 What is the legal status of ECDIS? What are the basic requirements that an ECDIS must fulfill to be equivalent to or better than paper chart?

Ans.

IMO has approved ECDIS vide Resolution A/817(19) in November 1995. The ECDIS supported with ENC provided by authorized Hydrographic Office is recognized as legal equivalent to paper charts under SOLAS V/20.

ECDIS should have a basic aim towards safe navigation, providing all the chart-information required for safe navigation, complying with SOLAS requirements. It should provide appropriate alarms / indications reducing navigational workload of OOD. Presentations & available scales must be same as paper chart. Also it should be possible to carry out route planning, position fixing & monitoring on it. It should be possible to update the ENCs in systematic & reliable way.

Requirement regarding ENC information & updated information:

ECDIS should be capable of displaying all SENC information. Operator should easily be able to get display base, standard display etc. as single operator action. Operator should be able to add or remove information easily. It should not however be possible to alter the contents. The charted information should be the latest & sufficient. Information must be from authorized HO.

Updated information must be stored separate from ENC. A record of updates is maintained in the same way as done in chart correction log. Operator should be able to update the ENC data manually. ECDIS should also accept official updates automatically. Display of updates should be possible if required.

Requirement regarding display mode:

North up or other orientation should be possible. It should be possible to choose true or relative motion display. It should be possible to place own ship in desired part of the screen. Indication must appear on the screen to state that the charted portion on display is at a scale larger than the scale of ENC. ECDIS should be capable of displaying information in specified colours & with clarity for,

(1) route planning & supplementary navigation tasks &
(2) route monitoring in size 270mm x 270mm. Operator should be able to see own route with own ship in the beginning of such route vector.

Requirement regarding colours & symbols used:

Colours & symbols should be as per App. 2 & 3 of S-52. Size of symbols, pictures etc. to be as per IEC pub. 1174. Operator seeing the display should be told if the own ship is in proportion of actual ship size or is a symbol only.

Requirement regarding route planning & monitoring:

It should be possible to do route monitoring & planning in simple & reliable manner. Alarm & indications to assist above to be as per app. 4 of S-52. It should be possible to do route planning for straight & curved segments.

Amendments to position , order etc. of waypoints should be possible. It should also be possible to include or remove a waypoint. Off-track alarm may be included for desired off-track range. It should be possible to see own ship's selected route ahead as well as past track at desired time intervals. EBL & range markers should be easily available. It should be possible to locate the position on display once its Latitude, Longitude are entered.

Requirement regarding inputs from other navigational equipment:

It should be possible to get radar information on the chart. It should be connected to system providing continuous position fixing , heading & speed information. Thus connection to GPS & Gyro would be ideal. The navigational information should be with respect to a common reference system. Its important that positioning system (say GPS) & the SENC should be on the same geodetic datum, otherwise there will be discrepancy between the observed position & satellite derived position owing to the difference in datum. It should be possible for the operator to adjust ship's geographic position manually.

Requirements regarding reproduction of voyage:

It should be possible to reproduce minimum elements required to reconstruct the passage track & to verify the official database. One should be able to know the ship's heading, speed, position, time from the recorded voyage. One should be able to find out regarding ENC source used, its edition & details regarding updating. It should not be possible to manipulate or change the recorded information.

Requirements to be fulfilled by ECDIS regarding, error indication, performance test, power supply & back up

Q. 30.4 What are the requirements regarding error indication, performance test, power supply & power back up?

Ans.

ECDIS should provide an indication when the input from the position fixing system or any other navigational information is lost. ECDIS failure should not develop into a critical situation. For this arrangements should be provided for safe take-over of ECDIS functions. Back-up arrangement facilities should be to provide means so that remaining part of the voyage can be conducted in safe manner.

ECDIS should be provided with means for either automatically or manually carrying out on-board tests of major functions. Alarms or indications being provided in case of system malfunction.

It should be possible to operate ECDIS along with equipment necessary for its normal functioning on emergency electrical power. Manual re-initialization should not be necessary for interruption of upto 45 seconds, in case of change over of power supply.

Raster charts & Vector charts

Q. 30.5 Distinguish between Raster charts & Vector charts, with special reference to the merits & demerits of each kind.

Ans.

A Raster chart is a visual scan of a paper chart. In this, the electronic charts are formed by digitized data stored as a single computer file. It is a computer based system, which uses charts issued by, or under the authority of, a national hydrographic office. e.g. Admiralty Raster Chart Service (ARCS). It has the advantage that additional electronic information may be added as separate data. Thus continuous electronic positioning may be provided, showing the movement of ship on the chart. Route planning, position plotting, referencing with shore picture etc. can be provided by integrating the chart with other equipment's.

A vector chart on the other hand is more complex. Every point on the chart is identifiable electronically or is digitally mapped. Each individual charted object & its attributes are obtained by digitally referencing & is based on individual geographic position. Each item is recorded separately & stored in a database. Information can thus be used in more ways in various combinations. Electronic Navigational Charts (ENC) are within the Electronic Chart Display System (ECDIS). The vector chart may be made up from layers of information. Due to this the chart of an area may be made to look complicated or simple as needed. The system thus is more flexible, there is a danger however that particular information layer may get erased. Provisions then will have to be made to ensure that certain information is not accidentally erased & the navigator is warned if any thing like this happens.

Lot of debating has already taken place between interested parties, for & against Raster charts. Raster supporters argue that those experienced in Raster find the system to be very good & are rigid over the argument & maintain that Raster are equivalent or better than paper charts.

Vector chart supporters say that, inaccuracies within Raster chart are less visible than paper charts. Zooming of a section can give more detailed information in respect of the area selected, whereas this is not true regarding Raster charts. ECDIS and 'intelligent information' is lost without the use of vector charts. The layering of information and selecting of useful data under a vector format is paramount to improving and increasing the capability of electronic navigation. To simply reproduce the existing paper chart by Raster, because it is cheap & easy, completely overlooks the idea of safer navigation.

British Admiralty has been strongly supporting Raster format and equivalency standards. Also its worth noting that UKHO offers the similar guarantee (liability for the incident or loss due to incorrect data) on its electronic charts as paper charts. Although it has been agreed while adopting the standards of performance for electronic chart display and information systems (ECDIS), that only vector-based digitized charts, which are used in such systems, could be legally accepted equivalents to paper charts, the production of vectored charts so far has been rather slow. This is because delivery of authorized electronic mapping data by the hydrographic authorities is a laborious & tedious process. In contrast, Raster charts, basically reproductions of existing paper charts, are far easier to obtain. They are also relatively straightforward to use, requiring little or no extra training of the navigating officer.

An IHO survey on the status of ENC production shows that by March 1998, more than 1,000 charts are estimated to be produced. A total of 3000 ENCs is aimed. This means that the ECDIS system may not come into play for few more years, if a substantial amount of ENC data is unavailable." Meanwhile, the Raster system has been tried and tested and is ready to use. Raster-supporters feel the system is more up and coming, and has been well approved by the industry. IMO naturally is under pressure to endorse the Raster charts in the mean time as paper equivalents, at least during interim period, provided they are based on authorized data and used in RCDS, which comply, with the IMO agreed performance standards. Such standards have been drafted and are ready for approval.

However, so far they have failed to gain sufficient support. The IHO is confident that all the required ENC data will be collated, checked and ready to use in two years.

Raster

Advantages : The biggest advantage of Raster charts is that they are direct copies of paper charts, which means the user does not have to worry about getting used to new colour & symbols. He uses familiar colours and symbols. They are cheaper, simpler and easier to produce as compared to Vector charts. Officially produced Raster charts are widely available. They can be used for all standard navigational tasks normally carried out with paper charts. Many of the functions of ECDIS may be performed on Raster charts.

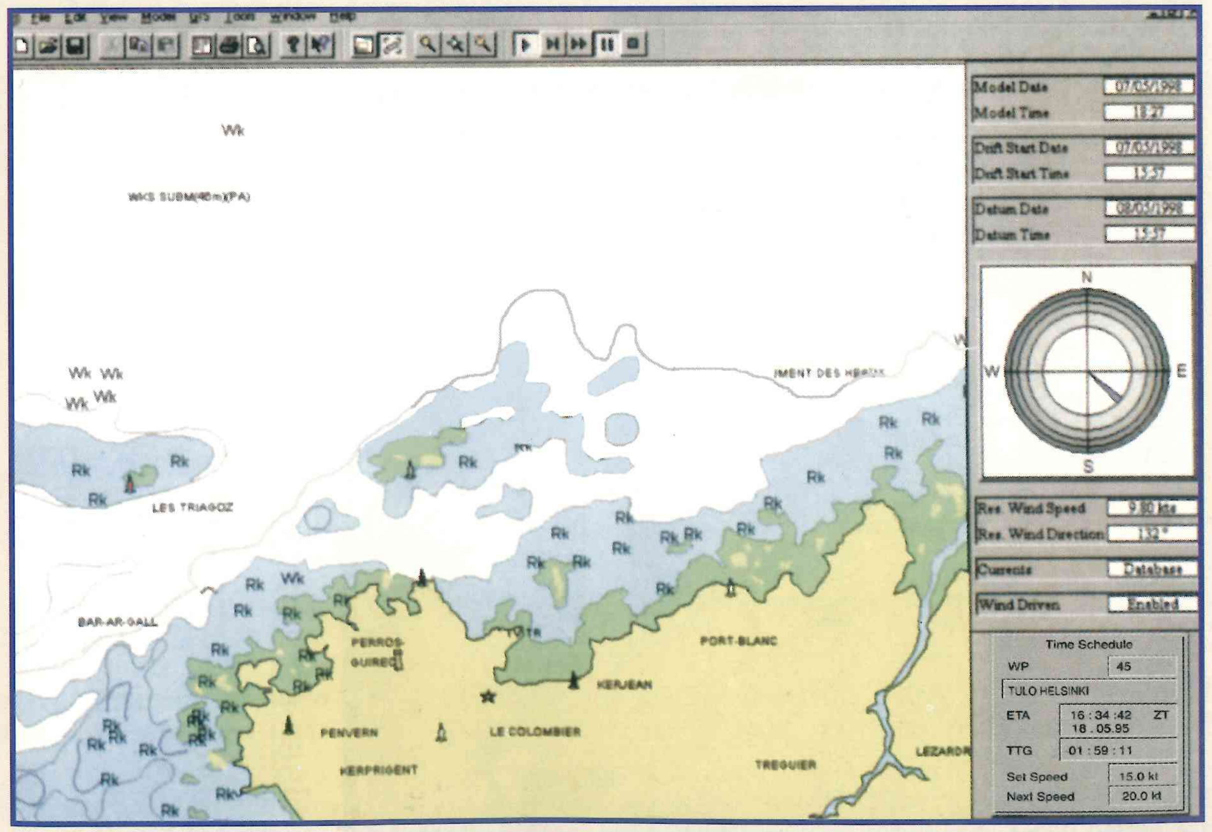
Disadvantage: Some of the Raster charts might appear cluttered up with too much of information. When survey was done for making of paper charts the type of ships, which were in minds of hydrographers were different e.g. drafts of the ships those days was much less. It was not intended that the chart will be used electronically, say to operate the guard ring of a particular depth contour. The datum used on the chart may be different from the datum of the position fixing system. It cannot be sensibly rotated to head up or other orientation. These charts have larger memory needs than vector charts.

Vector

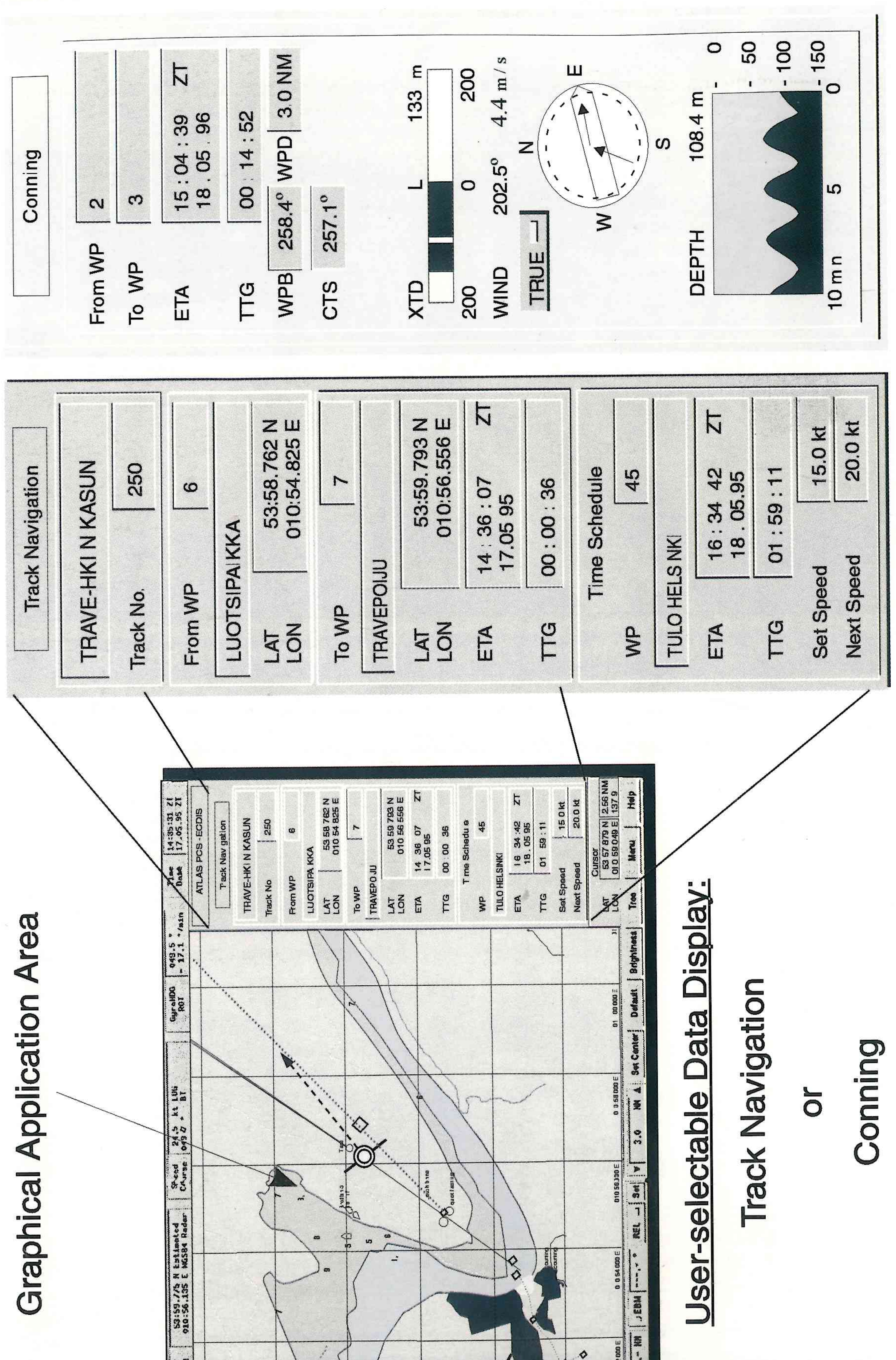
Advantage: These charts are made up of layers, which can be selected as per requirement or the type of work to be performed. User can zoom to see more details of a particular area. User can set safety depths, guard rings & warning alarms depending on own draft. Charts can be rotated to any angle or presentation.

Disadvantages: Charts are more complex & their production takes longer & is more costly. ECDIS standards will be finalized only after the passage of some more time. e.g. IEC is yet to approve the recommended ECDIS standards fully. Large sea areas are not likely to be available for several years.

Typical Wheel House Display of An Integrated bridge



ELECTRONIC CHART DISPLAY



Users will need to be trained to get used to new symbols, colour scheme etc. Also its more difficult to ensure quality & integrity of displayed data.

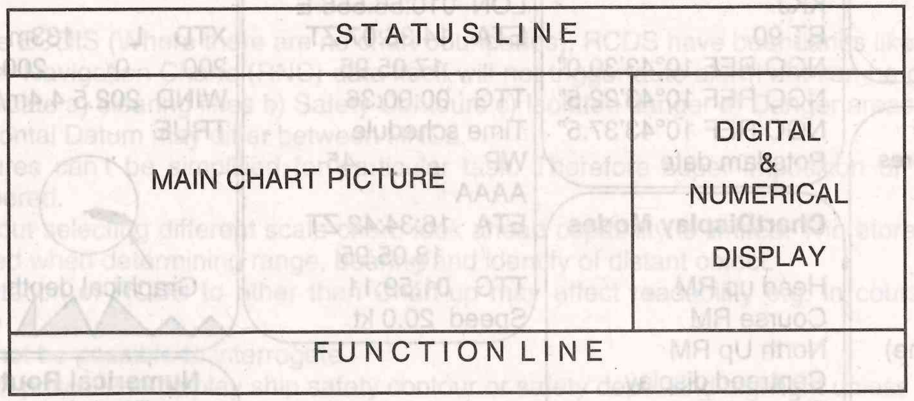
General features, with illustrations showing Navigational & Planning functions of CHARTPILOT ATLAS 9300, an ECDIS product developed by STN ATLAS ELEKTRONIK (Courtesy STN ATLAS ELEKTRONIK)

Main functions of ATLAS CHARTPILOT can be categorized in to two types, viz.
(a) Navigational,
(b) Planning & Consulting.

Navigational Console (bridge integrated)	Planning/Consulting Station: (located at chart table)
X Navigation	X Route Planning
X Route Monitoring	X Chart Update/Maintenance
X Track Keeping	X Data Backup
X Collision Avoidance	X Consulting Functions
X Grounding Avoidance	X File Management
X Docking	X Map Handling

Each workplace provides availability of all functions via network

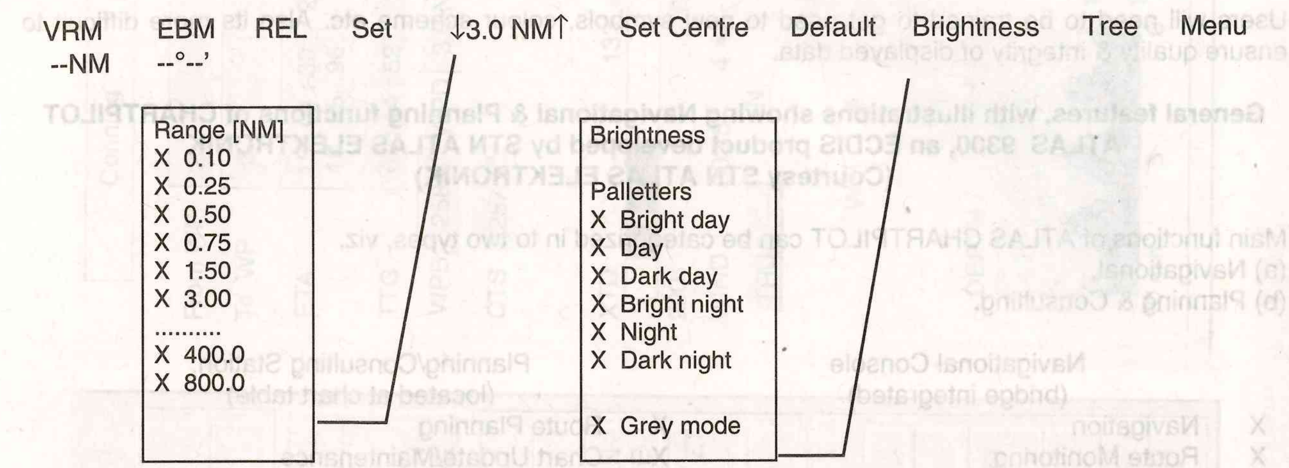
Normally the display screen, while it is being used for navigation display the following:
(a) Status Line on the upper part of screen,
(b) Function Line on the bottom part,
(c) Chart picture in the main portion of the screen &
(d) Digital, numerical data, presentation status & other required details on the right hand one fourth of the screen.



Status Line gives numerical display of position, speed, course, gyro heading, rate of turn, date & time.

LAT 53:59.775 N Estimated	Speed 24.5 kt LOG	Gyro HDG 049.5°	Time 14:35:31 ZT
LON 010:56.135 E WGS84 Radar	Course 049.7 BT	ROT -17.1°/min	Date 17.05.95 ZT

Function Line provides interactive tools & functions like Variable range marker, Electronic bearing marker, Range/scale, Set centre function, Display brightness, Function tree, Menu pages & Help windows.



Following are some of the displays regarding digital, numerical data, presentation status etc, as may be seen on the right hand one fourth of the screen.

Chart Projection
Mercator
Gauss Conform
Cylindric
Polyconic
Cylinder Equal Spaced
Gauss Kruegar

Bearing & dist from cursor to ship

Cursor
LAT....0.32 NM
LON....325.3°

User selectable Presentation features
coordinate grid
own ship symbol
range rings
bearing scale
own ship track(time)
curved headline prediction

Time Schedule Planning
Arrival speed
Actual Time of arrival
Distance to go
ETA
Time to go
TTG profile

Chart datum
WGS 84
WGS 72
ED 50
ED 79
AGD 1966
NAD 1927
ARC 1950
Tokyo
OSGB 1936
Indian
South American 69
KKJ
RT 90
NGO REF 10°43'30.0"
NGO REF 10°43'22.5"
NGO REF 10°43'37.5"
Potsdam date

ChartDisplay Modes
Head up RM
Course RM
North Up RM
Centreed display
True motion
T & R vectors

Anti Collision Fn
ARPA acq targets
Time past pos plot
Collision prediction with vector
Alarm or indication
Co,contour,others

Track Navigation
XXXX
Track No. 250
From WP 6
YYYY
LAT 53:58.762N
LON 010:54.825 E
To WP 7
ZZZZ
LAT 53:59.773 N
LON 010:56.556 E
ETA 14:36:07 ZT
17.05.95
TTG 00:00:36
Time schedule
WP 45
AAAA
ETA 16:34:42 ZT
18.05.95
TTG 01:59:11
Speed 20.0 kt

Graphical Route Planning
Interactive
X generating
X modifying
X deleting
X adding
X moving
of waypoints & tracks

Conning
From WP 2
To WP 3
ETA 15:04:39 ZT
05.07.96
TTG 00:14:52
WPB 258.4°
WPD 3.0NM
CST 257.1°
XTD L 133m
200 0 200
WIND 202.5 4.4m/s
TRUE
Graphical depth

Numerical Route Planning
X Way pt no.
X Position
X Bearing/distance
X Track Distance
X Profile/Planned speed
X Course/Track lmt
X Date
X Control/Sail mode
X Economy
X Radius

Only some of the displays have been illustrated pertaining mainly to the navigational functions. It can be seen that lot of valuable information is available merely at the touch of finger.

ECDIS provides all the important tasks regarding route planning, track keeping & monitoring as well as anti-grounding & anti-collision.

The Chart Information system allows check of all chart objects with cursor. It also allows for voyage recording with replay functions.

Following are some of the international technical standards, applied to the development of ECDIS.

1. International Electro technical Commission (IEC)
   IEC 447: Man Machine Interface.
   IEC 945: General requirements
   IEC 1162: Digital Interfaces
   IEC 1174: Operational & Performance Requirement for ECDIS
2. International Hydrographic Organization (IHO)
   IHO S52: Specification for Chart Content & Display Aspects of ECDIS.
   IHO S52: App. 2: Provisional Colours & symbols
   IHO S57 Transfer standards for digital hydrographic data
   IHO S57 Annex A to Appendix 2: ECDIS, Presentation Library.
3. IMO, Performance Standards for ECDIS.

Q. 30.6 What precautions must be observed when using RASTER Charts on board?

Ans

Maritime safety committee adopted amendments to performance standards for ECDIS to include the use of Chart . Display system (RCDS). The amendments Raster permit ECDIS to operate in 2 modes:

a. ECDIS mode where ENC data is used
b. RCDS mode where ENC data is not available

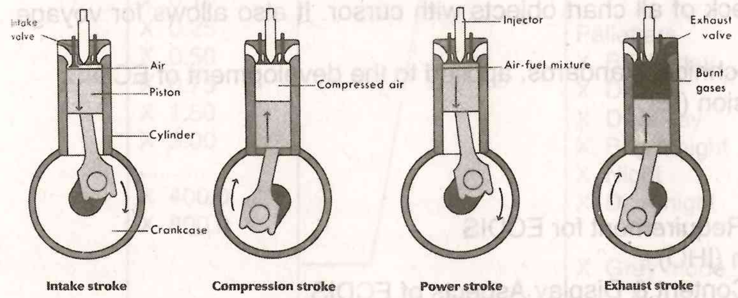
However RCDS mode does not have full-function ability of ECDIS and can only be used together with appropriate folio of paper charts.

Mariner's attention is drawn towards following limitations of RCDS mode,

1. Unlike ECDIS (Where there are no chart boundaries), RCDS have boundaries like charts.
2. Raster Navigation Charts (RNC) data itself will not trigger auto alarm but can be generated by user to indicate a) clearing lines b) Safety Contours c) Isolated danger d) Danger areas.
3. Horizontal Datum may differ between RNCs.
4. Features can't be simplified for particular task. Therefore super imposition of RADAR & ARPA hampered.
5. Without selecting different scale chart, look ahead capability is limited. Therefore inconvenience is caused when determining range, bearing and identify of distant object.
6. Orientation of RCDS to other than Chart-up may affect readability e.g. in course-up or route up mode
7. May not be possible to interrogate
8. It's not possible to display ship safety contour or safety depth and highlight unless previously done.
9. Depending on ENC source different colours may be used for same object. Day and Night colours may be different.
10. RNC is displayed at paper chart scale. Excessive enlarging may deteriorate.
11. In confined waters accuracy of chart data (Paper chart, ENC, RNC) may be less than fixing system in use (eg, DGNSS)

Conclusion:

Thus ECDIS has a number of advantages as compared to conventional paper chart, but one must not forget that ECDIS may be considered to be equivalent or better than the paper chart but it can never be called equal to a paper chart. As there is always going to be a difference between an electronic reproduction of chart & a real or a physical paper chart. Another bad thing, which is bound to happen, is gradual loss of 'art of position finding' or 'individual aptitude of real navigation'. The benefits of ECDIS in fields of safety & long term commercial profits are so significant that one is easily convinced now that ECDIS has arrived for good & is here with us to stay.



Diesel Rudolf: *[1858-1913] Born in Paris. He had German parents. He was a mechanical engineer & he developed an internal combustion machines that used heavy fuel oil as fuel. It proved simpler to use. The design of engine was simple. He patented his design in 1892. In 1913 he disappeared from a German ship mysteriously. This ship was bound for London.*

[Pic. Principle of Diesel Engine]

Chapter 31: Maintenance & Correction of Charts

Normally second mate is in-charge of maintaining charts & publications. It is his duty to maintain a record of charts & publications. He also prepares an indent for navigational items, charts & publications needed for voyage or required for replacing canceled editions onboard. Chart corrections must be carried out carefully. Entry regarding the corrections is made in appropriate places. False entries must never be made regarding charts corrected. Such a thing would severely jeopardize the safety of navigation. Future navigators will always rely on entries made. One can understand that in want of time charts were not corrected, but to make false entries regarding chart corrections is neither acceptable nor pardonable.

Chart folios:

Ships normally maintain folios depending on the kind of voyages that the ship is making. Thus a ship that is making voyages around Indian subcontinent may be having only one or two folios. Plying area may be geographically divided in two zones & ship will then have two folios with one folio having eastern zone charts & other folio having western zone charts.

Ships making fixed voyages may have a similar arrangement, thus folios known by the area.

A ship plying all over & having no fixed route may maintain international folio system or standard folio system maintained by the company or as per BA numbers. Thus BA 1 to BA 300 may be listed in folio 1. BA 301 to BA 600 may be listed in folio 2 & so on.

Second officer in a register must record the details of folios, which are maintained. A printed record of list of charts is sent to the head office.

Folio covers are made of canvass or other appropriate material capable of holding charts. Folio number, a list of charts within it & a table of correction record is pasted on outside of the folio cover.

The international Convention for the safety of life at Sea (SOLAS 1974)states; 'All ships shall carry adequate and up-to-date charts, sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage' (chapter V, Regulation 20).

The publication entitled How to Correct Your Chart the Admiralty Way (NP 294) is a simple guide towards correcting practices. Admiralty Notice to mariners may be consulted at or obtained from admiralty distributions, or they may be consulted at British mercantile marine offices, Customs Houses and at certain other places in the United Kingdom and overseas.

The content of the Notices to Mariners booklet is also available on the UKHO Website. This service is called the Admiralty Notice to Mariners ~On-Line~ (ANMO) service. This digital update service for admiralty paper charts and publications includes full-colour update patches (NM Blocks), and is available 24 hours a day, 7 days per week, anywhere in the world.

Maintenance of Charts: Action to take upon publishing of new or metric edition of a chart or upon permanent withdrawal of a chart

Q. 31.1 *As a second mate what action will you take if you find following information wrt. a particular chart in Weekly NM?*

(a) A New Edition is published on 15.04.96.
(b) A New Metric chart is published, 12.02.96.
(c) Chart is permanently withdrawn upon publishing of chart, BA 2215.

Hint:

(a) Insert remark ***'Cancelled vide say WNM 321 of 1996', 'New ed. pub. 15.04.96'*** (in large letters), on the reverse of the chart. This remark is also made in pencil, in chart correction log next to the chart number. Note down the chart number in 2nd mate's indent notebook. The chart need not be corrected any more. Indent is placed to procure the chart. Retain this chart in the folio till new chart is received & old chart is duly replaced.

(b) Similar remark & action as above, except that 'metric chart' entered instead of 'edition'.

(c) Insert remark ***' Chart permanently withdrawn, as per say WNM 471 of 1996 upon publishing of BA 2215'*** in large letters on reverse of the chart. This remark is also made in pencil in correction log. Enter in permanent ink, 'chart number 2215' in serial order in correction log, with appropriate remark in pencil viz, ***'New chart expected shortly, as per WNM 471 of 1996, replacing existing chart xxxx.'*** . Note down BA 2215 in 2nd mate's indent note book.
The withdrawn chart is retained in folio till the arrival of new chart. The old chart is not corrected any more. In fact previous chart number won't even appear in subsequent weekly notices.

Action to be taken upon receiving of a new chart

Q. 31.2 *The chart you had indented as per (a) above, is received on 21.12.96 at Durban by you. What are the various dates you will check on the chart at the time of receiving it? What entries will you make on the chart & in the correction log?. How will you update this chart ?*

Hint:

New Edition date is the most important date, which must be checked on the chart. Second mate finds, say following dates on the chart.

(1) Date of publishing 5th march 1948.
(2) New Ed. 14th Feb. 1962, New Ed. 15th April 1996.
(3) Printed on 2nd July 1996.
(4) A printed entry done by chart supplier depot.

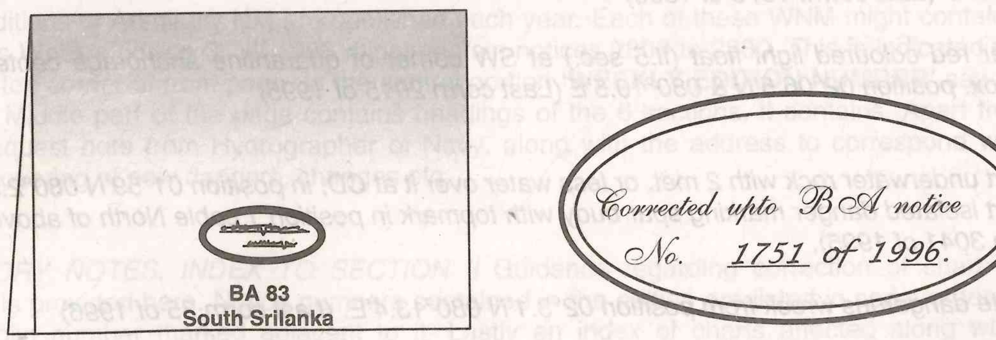


Fig. 31.1

(5) A record of small corrections between 15.04.96 & 02.07.96 in the permanent original print.
(6) A record of small corrections arising after the date, 02.07.96 till notice no. 1751 made by chart suppliers done with chart correcting pens.
Thus small corrections may be found as,

Small corrections:1996 960,961.1015,1235,1480,1516, 1589, 1612, 1613

Above entries regarding small corrections mean that chart depot has arranged to correct the supplied charts upto notice number 1751 of 96.. This particular chart however must not be having any small correction between notice 1613 & notice 1751.

Entry is made by 2nd Officer on the reverse of received chart regarding date & port of receipt.

Entry is made on the chart correction log next to the chart number regarding new edition date. All the corrections dated prior to this date may be deleted or erased on the log. On the reverse of chart, folio number etc maintained on board may be entered. This chart is replaced in appropriate folio in proper serial order. The chart which was canceled (& is now being replaced) is removed now. Additional remark of being 'replaced' is entered on reverse of canceled chart.

If you have received the latest ***'cumulative Notices to Mariner'*** book dated 1st Jan 97, then look for this chart & directly find out the numbers & dates of notices affecting this chart. You might find following details in the Cum. Notices to Mariner;

BA 2222 (N Ed 15.04.96)	1996: 960,961,1015,1235,1480,1516,1589,1612,1613,1781,2013,3011,3321

Small corrections viz. 1781, 2013, 3011, 3321 are corrected in this order. After corrections are made in permanent form on the chart, the entry to this effect is made in the chart & correction log.

A new chart received as above is not corrected by depot for temporary & preliminary corrections by Chart suppliers. These corrections have to be done by 2nd Officer, in pencil, the same can be erased or amended later. The T & P notices affecting this chart are given in **'Annual notices to mariner'**. The chart is corrected for the same. In addition to above the weekly notices to mariner of the current year is also checked for new notices (since the first notice). The entry regarding same is made in the space next to the entries for small corrections. **e.g. 1996 726(T) or 431(P).**

Chart Correction

Q.31.3 a. Explain how the chart correction is done? What are correction tracings?
b.Following is the relevant information extracted from various WNM regarding corrections to be made to chart 'ALPHA LIGHT TO ZULU ROADS'

1995:

2015: Enter obscured sector for Tango light (apron. pos. 02°13'N 080°19'E along 210° to 240° from seaward. (Last corrn. 1875 of 1995)

3041: Enter red coloured light float (fl.5 sec.) at SW corner of quarantine anchorage centered around approx. position 02°06.5'N & 080°10.5'E (Last corrn 2015 of 1995)

1996:

35: Insert underwater rock with 2 met. or less water over it at CD, in position 01°59'N 080°2.3'E. Insert isolated danger marking spar buoy with topmark in position 1 cable North of above rock.(Last corrn 3041 of 1995).

441: Delete dangerous wreck from position 02°3.1'N 080°13.4'E. (Last corrn 35 of 1996)

1016: Insert the following,
a) A lighted oil production platform in position 02°10'N 080°37'E.
b) Restricted area around above platform of radius of 7 cables. (Last corrn 441 of 1996)

Ans

a. Weekly notices to mariners contain permanent corrections, T & P notices & inserts etc. These affect the charts in a permanent or a temporary way. Permanent corrections are also called small corrections. The correction is done by a special pen with a fine tip. It is recommended that these corrections are done neatly, without cluttering up the chart area. The ink used is waterproof & of violet colour. The symbols & abbreviations given in BA chart 5011 must be used. Erasures should not be made. Any deletion must be done by correcting pen, with single staright line over the entry to be deleted. Care must be taken to not obscure any navigational information on the chart. Letters & the size of correction feature must be as small as legible & in the tune with the scale of the chart. One must correct the larger scale chart first. To paste the blocks (inserts), the corners must be marked on the chart first, gum stick is used instead of liquid gum to avoid smudging of the paper, important features matched if 100% matching is not possible.

Correction tracings are made for all permanent corrections except blocks (inserts) & are available with most chart agents. Correction can be faster using the tracings but while using them the WNM must still be referred. Tracings apart from the corrections will also contain the details like chart number, NM number, last correction, Identification particulars of standard folio

(b) Each notice, in addition to the information regarding corrections, gives numbers of charts affected, last correction affecting a particular chart, any additional remark re. small scale or fathom chart etc.

A WNM has two indices, viz.
(1) Charts affected & notices affecting them. &
(2) Index of notices with page on which the same is detailed.

As every notice indicates the number of previous correction, its advisable to first search the latest WNM on board to see if any chart is affected in that week, instead of searching the WNMs in serial order.

Thus in present case WNM 48/95 to WNM 15/96 are to be checked for correcting above chart. Going backwards it is found that notice no. 1016 of 1996 affects the chart. The notice no. noted down on a piece of paper. This notice will have information regarding the date of previous notice affecting the same chart & hence will lead to previous correction viz. 441 of 1996. This notice no. is also noted. This process of going backwards is continued till notice no. 1875 of 1995 is reached for which the chart has already been corrected. In proceeding as above only 5 out of 20 WNMs had to be opened. Moreover it's confirmed that no intermediate correction has been omitted. After establishing the link of small correction numbers, chart must be corrected in serial order. Entry must always be made only after corrections have been carried out.

Weekly Notices to Mariners

Q. 31.4 What information do you get in 'Weekly Notices to Mariners', (WNM)?

Ans.

Front page:

52 weekly editions of Admiralty NM are published each year. Each of these WNM might contain 70 to 80 notices. Thus Weekly edition 34 of 1996 might contain notices 2800 to 2880. This is indicated as **'2800 - 2880/ 96'** at top corner of front page. In the central portion **'WEEKLY EDITION NUMBER'** say 34,35 etc. is indicated. Middle part of the page contains headings of the 6 sections, it contains. Apart from above there is a request note from Hydrographer of Navy, along with the address to correspond with, in the event of discovering of new dangers, changes etc.

SECTION 1:

EXPLANATORY NOTES. INDEX TO SECTION II Guidance regarding correction of chart & various publications is provided here. Notice numbers contained in the edition are listed in serial order with page number & folio number marked adjacent to it. Lastly an index of charts affected along with notices affecting the same is provided in this section.

SECTION II:

ADMIRALTY NOTICES TO MARINERS, CORRECTIONS TO CHARTS;

This section begins with the heading, 'Admiralty Publications'. New charts, editions published or old charts withdrawn are listed here. Also announcement regarding, new charts, editions & charts to be withdrawn, scheduled to take place in near future are made under this heading. Announcement regarding publishing of new admiralty publication, supplements etc. is found here. The notice indicates, which books are due for replacement within one year & which new supplements are due for publication within 3 months. A valuable information regarding 'dates of current Admiralty publications / supplements' may be found in this part, under special notice published quarterly. Thus WNM 13, 26, 39, 52 will contain date of latest edition of Admiralty publications, supplements etc. Now a days this information is included in Cumulative NM also.

Main text of section II comprises of various notices providing corrections to be done to charts. A typical notice might be as follows.

2856 INDIA, West Coast - Approaches to Gulf of Khambat - Jafarabad Southwestwards - wreck
Insert symbol for dangerous wreck with notation PA in position 20° 49.1'N 071° 19.1'E
Chart [Last Correction] **-1474 [1418/96] 1486[New Edition 12/7/96]**

Above is *notice no. 2856*, pertaining to corrections regarding *dangerous wreck*, to be made on *BA charts 1474 & 1486.*
These charts are of geographical area, *'Gulf of Khambat on West coast of India'.*
Charts affected are BA 1474 & BA 1486.
Last correction for BA 1474 was as included in notice 1418 of 1996.
On BA 1486 (New Edition 12/7/96), above-mentioned correction was the first correction.

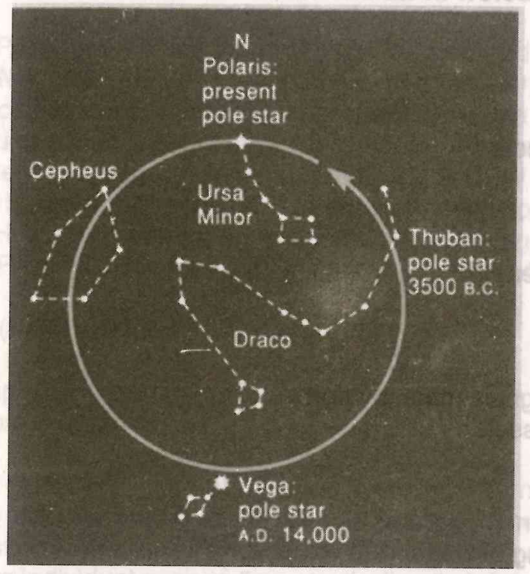
SECTION III:
REPRINTS OF RADIO NAVIGATIONAL WARNING;
Serial numbers of all NAVAREA - 1 messages in force is indicated. In addition to above, reprints of messages issued during the week is provided. A file should be maintained giving current navigational warnings including weekly reprints of messages published during subsequent weeks. In this section, messages pertaining to other NAVAREAS, HYDROLANT, HYDROPAC along with selected important messages for these areas are listed.

SECTION IV:
CORRECTION TO ADMIRALTY SAILING DIRECTIONS;
This section contains corrections to Sailing Directions. Once a month, list of corrections in force is published in this section. Certain details which are incorporated in 'corrections to charts' or 'List of Lights' may not be repeated under this section. Those corrections in force, regarding a Pilot's volume at the end of the year are published in **Annual Summary of Admiralty Notices to Mariner.** Thus a file containing latest corrections in force should be referred whilst consulting Admiralty Sailing Directions with current supplement.

SECTION V:
CORRECTIONS TO ADMIRALTY LIST OF LIGHTS & FOG SIGNALS;
The correction advised by this section should be directly made in the Admiralty List of Lights. Minor amendments may be in terms of canceling & replacing certain existing details in the volume. Details of new light established may be cut & pasted appropriately against the serial number of new light.

SECTION VI:
CORRECTIONS TO ADMIRALTY LIST OF RADIO SIGNALS;
Section VI forms the last part of the Weekly Edition. It contains the corrections to ALRS & may be detached from the rest of the book easily & handed over to the Radio Officer for correction.

In addition to above sections, WNM has blank hydrographic note forms, e.g. **H-102 (April 1990), H102 a (April 1990) & H102b(July 1995)**, along with necessary instructions to mariners regarding procedure to report navigational matters to Hydrographer of Navy, UK are provided. Thus mariner might forward any discrepancies observed between charted or published information & the actual facts, which he discovers in the course of his own investigation using the available equipment on board.



Rigveda: Rigveda 5-40-9 states that eclipses are caused by shadow. Rig 1-8-8.3 & 4 give methods of construction of ships to propel through ocean by gases. Precession of equinoxes & difference between sidereal & tropical year was known to rishies. Rate of precession was indicated in terms of ecliptic & relevant constillations.
[Pic. Cycle of Precession of Equinoxes, the period being 28500 years]

Chapter 32: Important Publications

Admiralty Sailing Directions (PILOTS)

Q. 32.1 What information do you get in Admiralty Sailing Directions? How is the same kept up-to-date?
Ans.
Admiralty Sailing Directions (ASD), popularly known as Pilots, provide valuable information that may be needed by a mariner regarding any area. Different ASD volumes cover various navigable areas of world over. A diagrammatic key showing, boundaries of geographical area covered by different volumes may be found in 'Admiralty Chart Catalogue'. General information about any area & the knowledge about local regulations, climatic conditions, anchorages, port facilities, harbour approaches etc. may be easily acquired by a mariner by reading appropriate volume. Thus ASDs are very useful for passage planning.

ASDs are in the process of being modernized in style, keeping in mind the new requirements & the advancements in shipping. Following is the typical layout of information provided in existing ASDs. In 1983 the style of ASDs was changed to modernize it. Average time between the two editions is 17 to 20 years. However certain volumes might need to be revised at interval of lesser duration (though not less than 5 years), in order to avoid bulking up of corrections.

ASD
1) Diagrammatic index of area covered under the volume & limits of charts for the area
2) Chapter I (General information for the area covered by volume)
3) Other chapters. (Forming the main text. Area covered under the volume is divided in various geographical sections. These chapters individually cover each geographical section.)
4) Appendices:
   (a) Extracts of port regulations of certain port.
   (b) List of ports available for under water repairs.
   (c) Principal ports with depths.
   (d) Radar ranges of various land points, islands, peaks etc.
5) Views
6) Alphabetic index.

Information available under chapter I is shown below in tabular form.

Chapter I	
General Remarks	Geography
	Population
	Agricultural, mineral products
	Currency
	Consular offices
Currents	Cause, origin
	Direction of currents & strength
	Diagrammatic illustration
Seiches, Sea level & Earthquakes	
Signals	Signal stations, various signals made by port
	Signals to be made by vessels
Buoyage	
Pilotage	Pilot vessel, pilot signals
	Notice required to be given
	Any special rules regarding pilotage
	Any private pilotage or optional pilotage system
Communications	By air, land, sea
Radio stations	
Fuel & repairs	
Regulations	Approaching ships
	Quarantine
Fishing Vessels	Special Signals, Nets used
	Favourable areas, seasons etc
Climate & Weather	Pressure distribution system
	Wind, Local winds, Gales, Frequencies of gale
	Cloud, precipitation, thunderstorm
	Fog & visibility
	Air & sea temperature, Relative humidity
Climatic Tables	Compiled for key geographical areas under volume, & are based on observations & studies made over several years
Other chapters (Main Text)	*Description of coast with off lying dangers*
	Anchorages good, bad & prohibited
	Approaches to ports & harbours & guidance to transit passages which are navigationally important, such as 'Strait of Tiran'.
	Tidal streams
	Cities, Port facilities, Communication etc.
	Piers, Stevedoring etc.

Corrections:

Selected urgent corrections are published in section IV of Weekly Edition. A list of corrections in force is published in the last week of each month under this section. Corrections in force at the end of year are reprinted in Annual Summary of Admiralty Notices to Mariner.

A file should be maintained, filing data from section IV, with latest list of corrections on top. Its not recommended that each time a correction is received, it's corrected for, or its pasted on volume. Instead at the time of referring an ASD volume ensures that current edition & supplement is referred along with corrections given in above-mentioned file.

Ocean Passages of the world

Q. 32.2 What information may be found in 'Ocean Passages For The World'? How is it kept upto date?

Ans.

Ocean Passages for the world (OPW) is published by Hydrographer of the Navy, Taunton. Its also known as **NP 136.** OPW is written for use in planning deep-sea voyages. It contains notes on meteorological factors affecting the passage. It guides a mariner to follow the best passage in a particular month, through a particular stretch. Its a unique Admiralty publication, in which sailing vessels are dealt with separately. In passage planning, both ASD & OPW are valuable publication to be referred. While the ASD would be generally required for coastal navigation, the OPW would be more required for ocean navigation. However, even for an exclusive ocean voyage one needs to consult ASD.

'Ocean Passages for the world' is mainly divided in 4 parts, viz.

1) Part I (Power vessels - chapter 1 to 8)
2) Part II (Sailing vessels - chapter 9 to 11)
3) A comprehensive general index.
4) Charts & diagrams.

Chapter I contains general passage planning information, viz. course calculations, weather factors, currents, ice etc. applicable to all seas. A general concept of meteorology is discussed in chapter I. A mariner must have the basic knowledge of meteorology in planning & carrying out an ocean voyage. In later chapters individual oceans & seas are discussed, for power as well as sailing vessels.

Later chapters typically may have following information wrt relevant ocean or sea.

→ *WIND & WEATHER*
→ *SWELL*
→ *CURRENTS*
→ *ICE*
→ *NOTES & CAUTIONS (wrt particular area, approaches or in respect of a unique phenomenon occurring in a place or regarding a particular practice in an area)*

Routes to & from in between key places within the coverage & routing information useful for inter oceanic passages.

This part of the publication is the essence of the book & constitutes the major portion of the volume. In addition to the recommended route, alternate routes, alteration points, routes for different seasons are given. Thus a navigator may make use of current & weather to the best of his advantage.

Book gives number of illustrative charts & diagrams showing principal routes between key places to guide a mariner in general. Additionally following charts are found.

a. World climatic charts for January / July.
b. World [Power / Sailing vessel] routes.
c. Tracks followed by Sailing & Auxiliary powered vessels
d. World ocean currents
e. Load line rules, zones, areas & seasonal periods.

OPW is kept up-to-date by periodical supplement. A small number of notices to mariners are published specially to correct sailing directions. A list of such notices in force is published at the end of each month in Weekly NM. Thus volume should be used in conjunction with the latest supplement & special notices to mariners as stated above.

Admiralty List of Radio Signals (ALRS)

Q. 32.3 Explain in brief, what information is provided by different volumes of Admiralty List of Radio Signals.

Ans.

Variety of Radio Information including information regarding relevant services etc. for the entire world, are covered in 6 volumes of Admiralty List Of Radio Signals, popularly known as ALRS.

ALRS volume 1 & 3 are published in 2 parts each. The two parts cover 2 different geographical areas of the world. ALRS volume 2 is also called NP 282, ALRS volume 3 as NP 283 & so on.

Different information covered by different volumes is as follows.

ALRS 1:-
Coast Radio Stations (public correspondence), Radio Medical Advice.
Reports of Quarantine, Pollution & Locust.
INMARSAT, Maritime Satellite Service, GMDSS, Distress & SAR procedure, Ship Reporting System.
Regulations for the use of Radio in territorial Waters & brief extract from 'The International Radio Regulations'.
Associated diagrams.
ALRS 2:
Radio Navaids :- Including Aero Radio beacon, Radio DF Stations, CRS giving QTG service, Calibration Stations, Racons & Ramarks.
Radio Time Signals, Legal Times, Standard Times.
Electronic Pos Fixing Systems. Associated Diagrams.
ALRS 3:-
Radio Weather Services & Navigational Warnings with other maritime safety information. Certain Meteorological Codes for the use of Shipping together with associated diagrams.
ALRS 4:-
List of Met. Observation Stations with associated diagrams. A digital version of this volume can be obtained in the form of 3.5" floppy disk. Order can be made on form provided in volume.
ALRS 5:-
Global Maritime Distress & Safety System (GMDSS); information, extracts from relevant International Radio Regulations & Services available to assist vessels using or participating in GMDSS. It also contains explanatory diagrams & extracts from International Radio Regulations.
ALRS 6:-
Provides information in respect of Pilot Services, Vessel Traffic Services and Port Operations. Now published in 5 parts. Areas covered by different parts are:Part 1,U K and Ireland, Part 2, Rest of Europe except mediterranean 286(3) Part 3, Mediterranean and Africa (including Persian Gulf),Part 4, Asia and Australia Part 5 Americas and Antarctica Includes maritime radio procedures essential to assist vessels requiring Pilots & / or entering port. Services to Small Crafts including information on Marina & Harbour VHF facilities. It also has procedures regarding sending ETA, requesting deep sea pilot, getting berthing information. Supplemented with over 75 associated diagrams.
ALRS 8:-
Satellite Navigation Systems, including comprehensive information on all aspects of satellite navigation systems & detailed explanations & advice on error sources.
ALRS9 or NP289 ALRS Small Craft: United Kingdom and the Mediterranean (including the Azores and the Canary Islands).
Corrections to ALRS volumes are published in WNM Editions under section VI. This section is separable from the rest of the booklet. Its also separately acquirable. Corrections are directly made in the volume by amending the text or pasting appropriately.

Sea distance tables

Q. 32.4 What publications are available on board ship to find navigable distances across the world.

Ans.
Navigable distances across the world may be found using Admiralty Distance Tables (ADT). It is also referred to as NP 350. Adm Dist Tables are published in 3 volumes, viz.

Vol. 1 NP 350(1): Atlantic Ocean & connected Seas.
Vol. 2 NP 350(2): Indian Ocean & connected Seas.
Vol. 3 NP 350(3): Pacific Ocean & connected Seas.

These distances are given in Nautical Miles (1852 m) & are the shortest navigable distance without considering the advantage of current & weather, as is done in OPW Trans-oceanic distances may be found by considering a linking port or position, common to both the oceans.

An easy distance guide, which has gained popularity on most ships is 'Reeds Distance Tables'. World map is divided in different coloured zones to form diagrammatic key for entering tables. These zones are named A,B,C,D,E etc. One may want to know distance between ports 'M' & 'N', which might be in zone E & B respectively. The mariner at once may open the relevant page of the book, showing tables of distances between ports of zone B & zone E.

Distances between major ports of the world especially from certain specific areas or falling under a particular category of tabulation, may be found in Brown's Almanac.
Distances along major routes between two ports may also be found in Routing Charts & Ocean Passages for the World.

Navigational Warnings

Q. 32.5 Write a short note on Navigational Warnings.
Ans.
Any change or development in an area, which may be of interest & is of navigational importance, e.g. long tow, in the area of dense traffic, Racon or Light becoming inoperative, new wrecks etc. must be conveyed to the shipping to promote safety. These may mainly be conveyed to the mariner by two methods:

(1) Normal navigational information by *Notices to Mariners.*
(2) More urgent navigational information by *Radio Navigational Warnings.*

There may be considerable delay in issuing of notices, due to many reasons. A relatively earlier warning of a navigational-change may be given by **Preliminary Notice** or **Navigational Warning.**

RADIO NAVIGATIONAL WARNINGS(ARE OF 3 TYPES)

→ *NAVAREA WARNINGS.*
→ *COASTAL WARNINGS.*
→ *LOCAL WARNINGS.*

NAVREA WARNINGS:
The world is divided in **16 NAVAREAS**. Navigational warnings for these areas are promulgated by World Wide Navigational Warning Service **(WWNWS)**, established jointly by **IHO** & **IMO.**

National coordinators for individual countries pass on Nav. Warnings originating from their respective countries, to *Area Coordinator.* These warnings are in English & useful for ships following main shipping routes through appropriate NAVAREAs.

COASTAL WARNINGS:
These normally supplement NAVAREA Warnings. These pertain only to coastal or near coastal regions & are issued by *National Coordinator.* Messages are in English & may also be in local language.
LOCAL WARNINGS:
Issued by Port or Naval Authorities. Information in these warnings may not be important for ocean going vessels & may only be in local language.

HYDROLANT & HYDROPACS:
Actually US is Area Coordinator for NAVAREA IV & XII, but above two warnings are issued by US Authorities, to cover rest of the world.

Annual summary of Admiralty Notices to Mariner

Q. 32.6 Write a short note on 'Annual Summary of Admiralty Notices to Mariner'

Ans.
Initial few notices, of each year deal with the same subject every year & are published with due modification & amendments, in 'Annual Summary of Notices to Mariner', in the month of January. The subjects are as follows:

01 *Admiralty Tide Tables, Addenda & Corrigenda.*
02 *Agent for the sale of Admiralty Charts & Hydrographic Publications.*
03A *Official Messages to British Flagged Merchant Ships - GBMS Organization.*
03B *Official Radio Messages to Merchant ships - The Allied Mercom System.*
04 *Distress & Rescue at Sea - Ships & Aircraft.*
04A *Distress & Rescue - Ship's Position & Reporting System.*
04B *The AMVER Organization.*
05 *Firing Practice & Exercise Areas.*
06 *Former Mine Danger Areas; Swept Routes & Instructions regarding Explosives picked up at Sea.*
07 *UK & USSR - Mutual Safety Procedures for Military Units & Formations outside Territorial Seas & Implications for Non Military Ships.*
08 *Information concerning Submarines.*
09 *British Isles - Warnings Broadcast by Coast Radio Stations & the BBC.*
10 *Minelaying & Mine Countermeasures Exercises.*
11 *North Atlantic Ocean - Ocean Weather Ships.*
12 *Territorial Waters & Fisheries Jurisdiction Claims.*
13 *World Wide Navigational Warning Service.*
14 *Availability of Notices to Mariners.*
15 *Under Keel Allowance.*
15A *Negative Storm Surges.*
16 *Protection of Historic & Dangerous Wreck Sites.*
17 *Traffic Separation Schemes.*
18 *Carriage of Nautical Publications.*
19 *Not issued.*
20 *Protection of Offshore Installations.*
21 *Canadian Charts & Publications Regulations.*
22 *US Navigation Safety Regulations Relating to Navigation, Charts & Publications.*

Reprints of 'Admiralty (T) & (P) notices' & 'Republished Australian or New Zealand (T) (P) Notices', which are in force on 1st January, are found in second half of 'Annual Summary to NM'. It also contains the reprints of all corrections to;
-Admiralty Sailing Directions,
-Mariner's Handbook &
-Ocean Passages for the World.

Indian Notices to Mariners

Q. 32.7 What are the contents of 'Indian Notices to Mariners'?

Ans:
Indian 'Notices to Mariners', Editions are published every fortnight. These are published by Naval Hydrographic Office, Dehradun. These fortnightly editions are very much similar to WNM of British Admiralty in most respects.
Its contents are:

I. Index of Charts affected. (List of Indian Charts & Indian Notices)
II. Permanent Notices. (Actual notices for correcting Indian Charts or small corrections)
III. Temporary & Preliminary Notices. (A list of those T & P Notices in force is published quarterly & text re published in Annual Edition of Indian Notices to Mariners).
IV. Marine Information.
V. Radio Navigational Warnings. (Only Warning pertaining to NAVAREA VIII [Indian Ocean] are reproduced in this section. Regarding the other NAVAREAS, HYDROPACKS & HYDROLANTS, only the serial numbers of Nav. Warnings in force are indicated in this section).
VI. Corrections to Sailing Directions. (A summary of corrections in force is issued in section VI of editions dated 1st Jan., 1st April, 1st July & 1st October.)

VII. Correction to List of Lights.
VIII. Correction to List of Radio Signals.

A Hydrographic Note (IH 8102), a form for sending a report based on observation differing from chart, is attached with NM Editions dated 1st of January, 1st April, 1st July & 1st October.

Chart Catalogue

Q. 32.8 Why is 'chart Catalogue' a very important publication?
Ans.
Chart Catalogue is an important nautical publication. Its most portion comprises of diagrammatic representation of Limits navigational charts in various regions. In addition to this the BA chart number, title of chart, date of publication, date of New Edition & Natural Scale for all the charts are shown in the geographical region. Catalogue also diagrammatically shows planning charts & small scale charts. In the beginning of catalogue a diagrammatic index of world region & hence different page of catalogue e.g. 'B' for SW England, D for Navigation to Sea etc. can be found.

It also gives the details of the agent from whom to procure them with price of each item. Its also referred to as NP - 131 & is published by Hydrographer of Navy, Taunton.

Chart Catalogue contains details regarding various Charts & publications, which may be known to Mariner prior purchasing the same. The information may be under one of the following heads.

- General Information.
- List of Admiralty Charts & Agents for sale of Chart & Publications.
- Numeric list of Charts & Publications.
- Limits of Admiralty Chart index.
- Limits of Small Scale Charts.
- List, chain details, title of Decca, Loran, Omega charts.
- Astronomical Charts regarding Azimuth, Stars, Ex-Meridian etc.
- Variation, Meteorological, Climate Charts.
- Time Zone, Load Line, Oceanographic, Water Density, Water Temperature, Current, Ice, Depth Contour, Bathymetric & Geophysical Charts.
- Stereographic & Gnomonic Charts.
- Wall & Outline Charts.
- Routing Charts.
- Fisheries Charts.

Catalogue also gives information regarding following products & services

1. Admiralty raster chart service
2. Small craft products
3. Wreck service
4. Tidal prediction

There is a provision for correcting the catalogue by the corrections obtained from WNM.

Guide to port entry

Q. 32.9 Why is 'guide to Port Entry' a very important publication?
Ans.
Guide to Port Entry (GPE), is published in two volumes covering the ports of entire world, giving variety of information regarding various aspects of ports. The information provided is thoroughly professional, & is of great value not only to ship Master but also to Chartrers, Owners & to various parties connected with shipping. Each volume is further divided in two parts. In first part description of port is given in very systematic way.

The second part consists of Yellow pages giving Plans & Mooring diagrams of various ports. GPE provides maximum details in minimum description, due to which a Ship's Officer finds it very useful & handy for reference. GPE generally describes a port under following headings:

PORT LIMITS
DOCUMENTS

PILOTAGE
ANCHORAGES
RESTRICTIONS
MAX. SIZE
HEALTH
RADIO, VHF, RADAR, TELEPHONE
POLICE, AMBULANCE, FIRE
EMERGENCY COORDINATION CENTRE
SERVICES (REPAIRS, SUPPLY OF CHARTS ETC., DERATTING, TANK CLEANING, SURVEY ETC.)
BANKS
STORING & STEVEDORING
SHIP SUPPLY SERVICE
SHORE LEAVE & IDENTITY CARDS
GARBAGE & WASTE OIL DISPOSAL
CURRENCY
SEAMAN'S CLUB
PORT REGULATIONS, SIGNALS
DEVELOPMENTS
DELAYS
SHIPMASTER'S / SHIP OFFICER'S REPORT
AUTHORITY, QUARANTINE, AGENTS.

Ship Master's report might give the current requirement of documents to be furnished before the Authorities & and certain other very handy information which is normally of great importance to a ship's master.

Tide related Publications

Q.32.10 List the different tide related Admiralty publications.

Ans

Admiralty Tide Tables (ATT) (NPs 201-204)
Worldwide coverage in 4 volumes, published annually. Provides daily predictions of time and height of high and low water for a substantial number of standard ports, secondary ports and the time height differences and harmonic constants for all ports where they are known. Thus,

NP No. Admiralty Tidal Tables (published annually)

201 Volume 1 United Kingdom and Ireland (including European Channel Ports).
202 Volume 2 Europe (excluding United Kingdom and Ireland), Mediterranean Sea and Atlantic Ocean
203 Volume 3 Indian Ocean and South China Sea (including Tidal Stream Tables).
204 Volume 4 Pacific Ocean (including Tidal Stream Tables for most European Waters e.g. Dover strait, N. Sea, France w. coast etc (approx 17 Editions.)

NP No. Co Tidal Atlases

214 Edition 2 Persian Gulf, 1999
215 Edition 1 South-East Asia, 1979 for 13 different areas covering different regions of the world. Including UK, Mediterranean, Red Sea, Indian Ocean Thailand, New Zealand, Pacific Ocean, Korea and Japan. Pacific, Antarctica are provided

Other Miscellaneous Tidal Publications are:

1. Admiralty Manual of Tides, 2. Admiralty Tidal Handbook No.1.(The Admiralty Method of Harmonic Tidal Analysis for long Period Observation). 3. Admiralty Tidal Handbook No. 2. Datums for Hydrographic Surveys. 4. Admiralty Tidal Handbook No. 3. Harmonic Tidal Analysis for short Period. 5. Loxon Binder for Admiralty Tidal Handbooks. 6. Tidal Harmonic Constants. 7.Dover, Times of High Water and Mean Ranges.

Newton Sir Isaac: *[1642- 1727]- Was born at Lincolnshire on Dec 25th 1642. His inventions started as young boy only. His contribution to mathematic physics & astronomy is unparallel. His research work in light, mechanics, calculus etc is incredible but he is most known for law of gravitational forces & motion. Modern tidal calculations & theories [equilibrium theory] originate from the theories & thoughts provided by Newton. Newton was a bachelor, MP from Cambridge University & a professor of mathematics. Newton might be the first person to report the principle of a sextant in the year 1700, this was not acknowledged due certain reasons.*

[Pic. Sir Isaac Newton]

Chapter 33: Theory of Tides

Creation of tides

Q. 33.1 How does Gravitation pull due to Moon & Sun create Tides?

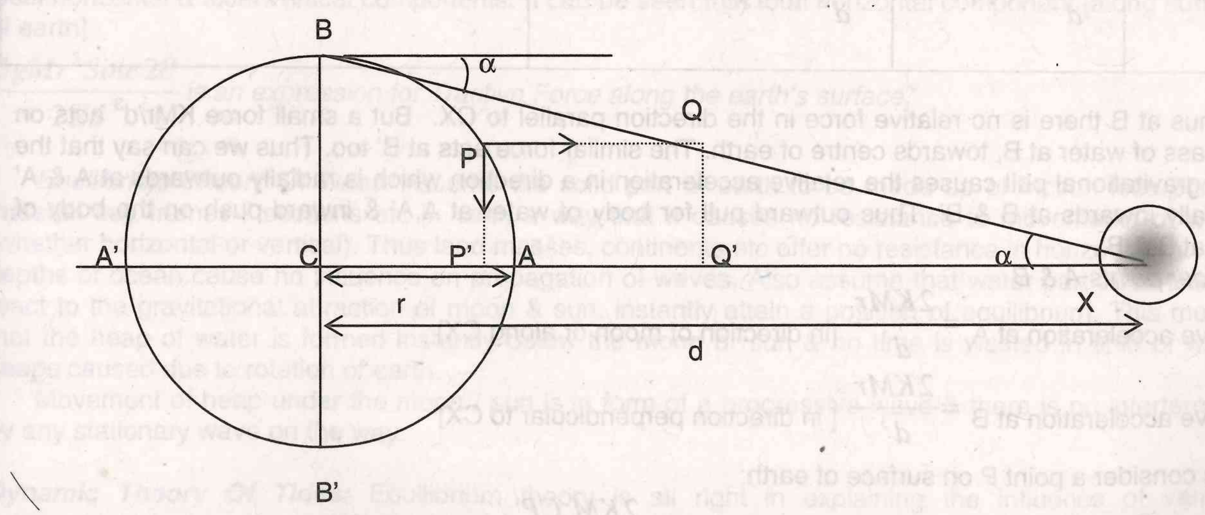


Fig 33.1

BAB'A' represents earth of mass = E. Let C be its centre.

X represents centre of moon whose mass = M
CX represents the distance between the centres of earth & moon & is equal to d, r is the radius of earth.
A unit mass of water on surface of earth at A is attracted by moon with a force,

$$= \frac{KM.1}{(d-r)^2} \ldots\ldots\ldots\ldots(1)$$

A unit mass of solid earth however,[being integrally attached to rigid earth] can be assumed as located at 'C' the centre of the earth.

The attraction force by moon there fore will be equal to, $\frac{KM.1}{d^2} \ldots\ldots\ldots\ldots\ldots(2)$

Force on unit mass is called acceleration. The relative acceleration exerted on water at A [as compared to adjacent earth] = (1)~(2)

After some approximation & assuming r/d ≈ 0 we get relative acc^n $= \frac{2KMr}{d^3}$

Similarly it can be shown that even the mass of water at position A' experiences a different lunar acceleration as compared with adjacent earth. In this case the acceleration on the water mass is smaller then that on the earth. The magnitude of difference in acceleration is again $= \frac{2KMr}{d^3}$

From above calculations it can be seen that the gravitational pull of moon causes a different acceleration on water masses at A & A' as compared to the integral rigid earth. Water mass at A experiences stronger acceleration than the earth & water mass at A' experiences weaker acceleration than the earth. As if the body of water at A wants to travel faster than the adjacent earth, towards the moon leaving the earth behind & also as if the earth wants to travel towards the moon leaving behind the body of water at A'. This causes the bulge or heap of water at A as well as A'

Let us now compare the force exerted on unit mass of water at B & unit mass of rigid earth at C.

Position	Force on unit mass	Component // to CX	Component $\perp_{ar}$ to CX
B	$\frac{KM.1}{d^2}(approx)$	$\frac{KM.1}{d^2} Cos\alpha = \frac{KM}{d^2}(appx)$	$\frac{KM.1}{d^2} Sine\alpha = \frac{KM}{d^2} \cdot \frac{r}{BX} = \frac{KMr}{d^3}(appx)$
C	$\frac{KM.1}{d^2}(approx)$	$\frac{KM.1}{d^2}(approx)$	Nil

Thus at B there is no relative force in the direction parallel to CX. But a small force KMr/d^3 acts on unit mass of water at B, towards centre of earth. The similar force acts at B' too. Thus we can say that the Lunar gravitational pull causes the relative acceleration in a direction which is radially outwards at A & A' & radially inwards at B & B'. Thus outward pull for body of water at A,A' & inward push on the body of water at B & B'.

Consider points A & B

Relative acceleration at A $= \frac{2KMr}{d^3}$ [in direction of moon or along CX]

Relative acceleration at B $= \frac{2KMr}{d^3}$ [in direction perpendicular to CX]

Let us consider a point P on surface of earth:

The relative acceleration at P in a direction // to CX$= \frac{2KM.CP'}{d^3} \ldots\ldots\ldots\ldots\ldots(3)$

Also the relative acceleration at P in direction perpendicular to CX$= \frac{KM.PP'}{d^3} \ldots\ldots\ldots\ldots(4)$

Relative acceleration in a direction // to CX is double of that in the direction perpendicular to CX. Make a rectangle PP'Q'Q so that PQ = 2PP'. The resultant acceleration in magnitude & direction will be $= \frac{KM.PQ'}{d^3}$ [This is called tide-generating acceleration due to moon]. Similarly tide-generating acceleration in case of Sun will be $= \frac{KSr}{d^3}$

Thus we find that tide-generating force is inversely proportional to the ***cube*** of earths distance from moon or sun. Through the pure gravitational pull is inversely proportional to ***square*** of the distances between two objects.

Acceleration caused on a sample mass at surfaces of earth by moon & gravitational acceleration caused by earth itself can be compared as follows:

g α E/r^2 & acceleration due to moon α M/d^2

The ratio of two $= \frac{acceleration\ due\ to\ moon}{g} = \frac{M}{d_1^2} x \frac{r^2}{E}$

or acceleration due to moon $= \frac{gMr^2}{Ed_1^2}$

This is how the acceleration due to moon can be written in terms of acceleration due to gravity. Equation (3) & (4), after modification & approximation can be written as follows [proof not included]

$$\frac{2gMr^3 Cos\theta}{Ed^3} \ldots\ldots\ldots\ldots // \ to\ CX \ldots\ldots\ldots\ldots(5)$$

$$\frac{2gMr^3 Sine\theta}{Ed^3} \ldots\ldots\ldots\ldots \perp ar\ to\ CX \ldots\ldots\ldots\ldots(6)$$

θ is the true zenith distance of moon from point P. These two components can be each resolved in to local horizontal & local vertical components. It can be seen that total horizontal component [along surface of earth]

$\frac{3gMr^3 Sine\,2\theta}{2Ed^3}$ *is an expression for Tractive Force along the earth's surface.*

Equilibrium Theory Of Tides: Assume the solid part of earth to be made up of friction less porous material say frames / sections etc in such a way that it causes no resistance to movements of water (whether horizontal or vertical). Thus land masses, continents etc offer no resistance in horizontal travel & depths of ocean cause no influence on propagation of waves. Also assume that water particles instantly react to the gravitational attraction of moon & sun, instantly attain a position of equilibrium. This means that the heap of water is formed instantly below the moon or sun & no time is wasted in shift of water heaps caused due to rotation of earth.

Movement of heap under the moon / sun is in form of a progressive wave & there is no interference by any stationary wave on the way.

Dynamic Theory Of Tides: Equilibrium theory is all right in explaining the influence of various astronomical factors in creating tidal forces, periodic HW's, LW & even the influence of declination of moon/sun in causing the variation of tide, but the fact remains that the assumption that rigid earth is made up of friction less porous material is not true. We will therefore introduce the existence of continents & land masses & restrict the depth of oceans (through which the tidal wave travels) to realistic level.

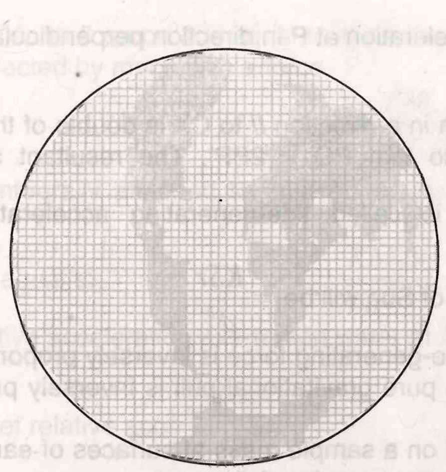


Fig 33.2

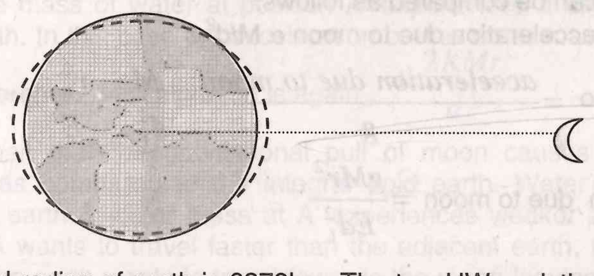


Fig 33.3

Introduction Of Oceanic Depths: Equatorial radius of earth is 6378km. The two HWs existing on opposite parts of earth make a tidal wave length equal to ½ the circumference of earth, i.e., approximately 20,000 km. A solar semidiurnal tidal wave over equatorial region may be traveling at 20,000/12 =1666km/hr. The frequency or velocity of tidal wave is a function of square root of water depth. For a tidal wave to travel at 1666km/hr the favourable depth of ocean should be over 22km, but the average depth of ocean is less than 4km. The tidal bulge or tidal wave as stated above would travel at about 700m/hr instead. This speed of bulge will depend on:

1. Tide generating force
2. Depth of ocean available.

Introduction of continents has 2 effects:

1. Obstruction to the movement of tidal bulge.
2. Creation of entrapped water masses or independent water basins helping in creating independent oscillatory waves to the tune basins size.

Obstruction by western edges of ocean basin

Water would pile against continent & cause pressure gradient. This pressure gradient is not astronomical but is terrestrial in origin. Drag a bucket half filled with water horizontally; see the pile of water on one side.

Pressure gradient causes flow of water down slope as a natural action. Coriolis force will deflect this flow. Coriolis deflection will be to the right in NH. This will cause a pile up towards south. An anticlockwise flow develops in Northern Hemisphere.

In a bucket of water if water is swirled it tends to pile up against bucket walls. Place a floating wooden /plastic chip on this swirling water. You will find a form of sine wave along bucket wall. The floating particle moves up & down in a cyclic way. Basin corners on the other hand are seen to perform up & down sea-saw movement about a central pivot position (node).

This movement of water over the basin tends to resemble a stationary wave. This rotary tidal motion about fixed node is termed as amphidromic system. The node at around centre of basin has steady water level & is called amphidromic point.

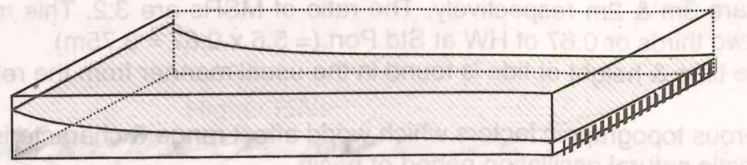


Fig 33.4

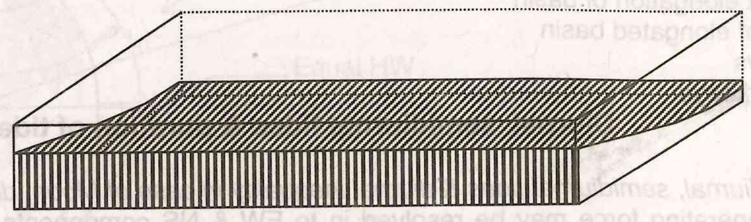


Fig 33.5

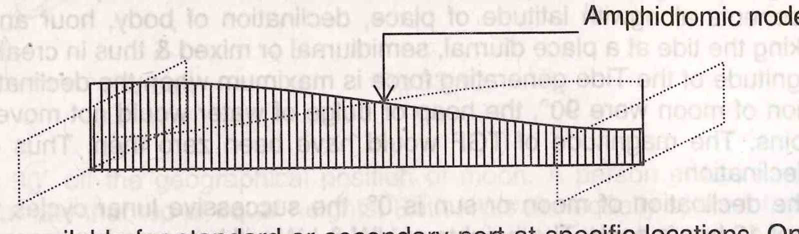


Fig 33.6

The Prediction is easily available for standard or secondary port at specific locations. One may want to find out height of tide, range etc for a position remote from the port. The predictions at the remote place may be found with the help of co-tidal charts. Co-tidal charts are accordingly prepared for certain areas where traffic around amphidromic point is dense & the deep drafted vessels may wish to seek the tidal height to find the under keel clearance. Co-tidal charts show the co-tidal lines which appear to radiate from amphidromic point & join the points of equal 'Mean High Water Interval (the mean time interval between the mer-pass of moon over Greenwich meridian & the time of next HW at the relevant place. Chart also shows Co-range lines which are the lines joining equal Mean Spring Range. (MSR = MHWS~MLWS)

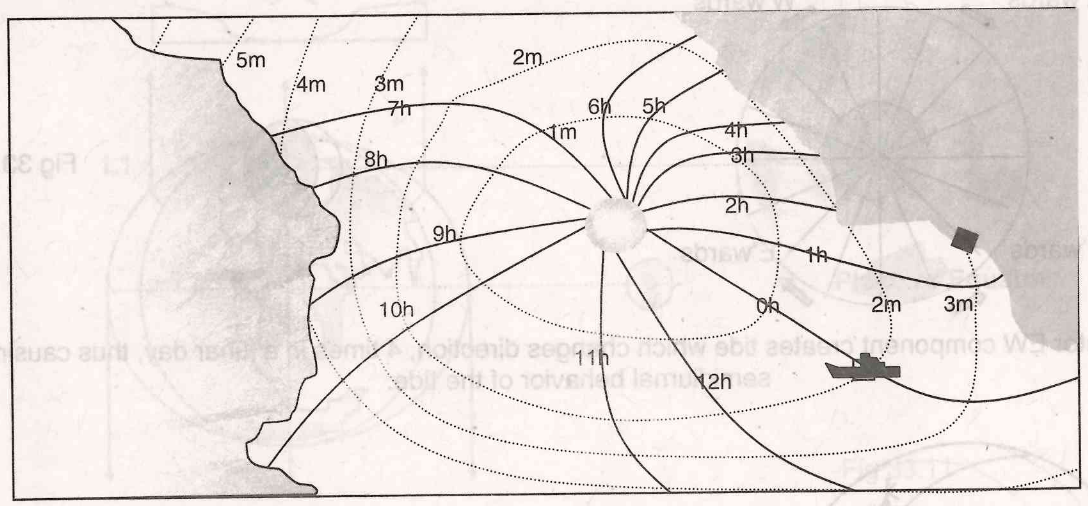


Fig 33.7

Let ◆ represent a standard port where the predictions on the date in question are as follows:

0230 5.6m HW
0845 2.2m LW

It is required to find the height of tide & the time of occurrence of HW at the ship's position.

Standard Port ◆ is between the co-tidal lines, 1h & 2h.(01h40m).

Ship is on the co-tidal line, 00h00m. i.e. the HW would occur 01h 40m before Std Port. The time of HW at ship's position will be 0230 – 0140 = 00h50m.

The MSRs are 3m & 2m respectively. The ratio of MSRs are 3:2. This means the HW at the ship's position will be two thirds or 0.67 of HW at Std Port.(= 5.6 x 0.67 = 3.75m)
The intermediate time & height of tide is found in the usual manner from the relevant curves provided.

There are numerous topographic factors which world affect range & characteristics of tide.
1. Characteristic natural oscillation period of basin
2. East west elongation of basin
3. Latitude of elongated basin
4. Open bays
5. Close end bays

Diurnal, semidiurnal tides & duration of tide

Q. 33.2 Show diurnal, semidiurnal tides & diurnal inequality in case of Moon, diagrammatically.
Ans. Tide generating force may be resolved in to EW & NS components along the Earth's surface. These components alongwith latitude of place, declination of body, hour angle of the body contribute towards making the tide at a place diurnal, semidiurnal or mixed & thus in creating diurnal inequality.

The magnitude of the Tide generating force is maximum when the declination of sun or moon is 0°. If the declination of moon were 90°, the heap or bulge of water would not move relative to the earth while the earth spins. The magnitude of TGF would have been zero then. Thus magnitude decreases with increasing declination.

While the declination of moon or sun is 0°, the successive lunar cycles will be of $12^h\ 25^m$ & solar cycle will be of 12 hours each. The heights of HW & LW will be same in successive cycles.

With the moon or sun having certain declination N or S, the successive cycle of HW-LW will be of different duration. The only latitude when duration of successive cycles are equal will be at equator with equal heights of HW & LW. As the latitude increases the difference in period of successive cycles increase too till you reach a latitude when sum (L+D) just equals 90°, when there is only cycle of HW & LW. We may say that, of the two successive cycles, the alternate cycle is of 0 hours duration & the other alternate cycle is bigger. The bigger cycle in case of sun is of 24h duration & in case of moon is of about $24^h\ 50^m$ duration.

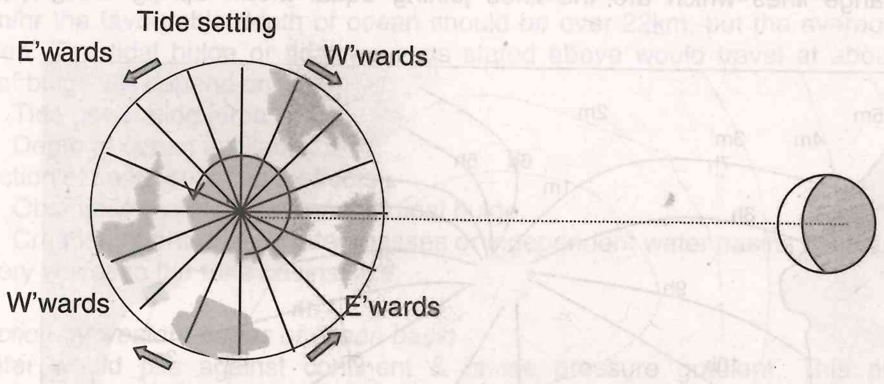


Fig 33.8

At equator EW component creates tide which changes direction, 4 times in a lunar day, thus causing semidiurnal behavior of the tide.

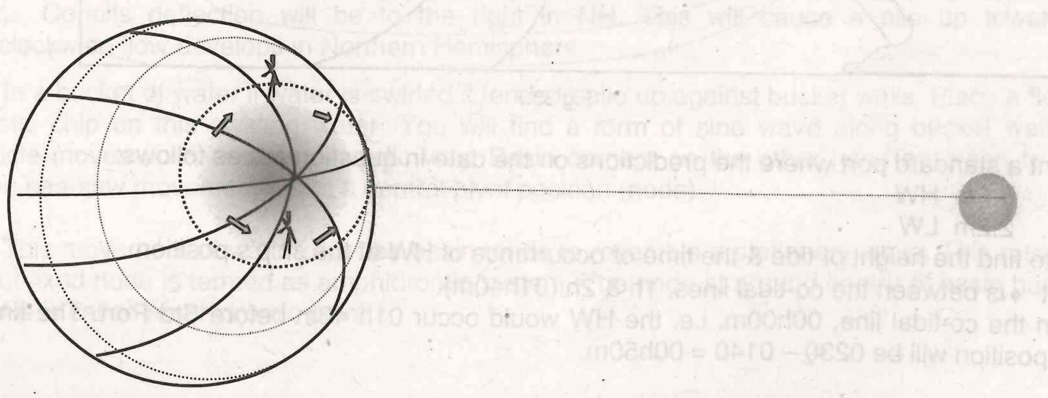


Fig 33.9

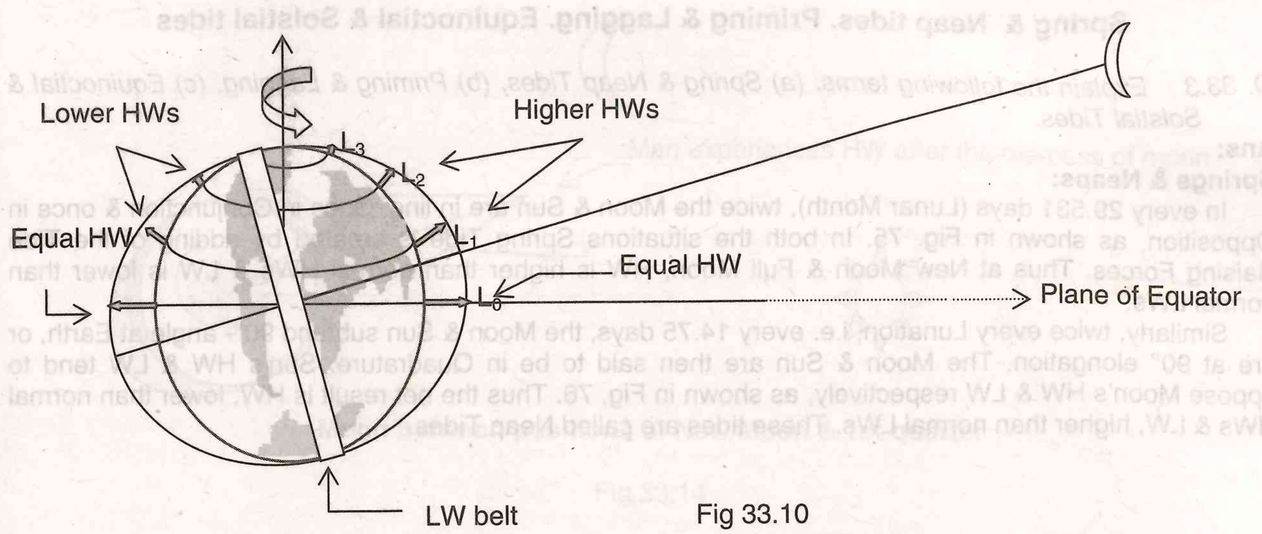


Fig 33.10

A belt of LW is seen 90° off the geographical position of moon. A person at L_0 i.e. at equator will experience 2 HW in 1 lunar day that too of equal heights. Both HWs are equally spaced from LW belt. At L_1 & L_2 the 2 HWs & 2 LWs will be experienced but as can be seen from the diagram, the HWs closer to line EX are higher than the other HW. Also the distances of these HWs from LW belt are different. Due to this the successive durations will be of different time. At L_3 & beyond this latitude there is going to be only 1 HW, as parallel does not go beyond the LW belt. In very high latitude thus tide which changes direction only 2 times in a lunar day, causing diurnal behavior of the tide.

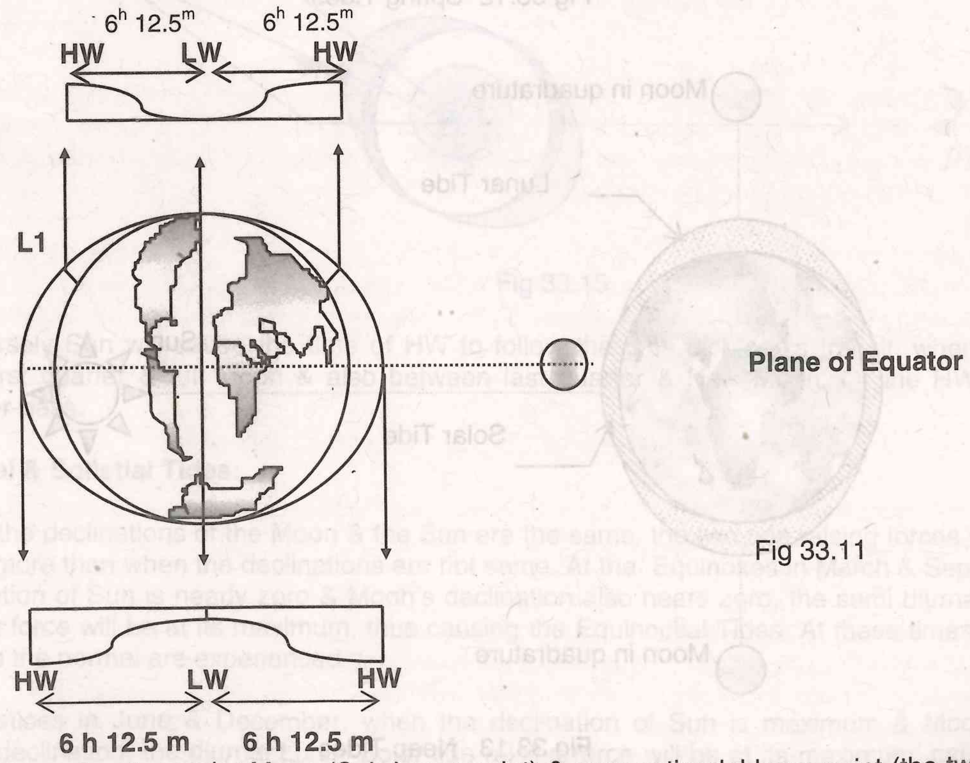


Fig 33.11

The heaps of water under Moon (Sub-Lunar point) & over antipodal lunar point (the two high waters) appear to be moving because the Earth underneath turns at a speed of 360° / 24 hr 50 min (aprox),wrt Moon.

Spring & Neap tides. Priming & Lagging. Equinoctial & Solstial tides

Q. 33.3 Explain the following terms: (a) Spring & Neap Tides, (b) Priming & Lagging, (c) Equinoctial & Solstial Tides.

Ans:

Springs & Neaps:

In every 29.531 days (Lunar Month), twice the Moon & Sun are in line. Once in Conjunction & once in Opposition, as shown in Fig. 75. In both the situations Spring Tide is created by adding of the Tide Raising Forces. Thus at New Moon & Full Moon, HW is higher than normal HWs & LW is lower than normal LWs.

Similarly, twice every Lunation, i.e. every 14.75 days, the Moon & Sun subtend 90°- angle at Earth, or are at 90° elongation. The Moon & Sun are then said to be in Quadrature. Sun's HW & LW tend to oppose Moon's HW & LW respectively, as shown in Fig. 76. Thus the net result is HW, lower than normal HWs & LW, higher than normal LWs. These tides are called Neap Tides.

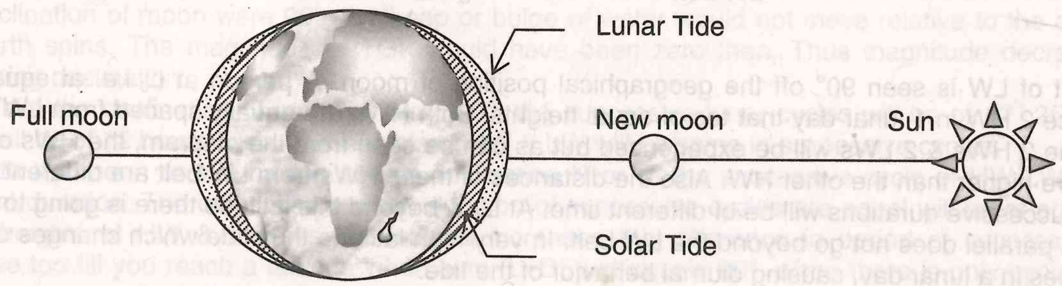


Fig 33.12 Spring Tides

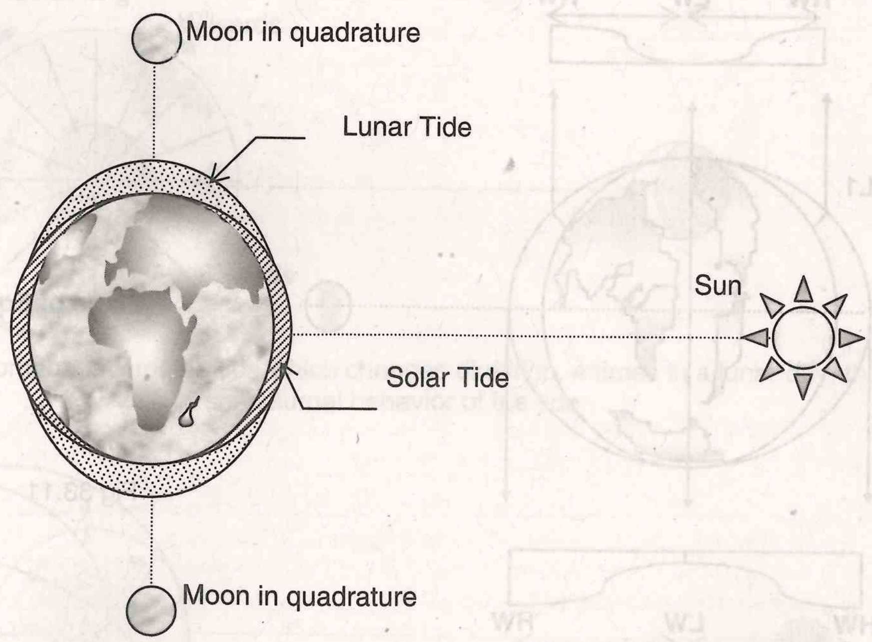
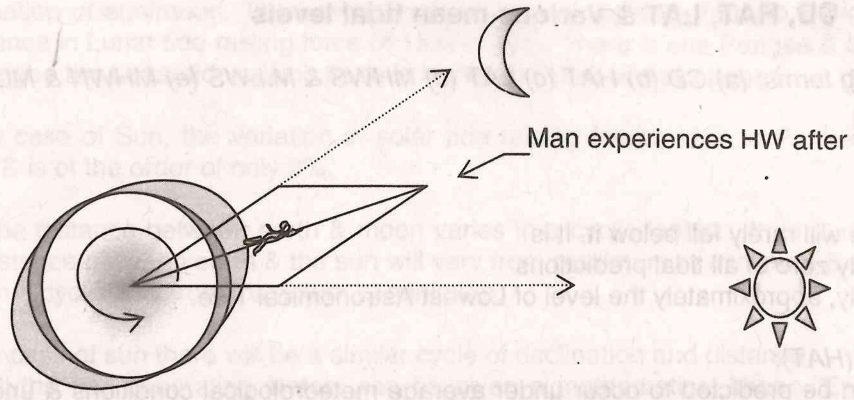


Fig 33.13 Neap Tides

Thus two spring & two neap tides will be experienced every Lunar Month. These tides do not, however synchronize the phases of Moon exactly, as stated above, because there is always a time lag between the action of the force & the reaction to it.



Moon between positions of New Moon & 1st quarter

Fig.33.14

Priming & Lagging:

Assuming that the positions of heap of water, Sun & Moon are stationary for some time. Then observer who is rotating along with Earth, will find Sun, heap & Moon in that order, on his meridian. Thus Sun's effect is to cause time of HW to precede the time of Moon's transit. This phenomenon is called Priming. Similar phenomenon will occur, when Moon is in a position after Full Moon & before 3rd quarter.

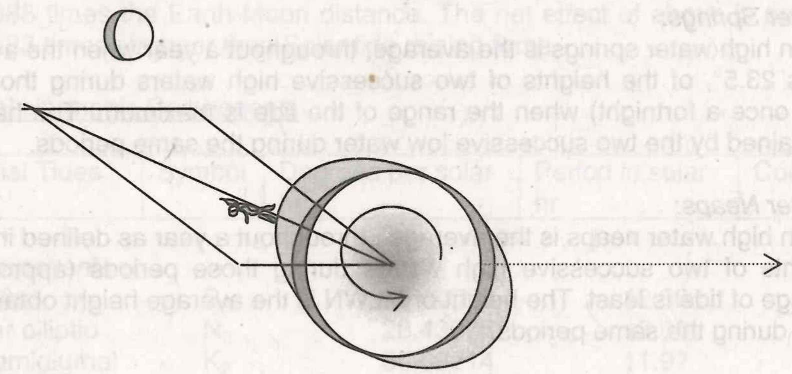


Fig 33.15

Conversely Sun will cause the time of HW to follow the time of Moon's transit, when the Moon is between first quarter & full Moon & also between last quarter & New Moon. Or the HW occurs after Moon's mer-pass.

Equinoctial & Solstial Tides:

When the declinations of the Moon & the Sun are the same, the two tide raising forces will tend to be in unison, more than when the declinations are not same. At the Equinoxes in March & September, when the declination of Sun is nearly zero & Moon's declination also nears zero, the semi diurnal Luni - Solar tide raising force will be at its maximum, thus causing the Equinoctial Tides. At these times Spring Tides higher than the normal are experienced.

At Solstices in June & December, when the declination of Sun is maximum & Moon also nears maximum declination, the diurnal Luni - Solar tide raising force will be at its maximum, causing Solstitial Tides. At these times, diurnal tides & the diurnal inequality are at maximum. It should be noted that unlike Sun, Moon reaches maximum declination to N & then S & back to N, every 27.322 days. The Moon's maximum declination varies between about 18.5°N / 28.5°N to 18.5°S / 28.5°S over an 18.6 year cycle.

CD, HAT, LAT & Various mean tidal levels

Q.33.4 Define the following terms: (a) CD (b) HAT (c) LAT (d) MHWS & M.LWS (e) MHWN & MLWN (g) MSL

Ans:

Chart Datum (CD):

A level so low, that the tide will rarely fall below it. It is

(1) Normally zero of all tidal predictions

(2) Normally, approximately the level of Lowest Astronomical Tide.

Highest Astronomical Tide (HAT):

Highest level which can be predicted to occur under average meteorological conditions & under any combinations of astronomical conditions. HAT,

(1) is not reached every year.

(2) may not be as high as the one caused by storm surges.

Lowest Astronomical Tide (LAT):

Lowest level which can be predicted to occur under average meteorological conditions & under any combinations of astronomical conditions. LAT,

(1) is not reached every year.

(2) may not be as low as the one caused by storm surges.

Mean High & Low Water Springs:

The height of mean high water springs is the average, throughout a year when the average maximum declination of Moon is 23.5°, of the heights of two successive high waters during those periods of 24 hours. (approximately once a fortnight) when the range of the tide is maximum. The height of MLWS is the average height obtained by the two successive low water during the same periods.

Mean High & Low Water Neaps:

The height of mean high water neaps is the average , throughout a year as defined in definition above (MHWS), of the heights of two successive high waters during those periods (approximately once a fortnight) when the range of tide is least. The height of MLWN is the average height obtained from the two successive low waters during the same periods.

Mean Sea Level:

The MSL is the average level which would exist in the absence of tides. Or the average level of sea surface over a long period, preferably 18.6 years. Mean Tide Level (MTL) can be calculated by meaning the heights of MHWS, MHWN, MLWN, & MLWS.

A few more factors affecting the tide at any place

Q. 33.5 Discuss the Simple Harmonic approach to the calculation of tidal height at a given place. what other factors affect characteristics of the tide at a place?

Ans.

Mathematical Approach To The Practical Prediction Of Tides:

Let the declination of sun be 0° & latitude of the place under consideration be also = 0°. A point on equator moves with respect to the sun at 15°/h. [Note 360°/24 = 15°/h]. But the bulge due to the sun is caused even at opposite point on earth. Therefore we may say the bulge or HW due to sun moves at double efficiency i.e. 15°x 2=30°/h. Under similar conditions the bulge of moon or HW due to moon may be assumed to travel at 2(360/24.84) = 28.98°/hr. In high latitudes the effect would be complex. Many other tide-affecting factors are cyclic. e.g. Every lunar month, the declination of moon changes from maximum north to maximum south. Every fortnight, there is a cyclic change of declination from 0° to maximum & vice versa. We have earlier seen that the tide raising force is has a relation with the

declination of sun/moon. The variation in the Moon's distance (due to Perigee & Apogee) can cause a difference in Lunar tide raising force of 15% to 20%. There is one Perigee & one Apogee every 27.3 days. At Perigee the Lunar tide raising force is higher than the one at Apogee.

In case of Sun, the variation in solar tide raising forces (due to Perihelion & Aphelion) is relatively small & is of the order of only 3%.

The distance between earth & moon varies in a cyclic fashion, thus during every revolution of moon the distance between earth & the sun will vary from maximum to minimum & hence the tidal force will also vary in a cyclic way from maximum to minimum.

In case of sun there will be a similar cycle of declination and distance.

All the tide generating factors can be given a mathematical shape. Each factor gives independent harmonic wave or independent partial tide. The actual tide observed would thus be algebraic combination of all the partial tides. As many as 400 such cyclic partial tides can be identified.

A combination of 7 major partial tides would give reasonably accurate results at a given port. Amplitude of the largest partial tide due to moon, [principal semidiurnal] may be considered 100 units on this scale. Main semidiurnal solar tide on the same scale will have amplitude of 46.6 units & so on.

The tide raising force caused by Sun is smaller as compared to the force caused by Moon. Even though Sun's average density is 3.91 times lower than Earth's average density, Sun because of its immense size can balance the mass of not less than 26 million Moons. Earth-Sun distance on the other hand is about 388 times the Earth-Moon distance. The net effect of above is that the Lunar tide raising force is about 2.33 times stronger than Solar tide raising force.

Principal Tidal Harmonic Components

Names of Partial Tides	Symbol	Degrees per solar hr	Period in solar hr	Coefficient ratio
Semidiurnal components				
Principal solar	S_2	30.00000	12.00	46.6
Langer lunar elliptic	N_2	28.43973	12.66	19.2
Lunisolar semidiurnal	K_2	30.08214	11.97	12.7
Larger solar elliptic	T_2	29.95893	12.01	2.7
Smaller lunar elliptic	L_2	29.52848	12.19	2.8
Lunar elliptic second order	$2N_2$	27.89535	12.91	2.5
Larger lunar evectional	V_2	28.51258	12.63	3.6
Smaller lunar evectional	λ_3	29.45563	12.22	0.7
Variational	μ_2	27.96821	12.87	3.1
Diurnal components				
Lunisolar diumal	K_1	15.04107	23.93	58.4
Principal lunar diurnal	O_1	13.94304	25.82	41.5
Principal solar diurnal	P_1	14.95893	24.07	19.4
Larger lunar elliptic	Q_1	13.39866	26.87	7.9
Smaller lunar elliptic	M_1	14.49205	24.84	3.3
Small lunar elliptic	J_1	15.58544	23.10	3.3
Long-period components				
Lunar fortnightly	M_f	1.09803	327.86	17.2
Lunar monthly	M_m	0.54437	661.30	9.1
Solar semiannual	Ssa	0.08214	2191.43	8.0

Later in this book tidal height calculation using 4 major partial tides is shown A simple Harmonic curve of there component would be as follows:

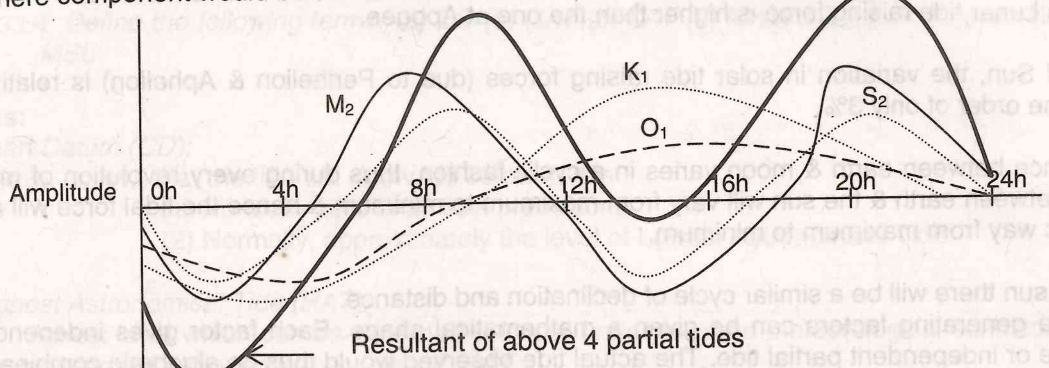


Fig 33.16

Terrestrial Factors

(a) *Size & shape of Oceans:* For tides to occur in a body of water, its essential that the tide raising forces are substantial & are acknowledged well by the water masses. For this to occur, water masses must, firstly be large enough & secondly should have appropriate natural period of oscillation. Atlantic tends to be more responsive to semi diurnal forces & thus is more influenced by phases of Moon than its declination changes. Thus largest tides will occur at springs near New or Full Moon. Pacific on the other hand is more responsive to diurnal forces. Thus largest tides are associated with greatest Luni - Solar declinations & thus will occur at solstices.
Mixed tides are characterized by large diurnal inequality.
Mediterranean & Baltic as bodies of water are too small to enable any effective tide change.

(b) *Shallow water effect:* A tidal wave upon entering shallow water tends to slow down steepening the wave front. This increases the height of waves. Due to this period of rise becomes shorter than period of fall. Thus range and / or period may be distorted due to shallow water.

(c) *Entering an estuary:* Amplitude of tidal wave increases considerably, as it enters an estuary, which normally is narrower as compared to a wider entrance. A large tidal range called Bore might occur as a result.

Difference between predicted height of tide & actual height of tide due to meteorological factors

Q. 33.6 Explain in brief effect of various unusual meteorological factors, which may cause the difference between predicted height of tide & the height of tide, observed.

Ans:
As stated earlier, the predicted times & heights should be accurate enough in average meteorological conditions. However the difference between the predicted & actual heights & times of tide are likely to be there if meteorological conditions are different from average.

(a) *Barometric Pressure:* A '34 millibars - difference' of Barometric pressure from average can cause a difference of about 0.3metre in height of tide. However the pressure change should be for considerable area. A low pressure will tend to raise the sea level.

(b) *Effect of Wind:* Effect of wind is variable & is not likely to follow a fixed thumb rule. The effect will depend on many factors such as,
(1) Topography
(2) Strength of wind
(3) Duration of continued blowing

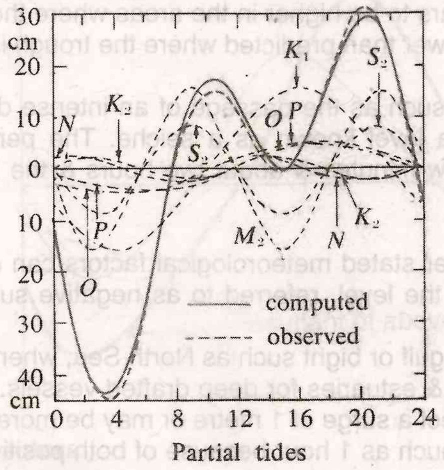
(4) Direction of wind w.r.t. coast, viz. on/offshore, or // to coast. Thus a strong onshore wind will have a piling effect to raise tidal level & vice-versa. Winds blowing along a coast tend to set up long waves, which travel along the coast. The sea level appears to be higher in the areas where the crest of the long wave is passing & sea level appears to be lower than predicted where the trough is passing.

(c) *Seiches:* Abrupt changes in weather conditions, such as the passage of an intense depression or line squall, may cause an oscillation in the sea level known as a seiche. The period between successive wave may be anything between a few minutes & about two hours & the height of the waves may be any thing from 1 cm up to 1 metre.

(d) *Positive & negative surges:* Combination of earlier stated meteorological factors can cause rise in sea level, referred to as positive surge & fall in the level, referred to as negative surge. A storm surge is severe positive surge.
Effect of positive surge is greatest while it affects gulf or bight such as North Sea, whereas negative surges can be very dangerous in shallow waters & estuaries for deep drafted vessels. Surging can be compounded by topography but one may expect a surge of 1 metre or may be more within a gulf or bight. HW, LW timings may be altered by as much as 1 hour because of both positive as well as negative surges.

(e) *Seismic waves (tsunamis):* Its usually the result of an undersea earthquake which sets up waves having no relevance with tides. These waves may be 100 miles long. The height may be very low while speeding through deep seas, but may become very high & devastating upon reaching shallow waters.

(f) *Tidal bore or Bore tide*
In a river if a large tidal range (Say more than 5m) combines with a gradually tapering basin & gradual decrease of depth up river; the water mass moving up river may take a shape of a water wall. Eg.5m high wall moving at 20 km/h in Amazon River & 8m high bore moving at 25 km/h in Fu Chun River in China.



Laplace: *[1749- 1827]- A French astronomer & mathematician. He had placed a popular theory of origin of solar system. He along with Newton is given credit for all modern work on the study of tides. He formulated the equations of motion for tides on a rotating earth Laplace was first to identify components of various tides.*

[Pic. Major Components of Tide added & compared to Observed Tide]

Chapter 34: Simple Tidal Calculations

ATT 1

STANDARD PORT

Prediction of tides, Std Port.

Q. 34.1 Find the tidal predictions for Portsmouth on 18th March,91. (ATT 1).

Hint.
Find out if the port is Standard or Secondary.
Standard ports are listed with page number on the back of front cover.
Standard ports are also marked in bold in the index at the rear part of the volume.
Standard port predictions are directly given on the relevant page of Part I as follows;

	MARCH	
	TIME	M
18	0020	4.6
	0535	0.4
M	1230	4.6
	1753	0.4

Note:
Predictions in part I are in the country's standard times & can be converted to GMT by direct application of Time Zone specified at the top corner of the page.
Datum for Tidal predictions must be same as datum for soundings on chart, as

'total depth at any place = charted depth + height of tide at that place'

Datum is normally adjusted to approximate LAT (Lowest Astronomical Tide). Thus if tide at any place falls to the level of LAT, the total depth at any place would become equal to charted soundings at that place. One should well understand that levels lower than LAT could be reached as an effect of particular meteorological condition. It may be said that the Tidal Level of a place should be same to Chart Datum of largest scale Admiralty Chart for that area.

Predictions in terms of GMT (Std Port)

Q. 34.2 Find out GMT & heights of HW & LW at Flushing on the AM of 3rd November,91.

Hint.
Flushing is Standard port. (As given in the back of front cover)
Time Zone = -0100

Predictions for AM	**3**	0540	0.8
		1129	4.2

Country's time + Time Zone = GMT.

Ans. GMT = 0440 & 1029 at LW & HW respectively.

To find the ht of tide at a given time (Std. Port)

Q. 34.3 Find out the height of tide at 0900 h local time, at Dover on 3rd March,92.

Hint.
Dover is Standard port included in ATT 1.
In ATT 1, Tidal curve diagram, along with graph to facilitate calculations is given for each standard port.
Predictions from part 1:

3	0543	1.1
	1041	6.0
	1800	1.2
	2252	6.3

Since we have to find the height of tide at 0900 h, we will only use the cycle of tide, which contains the time in question viz. 0900h Thus
LW at 0543 (1.1m) &
HW at 1041(6.0m) is the appropriate set.

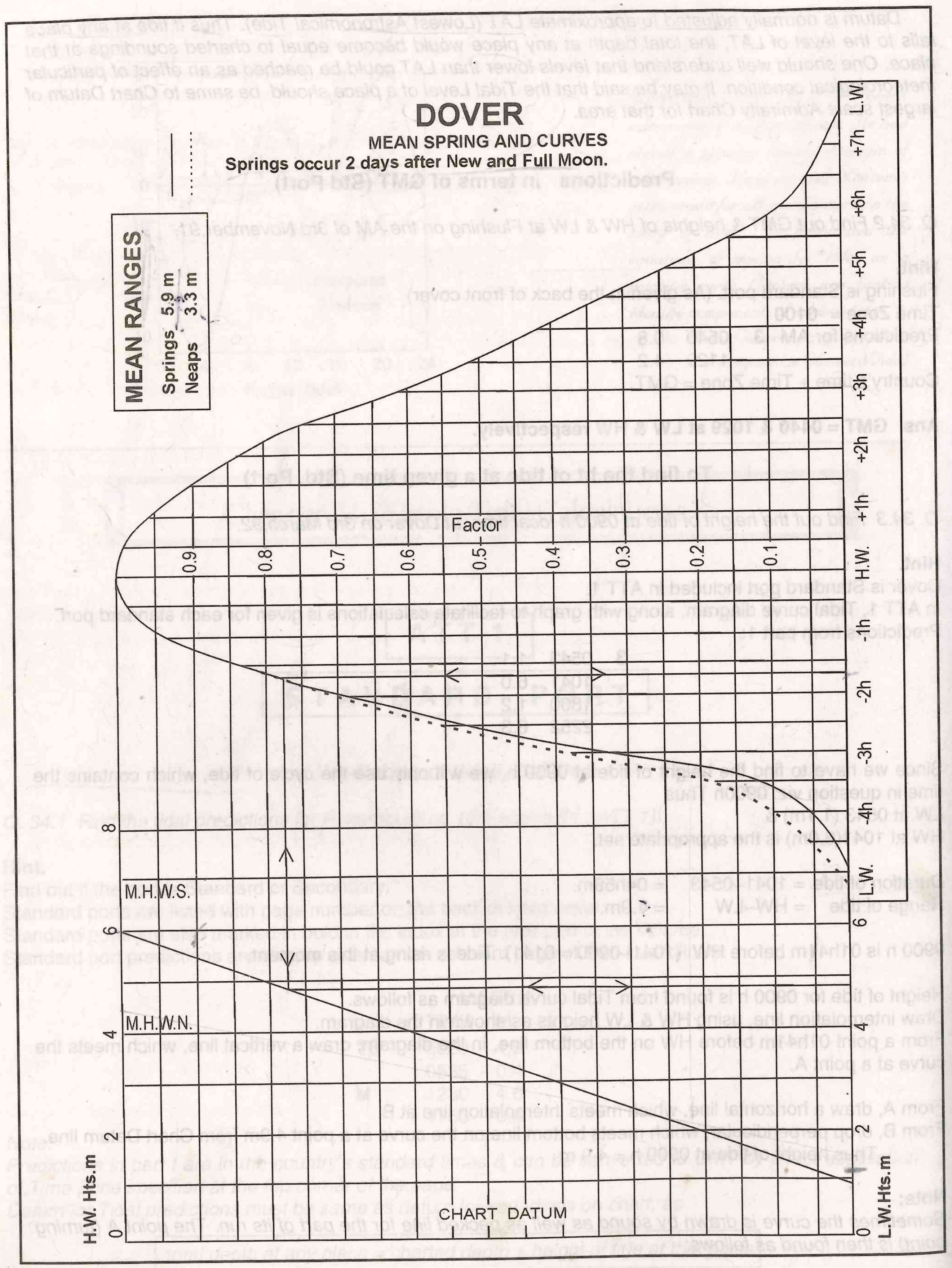
Duration of tide = 1041~0543 = 04h58m.
Range of tide = HW~LW = 4.9m.

0900 h is 01h41m before HW. (1041~0900 = 0141). Tide is rising at this moment.

Height of tide for 0900 h is found from Tidal curve diagram as follows.
Draw interpolation line, using HW & LW heights as shown in the diagram.
From a point 01h41m before HW on the bottom line, in the diagram, draw a vertical line, which meets the curve at a point A.

From A, draw a horizontal line, which meets interpolation line at B.
From B, drop perpendicular, which meets bottom line on the curve at a point 4.9m from Chart Datum line.
Thus height of tide at 0900 h = 4.9 m.

Note:
Sometimes the curve is drawn by sound as well as pecked line for the part of its run. The point A (turning point) is then found as follows:



If predicted range (4.9 m in above case) ≥ Spring range stated for the curve then A will lie on sound line. If predicted range ≤ Neap range, A will lie on pecked line. For intermediate values of predicted range i.e. Neap range < predicted range < Spring range, A will lie proportionately between the lines & can be found by visual interpolation.

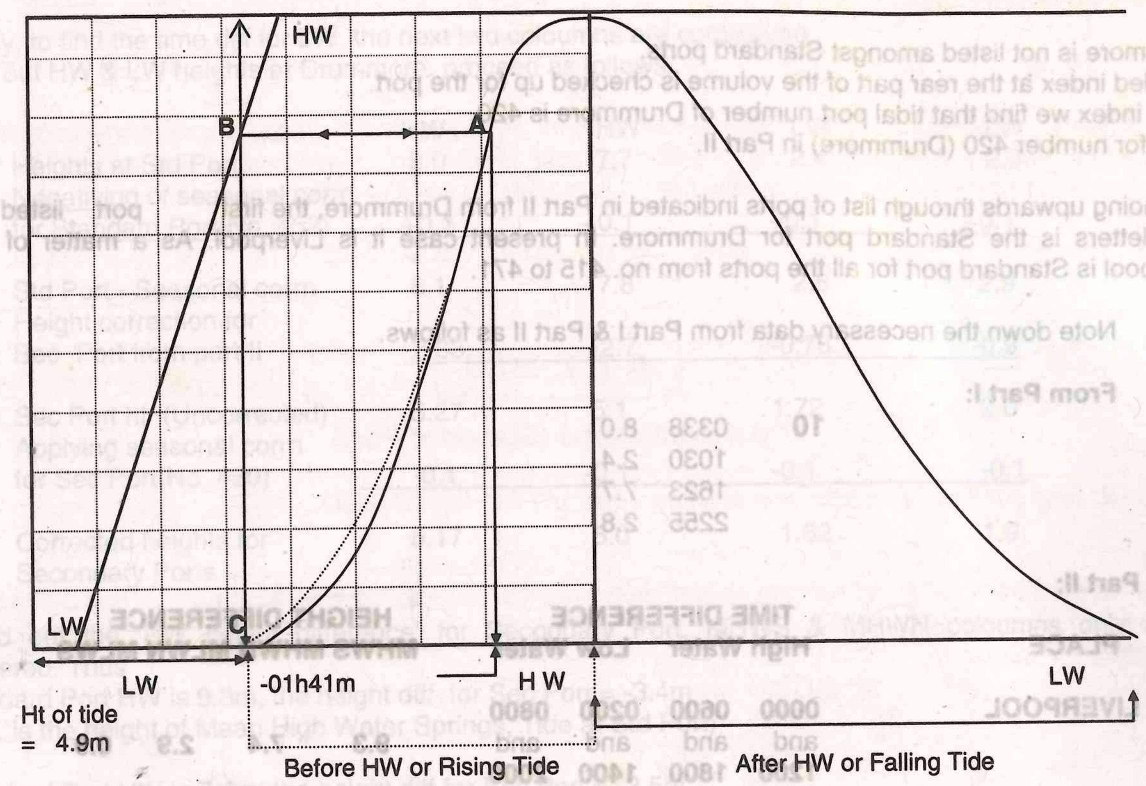


Fig. 34.2

To find the time when a particular tidal height is attained on a rising tide (Standard Port)

Q. 34.4 A position off Dover has a charted soundings of 5.4 m. When will the total depth in that position, increase to 10.3m, after 06h in the morning of 3rd March,92?

Hint.

Ht. of Tide = Total depth - Charted soundings.

∴ Ht. of Tide = 4.9m.

We will select same set of Tides as in last question. (Rising Tide)

Since the height of tide is known, we will enter the Tidal curve diagram with ht of tide. (Point C on tidal curve diagram).

From C go in a path, which is reciprocal to that of last question. (C to B to A etc)

We will reach a point 01h41m before HW.

01h41m before HW means 0900 h local time.

Ans. Thus total depth at 0900 h = 10.3m.

SEC PORT

To find tidal predictions (Secondary Port)

Q.34.5 Find the Tidal predictions for Drummore, for 10th April,92. (ATT 1)

Hint.
Drummore is not listed amongst Standard ports.
Detailed index at the rear part of the volume is checked up for the port.
From index we find that tidal port number of Drummore is 420.
Look for number 420 (Drummore) in Part II.

Going upwards through list of ports indicated in Part II from Drummore, the first port listed in bold letters is the Standard port for Drummore. In present case it is Liverpool. As a matter of fact Liverpool is Standard port for all the ports from no. 415 to 471.

Note down the necessary data from Part I & Part II as follows.

From Part I:

10	0338	8.0
	1030	2.4
	1623	7.7
	2255	2.8

From Part II:

No.	PLACE	TIME DIFFERENCE High Water		Low Water		HEIGHT DIFFERENCE MHWS	MHWN	MLWN	MLWS
452	**LIVERPOOL**	**0000 and 1200**	**0600 and 1800**	**0200 and 1400**	**0800 and 2000**	**9.3**	**7.4**	**2.9**	**0.9**
420	Drummore	+0030	+0040	+0015	+0020	-3.4	-2.5	-0.9	-0.3

SEASONAL CHANGES IN MEAN LEVEL

No.	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1
415-444				-0.1	-0.1
445-464				-0.1	0.0

To find the Tide timings at Drummore proceed as follows.

	HW	HW	LW	LW
Std Port timings	0338	1623	1030	2255
Time diff Sec Port	+0036	+0037.3	+0017.9	+0017.6
Sec Port timings	0414	1700.3	1047.9	2312.6

To find time difference for HW at secondary port, first two coloumns of time difference (concerning HW) only is considered.
To find time difference for 0338, we must consider time difference at 0000 h & 0600 h, as 0338 falls between 0000 h & 0600 h.
Thus for 0000 h time diff = +0030

& for 0600 h time diff = +0040
Interpolating between 0000 & 0600 we get time diff for 0338 as +0036.

Note:
We can not say that for 1800 h time diff. = +40 & for 2400 h time diff. = +30 & that the time diff for 0338 can be found by extrapolation. Extrapolation will give incorrect results. Hence choose the timing set within which Standard port timings to be corrected lies.

Similarly, to find the time diff for LW, the next two coloumns are considered.
To find out HW & LW heights at Drummore, proceed as follows.

	HW	HW	LW	LW
Heights at Std Port	8.0	7.7	2.4	2.8
Negativing of seasonal corrn for Standard Port(No. 452)	+0.1	+0.1	+0.1	+0.1
Std Port - Seasonal corrn	8.1	7.8	2.5	2.9
Height correction for Sec Port from part II	-2.83	-2.7	-0.78	-0.9
Sec Port ht (Uncorrected)	5.27	5.1	1.72	2.0
Applying seasonal corrn for Sec Port(No 420)	-0.1	-0.1	-0.1	-0.1
Corrected heights for Secondary Ports	5.17	5.0	1.62	1.9

To find out the 'HW height difference' for Secondary Port, MHWS & MHWN coloumns only are considered. Thus
If Standard Port HW is 9.3m, the height diff for Sec Port = -3.4m
(9.3 m. is the height of Mean High Water Springs, Tide at Std Port)

If Standard Port HW is 7.4m, the height diff for Sec Port = -2.5m
(7.4 m is the height of Mean High Water Neaps, Tide at Std Port)
If Standard Port HW is 8.1m, the height diff for Sec Port = -2.83m

Note:
Height difference corresponding to a given HW at Standard Port may be found by interpolation or extrapolation

Note: Extrapolation may be done some times, when HW or LW is outside the Spring- Neap values. e.g. in above case if HW was 9.5m > 9.3 or if HW was 6.8 < 7.3, the time difference would have been found by extrapolation.

Similarly, to find out the 'LW height difference' for Secondary Port. MLWS & MLWN coloumns only are considered.

Ans. Thus predictions for Sec Port are as follows;

0404	**5.17m**
1047.9	**1.62m**
1700.3	**5.0 m**
2312.6	**1.9m**

Note:
One need not worry about the difference in Chart Datums at Standard Port & Secondary Port. Necessary allowance is made in preparing the height difference for the Secondary Port, so that the height obtained for Secondary Port as above is above Chart Datum at Secondary Port.

One also need not worry about the difference in Time Zones of Standard & Secondary Port Adjustment is made in providing the time difference for the Secondary Port, so that the Tide timings obtained for Secondary Port, show the local time of Secondary Port.

For certain ports the time difference in Part II is replaced by "p", which means no suitable Standard Port is available & predictions can only be made by using Simplified Harmonic Method of prediction. Although height differences are included for these ports in order to find out tidal levels, but should not be used for obtaining daily predictions. e.g.

1296	Horten	59 26	10 29	*p*	*p*	*p*	*p*	-1.1	-0.8	-0.4	-0.1	0.24

In certain other cases, where intermediate heights are important or crucial, especially associated with large tidal range, Simple Harmonic Method of tidal predictions is advised. Thus in Part II, normal differences in time & height are provided but "c" is marked at the end of line e.g.

166	Boston	52 58	00 01	0000	+0010	+0140	+0050	-0.5	-1.0	-0.9	-0.5	3.31	c

ATT 2/3

Tidal predictions (Standard Port)

Q. 34.6 Find out predictions for tide at Cape Town,(ATT 2) on 28.04.92.

Hint.

Standard port HW & LW heights as well as timings can directly be read from part I. Thus procedure is same as ATT 1. Same procedure is followed for ATT vol 3. Tidal calculations are similar for ATT vol. 2 & 3. Thus,

	Time	m
28	0027	1.5
	0644	0.6
	1254	1.4
	1855	0.6

To find height of tide at any time on falling tide (Standard Port)

Q. 34.7 Find out height of tide at Masqat at 0600 h on 10.04.92.

Hint.

The curve shown in the beginning of Tide Tables approximates to a cosine curve & is usable for all the Standard Ports & large number of Secondary Ports. The curve is usable provided following criteria are satisfied:

(a) The duration of rise or fall must lie within the scope of graphs i.e. between 5 & 7 hours.

(b) There must be no shallow water correction (f4,F4,f6 & F6) shown in part III.

Masqat is Std Port.

Data from Part I

10	0105	2.4
	0824	0.8
	1601	2.4
	2113	1.8

To find out height of tide at 0600 h we will take corresponding set of HW & LW, as follows.

HW	0105	2.4
LW	0824	0.8

Duration of tide = 0824 ~ 0105 = 0719 h, which is more than 7h

From Part III it can be seen that Masqat has no shallow water corrections.

Criteria (a) is not satisfied, hence intermediate tide calculations should be done by the use of Simple Harmonic Method of Tidal Prediction (NP 159).

To find earliest time to sail out on a rising tide (Standard Port)

Q. 34.8 A vessel at even keel draft of 9.4 m. wants to sail out from Masqat as soon after sunrise as possible. Sailing is subject to enough water over a shoal, (marked 9 m.) at the entrance to the approach channel. At least a clearance of 1 m. is desired over the shoal. What is the earliest time at which the vessel can sail out on 20th Feb,92.

Hint.

Data from part I:

	20	0453	0.7
		1059	2.8
		1658	0.7
		2319	3.0
Relevant set of tides =		0453	0.7
		1059	2.8

Criteria (a) & (b) as stated in Q 89 is satisfied, hence the tidal curve diagram given in the beginning of the tables, may be used to assist in calculations of time of tide.

In present case duration of tide = 0606.

Since "earliest time of sailing" is asked, we will use the portion of tide before HW.

Since the duration is 06h 06m, we will interpolate between lines marked for 6 h & 7h.

Draw interpolation line using values:

LW = 0.7

HW = 2.8

Drop vertical line corresponding to height of 1.4 m., on interpolating line, then go horizontally till a point corresponding to duration of 06h 06m (visual interpolation), which lies between the rising side curves for the duration of 6 h & 7 h Then go vertically downwards, meeting the time axis at point - 03h40m. This means that the height of tide of 1.4 m. will occur at a time, 03h40m before HW. 1059~0340 = 0719 h.

Ans. Vessel must pass the shoal at 0719 LT.

To find height of tide at a given GMT on a falling tide (Std Port)

Q. 34.9 Find out the height of tide at Suez at 1100 h GMT on 28.04.92.

Soln.

Standard port's time zone = -0200

Data from part I **28**	0217	0.8
	0842	1.6
	1430	0.8
	2106	1.7

Criteria (a) & (b), stated in earlier questions are satisfied.

Local time + (-0200) = GMT = 1100

∴ LT = 1300h

Relevant tidal set =	0842	1.6m	HW
	1430	0.8	LW

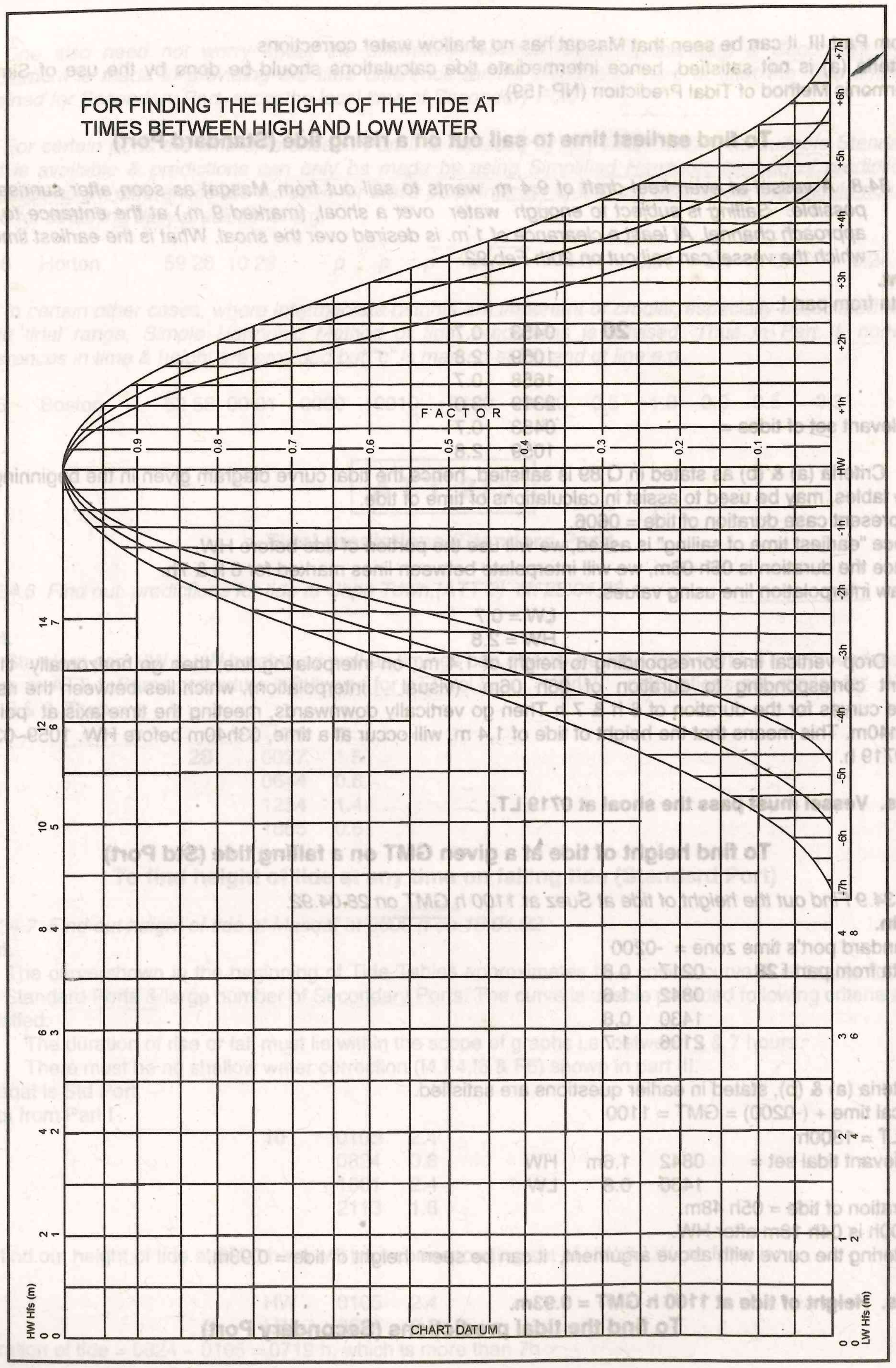
Duration of tide = 05h 48m.

1300h is 04h 18m after HW.

Entering the curve with above argument, it can be seen height of tide = 0.93m.

Ans. Height of tide at 1100 h GMT = 0.93m.

To find the tidal predictions (Secondary Port)



Q. 34.10 Find out tidal predictions for Navlakhi (no. 4331) on 01.03.92.

Hint.
Navlakhi is not a standard port.
From index we reach part II, where we find standard port to be Bombay.
Semidiurnal tides occur at Navlakhi & Bombay.
Tide times at secondary ports are found by direct application of time difference given for MHW & MLW.
Tidal heights at secondary port are found in same way as in case of secondary port-tidal heights of ATT.
Data from part I & II:

29	2228	3.7	HW
1	0453	1.9	LW
	1022	3.3	HW
	1610	1.2	LW
	2300	3.9	HW

From Part II:

No.	PLACE	TIME DIFFERENCE MHW	MLW	HEIGHT DIFFERENCE MHWS	MHWN	MLWN	MLWS
4359	**Bombay**			4.4	3.3	1.9	0.8
4331	Navlakhi	+0250	+0330	+2.8	+2.9	+ 0.2	00

SEASONAL CHANGES IN MEAN LEVEL

No.	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1
4359			0.0		
4331			-0.1		

To find the Tide timings at Navlakhi proceed as follows.

	HW	HW	LW	LW
Std Port timings 29th	2228	1st 1022	0453	1610
Time diff Sec Port	+0250	+0250	+0330	+0330
Sec Port timings	1st 0118	1312	0823	1940

	HW	HW	LW	LW
Heights at Std Port	3.7	3.3	1.9	1.2
Negativing of seasonal corrn for Standard Port(No. 4359)	00	00	00	00
Std Port - Seasonal corrn	3.7	3.3	1.9	1.2
Height correction for Secondary Port	+2.86	+2.9	+0.2	+0.06
Secondary Port ht	6.56	6.2	2.1	1.26
Applying seasonal corrn for Sec Port (No. 4331)	-0.1	-0.1	-0.1	-0.1
Corrected heights for Secondary Ports	6.46	6.1	2.0	1.16

To find tidal predictions for Secondary port

Q. 34.11 Find tidal predictions for Ras al Khafji on 18.01.92.
Sol.
Ras al Khafji is not a Std Port.
No. is 4260 C.
Std. Port is Mina al Ahmadi.
Tide timings show considerable diurnal inequality (i.e. duration between HW & LW is unequal & this inequality or difference in duration is considerable).

In part II average heights of higher & lower high & low water are indicated instead of MHWS, MHWN, MLWN, MLWS.

Calculations for secondary port however are done in the same way except that MHHW & MLHW are used for interpolation or extrapolation, instead of MHWS, MHWN respectively. Also MHLW & MLLW are used instead of MLWN & MLWS respectively.

Data from part I & II.

18	0432	0.5
	1145	2.2
	1526	1.9
	2129	3.1

From Part II:

No.	PLACE	TIME DIFFERENCE HHW	LLW	HEIGHT DIFFERENCE MHHW	MLHW	MHLW	MLLW
4262	**Mina al Ahmadi**			2.7	2.2	1.5	0.5
4257	Manifah	p	p	-1.4	-1.3	-0.6	-0.2
4260C	Ras al Khafji	+0002	+0022	-1.0	-0.8	-0.3	0.0

SEASONAL CHANGES IN MEAN LEVEL

No.	Jan. 1	Feb. 1	Mr. 1	Apr. 1	May 1
4231 to 4268	-0.1	-0.1			

To find the Tide timings at Ras al Khafji proceed as follows.

	LW	LW	HW	HW
Std Port timings	0432	1526	1145	2129
Time diff Sec Port	+0022	0022	+0002	+0002
Sec Port timings	0454	1548	1147	2131

	LW	LW	HW	HW
Heights at Std Port	0.5	1.9	2.2	3.1
Negativing of seasonal corrn for Standard Port(No 4262)	+0.1	+0.1	+0.1	+0.1
Std Port - Seasonal corrn	0.6	2.0	2.3	3.2
Height correction for Secondary Port	-0.03	-0.46	-0.8	-1.2
Sec Port ht(Uncor)	0.57	1.54	1.5	2.0
Applying seasonal corrn for Sec Port (No 4260c)	-0.1	-0.1	-0.1	-0.1
Corrected heights for Secondary Ports.	0.47	1.44	1.4	1.9

Ans. **Predictions for Ras al Khafji**

0454	**0.47**
1147	**1.40**
1548	**1.44**
2131	**1.90**

Note:

One need not worry about the difference in Chart Datums at Standard Port & Secondary Port. Necessary allowance is made in preparing the height difference for the Secondary Port, so that the height obtained for Secondary Port as above are above Chart Datum at Secondary Port.

One also need not worry about the difference in Time Zones of Standard & Secondary Port Adjustment is made in providing the time difference for the Secondary Port, so that the tide timings obtained for Secondary Port, show the local time of Secondary Port.

To find tidal predictions at (Secondary Port)

Q. 34.12 Find out tidal predictions for Hamelin Bay (Australia, ATT III) on 19.02.92.

Hint.

Hamelin Bay is not a Std Port.

No as per index = 6216.

Data from part I & II

18	1002	1.0
	1807	0.3
19	0024	0.5
	0257	0.5
	1031	0.9
	1815	

From Part II:

No.	PLACE	TIME DIFFERENCE HHW	LLW	HEIGHT DIFFERENCE MHHW	MLHW	MHLW	MLLW
5339	**Tanjong Priok**			**0.9**	Δ	Δ	**0.3**
6216	Hamelin Bay	+1230	+1230	-0.1	Δ	Δ	+0.1

SEASONAL CHANGES IN MEAN LEVEL

No.	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1
5339			negligible		
6216	-0.1	-0.1	-0.1		

To find the Tide timings at Hamelin Bay proceed as follows.

	LW	HW	LW	HW
Std.Port timings	1807	0024	0257	1031
Time diff Sec Port	+1230	+1230	+1230	+1230
Sec Port timings	0637	1254	1527	2301

To find heights at Secondary Port:

	LW	HW	LW	HW
Heights at Std Port	0.3	0.5	0.5	0.9
Negativing of seasonl corrn for Standard Port(No. 5339)		negligible		
Std Port - Seasonal corrn	0.3	0.5	0.5	0.9
Height correction for Secondary Port	+0.1	+0.03	+0.03	-0.1
Sec Port hts(uncor.)	0.4	0.53	0.53	0.8
Applying seasonal corrn for Sec Port (No. 6216)	-0.1	-0.1	-0.1	-0.1
Corrected heights for Secondary Ports	0.3	0.43	0.43	0.7

Note: Tides at both Standard as well as Secondary Port are diurnal. Only one HW & one LW height difference is tabulated in part II. Difference for each tidal level must be obtained by interpolation or extrapolation, using these values (one HW & one LW) against each of tidal heights at Standard Port.

ADMIRALTY TIDE TABLES, COVERAGE & GENERAL ARRANGEMENTS

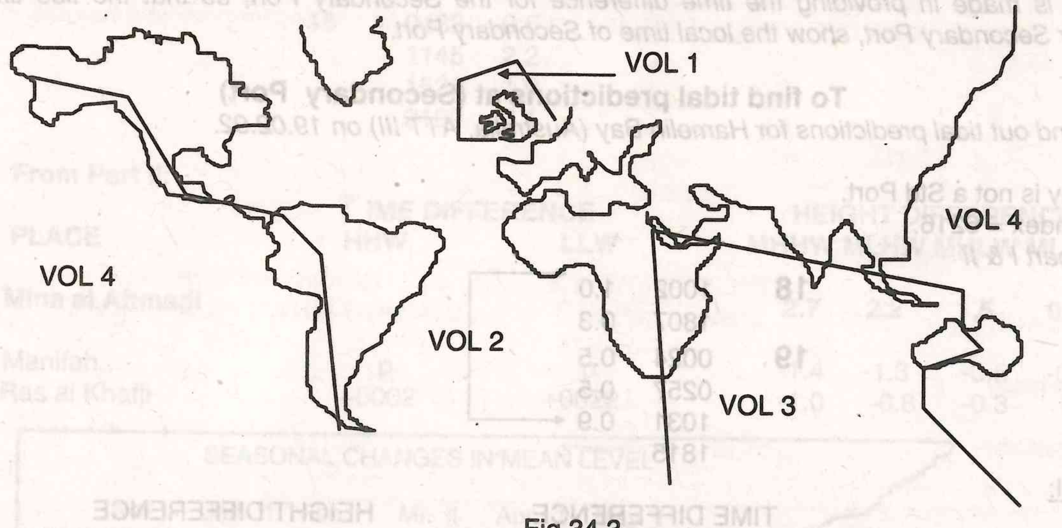


Fig 34.3

Admiralty Tide tables provide predictions of times & heights of high & low water. Each tide table has selected number of standard port & a large number of secondary ports. Part III of each volume list information regarding harmonic constants. Tables also give information regarding tidal stream of limited number of ports.

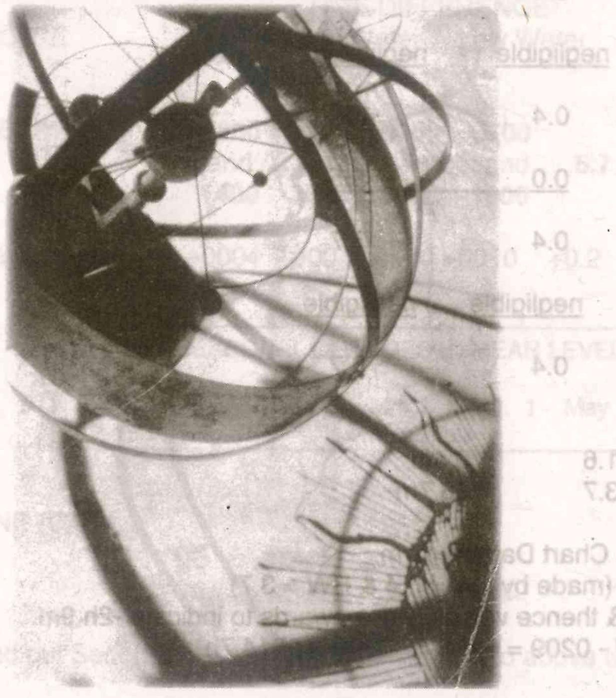
Tide tables were covered under 3 volumes earlier viz.
Vol 1: European waters (including Mediterranean).
Vol 2: Atlantic & Indian Ocean
Vol 3: Pacific Ocean & adjacent seas.

Solved examples, are done for the year 1992. (Tables in 3 volumes).
Now Admiralty Tide Tables are published annually in 4 volumes as follows:

Volume 1:	UK & Ireland (including European Channel ports)
Volume 2:	Europe excluding UK & Ireland, Mediterranean & Atlantic Ocean.
Volume 3:	Indian Ocean & South China Sea.
Volume 4:	Pacific Ocean (including tidal stream tables.)

Thus ATT vol 1 contains only UK & Ireland areas & remaining European ports are included in ATT volume 2. Thus ATT volume now has remaining European (including Mediterranean) ports & Atlantic areas from previous ATT volume 2. Earlier ATT 2 covered Atlantic & Indian Ocean areas, now Indian Ocean areas are covered in ATT volume 3. Earlier ATT 3 areas are now covered in ATT 4.

Method of predicting: which is discussed for finding predictions for ports of ATT1 can be used for UK, Ireland ports (ATT 1), as well as for European ports of volume 2. Also method of predicting which is discussed for finding predictions for ports of ATT 2 & 3 can be used for other ports i.e. remaining ports in ATT 2, Ports of ATT 3 ATT 4.



Indian Vedas & Astronomy: *Vasishtha, Parasara & Garga were the Vedic stalwarts in astronomy. Yajurveda 3.6 states that earth revolves round the sun & moon round the earth. All [celestial bodies are kept in their position by the force of attraction. Concept of Aakershan (gravitational attraction) was known. Relative sizes of sun, earth & moon are referred to in Atharvaveda 14.1-1-12. Rig Veda explains the occurrence of Eclipses, constellations, propelling of a ship through ocean by gases. Precession of Equinoxes, Sidereal & Tropical Year etc.*

[Pic. A model of Celestial Sphere showing Ecliptic & Equinoctial]

Chapter 35: More Examples on Tide

To find time at which a particular height of tide will be reached on a falling tide (Secondary Port)

Q. 35.1 Find out earliest time on AM of 22nd January 92, so that a ship of draft 8m can pass over the shoal, to sail out, keeping allowance of one meter under the keel, while passing the shoal (marked 6 m on chart) near the entrance to Setubal. (No. 1744, ATT 1)

Hint. *Maximum. draft + U/K clearance = Charted depth + Height of tide.*

∴ Ht of tide = (8+1) - 6 = 3 m.
Ship has a chance to sail out, if the height of tide is 3 m. or more while crossing the shoal marked 6 m.
Setubal is Secondary port. (No. 1744)
From Part II, Std. Port is Lisbon. (No. 1741)
Pick up relevant data from part I & II.
Thus,
TIME ZONE **(GMT)**

21	2158	0.4	LW
22	0443	4.2	HW

We will find out Secondary Port prediction relevant to above two tides. Thus

	LW	HW
Std Port timings	2158	0443
Time Diff Sec Port	+0003.6	-0019.3
Sec Port timings	2201.6	0423.7

	LW	HW
Heights at Std Port	0.4	4.2
Negativing of seasonal corrn for Standard Port(No. 1741)	negligible	negligible
Std Port - Seasonal corrn	0.4	4.2
Height correction for Secondary Port	0.0	-0.5
Secondary Port Ht	0.4	3.7
Applying seasonal corrn for Sec Port(No. 1744)	negligible	negligible
Corrected heights for Secondary Ports	0.4	3.7

LW	**21st**	2201.6	0.4m
HW	**22nd**	0423.7	03.7m

Enter the curve for Lisbon, with height above Chart Datum = 3 m.
Go vertically downwards till interpolation line (made by LW = 0.4 & HW = 3.7)
Turn to right, till the ascending part of curve & thence vertically downwards to indicate -2h 9m.
Thus a height of tide of 3 m. will occur at HW - 0209 = 0423.7 - 0209 = 0214.7h.

Note:
While using the Standard Port curve for finding out intermediate height or time of a particular height of tide, following points should be noted.
(a) Interpolation line is drawn using HW/LW at Secondary Port.
(b) If its required to interpolate between sound line (springs) & pecked line(neaps), relevant tidal range of Standard Port is considered. Thus in above case since present relevant tidal range at Std. Port is 3.8 m. we if required would have used sound line, as 3.8 > 3.3 (spring mean range). Extrapolation beyond the sound & pecked lines is not permitted.(Also see note at the end of ans to Q 34.3)

Ans Vessel must pass over the shoal before 0214.7 h on 22nd Jan.

To find the height of tide at given GMT on a rising tide, (Secondary Port)

Q. 35.2 Find height of tide at 1200 h GMT on 06.03.92 at Darnettness.

Hint.
Darnett ness is not a Std Port.
From index, we find its number to be 108c.
From Part II, we find the Standard Port to be Sheerness (no. 108)
Time Zone for both ports is GMT.
Data from Part I & II:

From Part I:

06	0128	5.7
	0749	0.5
	1349	5.8
	1952	0.6

From Part II:

No.	PLACE	TIME DIFFERENCE High Water		Low Water		HEIGHT DIFFERENCE MHWS	MHWN	MLWN	MLWS
108	**SHEERNESS**	**0200 and 1400**	**0800 and 2000**	**0200 and 1400**	**0700 and 1900**	**5.7**	**4.8**	**1.5**	**0.6**
108c	Darnettness	+0004	+0004	0000	+0010	+0.2	+0.1	0.0	-0.1

SEASONAL CHANGES IN MEAN LEVEL					
No.	Jan. 1	Feb. 1	Mr. 1	Apr. 1	May 1
72-133			Negligible		

TIME ZONE (GMT)

06	0749	0.5	LW
	1349	5.8	HW

We will find out Secondary Port prediction relevant to above two tides. Thus

	LW	HW
Std Port timings	0749	1349
Time diff Sec Port	+0008.9	+0004
Sec Port timings	0757.9	1353

	LW	HW
Heights at Std Port	0.5	5.8
Negativing of seasonal corrn for Standard Port(No. 108)	00	00
Std Port - Seasonal corrn	0.5	5.8
Height correction for Secondary Port	-0.1	+0.2
Secondary Port Ht	0.4	6.0
Applying seasonal corrn for Sec Port(No. 108c)	00	00
Corrected heights for Secondary Ports	0.4	6.0

Entering the curve for Sheerness from time axis at -0153 (1200 GMT is 01h53m before HW at Darnettness), we get height of tide = 4.6 m.

Ans. Ht of tide at 1200 GMT = 4.6m.

Ports for whom there is no suitable Standard Port for finding daily predictions

Q. 35.3 Find the tidal predictions for Manifah on 18.01.92.
Hint.
In part II time difference is replaced by 'p', which means that, no suitable Standard Port is available for Manifah. Predictions are made by simple harmonic method of tidal predictions.
Height difference included for this port is to enable tidal levels to be obtained but they should not be used for obtaining daily predictions.

Simple Harmonic Method of tidal predictions is explained later.

To find earliest time to sail out on a rising tide(Secondary Port)

Q. 35.4 Find the earliest time to sail out from Walnut Groove (Sacramento River, ATT 3), after 7 o'clock in the morning of 17th Feb,92. Master wanted a height of tide of at least 1 m. at the time of sailing.

Hint.

Walnut Groove is Sec Port(No 9301, Std Port being San Francisco, No 9305).
Relevant data from Part I & II:

17	0356	0.5
	1013	2.0

After applying the time & height difference for the Secondary Port, we get the Sec.Port predictions as,

0948	0.2
1605	1.13

Since criteria (a) & (b) stated earlier i.s satisfied, the time of given intermediate tide may be found with acceptable accuracy.

Duration	=	06h17m
Given Ht. of Tide	=	1.00 m.
From curve, time	=	-0130h
1605 ~ 0130	=	1435h

Ans. Earliest the height of 1 m occurs will be at 1435h.

TO FIND MEAN LEVELS AT PORTS, HARBOURS COVERED BY ATT 1

To find out mean tidal levels at a Standard Port,(ATT 1)

Q. 35.5 Find out heights of different mean tidal levels at Dover.

Sol.

Dover is Std Port. The heights of mean tidal levels of Std Port can directly be found out from table V of Tide Tables. Thus:

At Dover

LAT	0.0	HAT	+7.3
MLWS	+0.8	MHWS	+6.7
MLWN	+2.0	MHWN	+5.3
	MSL +3.7		

To find mean tidal levels at a Secondary Port (ATT I)

Q. 35.6 Find out heights of different mean tidal levels at Oostende.

Sol.

Oostende is Sec Port(No 1564, for which Std Port is Flushing).
The values of MLWS, MLWN, MHWN & MHWS may be found for Sec Port by direct application of appropriate height difference tabulated in Part II. Values of these four tidal levels for Std. Port may be found from table V as well as from data given in Part II. Thus:

At Flushing

MLWS	+0.3	MHWS	+4.7
MLWN	+0.8	MHWN	+3.9

Applying the height difference for Oostende,

MLWS = +0.3+0.1 = +0.4 MHWS = +4.7+0.3 = +5.0
MLWN = +0.8+0.3 = +1.1 MHWN = +3.9+0.3= +4.2
MSL = +2.69

Values of HAT & LAT may be found for Secondary Port by extrapolating beyond the given differences for a tide of Std Port. Thus;

From Part II:

Flushing	**MHWS**	**4.7**	**MHWN**	**3.9**	**MLWN**	**0.8**	**MLWS**	**0.3**
Oostende		**+0.3**		**+0.3**		**+0.3**		**+0.1**

For Flushing HAT = +5.2 & LAT. = -0.2
Difference of height for Oostende at MHWS & MHWN is +0.3.
∴difference for HAT or 5.2 = +0.3.

Hence HAT Oostende = 5.2 + 0.3 = 5.5 m.
Similarly using the differences for MLWN & MLWS, we get the difference for -0.2 = -0.1.
Hence LAT Oostende = -0.2 -0.1 = -0.3m.

TO FIND MEAN LEVELS AT PORTS, HARBOURS COVERED BY ATT 2 & ATT 3

Note:
Table V in both the volumes of Tide Tables gives the values of LAT, MSL & HAT for the Standard Ports. Values for MLWS, MLWN, MHWN, MHWS, are shown for those ports where the tide is mainly Semi-diurnal.

Where there is large Diurnal inequality the values of MLLW, MHLW, MLHW, MHHW are shown.
The values of MLWS, MLWN, MHWN, MHWS for Secondary Ports (with Semi-diurnal Tides) are found directly by applying the height difference given in Part II.

Similarly the values of MLLW, MHLW, MLHW & MHHW for Secondary Port (with large Diurnal inequality) are found directly by applying the height difference given in Part II.
The values of HAT & LAT. are found by linear extrapolation.

Thus the procedure is exactly similar to the one discussed for ATT I.

To find MHHW & HAT at Edithburgh(ATT 3)

Q. 35.7 Find MHHW & HAT at Edithburgh.

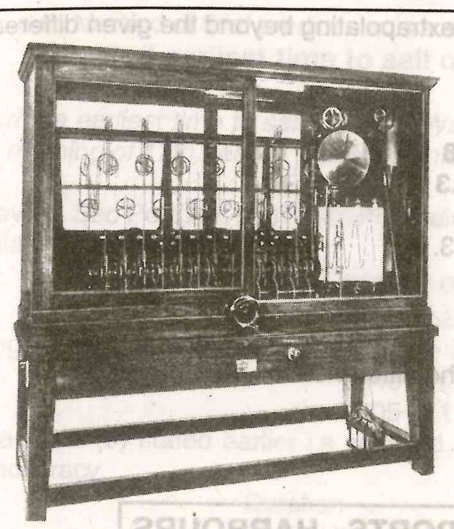
Hint .

<u>Data from Part II:</u>

	HEIGHT DIFFERENCE	
	MHHW	**MLHW**
Port Adelaide	**2.4**	**2.0**
Edithburgh	-0.5	-0.7
MHHW Edithburgh =	+1.9	
HAT, Port Adelaide =	+3.1 (from table V).	

Extrapolating using the differences for 2.4 & 2.0, we get difference for +3.1 is -0.15.
Hence HAT at Edithburgh = +3.1 - 0.15 = +2.95 m.

Ans. MHHW Edithburgh = +1.9 m. & HAT Edithburgh = +2.95 m.



Lord Kelvin: *[1824- 1907] or William Thomson was born on 26th June 1824 in Belfast. He published 661 papers & 70 inventions. He is known for Galvanometer, absolute zero etc he also invented a mechanical tide predictor that could calculate the tide based on simple harmonic method of tide analysis.*

[Pic. Tide calculating machine with mechanical gearings, 1924]

Chapter 36: Simple Harmonic Method of Tidal Predictions

Simple Harmonic Method of tidal prediction

Q. 36.1 In what cases you must find the height of tide using Simplified Harmonic Method of Tidal Prediction?

Ans:

ATT 1: For certain secondary ports the time differences are replaced by "p", indicating that no suitable Standard port is available & predictions can only be made by using Simplified Harmonic Method of Tidal Prediction (NP 159).

In some other cases the use of Simplified Harmonic Method of Tidal Prediction is recommended where the intermediate heights are important & may be found more accurately using NP 159. These ports are indicated in part II by "c".

ATT 2 & 3: Standard curves may be used for the standard & secondary ports in ATT volume 2 & 3. The curves may be entered using time before or after HW, height of tide etc. provided that each of the following criteria is satisfied.

(a) The duration of rise or fall must lie within the range of graphs i.e. between 5 & 7 hours.

(b) There must be no shallow water correction (f4,F4,f6 & F6), shown in part III.

If either of these criteria is not met, intermediate heights must be predicted by the use of SHM of Tidal Prediction NP 159.

Principle of Harmonic Tidal Analysis

Q. 36.2 Explain the principles of Harmonic Tidal Analysis.

Ans:
The tides at certain places may have to be found by Simplified Harmonic method as stated earlier. Thus various constituents responsible for creation of tide raising forces may be plotted as Cosine curves. Each tidal constituent has a speed, amplitude & phase. Periods & amplitudes of these curves are calculated. Speed, which is calculated astronomically is expressed in degrees per hour. The four principal constituents used are **M2, S2, K1, O1.**

M2: Is principal lunar semi diurnal constituent. To calculate amplitude relevant to this constituent a hypothetical Moon is considered which, has a circular orbit, moves at average speed of actual Moon, is halfway between apogee & perigee positions, is at an average N'ly or S'ly declination.

S2: Is principal solar semi-diurnal constituent. Relevant amplitude is calculated using a hypothetical Sun & similar conditions as used above in case of Moon.

K1: Is a "Luni-Solar, (declination based) diurnal constituent". It allows for Sun's declination & a part of Moon's declination.

O1: A "declination based Lunar diurnal constituent". It allows for the rest of Moon's declination.

One complete cycle is of 360°. Semidiurnal components, like S2 has 2 complete cycles per day. Thus speed is 720° per day or 30° per hour. Similarly the relevant speeds per hour for M2, K1, O1 are 28.98°, 15°.04, 13°.94 respectively.

Now since phase of 360° or 720° is associated with a period of 24 hours, the phase is represented on time axis. Since the tide raising forces do not act instantaneously, each constituent has a time-lag or a phase-lag. This time-lag or phase-lag can be determined by tidal analysis.

Certain other terms, which will be used in SHM of tidal analysis are as follows.

Tidal Angle:
Is an angle that represents the instant on a particular date, when the Standard Tractive Force (STF) of a constituent is maximum on Greenwich Meridian.

Thus for constituent M2 $\dfrac{TidalAngle}{28.98}$ = Time of transit of hypothetical Moon, modified for effects of Moon's changes in distance. Similarly S2, divided by 30, is approximately equal to the time of transit of Hypothetical Sun, modified for the effects upon the semidiurnal tide, as a whole, of changes in declination of the Moon & Sun, & also for the effects of the Sun's changes in distance.

Difference in the tidal angles of M2 & S2 is a measure of angular distance between Sun & Moon & thus is indicative of Lunar-Phase. Thus difference is maximum of quarters & minimum on New & Full Moon.

Harmonic Constant (g):

Expressed in angles, represents the interval or lag between the instants when a Standard Tractive Force (STF) is maximum on Greenwich Meridian & when HW respective to that force, occurs at some particular place as recorded in standard time at that place.

Thus in case of M2 $\dfrac{g}{28.98}$ = interval in hours between transit of hypothetical Moon & HW due to M2.
Similar interval can be found in case of Sun with the help of g of S2. The transits of Moon & Sun tend to coincide at Full & New Moon, but since the lags of M2 & S2 are not same their respective HWs will not coincide on these days, in European Waters when the Moon's transit is at say 0140 or 1340 h & not at 0000 h or 1200 h, the two HWs will coincide & Spring Tides will take place.

The interval between Full or New Moon & Spring Tides, at any particular place, is known as the "age of tide"

$$\text{Age of Tide in days} = \frac{g.of.S2 - g.of.M2}{24}$$

Thus if g of S2 is 075° & g of M2 is 029°, then 075° - 029° / 24 ≈ 2 days. i.e. Spring Tides will occur after about 2 days of Full or New Moon.

Tidal Factor:

Is the expression of increase or decrease in average magnitude of STF on a particular day. e.g. Tidal Factor for M2 is large when Moon is at less than its average distance from Earth.

Amplitude(H):

Amplitude or the Harmonic Constant H is half of the range or height of HW above mean level, in response to STF at any place.

Mean Sea Level Zo:

This is average level of the sea above chart datum as determined from a long series of observations. At most places this level is subject to seasonal changes due to meteorological conditions. Its given in part III of Tide Tables for the ports included there.

Semidiurnal Components:

Neap tides occur twice in 27.32 days or once in 13.6 days approximately. Which means that the relative speed between the two diurnal constituents viz. K1 & O1, is 720° per 27.32 days or 360° per 13.6 days or 1.1° per hour. Thus we deduce that speed K1 = 15.04° per hour & speed O1 = 13.94° per hour. (speed K1 - speed O1 = 1.1° per hour)

(Note: Moon changes meridian at the rate of 360° per 24.84 h or 14.49° per hour. Also the average speed of K1 & O1 = ½ [15.04° + 13.94°] = 14.49° per hour.)

Harmonic Constituent K1:

This constituent is Luni-Solar, because it is the response to the combination of the average Lunar Diurnal & average Solar Diurnal tractive forces. Two third of forces represented by K1 are assumed to be Lunar.

Tidal angle divided by 15 will give the time in hours at which the upper transit of Moon occurs with N declination, or Lower transit occurs with S declination, on the day of Moon's maximum declination, modified for various effects.

g of K1 is the lag in the response to this force.
Tidal factor for K1, varies with the declination of Sun & distance of Moon.
H of K1 is average amplitude of wave created in response to this force.

Harmonic Constituent O1:

This is Lunar constituent. Time of maximum tide raising effect depends on time of Moon's transit & declinations of Moon & is modified for certain effects. Very approximately Tidal Angle for O1 is equal; to the difference between the tidal angles of M2 & K1.

Tidal Factor is maximum when Moon is nearest to Earth.
H in this case is increase at Springs or decrease at Neaps in amplitude of Diurnal Tide.

Modification of the Tidal Angles & Factors for K1 & O1 for the maximum declination of Moon which are small in size are embodied. These are due to effects of Moon's variation in maximum declination in a nineteen-year cycle. Modification depends on the maximum declination throughout the current year.

Tidal prediction using NP 159

Q. 36.3 Explain method of tidal prediction using NP 159.

Ans: Following table shows various details to be inserted in the prediction form on the left side. Required explanation is given on the right hand side.

01.	Zo	**Find from part III. If data not given in part III, owing to large fortnightly variation. Then find from table VI. Its corrected value of ML, corrected for fortnightly shallow water correction. To enter table first find X, the number of days after Full or New Moon , when Spring Tide occurs.**
02.	Seasonal Correctio n	**Read from part III & applied to Z0 (its +ve or -ve)**
03.	Sum=ML	**Sum of Zo & Seasonal correction**
04.	A1	**Its Tidal Angle on the day of prediction, found from table VII. In table VII Tidal Angle & Factors for 4 constituents is given. Data is amended to include effect of 19 other minor constituents.**
05.	A2	**Its found from table VII. Its tidal Angle on subsequent day.**
06.	A1-A2	**Decrease of Tidal Angle in one day i.e. (A1 - A2). Thus increase of tidal angle is marked as negative.**
07.	360.n	**'n' is smallest integer,viz.0,1,2 etc. to make [(A1 - A2) + 360.n] > 600 in case of M2 & S2 & is more than 300 in case of K1 & O1.**
08.	(A1-A2) + 360.n = p	**A1 - A2 + 360.n = p = Daily Rate.**
09.	p / 24	**Hourly Rate**
10.	A1	**Re-entered**
11.	g	**Lag for particular port for the 4 constituents obtained from part III of Tide Tables.**
12.	A1+g	**Add lines 10 & 11**
13.	F2	**Value of Factor on the day of prediction, obtained from table VII.(factor is a measure of Standard Tractive Force)**
14.	F1	**Value of Factor on succeeding day, obtained from table VII**
15.	P = F2-F1	**Increase in Factor - value.**
16.	P / 24	**Hourly rate of increase in Factor- value**
		Lines 1 to 16 need to be filled up only once each day
17.	Time = T	**If the time is 0812, then enter 8.2. (12 / 60 = 0.2)**
18.	p / 24	**Re-write p / 24**
19.	p / 24 xT	**Gives total change of A till the required time.**
20.	A1+g	**Re-write line 12**
21.	$(A1+g) - \frac{pT}{24} = \theta$	**Angle corrected for particular place & till the minute of observation.**
22.	Sin θ	**Enter for semi-diurnal components only.**
23.	Cos θ	**For all four components.**
24.	P / 24	**Re-write line 16, (hourly rate of increase of Factor)**
25.	P / 24 x T	**T is time of prediction, (line 17)**
26.	F1	**Re-write Factor value for the day of prediction**
27.	F1+P.T/24 = Ft	**Factor value corrected for the minute of prediction.**
28.	H	**From part III. (H is amplitude)**
29.	H x Ft	**Amplitude corrected for the prediction time.**
30.	(H x Ft) Sin θ	**For semidiurnal constituents only.(M2 & S2)**

31. (H x Ft) Cos θ — For all 4 constituents.

32. R Sin r : R Cos r — R.Sin r = H x Ft Sin θ (for M2) + H x Ft Sin θ (for S2)
R.Cos r = H x Ft Cos θ (M2) + H x Ft Cos θ (M2)

33. r : R — r & R are found by elimination process, thus $\frac{R.Sinr}{RCosr}$ = Tan r (thus R is eliminated & value of r can be found). Similarly by squaring the two i.e. R Sin r & R Cos r & adding the two, Sine r & Cos r can be eliminated & value of R may be found. $(R\ Sin\ r)^2 + (R\ Cos\ r)^2 = R^2(Sin^2 r + Cos^2 r) = R^2(1) = R^2$. Thus R may be found. In the 4th coloumn enter Mean Level (line 3)

34. 2r:R^2 — Enter in first two coloumns

35. f4 : F4 — f4 & F4 found from Part III, (are the quarterdiurnal tide values. Enter in first two coloumns.)

36. 2r+f4= d4: R^2.F4=D4 — d4 is the phase of quarterdiurnal tide & D4 is the amplitude of same tide. Enter d4 & D4 in first two coloumns respectively. Find h4 = 'D4 Cos d4' (h4 = height correction due to q-d tide) & enter value in 4th coloumn.

37. 3r : R^3 — Insert the values in first two coloumns.

38. f6 : F6 — Find from Part III, (are the sixthdiurnal tide values, entered in first two coloumns..

39. 3r+f6= d6: R^3.F6 = D6 — d6 is the phase of sixthdiurnal tide & D6 is the amplitude of the same tide. Find height correction due to sixthdiurnal tide, h6= D6 Cos d6. h4 & h6 are summed algebraically to the combined s-d & D tides, to give corrected height for required time.

40. Predicted height — Sum = H.ft Cos θ (M2) + H.ft Cos θ (S2) + H.ft Cos θ (K1) + H.ft Cos θ (O1) + Mean Level + quarterdiurnal height correction + sixthdiurnal height correction

To find height of tide at a port using SHM of tidal analysis

Q. 36.4 Find the height of tide at Tianjin (China), at 1124 h on 11th April. The data given is as follows:

Time zone -0800 — APRIL 11

0330	1.9
0827	3.5
1557	0.8

No.	PLACE	M.L .Zo	M_2		S_2		K_1		O_1		1/4-diurnal		1/6-diurnal	
		m.	g°	H.m.	g°	H.m.	g°	H.m.	g°	H.m.	f4	F4	f6	F6
7366	TIANJIN	2.41	097	1.19	175	0.34	164	0.39	104	0.29	256	0.052	No	data

SEASONAL CHANGES IN MEAN LEVEL

No.	Apr. 1	May 1
7353 - 7468	- 0.1	0.0

Hint: The duration of tide is 07h 30m. Its > 7h Thus SHM of tidal analysis is recommended.

		M2	S2	K1	O1
01.	Zo	2.41			
02.	Seasonal Correction	-0.10			
03.	Sum=ML	2.31			
04.	A1	196	351	226	320
05.	A2	222	351	224	347
06.	A1-A2	-026	000	002	-027

		M2	S2	K1	O1
07.	360.n	720	720	360	360
08.	(A1-A2) +360.n = p	694	720	362	333
09.	p / 24	28.917	30	15.083	13.875
10.	A1	196	351	226	320
11.	g	097	175	164	104
12.	A1+g	293	526	390	424
13.	F2	1.13	1.15	0.94	1.21
14.	F1	1.11	1.16	0.92	1.21
15.	P = F2-F1	0.02	-0.01	0.02	0.00
16.	P / 24	0.0008	-0.0004	0.0008	0.0000
17.	Time = T	11.4			
18.	p / 24	28.917	30	15.083	13.875
19.	p / 24 xT	329.654	342	171.946	158.175
20.	A1+g	293	526	390	424
21.	(A1+g) -pT / 24 = θ	-36.654	184	218.054	265.825
22.	Sin θ	-0.597	-0.070		
23.	Cos θ	0.802	-0.998	-0.787	-0.073
24.	P / 24	0.0008	-0.0004	0.0008	0.0000
25.	P / 24 x T	0.0091	0.0046	0.0091	0.0000
26.	F1	1.11	1.16	0.92	1.21
27.	F1+P.T/24 = Ft	1.1191	1.1646	0.9291	1.21
28.	H	1.19	0.34	0.39	0.29
29.	H x Ft	1.332	0.396	0.362	0.351
30.	(H x Ft) Sin θ	-0.795	-0.028		
31.	(H x Ft) Cos θ	1.068	-0.395	-0.285	-0.026
32.	R Sin r : R Cos r	-0.823	0.673		
33.	r : R	309.3°	1.0631	Mean Level =	2.3100
34.	2r:R^2	258.6°	1.1302		
35.	f4 : F4	256	0.052		
36.	2r+f4 = d4: R^2.F4=D4	154.6	0.0589	D4Cosd4 =	-0.0532
37.	3r : R^3	207.9°	1.201		
38.	f6 : F6	000	000	(No data given	in Part III)
39.	3r+f6 = d6 : R^3.F6 = D6	207.9°	000		
40.	Predicted height			2.6188m	

Predicted height = Sum of 'H x Ft Cos θ' for 4 constituents.
+ ML + D4.Cos d4 + D6.Cos d6
= 1.068 - 0.395 - 0.285 - 0.026 + 2.310 - 0.0532 + 000.00
= **2.6188 m = Ans.**

Alternate method (short cut) for finding out height of tide with reasonable accuracy

1. The factor for the time in question is found by interpolation. Value of F for 0000h on the day of prediction & the next day is read from table VII. This value F_t is found for all 4 constituents.
2. H is read from part III & HF_t is entered for all constituents.
3. Hourly rate of change of tidal angle i.e. p/24 is straightaway taken as 29.0°, 30.0°, 15.0° & 13.9° for M2, S2, K1 & O1 respectively.
4. A_1 is the tidal angle on the day of prediction & 'g' is the lag found from part III, T is the time of prediction ($11^h\ 24^m$ means 11-4 hours)
Write down θ = $\left[(A_1 + g) - \frac{pT}{24}\right]$ for all 4 constituents.

5. Write down Sine θ values for first two constituents & Cos θ values for all 4 constituents & in the next row write down HF_tSine θ values for first two & HF_t Cosθ values for all 4 & next
6. R Sine r = Σ HFt Sinθ of first two constituent & RCosr = ΣHFt Cosθ of first two constituent. Solve these two equations & get R & r. From R & r. Calculate d4, D4, d6 & D6.
7. Predicted Height = ML + Σ HFt Cosθ (for all 4 constituent) + D4Cosd4 + D6Cosd6

Q. 36.5 Find the height of tide at 1330h on 14/2/92 at Sunday Is.

Sol.
Port No. = 6275a
ML = 3.39m

S. correction = - 0.05, ML = 3.34 m T = 13.5

	M_2	S_2	K_1	O_1
A_1	239°	013°	319°	308°
g	343°	058°	320°	278°
$(A_1 + g) - pT/24 = \theta$	190.5°	026°	76.5°	38.35°
Ft	1.1281	1.24	0.9844	1.2681
H	2.17	0.97	0.32	0.20
H.Ft Sinθ	-0.4461	0.52727		
H.Ft Cosθ	-2.4070	1.08106	0.07354	0.1989
R Sinr =	0.08117	Rcosr =	-1.32594	
$f_4 = 105°$	$F_4 = 0.025$	$f_6 = 325°$	$F_6 = 0.005$	

$\Sigma H F_t \cos\theta = -1.0535$ m ∴ r must be in 2^{nd} Quadrant, thus r = 176.5°
R = 1.3171 $d_4 = 98°$ $D_4 = 0.0441$ $d_6 = 134.5°$ $D_6 = 0.0117$ $D_4 \text{ Cos} d_4 = -0.0061$
$D_6 \text{ Cos} d_6 = -0.0082$ ∴ Predicted height = 3.34 – 1.0535 – 0.0061 – 0.0082

Ans = 2.2722m

Tidal Streams given in Admiralty Tide Tables

Q. 36.6 What information is provided in Admiralty Tide Tables, regarding Tidal Stream? Explain with suitable illustrations.

Ans.
Following data regarding tidal stream is provided in ATT volumes:

(1) Tidal Stream tables for specific areas near certain ports / passages are provided in part Ia of ATT volume 2.

(2) Position of the specific area, for which tidal streams are provided is given at the head of the page, just under the name of specific area.

(3) Following details for each day of the year is provided.
 (a) Date & day of prediction.
 (b) Slack water times, in terms of zonetime normally maintained by specific territory or in terms of official time of nation.
 (c) Dominant directions of tidal stream, in that specific area, when the strength reaches maximum. e.g. (+) direction 300° & (-) direction 120°. Thus normal prediction gives direction only in terms of (+) or (-) & it is assumed that throughout the day except at the time of slack waters, the stream direction is either along 300° or 120°.
 (d) Time & strength of tidal stream, at the time of reaching maximum force in +ve as well as -ve direction.

 (e) Remark at the base of page, regarding the fact whether the effect of current is included in the prediction or not. At this stage its worth mentioning that Current as different from Tidal Stream is meteorological in origin & may not be accurately predicted in advance.

(4) Dates of New Moon & Full Moon as ● or O respectively.
Thus a typical layout of above data is as shown in fig.
Seeing the predictions for 16th December.
On 16th, slack water occurs at 0201h. At 0609 h tidal stream is strongest at 1.2 kn & is towards 158°T. Tidal rate gradually reduces & its slack water again at 1006 h At 1311 h tidal stream is strongest in opposite direction i.e. along 338°T.

Tidal streams may be diurnal, semidiurnal or mixed. When these streams are semi diurnal in character they can be predicted by reference to suitable Standard Port by tables printed on the navigational chart. In areas where the diurnal inequality of the tidal streams is large this procedure is not followed.

SINGAPORE STRAIT - NORTHERN APPROACHES TO SELAT DURIAN

lat 1°00'N long 103°34,E

TIDAL STREAM PREDICTIONS (RATES IN KNOTS)
POSITIVE (+) DIRECTION 158° NEGATIVE (-) DIRECTION 338°

TIME ZONE -0700 YEAR 1991

OCTOBER **NOVEMBER** **DECEMBER**

	SLACK TIME	MAXIMUM TIME	RATE
16	0201	0609	1.2
M	1006	1311	-0.8
	1724	1916	0.2
	2107		
17		0019	-0.5
TU	0257	0659	1.0
	1029	1352	-1.0
	1743	2032	0.6
	2332		

CURRENT NOT INCLUDED IN PREDICTIONS, 0.3 kn FROM APRIL TO NOVEMBER AND 0.7 kn FROM DECEMBER TO MARCH DIRECTION 338°. STREAM IN DIRECTION 158° STARTS FLOWING S & TURNS SE. STREAM IN DIRECTION 338° STARTS FLOWING N & TURNS NW.

Data provided in part III a of ATT re. Tidal Streams

Q. 36.7 Explain in brief, the data provided in part III a, which is utilized in finding out the direction & rate of tidal stream at specific positions mentioned thereat.

Ans:
The SHM of Tidal Prediction, which is discussed earlier can be used to predict Tidal Streams for certain specific positions for which data is given in part IIIa of ATT volume 2. The constants are to be used in the same way as for Tidal Predictions with the values of "H" given in knots instead of metres.

Once the candidate is well versed with the SHM, he may attempt SHM for Tidal Streams. However he must keep following points in mind.

(a) Tidal Streams are astronomical in origin & must be understood as different from current, which is mainly meteorological in origin. Thus the extent of current experienced may be quite different from what was predicted.

(b) In SHM purely astronomical equations are dealt with. Ship will experience the mixed effect. Hence, as Zo = Mean Level is taken as base height in case of SHM of Tidal height prediction, in the same way Zo = existent current (of no astronomical cause) is taken as basic stream (current), which is already prevailing.

(c) At all the times we deal in current & not height & we finally calculate rate of tidal stream for a given time.

(d) Tidal Streams, thus calculated may not be true for another position which is very close to given position for which calculations are made. Tidal levels, however may be nearly same at the two positions.

(e) In most cases, its assumed that the current is only along two directions, mutually opposite to each other & the direction alternates every slack water. Thus two directions may be indicated under Direction coloumn, viz 060 under (+) direction & 240 under (-) direction. Hence a final rate obtained of -2.1 kn will mean that the tidal stream is along 240°T, with a rate of 2.1 kn.

(f) In certain cases, direction of setting of stream keeps changing with the rate. 2 rows of constituents are given instead of one. Thus 2 different rates are obtained, one along N & other along E. If the rates obtained are N 0.3 (+) & E 0.4 (-), the resultant direction & rate is to be found by making a parallelogram of forces as shown in fig.

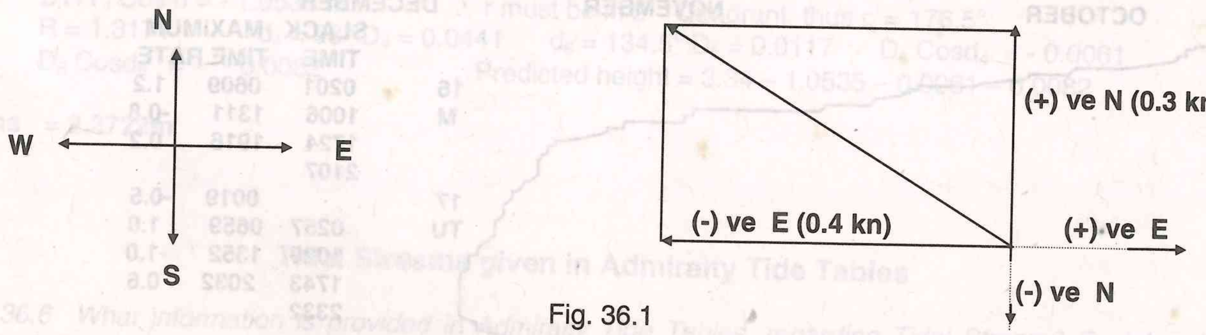


Fig. 36.1

From above resultant direction = 307°T & rate = 0.5 kn.

To calculate Tidal Stream at any place

Q. 36.8 Find direction & rate of Tidal Stream at 0742 Singapore Time, over position 001° 14'N 103° 19.0'E, in Singapore Strait on 7th March 1991. The data given is as follows:

Time zone -0800

No.	lat long N E	Direction (+)	Direction (-)	ML Zo kn	M2 H.kn. g°	S2 H.kn. g°	K1 H.kn. g°	O1 H.kn. g°	1/4-diurnal f4 F4	1/6-diurnal f6 F6
470	1°14' 103°19'	300	120	+0.08	130 0.57	180 0.17	244 0.21	098 0.27	NO DATA	NO DATA

Ans:

		M2	S2	K1	O1
01.	Zo	+0.08			
02.	Seasonal Correction	......			
03.	Sum=ML	+0.08			
04.	A1	153	006	287	234
05.	A2	175	006	286	257
06.	A1-A2	-22	000	001	-23
07.	360.n	720	720	360	360
08.	(A1-A2) +360.n = p	698	720	361	337
09.	p / 24	29.083	30.000	15.042	14.042
10.	A1	153	006	287	234
11.	g	130	180	244	098
12.	A1+g	283	186	531	332
13.	F2	0.88	1.34	0.70	0.93
14.	F1	0.90	1.33	0.71	0.94
15.	P = F2-F1	-0.02	0.01	-0.01	-0.01
16.	P / 24	-0.0008	0.0004	-0.0004	-0.0004
17.	Time = T	7.7			
18.	p / 24	29.083	30.000	15.042	14.042
19.	p / 24 xT	223.939	231.000	115.823	108.123
20.	A1+g	283	186	531	332
21.	(A1+g) -pT / 24 = θ	59.061	315	415.177	223.877
22.	Sin θ				
23.	Cos θ	0.5141	0.7071	0.5710	-0.7208
24.	P / 24	-0.0008	0.0004	-0.0004	-0.0004
25.	P / 24 x T	-0.0062	0.0031	-0.0031	-0.0031
26.	F1	0.90	1.33	0.71	0.94
27.	F1+P.T/24 = Ft	0.8938	1.3331	0.7069	0.9369
28.	H	0.57	0.17	0.21	0.27
29.	H x Ft	0.5095	0.2266	0.1484	0.2530
30.	(H x Ft) Sin θ				
31.	(H x Ft) Cos θ	0.2619	0.1602	0.0847	-0.1824
32.	R Sin r : R Cos r				
33.	r : R				
34.	2r:R²				
35.	f4 : F4				
36.	2r+f4 = d4: R².F4=D4				
37.	3r : R³				
38.	f6 : F6				
39.	3r+f6 = d6 : R³.F6 = D6				
40.	Predicted rate				(+) 0.4044 kn

Predicted Rate = Sum of 'H x Ft Cos θ' for 4 constituents.
+ Zo+ D4.Cos d4 + D6.Cos d6
= 0.3244 + 0.08 + 0.00 + 0.00
= 0.4044 kn.

Since sign is positive the direction of stream is along 300°T.
Many rows are not filled up because there is no data regarding quarter-diurnal & sixth-diurnal constituents.

Ans: Tidal Stream ≡ 300°T x 0.4 kn.

To find resultant rate & direction of Tidal Stream using N & E component

Q. 36.9 Tidal Streams for Strait of Hormuz (No 420 / position 26° 22.2' 56° 41.7' E) on the 15th October,91 at 1930 h were found to be; N: 0.312 (-) kn & E: 0.172 (+). Find the direction of Tidal Stream & rate at that time.

Hint:

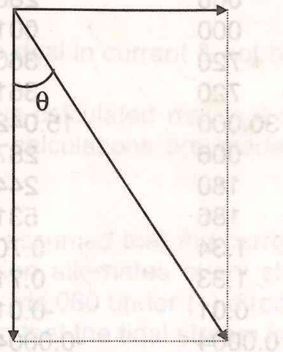


Fig. 36.2

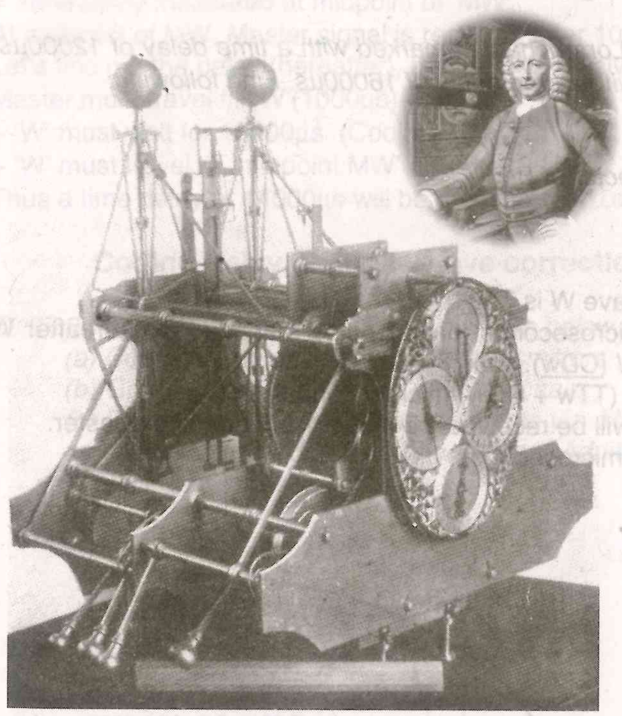
N (-) ≡ S

resultant rate $= [(0.312)^2 + (0.172)^2]^{1/2}$
$= 0.356$ kn.

$\tan\theta = \dfrac{0.172}{0.312} \quad \therefore \theta = 28.9°$

Direction = 180 - 28.9 = 151.1°T

Rate = 0.356 kn



John Harrison: *[1693-1776] Born in West Yorkshire an English clock maker, in 1735 made the first successful & accurate Chronometer, In 1726 he made the first gridiron compensating pendulum [counteracting temperature changes] this was incorporated in to chronometer which was used to calculate longitude of the place. For this he won the reward of 20,000.*

[Pic. Harrison's Chronometer No. 1, Inset: John Harrison]

Chapter 37: LORAN System

LORAN C is coastal cum ocean navigation system & stands for long range navigation system. Omega on the other hand is only meant for ocean navigation. Omega system has been switched off now & is not used any more.

In LORAN C there are several chains, each having a master transmitter & 3 to 4 secondary stations, named W,X,Y,Z stations. System frequency is 100 kHz, all stations transmit on 100 kHz. Transmission obviously is not simultaneous & follows strict schedule. Thus each transmitter gets a chance to transmit in specified interval in transmission cycle, which recurs. Transmission cycle period as measured in microseconds is called Group repetition interval. Transmission is arranged in such a way that regardless of path taken by transmitters (sky or ground), master signal is heard before 'W', 'W' is heard before 'X', 'X' is heard before 'Y', 'Y' is heard before 'Z' anywhere in system coverage. A loran receiver measures delay in arrival of the secondary transmissions as compared to master's transmission. Lattice on chart is marked as per the time delay measured at respective hyperbolae.

Omega navigation system had a single chain consisting of 8 transmitters located in different parts of world. Main frequency transmitted by these 8 station was 10.2 kHz. Additionally each station transmitted specific frequency each & some other frequencies to help doing lane identification. Omega was never, a popular position fixing system with ships for the accuracy that it provided & the time taken in correction of reading before it could be plotted. The only reason that it was continued till now was that it was the only total earth based global position fixing system & the only non-celestial system, which could give a fix in middle of ocean.

In the foregoing discussion we will study some of the aspects of the two systems regarding plotting.

Loran C lattice, Coding delay, Base line

Q. 37.1 If base line extension beyond slave W, in a Loran chain is marked with a time delay of 12000µs. Baseline extension beyond Master is marked with a time delay of 16000µs. Find following:
(a) Coding delay of slave W.
(b) Distance between Master & Transmitter W.
(c) Time delay measured on perpendicular bisector of B-L.

Hint.
(a)
Let's say 'traveling time for a signal from Master to slave W is TTw
After Master has started its transmission, in TTw microseconds Master pulse reaches W. Thereafter W waits for an extra time interval called Coding Delay W (CDw).
Total delay in transmission of W as compared to M = (TTw + CDw) microseconds.
Also anywhere on baseline extension beyond W, W will be received CDw microseconds after Master.
Thus in present illustration Coding Delay W = 12000 microseconds.

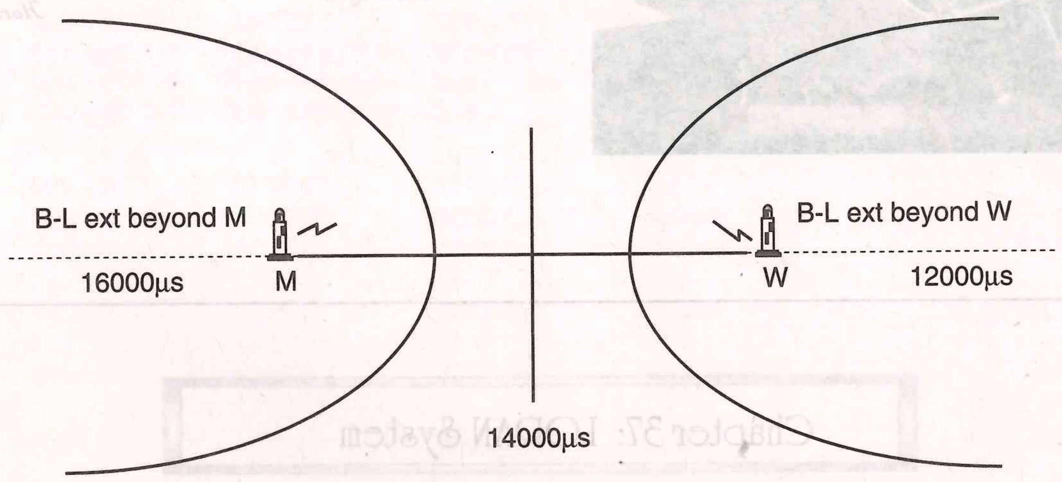


Fig. 32.1

(b)
On same lines, since time delay measured on B-L extension beyond M is
= Time delay measured on a point just beyond M
= 16000 microseconds.
It can be seen that this delay is due to
'time taken for signal to travel from M to W'
+ waiting for 12000µs, by transmitter 'W'
+ 'traveling time of W's signal from W to M'
∴ time taken for signal to travel from (M To W & then W to M)
= 16000 - 12000 µs.
= 4000µs.

∴ Traveling time of signal through a distance, MW = 2000µs.
Since EM signal travels at 3 lac km per 10 lac microseconds,
Distance MW = 600 km.

(c)
Time delay measured at any point along the perpendicular bisector of B/L
= Time delay measured at midpoint of 'MW'
At midpoint of MW, Master signal is received after 1000µs of beginning of transmission by Master.
Let's find out the delay (hereafter), before W is received at 'midpoint MW'.
Master must travel till 'W'(1000µs).
+ 'W' must wait for 12000µs. (Coding Delay).
+ 'W' must travel till 'midpoint MW' (1000µs).
Thus a time delay of 14000µs will be measured at ⊥ar bisector.

Coding Delay, GRI, Skywave corrections, indicated on Loran C lattice chart

Q. 37.2 From the part of Loran C chart shown below, find the following:
(a) Coding delay of various slave transmitters.
(b) Group Repetition Interval of Loran chain.
(c) Position of the vessel if the readings viz. MX - 14476 & MY - 37880 were obtained from a Loran receiver, during a day time observation. Additional Secondary Phase corrections are incorporated in printing of the lattice.

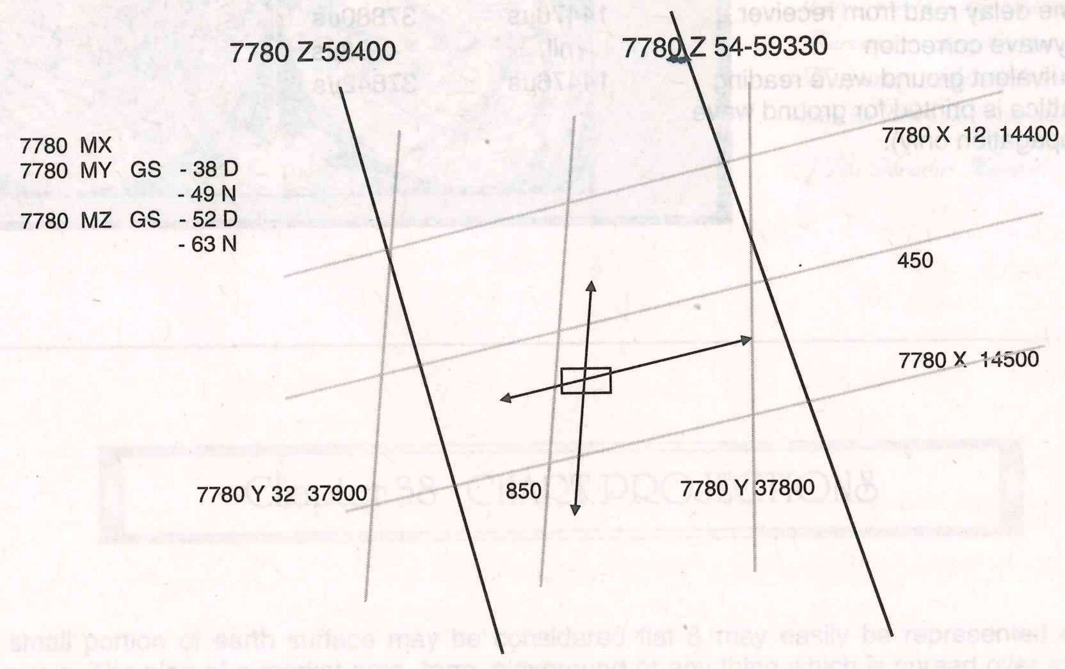


Fig. 37.2

Hint.
(a) & (b)
Complete description of lattice representing time delay of slave X as compared to Master can be seen on the chart. This being *7780 X 12 14400,*

Means that:
7780 is chain number. It also means that the GRI = 77800µs.
X is the slave transmitter of which time delay measured by the respective lattice = 14400µs.
12 indicates that the coding delay for first slave viz. X is 12000µs.
14400 is the time delay in terms of microseconds.
Similarly the coding delay for Y & Z slave transmitters are 32000µs. & 54000µs respectively.

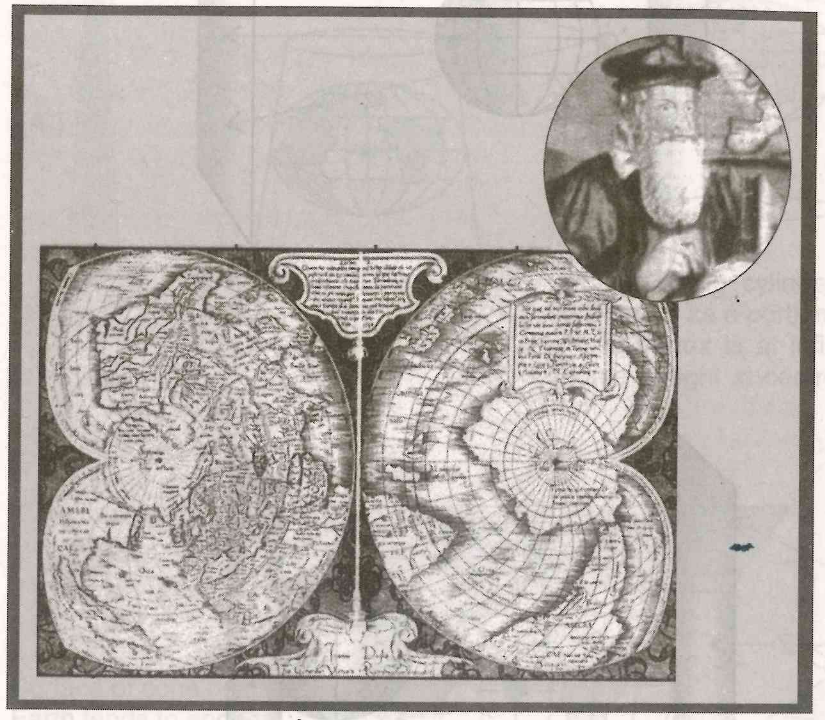
(c)
Skywave corrections to be applied to time delay readings corresponding to various lattices in the area (covered in the portion of chart where the skywave corrections are specified) are as follows:

7780 MX		
7780 MY	GS	- 38 D
		- 49 N
7780 MZ	GS	- 52 D
		- 63 N

'7780 MX' without specifying any correction indicates that, in this part of the area covered by chart, Loran receiver will normally find ground wave component of both, the Master as well as slave-X, stronger than respective sky wave component. Or GW will normally dominate over sky wave component. No sky wave correction is to be applied to the reading MX-14476.

'7780 MY GS -38 D' indicates that in this part of the area covered by chart, Loran receiver will normally find dominant ground wave component in case of Master & dominating sky wave component in case of slave Y. Since the observation was made in day time, a correction of minus 38 microseconds is to be applied to the time delay readings obtained. Thus:

	7780 X	7780 Y
Time delay read from receiver	14476μs	37880μs
Skywave correction	nil	- 38μs
Equivalent ground wave reading (Lattice is printed for ground wave propagation only).	14476μs	37842μs



Mercator Geradus: *[1512-1594] Born in present Belgium. His original name was Gerard kremer. A Flemish geographer. He developed a projection in which a spherical earth could be mapped on a flat sheet of a paper. This projection became so popular that it is even used by navigators today. A balloon, blown till its sides touch the inner surface of a circumscribing cylinder as explained then would approximate today's Mercator projection. In 1569 Mercator published the first world map on Mercator projection.*

[Pic. Geradus Mercator & his World Map]

Chapter 38 CHART PROJECTIONS

A small portion of earth surface may be considered flat & may easily be represented on a plane surface, e.g. The plan of a market area, farm, playground or any thing which is spread over a few acres, e.g. Plan of a small town ship.

The problem arises when a large area of earth surface which has a spherical shape is to be represented on a flat surface. This process of presenting earth's surface, on a flat plane, so that latitudes & longitudes are appropriately represented wrt land features, is called projection.

a. Mathematical Projection: Chart projection may be purely mathematical, i.e. To plot the graticule of a parallel or a meridian a mathematical relation ship is used to achieve certain objective.

b. Perspective Projection: The projection may be purely perspective i.e. The earth is assumed spherical, made of transparent material (except for the features) & a powerful 'point source' of light is placed at certain position. The shadow of features, parallels & meridians are recorded on a screen. Position of screen varies in different perspectives.

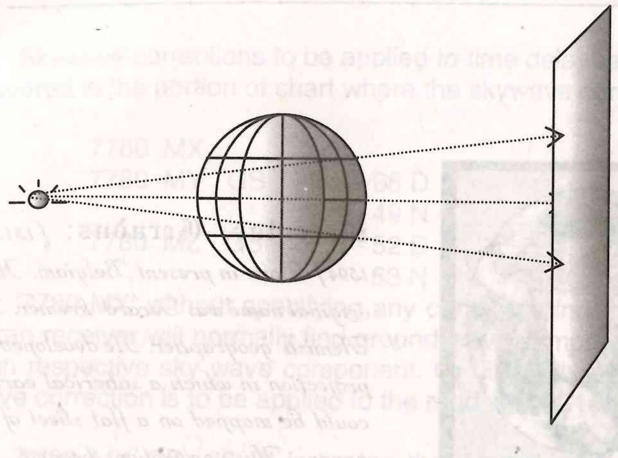


Fig. 38.1

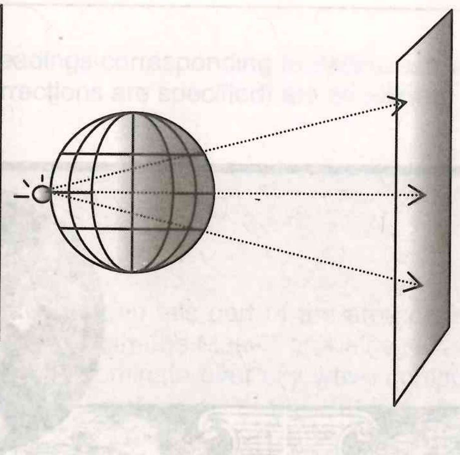


Fig 38.2

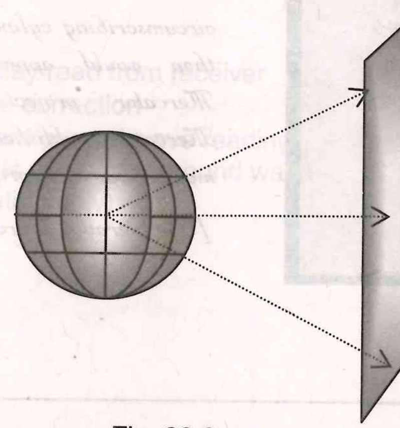


Fig. 38.3

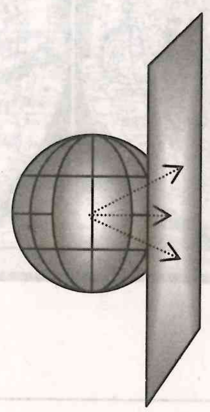


Fig 38.4

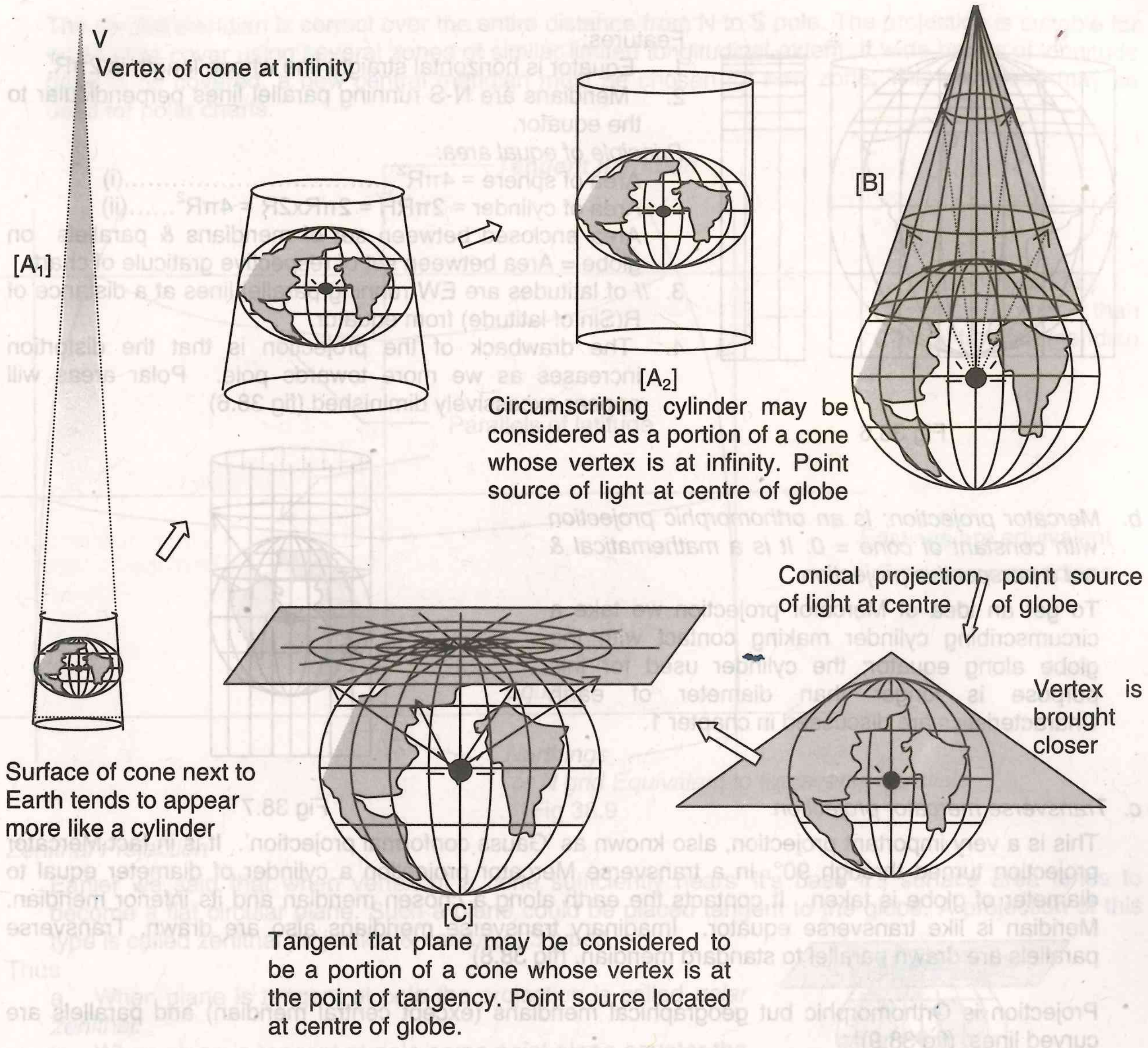
a. The projection may be partly perspective & partly mathematical or

b. It may completely be perspective as well as mathematical.

Strictly speaking, mathematically the term projection means perspective projection. We will now view the globe in certain perspectives to understand formation of some of the basic projections.

Let us assume that the entire earth made up of a transparent material except for the outlines of land feature, parallels of latitudes & the meridians, let there be a powerful point source of light which can be located some where along the diameter of earth or may be on extension of diameter.

Also let there be a coaxial cone placed on the earth the cone may have it's vertex on earth fig 38.5[c], or at a point elevated above earth fig 38.5[B] or at infinity fig 38.5A_1 & A_2].



By gradually changing the position of the vertex of cone, the projection gradually changes from cylindrical [A_1, A_2] to conical [B] & then finally to zenithal[C].

Fig 38.5

Cylindrical Projections
a. *Cylindrical equal Area projection*
b. *Mercator projection*
c. *Transverse mercator projection*

a. *Cylindrical equal Area projection*
The beam from line source placed along axis of spin traveling perpendicular to inner concave of cylinder & // to plane of equator at all levels. Cylinder being circumscribing the earth & contact is along the equator.

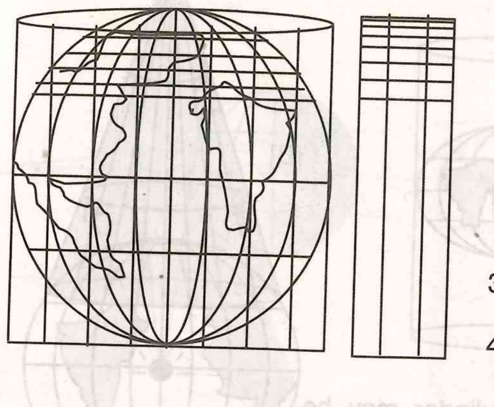


Fig 38.6

Features:
1. Equator is horizontal straight line whose length is $2\pi R$.
2. Meridians are N-S running parallel lines perpendicular to the equator.

Principle of equal area:
Area of sphere = $4\pi R^2$..................................(i)
Area of cylinder = $2\pi RH = 2\pi Rx2R = 4\pi R^2$......(ii)
Area enclosed between set of meridians & parallels on globe = Area between set of respective graticule of chart.
3. // of latitudes are EW running parallel lines at a distance of R(Sin of latitude) from equator.
4. The drawback of the projection is that the distortion increases as we more towards pole. Polar areas will appear excessively diminished.(fig 38.6)

b. *Mercator projection: Is an orthomorphic projection with constant of cone = 0. It is a mathematical & not a perspective projection.*

To get an idea of Mercator projection we take a circumscribing cylinder making contact with the globe along equator; the cylinder used for this purpose is longer than diameter of earth Characteristics are discussed in chapter 1.

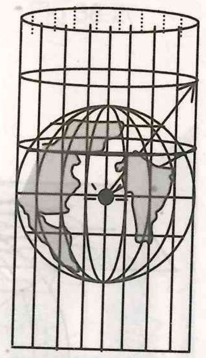


Fig 38.7

c. *Transverse mercator projection*

This is a very important projection, also known as 'Gauss conformal projection'. It is in fact Mercator projection turned through 90°. In a transverse Mercator projection a cylinder of diameter equal to diameter of globe is taken. It contacts the earth along a chosen meridian and its inferior meridian. Meridian is like transverse equator. Imaginary transverse meridians also are drawn. Transverse parallels are drawn parallel to standard meridian. (fig 38.8)

Projection is Orthomorphic but geographical meridians (except central meridian) and parallels are curved lines. (fig 38.9)
This projection can be used for limited belt on either side of a longitude. Central meridian has zero distortion even for polar areas. It is a very accurate projection for surveys.

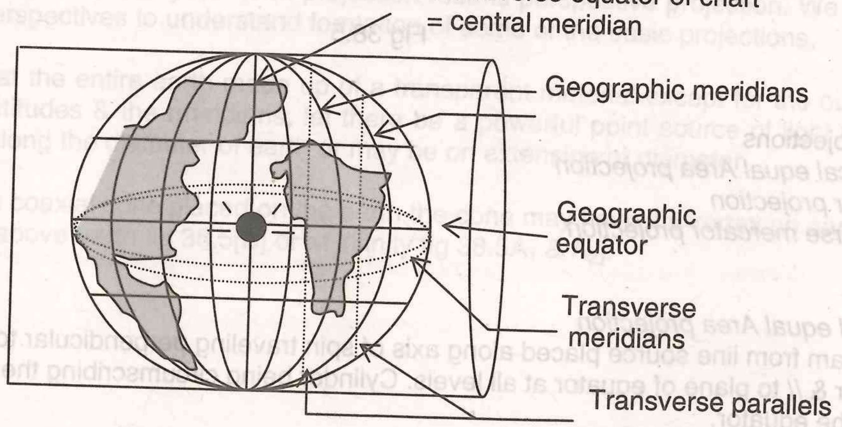


Fig 38.8

The central meridian is correct over the entire distance from N to S pole. The projection is suitable for world wide cover using several zones of similar limited longitudinal extent. If wide bands of longitude have to be covered, a new central meridian must be chosen for new zone. This projection may be used for polar charts.

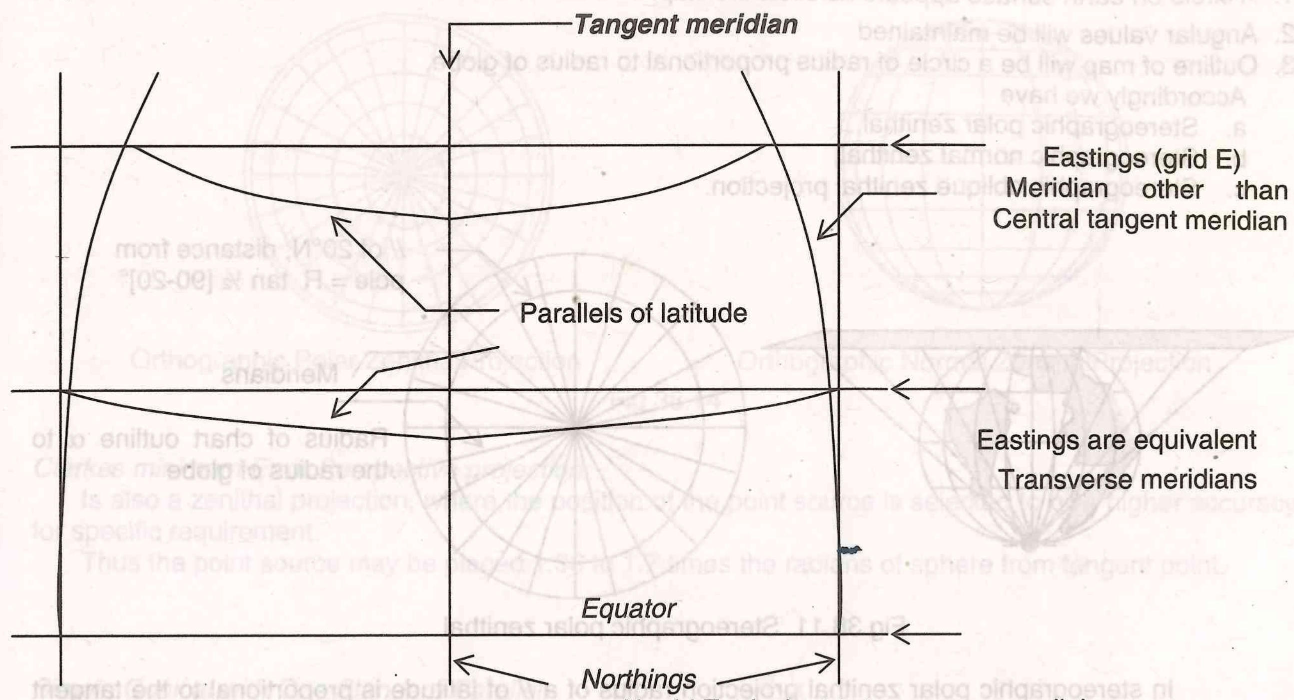


Fig 38.9

Zenithal Projection

Earlier we said that when vertex of a cone sufficiently nears' it's base it's surface area tends to become a flat circular plane. Such a plane could be placed tangent to the globe. A projection of this type is called zenithal projection & can be of 3 types.

Thus
a. When plane is tangent at pole the projection is called *polar zenithal.*
b. When plane is tangent at pole some point along equator the projection is called *normal zenithal.*
c. When plane is tangent some where else (is neither at pole nor at equator) the projection is called *oblique zenithal.*

Gnomonic projection: (Central zenithal projection) of above three type can be created when the point source is at centre of the earth. It is not orthomorphic, it is perspective projection though & is used for very small scale. Accordingly we get
a. polar gnomonic (discussed in chapter 1)
b. Normal gnomonic &
c. Oblique Gnomonic projection

The common features are
a. The area around the tangent or (contact point) has minimum distortion.
b. All great circles (meridians, equator) will always be seen as straight line & vice versa.
c. Rhumb lines & // of latitude would appear curved.

Fig 38.10

Stereographic projection: is a zenithal projection when the point source of light is diametrically opposite to the tangent point of flat screen. This projection is used in polar regions. Stereographic projection normally satisfies 3 properties:

1. A circle on earth surface appears as circle on map.
2. Angular values will be maintained
3. Outline of map will be a circle of radius proportional to radius of globe.
   Accordingly we have
   a. Stereographic polar zenithal,
   b. Stereographic normal zenithal,
   c. Stereographic oblique zenithal projection.

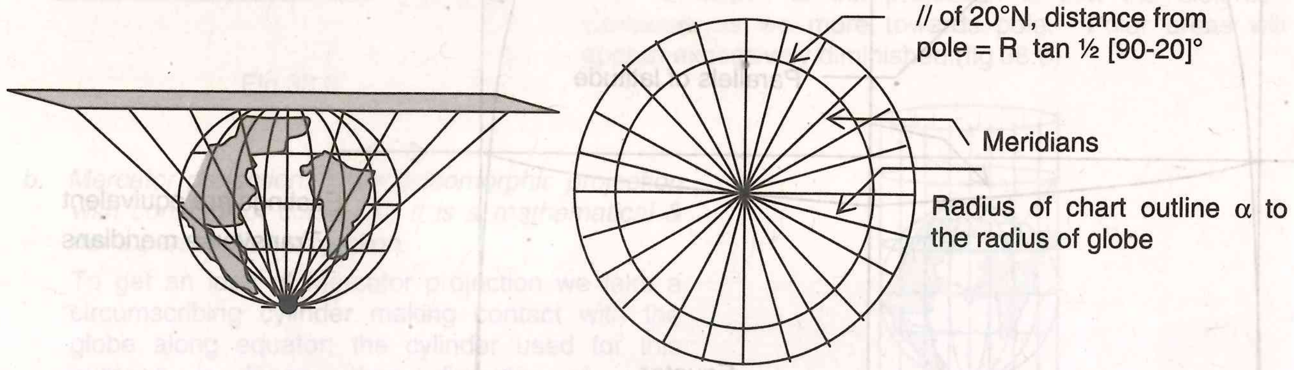


Fig 38.11 Stereographic polar zenithal

In stereographic polar zenithal projection radius of a // of latitude is proportional to the tangent of half of its co-latitude x Radius of globe. It is orthomorphic projection with less distortion as compared to Polar Gnomonic chart which is not orthomorphic.

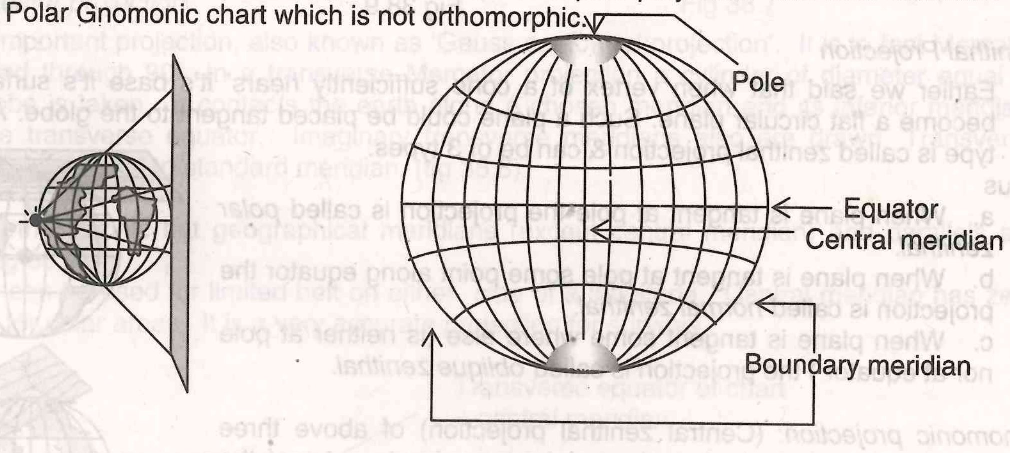


Fig 38.12 Stereographic normal zenithal

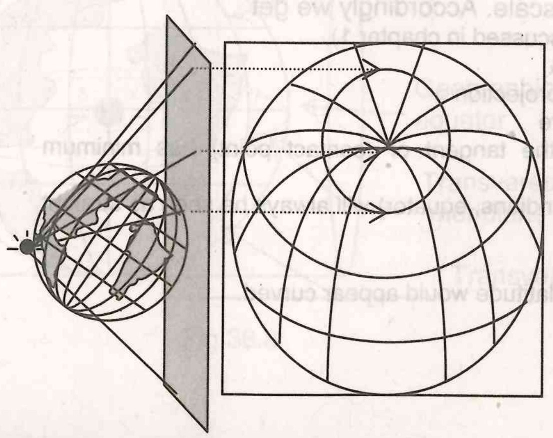


Fig 38.13 Stereographic oblique zenithal projection

Orthographic Projection:

Is an azimuthal projection where the point source lies at infinity so that rays will traverse through the transparent earth & cast shadows of lines of the hemisphere which lies towards the screen or the tangent plane.

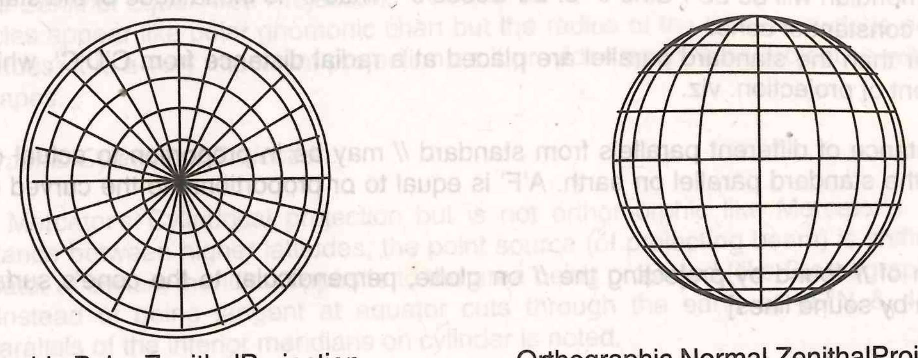


Fig 38.14

Clarkes minimum Error Perspective projection:

Is also a zenithal projection, where the position of the point source is selected to give higher accuracy for specific requirement.

Thus the point source may be placed 1.36 to 1.7 times the radians of sphere from tangent point.

Simple Conical with One Standard Parallel

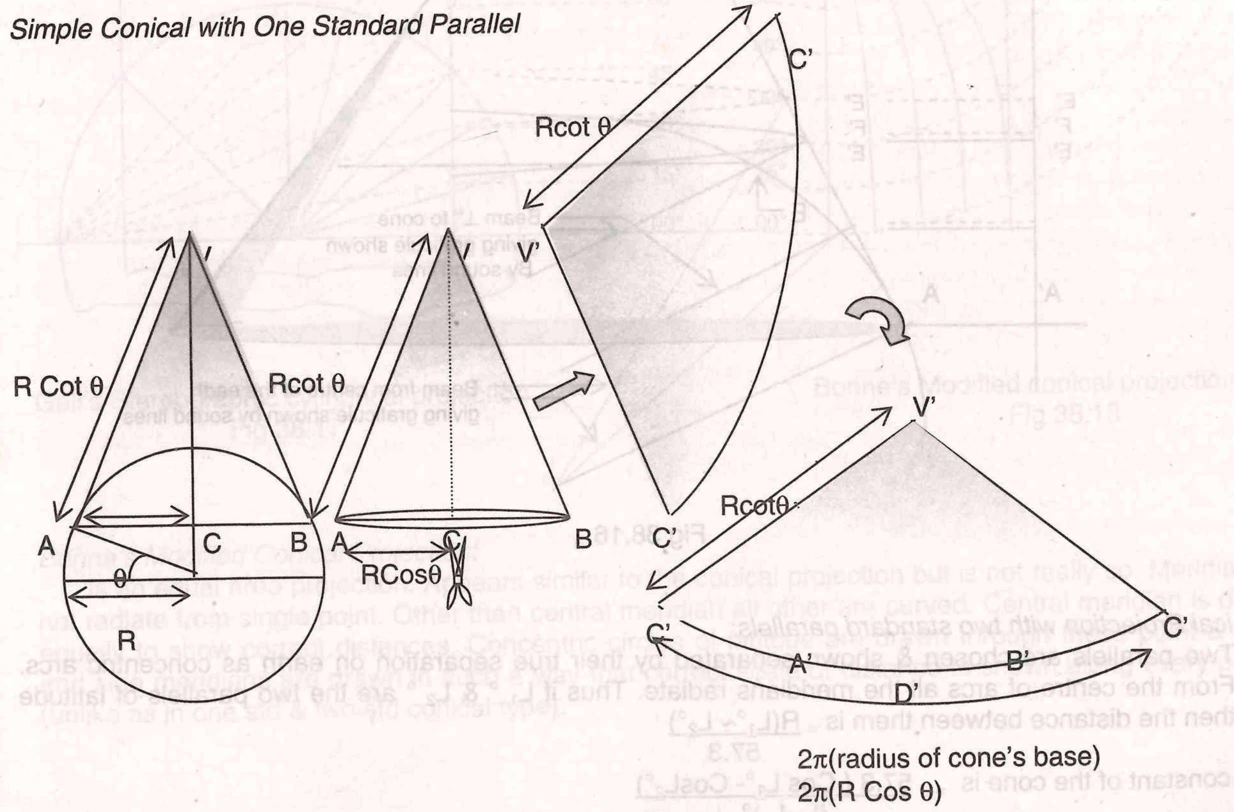


Fig 38.15

360° of meridians are reduced to an angle of C'V'C'.

The circumference of a circle whose radius is R Cot θ is = 2π(R Cot θ). ......(1)

Length of arc C'A'D'B'C' is 2π(R Cos θ) = circumference of the base of cone.......(2)

Ratio between (1) & (2) $= \dfrac{2\pi(R \cot\theta)}{2\pi(R \cos\theta)} = \dfrac{1}{\sin\theta}$

∴ If the angle between two meridians as measured by an ordinary protractor is 20°, the actual d'long between the meridian will be 20°/ Sine θ° or 20 Cosec θ°. Thus θ° is the latitude of the standard parallel & Sine θ° is the constant of cone.

Parallels other than the standard parallel are placed at a radial distance from C'D'C', which depends on the requirement of projection. viz.

a. The distance of different parallels from standard // may be in proportion to actual distance of that parallel from the standard parallel on earth. A'F' is equal to or proportional to the curved distance AE on earth.

b. Position of // found by projecting the // on globe, perpendicular to the cone's surface. [Projecting beams shown by sound lines]

c. Position of // found by projecting the // on globe, radially outwards from the centre of globe. [Projecting beams shown by pecked lines]

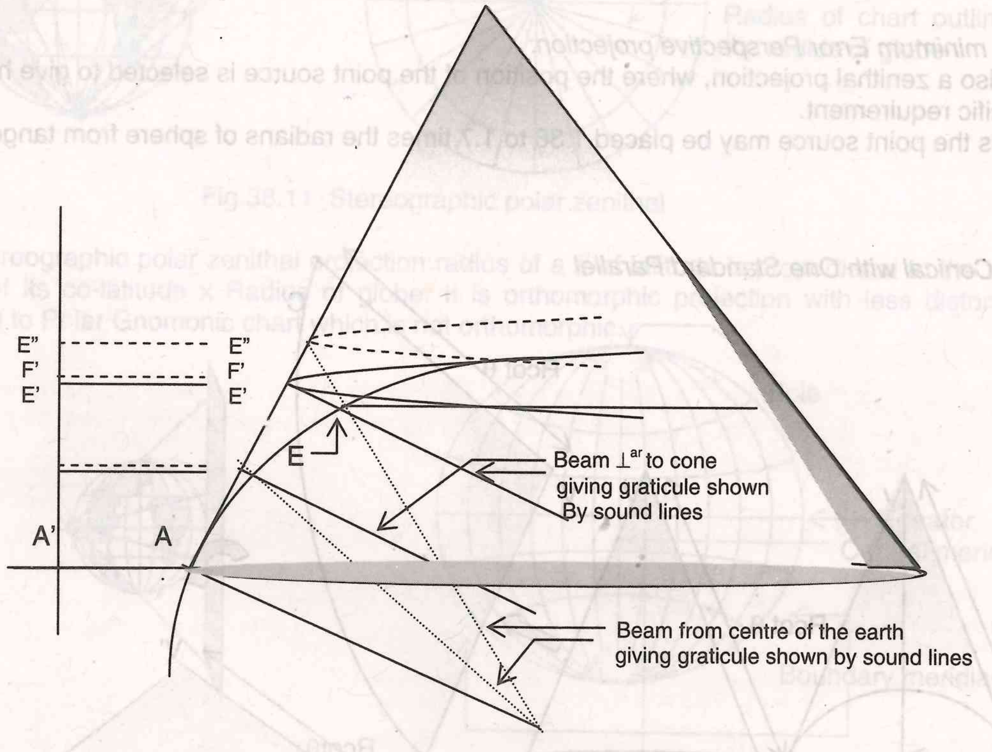


Fig 38.16

Conical Projection with two standard parallels:

Two parallels are chosen & shown separated by their true separation on earth as concentric arcs. From the centre of arcs all the meridians radiate. Thus if L_1 ° & L_2 ° are the two parallels of latitude then the distance between them is $= \dfrac{R(L_1° \sim L_2°)}{57.3}$

The constant of the cone is $= \dfrac{57.3\,(\cos L_1° - \cos L_2°)}{(L_2 - L_1)°}$

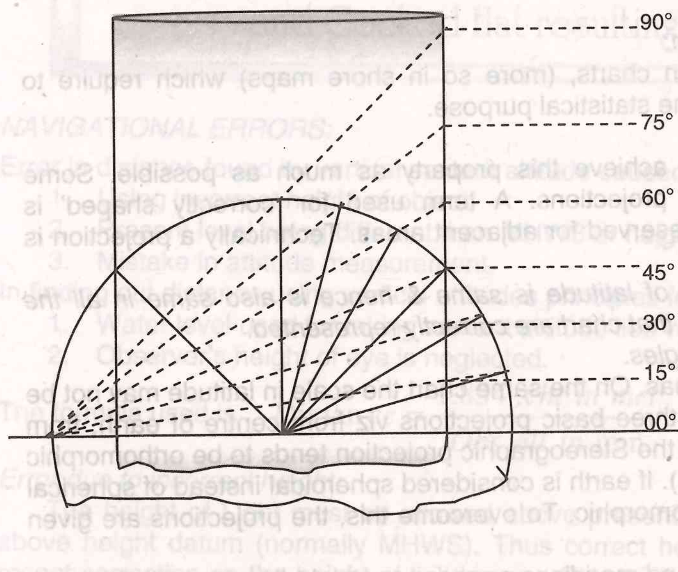
Also the radius of the first standard parallel is $= \dfrac{R\cos L_1}{\text{Const of cone}}$

Lambert's Conical Orthomorphic Projection: Is a modification of conical projection with 1 or 2 standard parallels. The // other than standard // appears concentric arcs with distance between them chosen so that projection is orthomorphic.

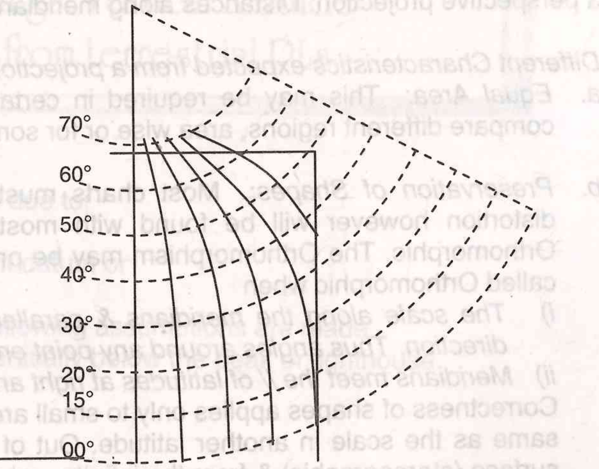
Lambert's Polar Zenithal Equal Area Projection:
Concentric circles appear like polar gnomonic chart but the radius of the latitude circle is equal to chords of their co-latitudes. It is a very important projection as it provides equal area projection with a very small distortion in shapes.

Gall's Stereographic Cylindrical Projection:

Similar to Mercator's Cylindrical projection but is not orthomorphic like Mercator's. to control the increasing distance between higher latitudes, the point source (of projecting beam) is shifted from centre of earth to equator at certain meridian opposite to the area being projected,(like Stereographic projection). The cylinder instead of being tangent at equator cuts through the earth at 45°N & 45°S& distance between the parallels of the inferior meridians on cylinder is noted.



Gall's Stereographic cylindrical projection
Fig 38.17



Bonne's Modified conical projection
Fig 38.18

Bonne's Modified Conical Projection:
Is an equal area projection. Appears similar to the conical projection but is not really so. Meridians do not radiate from single point. Other than central meridian all other are curved. Central meridian is divided equally to show correct distances. Concentric circles of latitude are drawn through these point & in the end side meridians are drawn in such a way that correct scale of distance is shown along every parallel (unlike as in one std & two std conical type).

Polyconic Projection:

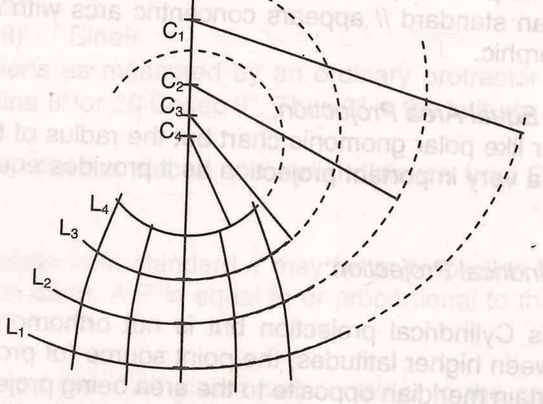


Fig 38.19

Polar Zenithal Equidistant:

Pole appears in the centre. Circles of latitude are drawn at equidistant interval up to equator. It is not a perspective projection. Distances along meridian are true distance but not along the parallel of latitude.

Different Characteristics expected from a projection:

a. *Equal Area:* This may be required in certain charts, (more so in shore maps) which require to compare different regions, area wise or for some statistical purpose.

b. *Preservation of Shapes:* Most charts must achieve this property as much as possible. Some distortion however will be found with most projections. A term used for 'correctly shaped' is Orthomorphic. The Orthomorphism may be preserved for adjacent areas. Technically a projection is called Orthomorphic when

   i) *The scale along the meridians & parallel of latitude is same & hence is also same in all the direction. Thus angles around any point on that chart are correctly represented.*

   ii) *Meridians meet the // of latitudes at right angles.*

   Correctness of shapes applies only to small areas. On the same chart the scale in latitude may not be same as the scale in another latitude. Out of three basic projections viz from centre of earth, from surface (stereographic) & from the infinity, only the Stereographic projection tends to be orthomorphic (not even cylindrical projection is orthomorphic)). If earth is considered spheroidal instead of spherical then even Stereographic projection is not orthomorphic. To overcome this, the projections are given mathematical form to get orthomorphism.

c. *Preservation of Direction:* Parallel of latitudes and meridians appear as straight lines perpendicular to each other as in Mercator's projection and is a very useful projection for navigation purpose . The bearing can be very easily transferred from any point on the chart to any other point on the chart. A single compass rose can be used for the entire chart.

d. *Preservation of shortest distance, represented by straight line:* All Gnomonic projections would preserve this property. Any line joined between two points is an arc of a great circle & hence also the shortest route between those two points on earth.

Galileo: (1564-1642) Galileo was born in Pisa, Italy. Galileo studied medicine but was never interested in medicine. He was interested in mathematics instead. He was convinced with the Copernicus's theory of earth revolving around sun. He used & improvised the refracting telescope. He is known for 'laws of falling bodies, law of pendulum, discovery of Jupiter's satellites etc. He was summoned & ordered by Roman Catholic Church not to defend Copernicus's theory. In 1979 Church admitted the mistake committed earlier.

[Pic. Galileo]

Chapter 39: Errors in Bearings, Vertical Altitude and Cocked Hat resulting from terrestrial PLs

NAVIGATIONAL ERRORS:

Error in distance found by vertical sextant altitude caused due to;

1. Using incorrect height of object,
2. Present level being different than MHWS or height datum or
3. Mistake in attitude measurement.

In finding out distance using vertical attitudes principles following assumptions are made.

1. Water level used for taking sextant attitude lies vertically below the peak or lighthouse
2. Observer's height of eye is neglected.

The formula used is $Distance = \dfrac{1.854\ x\,ht\ in\ met}{Obs\ alt\ in\ min}$

Error due to incorrect height:

The height of Light must be allowed above present level, whereas the height given on the chart is above height datum (normally MHWS). Thus correct height may not be indicated on chart owing to a recent correction on the height of lighthouse. Either will cause an error in height. Such error in height is used in the formula. $Error\ in\ distance = \dfrac{1.854\ x\ error\ in\ ht\ (m)}{Obs\ alt\ in\ min}$

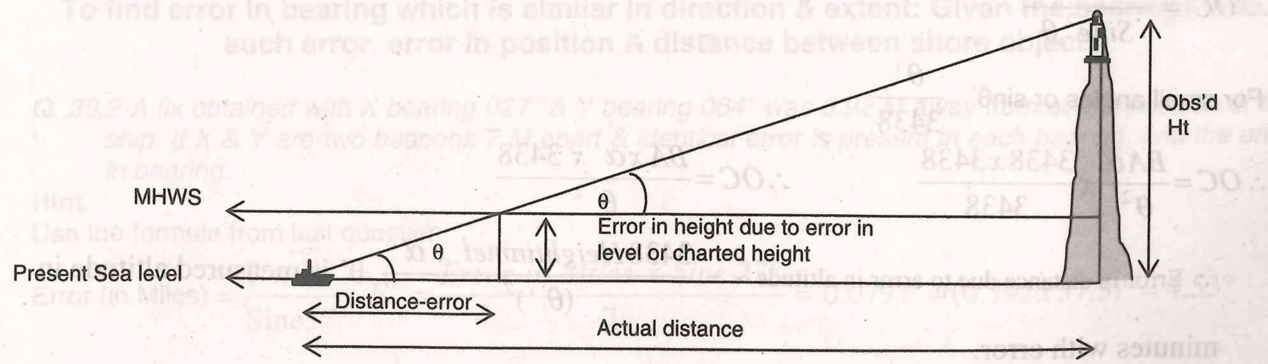


Fig 39.1

Error due to incorrect altitude:

A mistake in measured attitude will result in a wrong distance. An attitudes higher than the actual would result in giving a position closer to the shore & vice versa.

Thus if a vertical attitude is taken of a light 30m high & if an index error of 2'off was not applied the distance calculated would be more than actual. The error in distance as shown in the fig is OC.

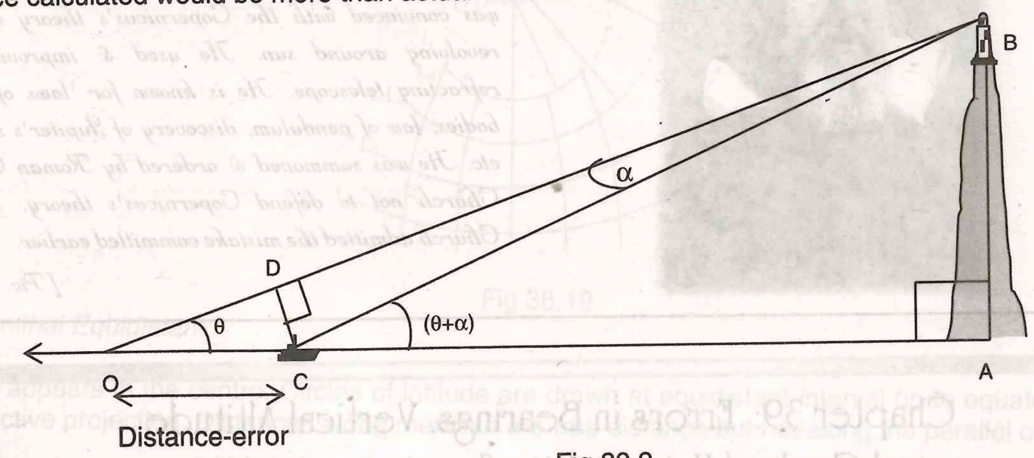


Fig 39.2

In fig OC= error in distance & α is the error in measured attitude.

$\angle BOC + \angle OBC = \angle BCA$. Also,

$$\frac{BA}{OB} = Sin\theta \quad ....(1)$$

$$\frac{CD}{CB} = Sin\alpha \quad ....(2)$$

$$\frac{CD}{OC} = Sin\theta \quad ....(3)$$

From (2) & (3) CD = CB Sin α = OC Sinθ

or CB Sin α = OC Sinθ ---------- (4)

From (1) BA = OB sin θ ----------(5)

In (4) & (5), Product of LHS = Product of RHS

$\therefore$ BA X CB sinα = OB sinθ X OC sinθ

OB $\approx$ CB $\therefore$ cancels.

$\therefore$ BA sin α = OC sin^{2}θ

$$\therefore OC = \frac{BA\,Sine\,\alpha}{Sine^2\,\theta}$$

For small angles or sinθ' $\dfrac{\theta'}{3438}$

$$\therefore OC = \frac{BA\alpha}{\theta^2} x \frac{3438 x 3438}{3438} \qquad \therefore OC = \frac{BA x \alpha \;\; x\, 3438}{\theta^{\,2}}$$

$\therefore$ Error in distance due to error in altitude $\alpha = \dfrac{3438\,Heightinmet\;x\;\alpha^{\,o}}{(\theta')^2}$ θ' is measured altitude in minutes with error.

Error caused in fix due to similar error in bearings. Effect of angle of cut on accuracy

Q. 39.1 Find out the error caused in fix, due to similar error of 1.5° in bearings of two objects, 50° apart & have a distance of 10 M between them. What would have been the error if the two objects were 90° apart instead?

Soln. ***Formula:***

$$\text{Error in fix(M)} = \frac{Distance\ between\ objects\ in\ M}{Sine\ of\ angular\ seperation} \text{ x Bearing error in Radians}$$

Bearing error in radians = 1.5/57.3

$$\text{Error in M} = \frac{10}{Sine50} \text{ x } \frac{15}{57.3} = 0.34.$$

Ans. Error in fix = 0.34 M

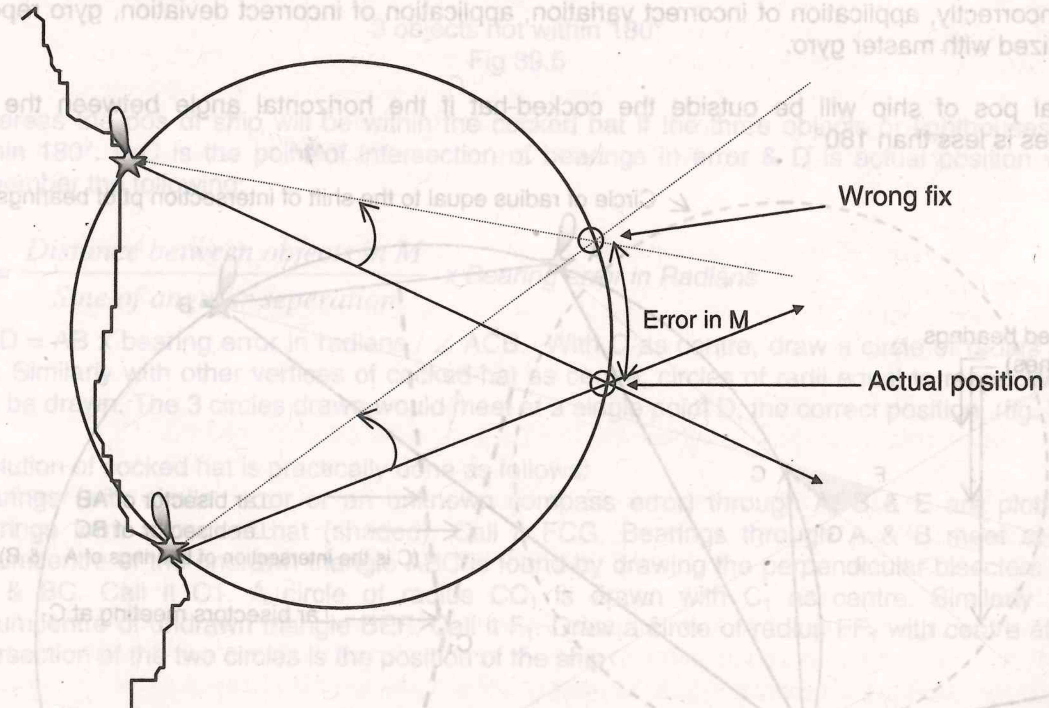


Fig. 39.3

To find error in bearing which is similar in direction & extent: Given the bearings with such error, error in position & distance between shore objects

Q. 39.2 A fix obtained with X bearing 027° & Y bearing 064° was 0.92 M away from actual position of the ship. If X & Y are two beacons 7 M apart & identical error is present in each bearing, find the error in bearing.

Hint.

Use the formula from last question

$$\text{Error (in Miles)} = \frac{7 \text{ x } E^c}{\text{Sine}37} \therefore E^c = \frac{Error\ in\ Miles\ x\ Sine\ 37°}{7} = 0.0791^c = (0.791 x 57.3)° = 4.53°$$

Ans. Error = 4.53°

Cocked Hat:

3 instead of 2 position lines if plotted may not meet at a single point, the triangle ofpos lines thus formed is called cocked hat. Cocked hat could be due to

I) *The unknown and hence uncorrected error of compass*, which may be upto $^1/_2$°.
II) *The Error in observation due to limitations of compass* that can be up to $^1/_2$°.
III) *Error in actual plotting of lines*, which can be up to $^1/_4$°.

The cocked hat could be also due to:

IV) Interval between the successive bearings, the fast speed of the ship causing substantial distance run between the successive bearings, the discrepancy in the port & starboard repeaters.
V) *Inaccuracy of surveys*
VI) *Object wrongly identified.*

Out of the first three sources of errors the errors, II & III are random error. Error I has definite sign & is affecting all the three bearings in similar way.
Similar & fixed error applied on all the three bearings: The examples are constant error on EBL, gyro error applied incorrectly, application of incorrect variation, application of incorrect deviation, gyro repeater not synchronized with master gyro.

Actual pos of ship will be outside the cocked-hat if the horizontal angle between the extreme lighthouses is less than 180°.

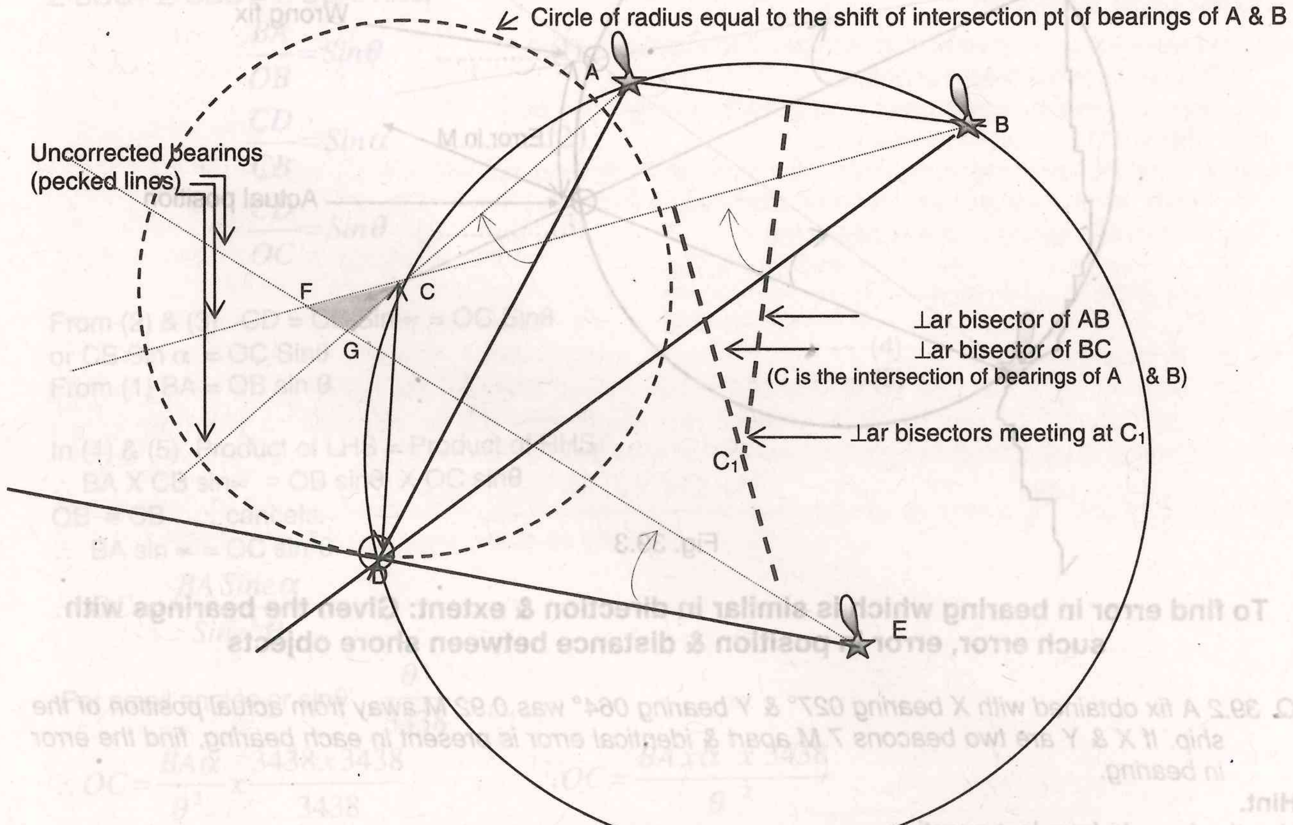
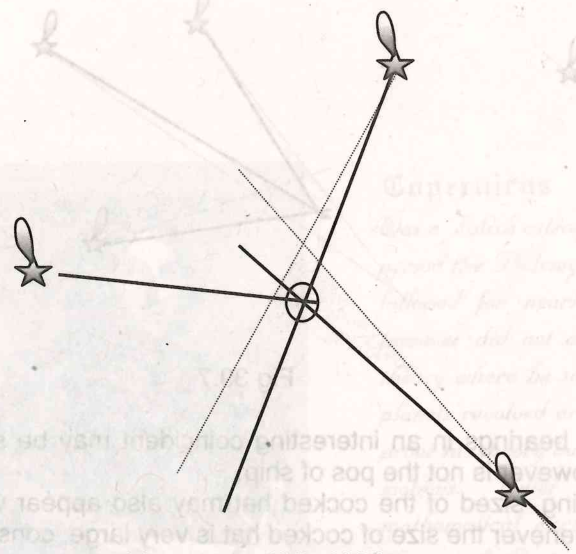


Fig 39.4 3 objects within 180°



3 objects not within 180°
Fig 39.5

Whereas the pos of ship will be within the cocked hat if the three objects or lighthouses are not within 180°. If C is the point of intersection of bearings in error & D is actual position we must remember the following:

(1) $CD = \dfrac{\textit{Distance between objects in M}}{\textit{Sine of angular seperation}}$ *x Bearing error in Radians*

$\therefore$CD = AB x bearing error in radians / ∠ ACB. With C as centre, draw a circle of radius equal to CD. Similarly with other vertices of cocked-hat as centre, circles of radii equal to respective errors can be drawn. The 3 circles drawn would meet at a single point D, the correct position. (fig. 39.4)

(2) Resolution of cocked hat is practically done as follows:
Bearings (with similar error or an unknown compass error) through A, B & E are plotted. The bearings form a cocked hat (shaded). Call it FCG. Bearings through A & B meet at C. The circumcentre of the undrawn triangle ABC is found by drawing the perpendicular bisectors of sides AB & BC. Call it C1. A circle of radius CC_1 is drawn with C_1 as centre. Similarly find the circumcentre of undrawn triangle BEF. Call it F_1. Draw a circle of radius FF_1 with centre at F_1. The intersection of the two circles is the position of the ship

(3) Two position circles corresponding to horizontal angles between AB & BE respectively may be drawn to find actual position of ship, D. The principle is discussed in chapter 7 under horizontal angle.

Different (magnitude - sign) errors on 3 bearings:

Different or random errors on the three bearings may make a cocked hat or may not give a cocked hat & cause three lines to meet at a single point. Unless the three errors with their signs is precisely known it is impossible to find the position of ship by using the formula. If the errors are dissimilar then the cocked hat cannot be resolved. All 3 lines meeting at a point does not mean there is no error on bearings. The meeting point may not be the ship's position. (fig 39.6)

When cocked hat is formed, ship's pos may be within the cocked hat or it may be outside the cocked hat. (fig 39.7 & fig 39.8) It is almost impossible to determine the exact position of ship. Practically we may proceed as follows: The vertex of triangle closest on the side of danger is considered as ship's pos but ship may be even beyond that point.

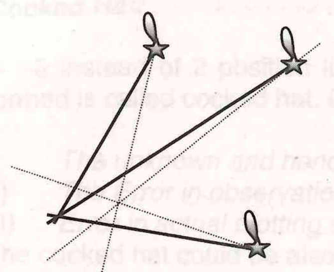


Fig. 39.6

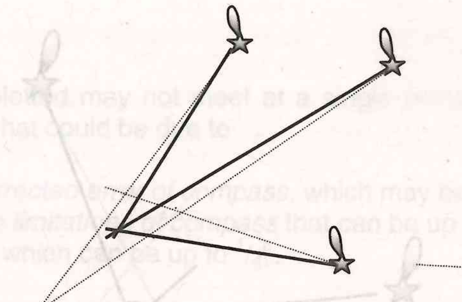


Fig 39.7

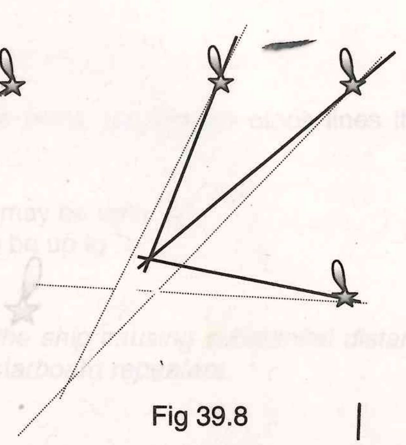


Fig 39.8

The total errors in 3 bearings in an interesting coincident may be such that 3 pos lines meet at a single point. This point however is not the pos of ship.

During the coasting, sized of the cocked hat may also appear very big owing to the very large scale of the chart. But whenever the size of cocked hat is very large, consider the following:

a. Rechecking the bearing with a possible additional bearing.
b. Probability of ship being at the vertex closer to the side of danger.
c. More importance is given to the shore objects, which are closest or close to the danger of interest.
d. Some times the lighthouse is repositioned so confirm the position.

To understand the effect of similar & equal errors on bearing lines students are advised to practice following:

Q.39.3: 'T', 'X' & Aero RC beacon were plotted as 342°, 51.5°T & 119.5°T to give a cocked hat, find the position of ship,

(a) when amount of error is known as 5° (using formula for displacement of pos as discussed viz.

$$\text{shift} = \frac{\textit{Distance between objects in M}}{\textit{Sine of angular seperation}} \times \text{Bearing error in Radians}$$

(b) when amount of error is not known, use perpendicular bisector method.

Hint:

(a) Let ABC be cocked hat, A is intersection of bearings from X & T. B is intersection of bearings from X & aero beacon. If D is correct position then
DA = 5/57.3 x 6.75 / Sine 69.5° = 0.63M. Similarly DB = 0.54M & DC = 1.32M.

(b) Let the bearings through T & X meet at A. Draw perpendicular bisectors of TX & AX respectively meeting at A'. Draw a circle of radius equal to AA'& A' as centre. Let the bearings through X & B_n meet at B. Draw perpendicular bisectors of XB_n & XB respectively meeting at B'. Draw a circle of radius equal to BB'& B' as centre. The intersection of the two circles is the position of the ship.

Ans: Pos: 02°6.65'N, 080°6.65'E

Q.39.4: 'U' buoy, T light & X light bore 007°, 267°C & 161°C respectively. Prepare cocked hat & thereafter find pos of ship & error by bisector method.

Ans: Pos: 02°13.35'N 080°23.8'E, Error in bearings = 6°W.


Ptolemy


Copernicus

Copernicus Nicolaus: *(1473-1543)* *Was a Polish astronomer. During Copernicus's period the Ptolemy's theory was already being followed for nearly 1400 years. Copernicus however did not accept it & gave a simpler theory where he suggested that earth & other planets revolved around the sun. He could not prove his theory but explained various heavenly motions. Later Galileo's & Kepler's mathematical work in astronomy proved the theory of Copernicus correct. In ancient Greece & India this heliocentric behaviour of bodies was known.*

Chapter 40: Error in astronomical PLs and Cocked that due same, Error due to mistake in transfer of a PL

Running Fix of astronomical position lines

In a fix obtained by running astronomical position line may have error because of two reasons.

a. *Error in position of fix caused due to error in 'distance run' applied between 2 sights.*
b. *Error in position of fix caused due to error in 'course run' applied between 2 sights.*

a. Error in position of fix caused due to error in 'distance run' applied between 2 sights.

Let PQ be the PL from 1st sight.
Let ∝ be the angle between the course run & P/L
Let P_1Q_1 & P_2Q_2 be the incorrect & correct transferred lines Let x be the distance between them.
Let error in distance run be = d
So that x/d = Sin ∝ or x = d Sin ∝ - - - - - (1)
Let θ be the ∠ between PQ & RS the PLs obtained in the two sights.

Also distance-error between correct & incorrect fixes, AB = x/Sin θ - - - - - -(2)

From (1) & (2) error, $AB = \frac{d \sin \alpha}{\sin \theta}$

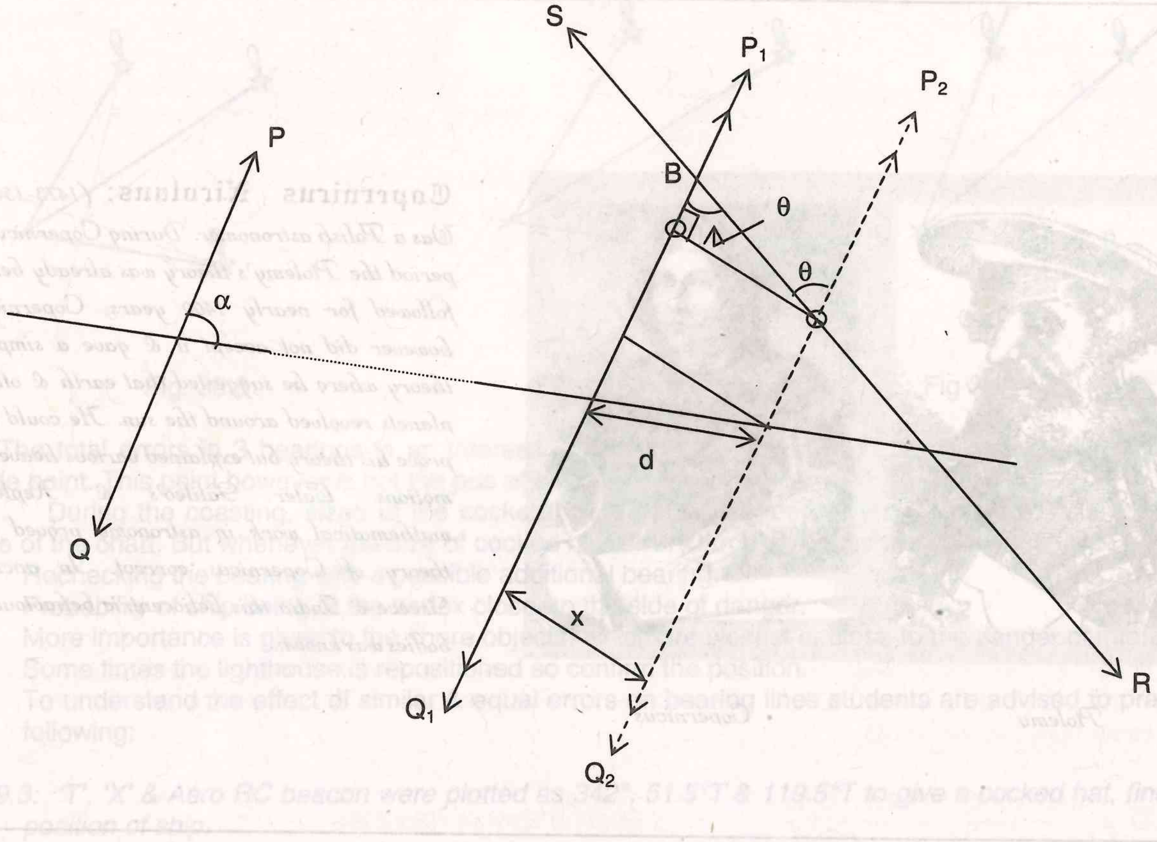


Fig 40.1

b. Error in position of fix caused due to error in 'course run' applied between 2 sights.

Let PQ be the PL from 1st sight.

Let P_1Q_1 & P_2Q_2 be the incorrect & correct transferred PLs

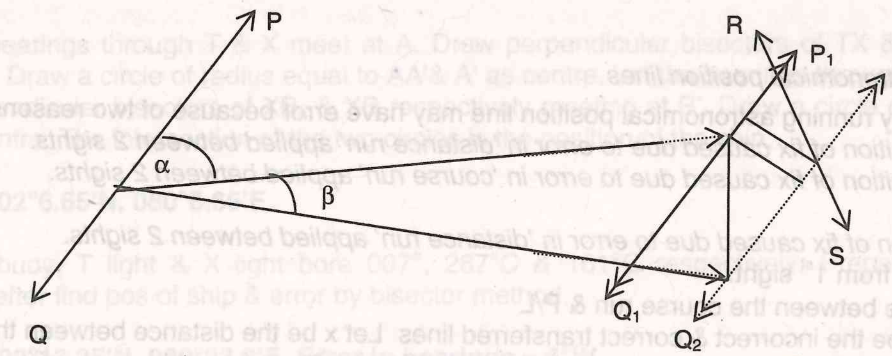


Fig 40.2

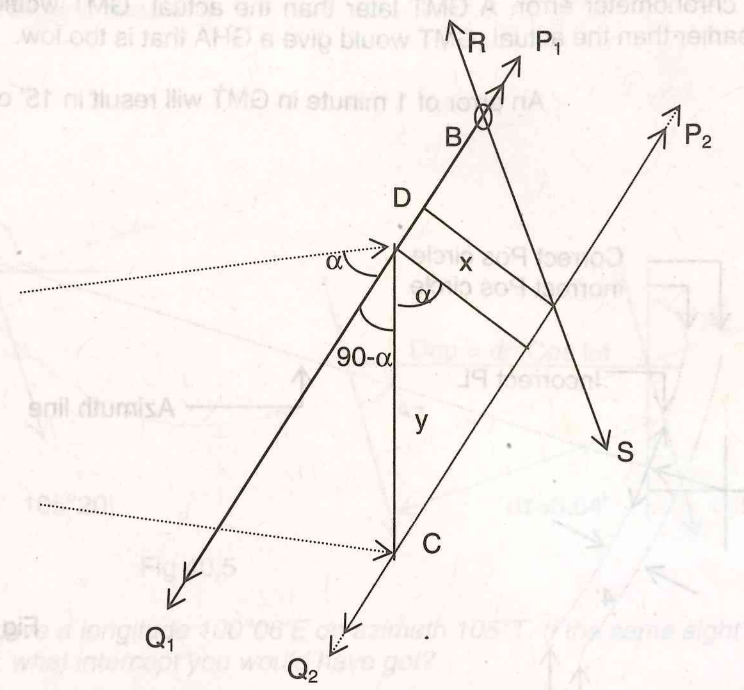


Fig 40.3

Let $\propto$ be the angle between 1st PL & incorrect course

Let $\propto$ ($\propto + \beta$) be the angle between 1st PL & correct course

'PL transfer point' would Shift from C to D through distance y & y = distance run X β^C

$= \frac{\text{distance X } \beta^\circ}{57.3}$ - - - - - (3)

Let RS be the PL from 2nd sight & $\angle$ between PQ & RS be = θ

Let x be the perpendicular distance between P_1Q_1 & P_2Q_2 so that

$\frac{x}{\text{Error in fix}} = \text{Sin } \theta$ or error in fix $= \frac{x}{\text{Sin } \theta}$ - - - - - (4)

Also $\frac{x}{y} = \text{Cos} \propto$ or $x = y \text{ Cos} \propto$ - - - - - (5)

Substitute (5) in (4), we get

Error in fix $= \frac{\text{Y Cos} \propto}{\text{Sin } \theta}$ - - - - - (6)

Substitute (3) in (6)

We get error in fix $= \frac{\text{distance run X } \beta^\circ}{57.3} \times \frac{\text{Cos} \propto}{\text{Sin } \theta}$

Normally PL is perpendicular to azimuth line in case of astronomical position lines. Geographical, position of the body which was used for sight lies on azimuth line extended in the direction of body.

Error in Zenith Distance (dz)

The true zenith distance (TZD) may be in error due to various reasons. Let us suppose that an index error of 2'on the are was applied as 2' off the arc. Where you should have reduced 2' from sextant altitude you added 2'. This will make true altitude 4' too high. Or the TZD will be 4' too low. To rectify this mistake one must increase TZD by 4 minutes or 4 miles. Or the PL must be shifted away from GP by 4 miles. dz may also arise due to mistake in applying dip.

Error in observed longitude (dh), due to mistake in applying Chronometer error: LHA is calculated using TZD, latitude and declination. GHA is based on on incorrect GMT which is obtained by applying wrong chronometer error. A GMT later than the actual GMT would give a GHA that is too high and a GMT earlier than the actual GMT would give a GHA that is too low.

An error of 1 minute in GMT will result in 15' of error in GHA

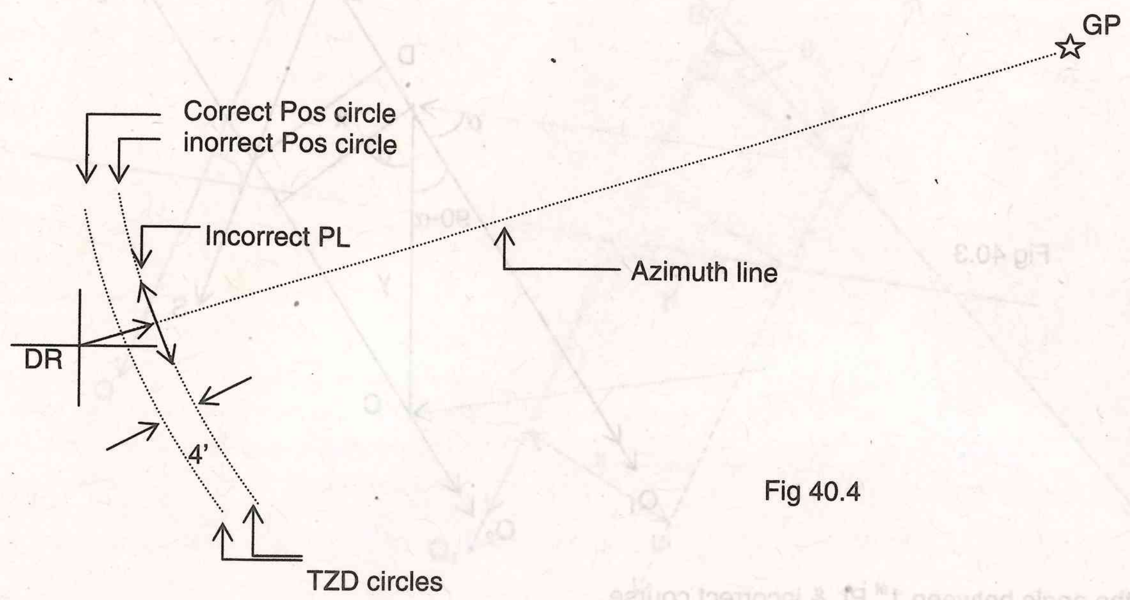


Fig 40.4

Q.40.1 The Chronometer error of 1^{m}30^s slow was not applied for a longitude sight. The calculated longitude was 37°E. Find correct longitude for drawing the PL.

Ans.

The mistake stated in above question will result in a GHA that is 01^{m}30^s before the sight time i.e. GHA too low by an amount equal to 1.5 x 15 = 22.5' = dh

One may remember a simple thumb rule viz. Long East G least & Long west G best

In present case longitude is East. G < L or LHA >GHA or LHA – GHA = longitude = 37°

To rectify the mistake GHA is increased by 22.5' the longitude would reduce by 22.5' & become 36° 37.5'E

Note : In above example if long was 37° W then equation would have been GHA – LHA = longitude = 37° & after rectifying the mistake the correct longitude would be 37° 22.5 W.

Alternately we may say that an earlier GMT shifts the position line to the East & therefore correct position line lies to the West. A later GMT shifts the position line to the West & therefore correct position line lies to the East.

Relationship between dz and dh

dz = Error in TZD or shift of PL towards or away from GP.

Dh = Error in GHA or d'long (East or west) caused to calculated longitude.

Dz and dh are related by following equation.

Dz = dh Cos latitude x Sine Azimuth

Q.40.2 A sight worked using DR latitude 40°N gave calculated longitude 105° 15'E the correct longitude however was 105°20'E. Find the shift of PL required towards or away from GP. Given : Azimuth = 72° T

Ans.

In this example we know dh but dz is required.

Dz = dh Cos lat Sine Azimuth

= 5 Cos 40°Sine 72° = 3.64'

[Note: dz may also be found by plotting to scale.}

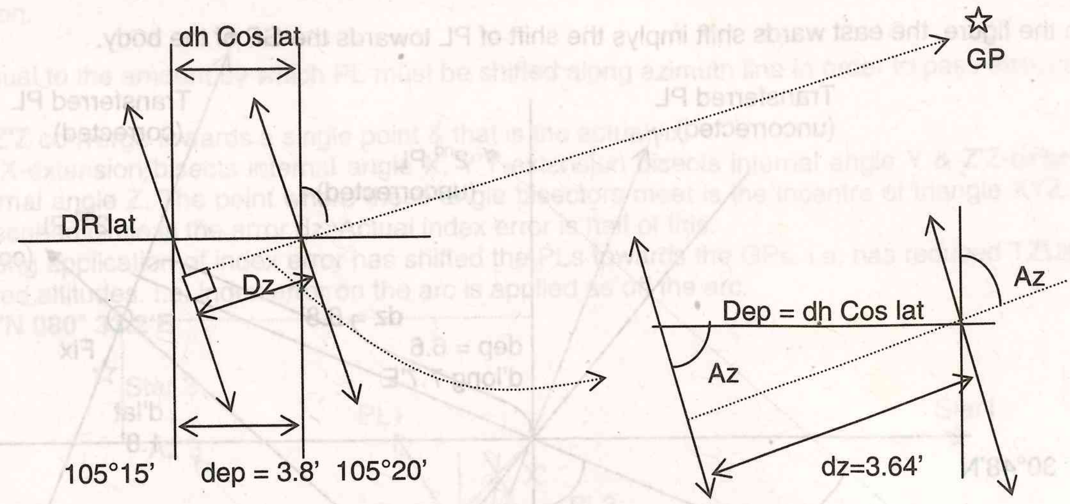


Fig 40.5

Q.40.3 DR: lat 40°N 100°E, A sight gave a longitude 100°06'E on azimuth 105°T. If the same sight was calculated by intercept method, what intercept you would have got?

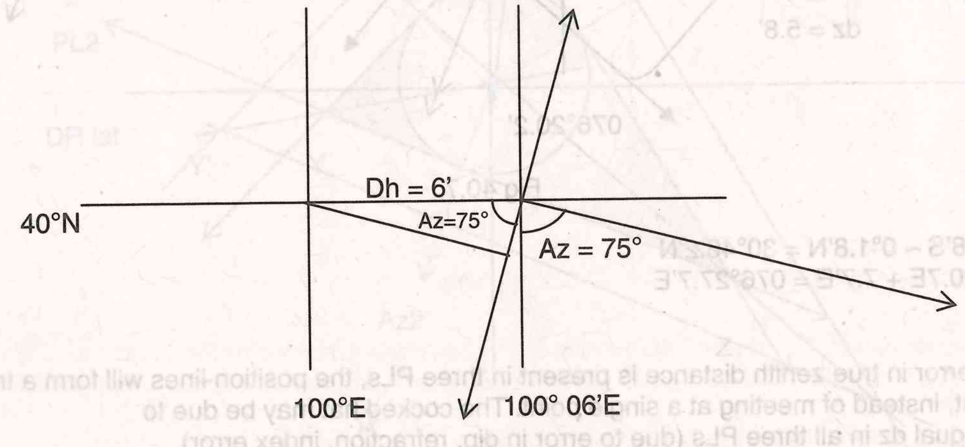


Fig 40.6

dz = dh Cos latitude x Sine Azimuth = 6 Cos 40° x Sine 75° = inter cept (towards)

Q40.4 At 1530h, DR latitude, 30°30'S was used to calculate a sun's sight, where a longitude of 075°44' E was obtained. Sun's azimuth then was 248°T & ship was steering 120°T @ 12kn. Three hours later another sight was calculated using a DR, found by running the latitude at 1530h & the calculated longitude. The sight gave an intercept of 3' away on an azimuth of 140°T. It was found later that, for the first observation the dip was not applied at all, (HE 15m). For the second observation a chronometer error of 21s fast was applied as 21s slow. Find the position at the time of second observation.

Sol^n:

The second sight was calculated using the DR 30°48'S, 076°20.2'E. Normally the first PL should have been transferred from here but since dip was not applied in the earlier sight, TZD would be too low by 6.8' To rectify the mistake the transferred PL must be moved by 6.8' away from the GP_1.

Second Sight: Total error in time was 42sec. @ 15.041° per hour, the dh or error in hour angle = 10.53'

Also dz = dh Sine azimuth Cos lat, we get dz = 5.8'.

Due to the higher GMT PL had shifted to west. To rectify the mistake, we must shift back the PL to east side.
From the figure, the east wards shift implys the shift of PL towards the GP of the body.

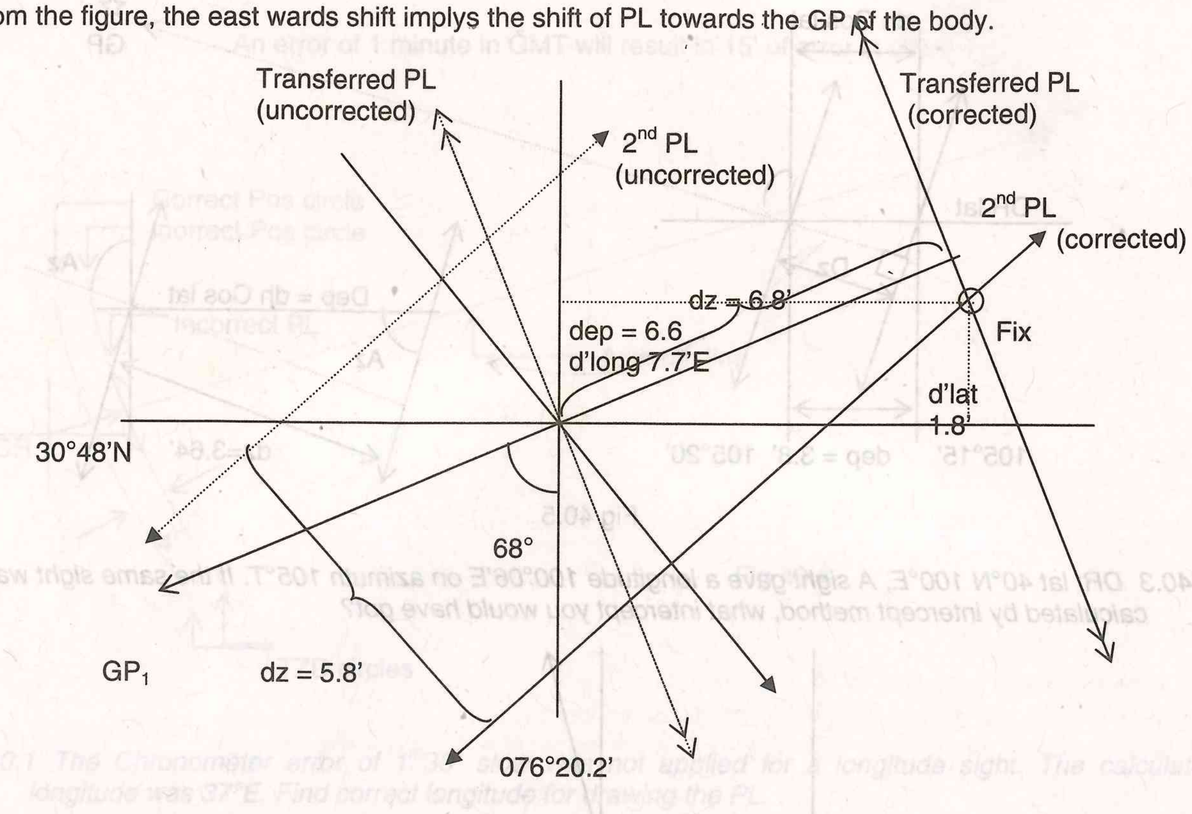


Fig 40.7

Fix = 30°18'S ~ 0°1.8'N = 30°46.2'N
076°20.7E + 7.7'E = 076°27.7'E

Cocked Hat

If dz, or the error in true zenith distance is present in three PLs, the position lines will form a triangle, called cocked hat, instead of meeting at a single point. The cocked hat may be due to

a. similar & equal dz in all three PLs (due to error in dip, refraction, index error).
b. Different dz in the three PLs

In case of a, the dz and hence the correct fix may be found by plotting.

In case b, where there is different dz in all the three PLs, the fix cannot be found by plotting. Also the correct fix can be found only if the individual dz_s are known.

Now we will find dz, by plotting an astronomical cocked hat & running the three PLs uniformly.
To find the position of fix we proceed as follows:

1) On an appropriate scale, plot the three PLs wrt DR. The cocked hat thus formed may be called XYZ.
2) Determine directions of the GP, GP_2, GP_3 wrt DR.
3) *Along the azimuth line*, shift the PL by (say)1 cm *either towards GP or away from GP* for all the three PLs. The new triangle formed is X'Y'Z'.
4) The Ship's position will be either along XX'YY' ZZ' extension or X'X Y'Y & Z'Z extension.

Let us take a case where all 3 PLs have intercept towards the body or GP:

Q.40.5 A simultaneous observation was made using three stars, calculated using intercept method. DR used was 02°20'N 080°33'E. Azimuths & intercepts obtained were as folows:
Star 1 Azimuth 060°T Intercept 2.2' Towards
Star 2 Azimuth 200°T Intercept 1.6' Towards

Star 3 Azimuth 317°T Intercept 1.5' Towards
If an index error was wrongly applied in all the three observations. Find th eindex error & the ship's position.

Ans

dz is equal to the amount by which PL must be shifted along azimuth line in order to pass through the fix.
X'X, Y'Y & Z'Z converge towards a single point & that is the actual fix.

Note X'X-extension bisects internal angle X, Y'Y-extension bisects internal angle Y & Z'Z-extension bisects internal angle Z. The point where these angle bisectors meet is the incentre of triangle XYZ. The radius of inscribed circle is the error dz. Actual index error is half of this.

The wrong application of index error has shifted the PLs towards the GPs. i.e. has reduced TZDs. i.e. has increased altitudes. I.e. index error on the arc is applied as off the arc.

Pos. 02°20'N 080° 33.2'E

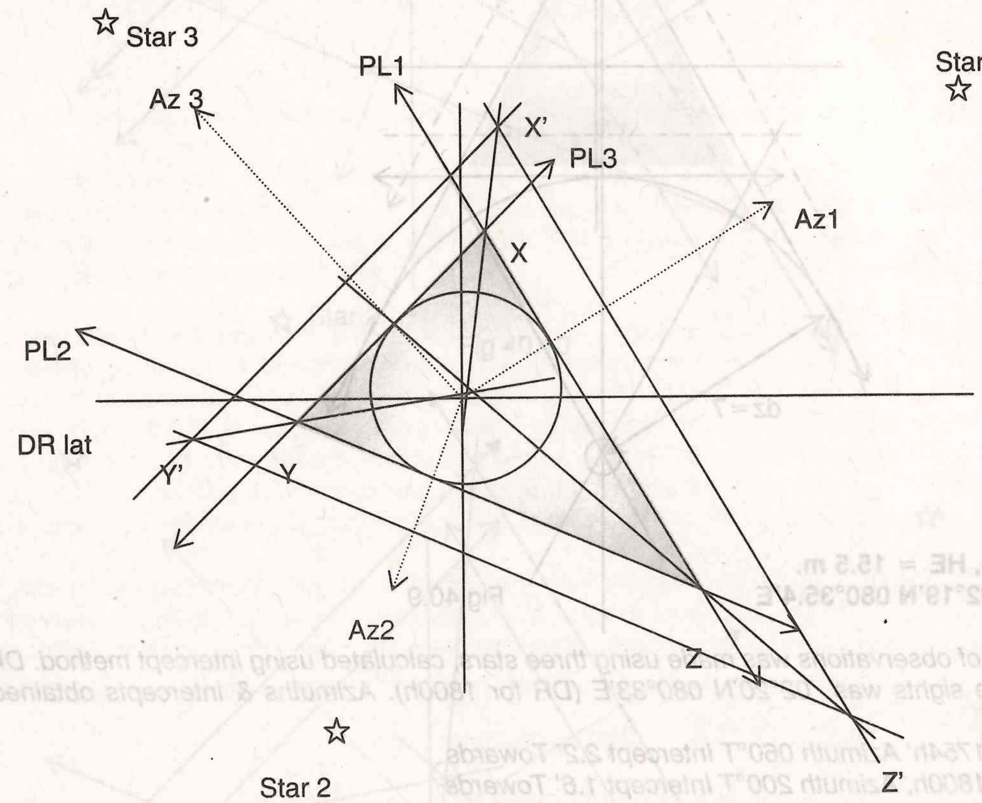


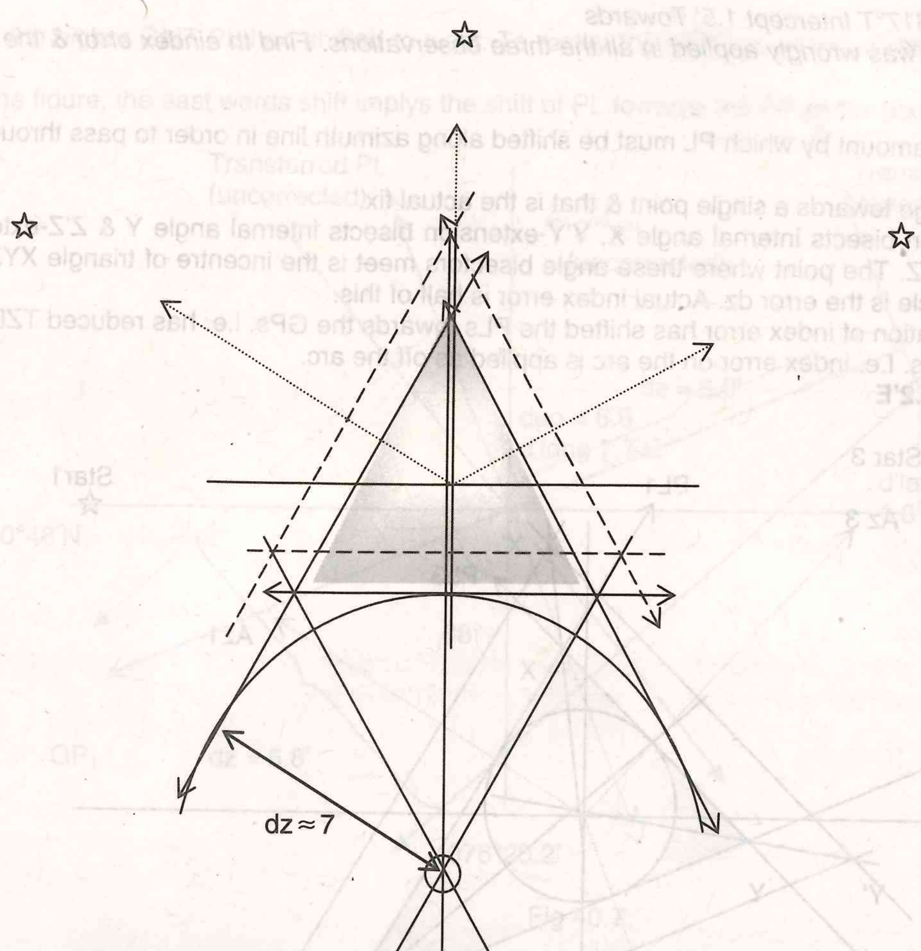
Fig. 40.8

Situation where an equal & similar error in altitude or true zenith distance has been the cause of the cocked hat. The names of the intercepts are not same.

Q.40.6 DR 02° 08'N 080° 36'E
Star 1: Azimuth 063°T Intercept 2' Towards
Star 2 :Azimuth 000°T Intercept 3' Away
Star 3 :Azimuth 300°T Intercept 2.5' Towards
Later it was realised that the dip correction was not applied in all the three observations, find the height of eye of observer above sea level.

Sol

The TZDs in the three observations are too small by 4.4', i.e. the true altitudes are too big by 4.4'. This is because a dip correction of 4.4' was not applied in each of the observations. The height of eye therefore = 6.2m



Ans dz ≈ 7', HE ≈ 15.5 m.
Pos = 02°19'N 080°35.4'E

Fig 40.9

Q.40.7 A set of observations was made using three stars, calculated using intercept method. DR used for all three sights was 02°20'N 080°33'E (DR for 1800h). Azimuths & intercepts obtained were as folows:
Star 1: 1754h' Azimuth 060°T Intercept 2.2' Towards
Star 2: 1800h, Azimuth 200°T Intercept 1.6' Towards
Star 3: 1806h, Azimuth 317°T Intercept 1.5' Towards
If an index error was wrongly applied in all the three observations. Find th eindex error & the ship's position at 1800h. Given, ship's course 100°T & speed 12kn.

Sol^n

Plot the three PLs with intercepts from the DR at 1800h. The three PLs are identified by the time of observation stated next to the PLs.

Plot a course of 100° through the intersection of PLs at 1754h & 1806h.
Run PL at 1754h forward along 100°T,by 1.2miles.
Run PL at 1806, backwards along 280°T, by 1.2miles.

PL at 1800h need not be run.
Now identify a cocked hat for 1800h-observations.
Resolve this modified cocked hat of 1800h, as usual on a separate drawing.

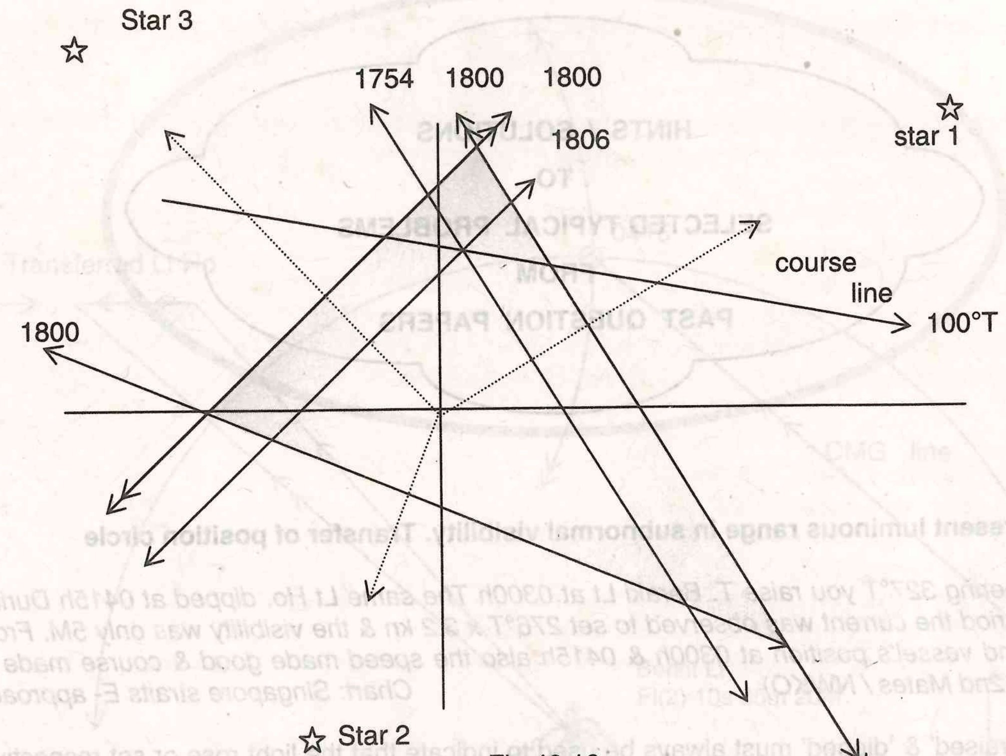


Fig 40.10

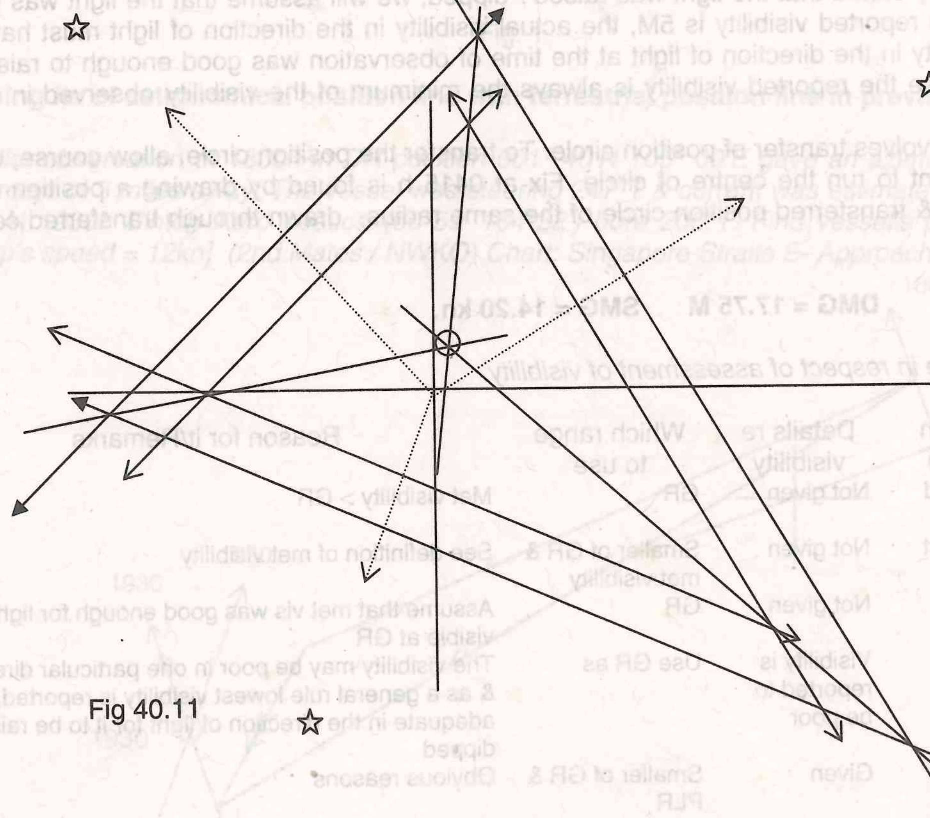


Fig 40.11

HINTS / SOLUTIONS TO SELECTED TYPICAL PROBLEMS FROM PAST QUESTION PAPERS

Present luminous range in subnormal visibility. Transfer of position circle

Q.1 *While steering 327°T you raise T. Beraki Lt at 0300h The same Lt Ho. dipped at 0415h During the above period the current was observed to set 276°T x 3.2 kn & the visibility was only 5M. From the above, find vessel's position at 0300h & 0415h also the speed made good & course made good. HE 15m (2nd Mates / NWKO) Chart: Singapore straits E- approaches.*

Hint.

The terms 'raised' & 'dipped' must always be used to indicate that the light rose or set respectively at Geographical Range. In present question however the statement made in question should be, 'first sighted at 0300h & last sighted at 0415h'. This is because the meteorological visibility is only 5M. But since it is specifically stated that the light was raised / dipped, we will assume that the light was raised & dipped. Though the reported visibility is 5M, the actual visibility in the direction of light must have been good. Or the visibility in the direction of light at the time of observation was good enough to raise or dip the light. In any case the reported visibility is always the minimum of the visibility observed in different directions.

This question involves transfer of position circle. To transfer the position circle, allow course, distance & drift due to current to run the centre of circle. Fix at 0415 h is found by drawing a position circle of radius equal to GR & transferred position circle of the same radius, drawn through transferred centre for 0415 h.

Ans CMG = 317°T DMG = 17.75 M SMG = 14.20 kn.

Following is a guide in respect of assessment of visibility.

Day / Night	Remark in Question	Details re visibility	Which range to use	Reason for it/Remarks
D	Lt Ho Raised /Dipped	Not given	GR	Met visibility > GR
D	Lt Ho 1st/last seen	Not given	Smaller of GR & met visibility	See definition of met visibility
N	Lt raised /dipped	Not given	GR	Assume that met vis was good enough for light to be visible at GR
N	Lt raised / dipped	Visibility is reported to be poor	Use GR as	The visibility may be poor in one particular direction & as a general rule lowest visibility is reported, but adequate in the direction of light for it to be raised or dipped
N	Lt 1st / last seen	Given	Smaller of GR & PLR	Obvious reasons
N	Lt Ist / last seen	Not given	Smaller of NR & GR	Assume that met vis = 10 M

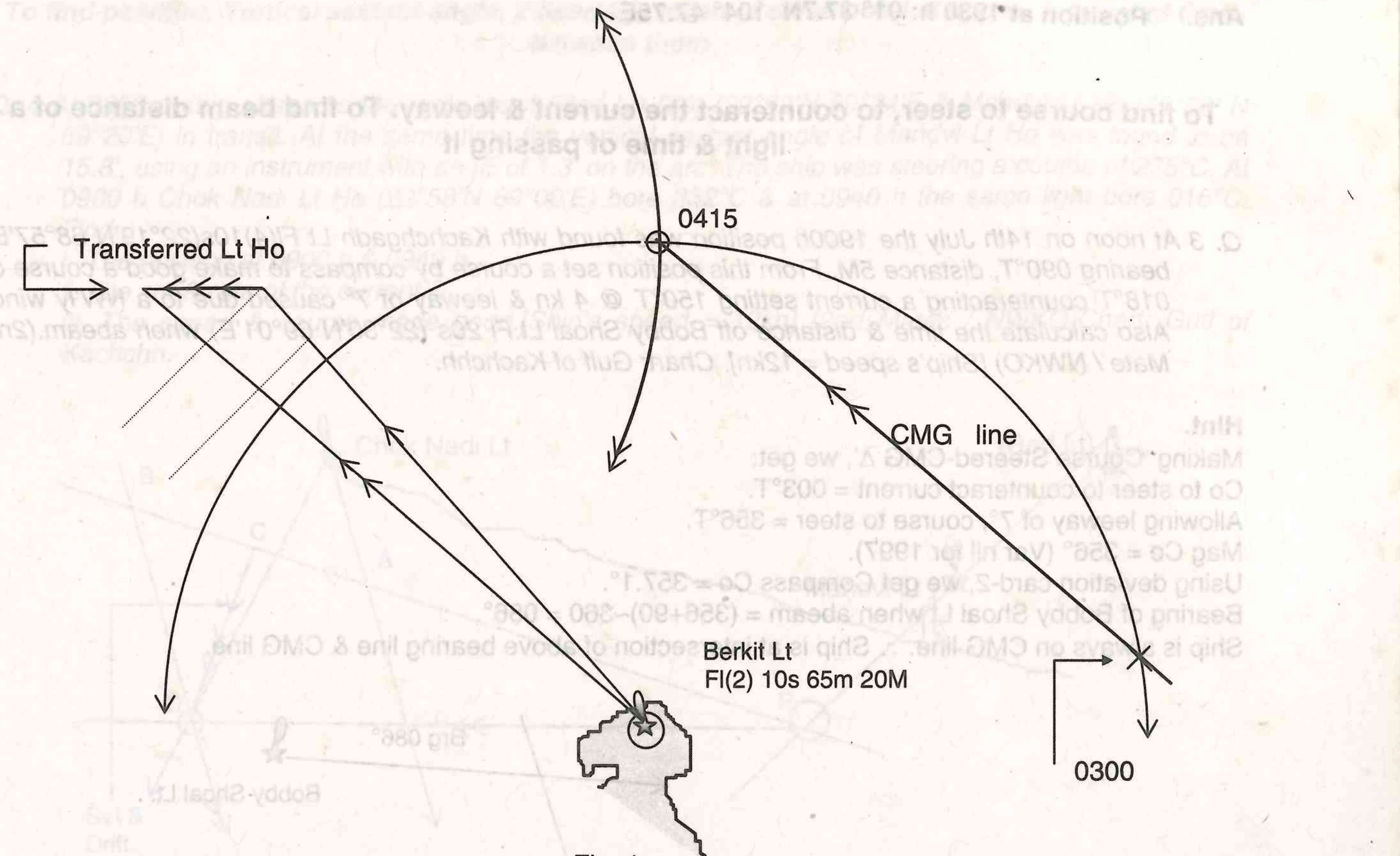


Fig. 1

Running fix of astronomical position line with terrestrial position line in prevailing current

Q.2 A stellar observation at 1830h in DR position 001° 40'N 105° 00'E gave an azimuth of 250°T & an intercept of 3 miles away. The vessel was steering 247°T & current was estimated to set 215°T x 4 kn. At 1930h Binton Aero beacon (00°55' 104°32') bore 200°T. Find vessel's position at 1930h. [Ship's speed = 12kn] (2nd Mates / NWKO) Chart: Singapore Straits E- Approaches.

Hint.

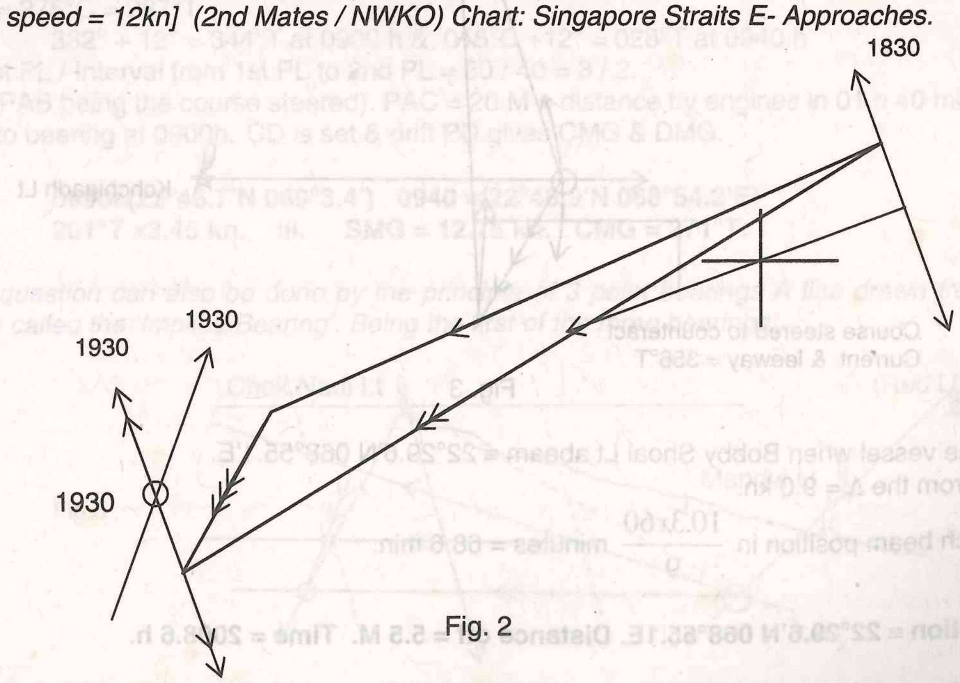


Fig. 2

Ans. Position at 1930 h: 01° 37.7N 104° 47.75E

To find course to steer, to counteract the current & leeway. To find beam distance of a light & time of passing it

Q. 3 At noon on 14th July the 1900h position was found with Kachchgadh Lt Fl(4)10s(22°19'N 68°57'E) bearing 090°T, distance 5M. From this position set a course by compass to make good a course of 018°T counteracting a current setting 150°T @ 4 kn & leeway of 7° caused due to a NW'ly wind. Also calculate the time & distance off Bobby Shoal Lt.Fl 20s (22°30'N 69°01'E) when abeam.(2nd Mate / NWKO) [Ship's speed = 12kn] Chart: Gulf of Kachchh.

Hint.

Making 'Course Steered-CMG Δ', we get:
Co to steer to counteract current = 003°T.
Allowing leeway of 7°, course to steer = 356°T.
Mag Co = 356° (Var nil for 1997).
Using deviation card-2, we get Compass Co = 357.1°.
Bearing of Bobby Shoal Lt when abeam = (356+90)~360 = 086°.
Ship is always on CMG line. ∴ Ship is at intersection of above bearing line & CMG line.

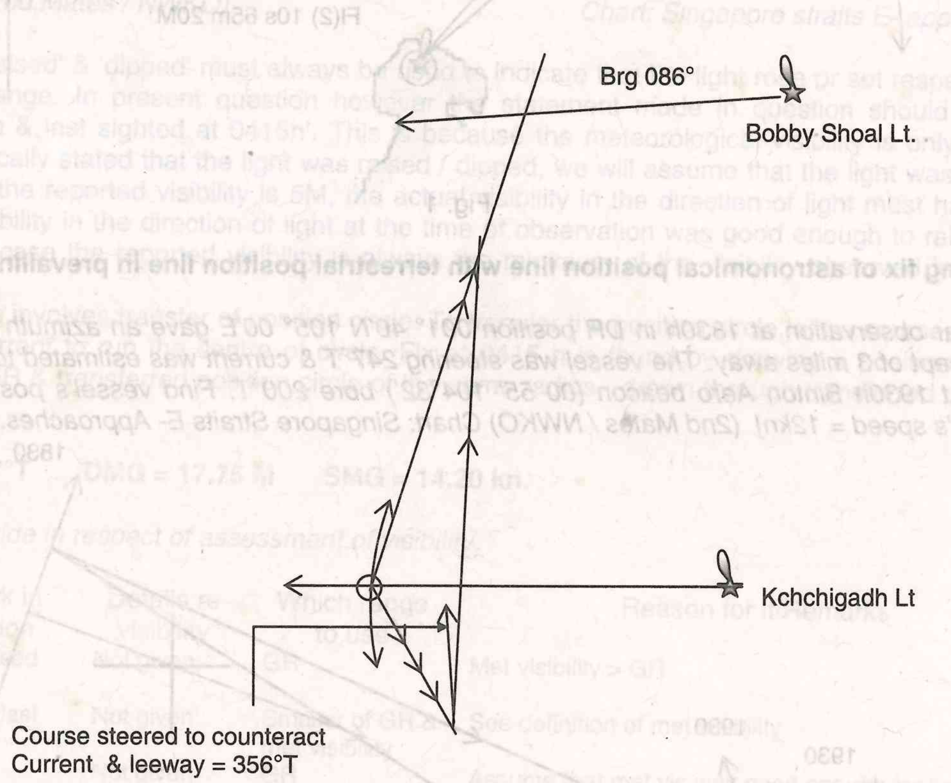


Fig. 3

Position of the vessel when Bobby Shoal Lt abeam ≡ 22°29.6'N 068°55.1'E.
SMG found from the Δ = 9.0 kn.

Ship will reach beam position in $\frac{10.3x60}{9}$ minutes = 68.6 min.

Ans. Position ≡ 22°29.6'N 068°55.1E. Distance off = 5.5 M. Time = 2008.6 h.

To find position. Vertical sextant angle, 2 bearings taken of same point at known interval of time between them

Q. 4 At 0800 a ship observes the radio mast (Red Lt) (70) (22°52'N 69°24'E & Mandvi Lt Ho (22°50' N 69°20'E) in transit. At the same time the vertical sextant angle of Mandvi Lt Ho was found to be 15.8', using an instrument with an IE of 1.3' on the arc. The ship was steering a course of 275°C. At 0900 h Chok Nadi Lt Ho (22°58'N 69°00'E) bore 332°C & at 0940 h the same light bore 016°C.
Find:
i. The position at 0900 h & 0940 h
ii. The set & rate of the current &
iii. The speed & course made good.[Ship's speed = 12kn] (2nd Mates / NWKO)Chart: Gulf of Kachchh.

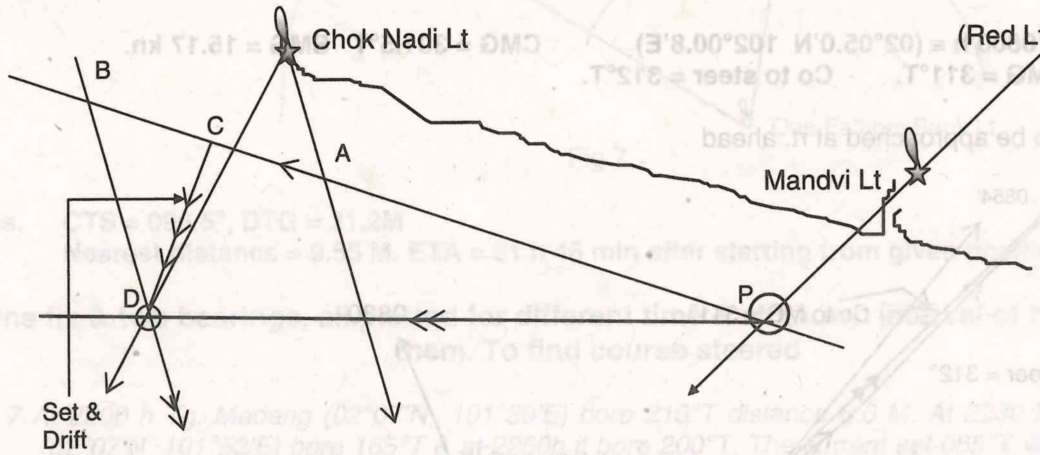


Fig 4

Hint.

Vertical Obs alt = 00° 14.5'

Dist (M) = $\frac{Ht.(m)x1.854}{Altitude} = \frac{37x1.854}{14.5}$ = 4.73 M

Co steered = 275°C = 287°T

Bearings: 332° + 12° = 344°T at 0900 h & 016°C +12° = 028°T at 0940 h

Interval to1st PL / Interval from 1st PL to 2nd PL = 60 / 40 = 3 / 2.

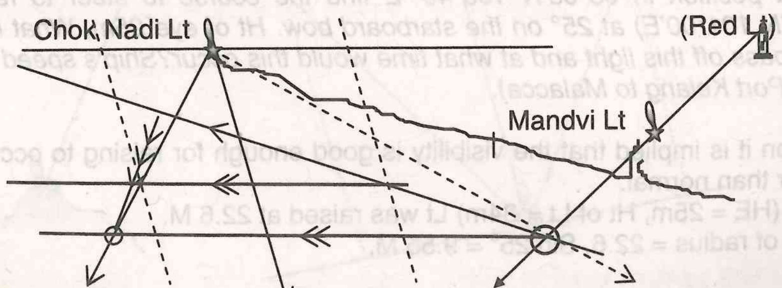
= PA / AB. (PAB being the course steered). PAC = 20 M = distance by engines in 01 h 40 min.

Draw BD // to bearing at 0900h. CD is set & drift PD gives CMG & DMG.

Ans. i. 0900≡(22°46.7'N 069°3.4') 0940 ≡(22°46.9'N 068°54.2'E)
ii. 201°T x3.45 kn. iii. SMG = 12.75 kn. CMG = 271°T.

The above question can also be done by the principle of 3 point bearings A line drawn from P to Chok Nadi can be called the 'Implied Bearing'. Being the first of the three bearings .

Fig 5



Ship steering a steady course bearings of a fixed object taken from 3 different positions at known time / distance interval, to find CMG

Q. 5 A vessel steering 300°T observes Releigh shoal Lt.(02°07'N 101°54'E) to bear as follows
0800h 285°T 0830h 203°T 0854h 140°T.
At 0854h Tg Medang Lt (02°07'N 101°39'E) bore 245°T. Find the vessel's position at 0800h, also course & speed made good. From 0854h position draw a course so as to have BW,Fl 5 sec Buoy (02°23'N 101°36'E right ahead, counteracting the current experienced. (2nd Mate / NWKO Chart: Malacca Strait (Ship's Speed 12 kn)

Hint.
Buoy in this question is probably is expected to be passed at a close range. Hence from 0854 position draw a straight line to the buoy to indicate the Co to MG = 311°T.

Ans. Pos at 0800 h ≡ (02°05.0'N 102°00.8'E) CMG = 301.5°T SMG = 15.17 kn.
Co to MG = 311°T. Co to steer = 312°T.

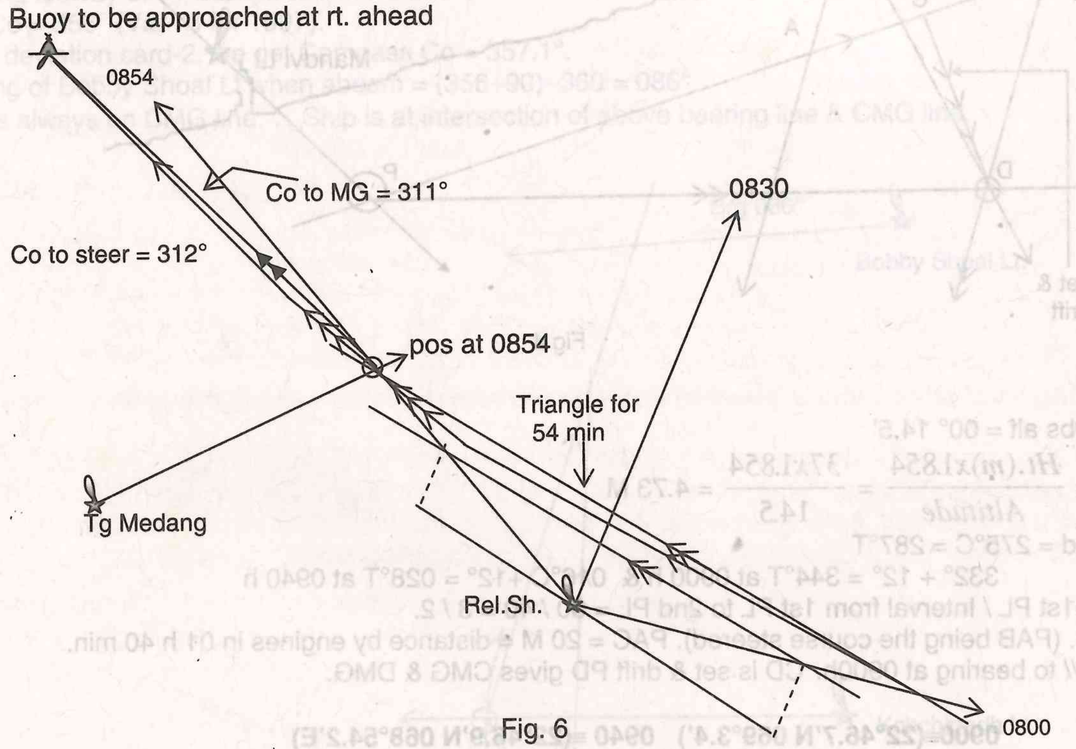


Fig. 6

To find the course to steer so that a light at a given distance lies at a particular angle on bow

Q. 6 From a position in 03°05'N 100°40' E find the course to steer to raise One Fathom Bank Lt (02°53'N 101°00'E) at 25° on the starboard bow. Ht of eye 25m. What is the nearest distance you would pass off this light and at what time would this occur? Ship's speed 12 kn. (2nd Mate / NWKO) Chart: Port Kelang to Malacca).

Hint.
In the question it is implied that the visibility is good enough for raising to occur. For that matter visibility may be better than normal.
GR = 22.6 M (HE = 25m, Ht of Lt = 34m) Lt was raised at 22.6 M.
Draw a circle of radius = 22.6. Sin 25° = 9.55 M.

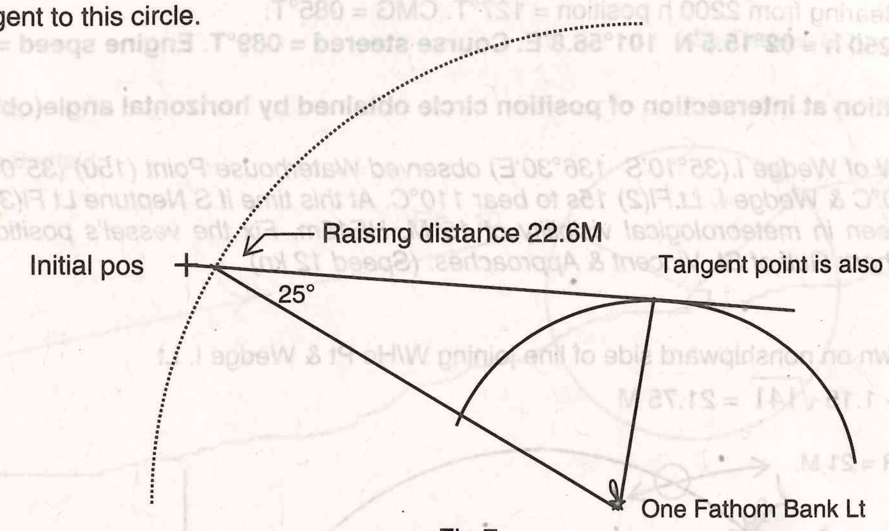


Fig 7

Ans. CTS = 096.5°, DTG = 21.2M
Nearest distance = 9.55 M. ETA = 01 h 46 min after starting from given position.

One fix & two bearings, all plotted for different time & at known interval of time between them. To find course steered

Q. 7 At 2200 h Tg. Medang (02°07'N 101°39'E) bore 210°T distance 8.0 M. At 2230 h Raleigh Shoal (02°07'N 101°53'E) bore 165°T & at 2250h it bore 200°T. The current set 065°T @ 3 kn. Find the course being steered & position of the ship at 2250h (2nd Mate / NWKO) Chart: Port Kelang to Malacca.

Hint.
In a problem where a fix & 2 bearings as above is given, The direction of CMG may be found using the principle of 3 point bearings,(bearing of a fixed object from 3 positions).
Assume that the first bearing of Ral. Shoal was taken at 2200h.

In a Co steered-CMG Δ there are 6 components viz. CMG, DMG, Co steered, Distance by engine, Set & Drift. Out of 6, 4 components must be known. Remaining two components may be then found. In present case CMG, DMG, Set & Drift is known. Co steered & Engine distance may be found out easily.

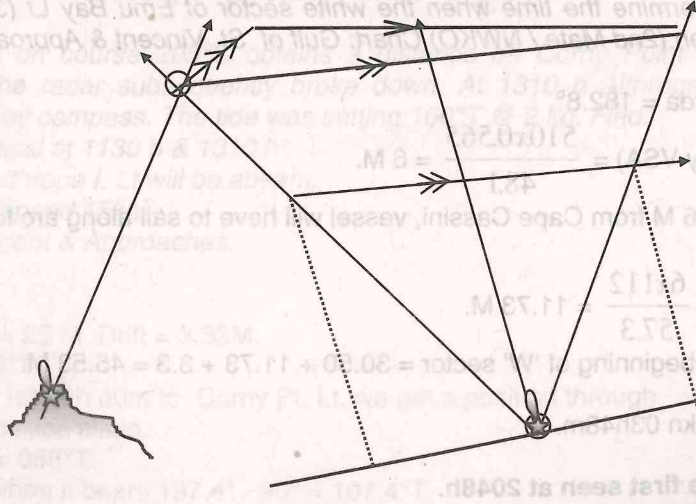


Fig. 8

Implied Bearing from 2200 h position = 127°T. CMG = 085°T.

Ans. Pos at 2250 h ≡ 02°15.5'N 101°56.8'E. Course steered = 089°T. Engine speed = 13.2 kn.

Fixing the position at intersection of position circle obtained by horizontal angle(obtuse) & PLR

Q. 8 A vessel NW of Wedge I.(35°10'S 136°30'E) observed Waterhouse Point (150) (35°04'S 136°12'E) to bear 220°C & Wedge I. Lt.Fl(2) 15s to bear 110°C. At this time if S Neptune Lt Fl(3)20s141ft16 M was first seen in meteorological visibility of 15 M. HE15m. Fix the vessel's position.(2nd Mate / NWKO). Chart: Gulf of St. Vincent & Approaches. (Speed 12 kn)

Hint.

Angles = 20° drawn on nonshipward side of line joining W/Ho Pt & Wedge I. Lt

GR = $2.09\sqrt{15} + 1.15\sqrt{141}$ = 21.75 M

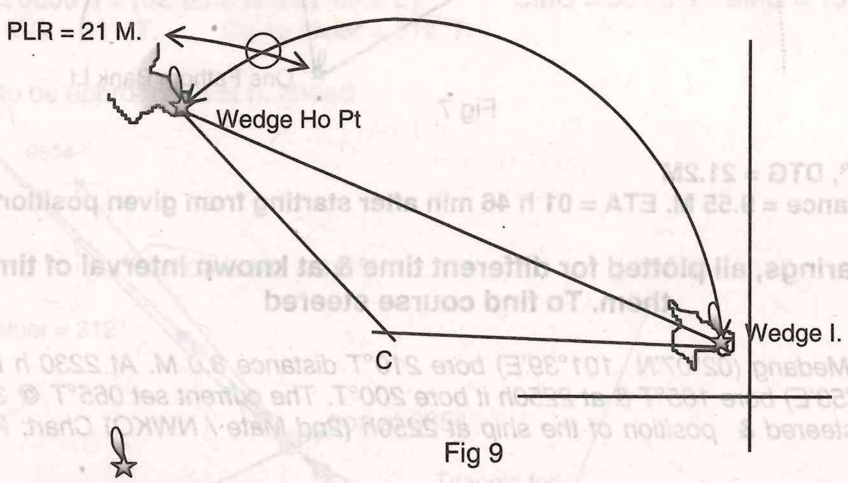


Fig 9

Ans. Fix ≡ 35°01.4'S 136°17.75'E

VSA, sailing round arc, light when 1st visible

Q. 9 At 1700h from a vessel steering 165°C, Cape Borda Lt Ho. bore 180°C & the vertical sextant angle of the same light was 0°45.1' (IE 3.0' off the arc). Find the position at this time. The vessel altered course to 077°T. It is required to keep a minimum of 6 M off Cape Cassini (127) (35°35'S 137°20'E). Determine the time when the white sector of Emu Bay Lt (35°35'S 137°30'E) will just begin to be seen.(2nd Mate / NWKO) Chart: Gulf of St. Vincent & Approaches.[Speed 12Kn]

Hint.

True brg of Cape Borda = 182.8°.

Dist off from Lt Ho (by VSA) = $\frac{510x0.565}{48.1}$ = 6 M.

To maintain a dist of 6 M from Cape Cassini, vessel will have to sail along arc for an arc = 112°. Radius of arc being = 6 M.

Distance along arc = $\frac{6x112}{57.3}$ = 11.73 M.

Total distance till the beginning of 'W' sector = 30.50 + 11.73 + 3.3 = 45.53 M.

Steaming time @ 12 kn 03h48m.

Ans. 'W' Lt will be first seen at 2048h.

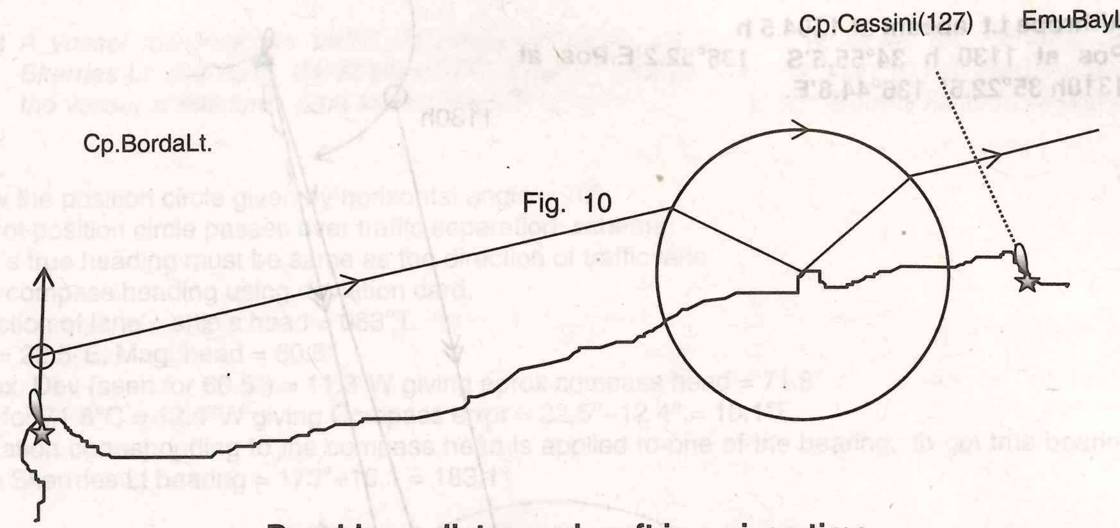


Fig. 10

Reaching a distressed craft in a given time

Q. 10 A trawler is reported in distress in 35°15'S 138°20'E. Your vessel is in position 34°44'S 138°10'E responds to a request from the local RCC to arrive at the distressed craft in 2 hours time. If the prevailing current in the Gulf of St. Vincent is known to set 335°T @ 3 kn , determine the course to steer & engine speed required to meet this request. (2nd Mate / NWKO) Chart: Gulf of St. Vincent & Approaches.

Hint.

Its not clear as to whether RCC wants rescuing vessel to reach the position stated in question or reach to the distressed craft which is presently in the position stated. This is because if the distressed craft is floating or underway, then the distressed craft as well as rescuing vessel will be affected by current in the same way.

Thus if,

(1) *Distressed craft is drifting along current*: Simply draw a line to the position of distressed craft. This line straightaway gives CTS & Co To MG.
Co to steer = 165°T Speed to steam at = 16.05 kn.

(2) *Distresses craft is anchored*: CTS will have to be found using 'Co-steered-CMG' principle.
Co to steer 163.5°T. Speed to steam at 19 kn.

Running of position circle to get fix

Q.11 At 1130 h a vessel on course 205°C obtains a distance off Corny Point Lt.Ho.Fl(4) (34°54'S 137°00'E) of 7M. The radar subsequently broke down. At 1310 h Althrope I.Lt.Fl14s (35°22'S 136°52'E) bore East by compass. The tide was setting 160°T @ 2 kn. Find:
i) The position of vessel at 1130 h & 1310 h
ii) The time when Althrope I. Lt will be abeam.
(2nd Mate / NWKO)[Speed 15kn]
Chart: Gulf of St. Vincent & Approaches.

Hint.

Dist by engine in 01hr40m = 25 M. Drift = 3.33M.
TrueCo = 197.35°T.= 197.4°T.
Applying Co steered & drift for 01h 40m to Corny Pt. Lt, we get a position through which to transfer original position circle.
Brg of Althrope Lt= 090°C = 088°T.
Althrope Lt will be abeam when it bears 197.4° - 90° = 107.4°T.
SMG = 16.62 kn.

Ans. Althrope Lt abeam at 1304.5 h
Pos at 1130 h 34°55.5'S 136°52.2'E.Pos at 1310h 35°22.5' 136°44.8'E.

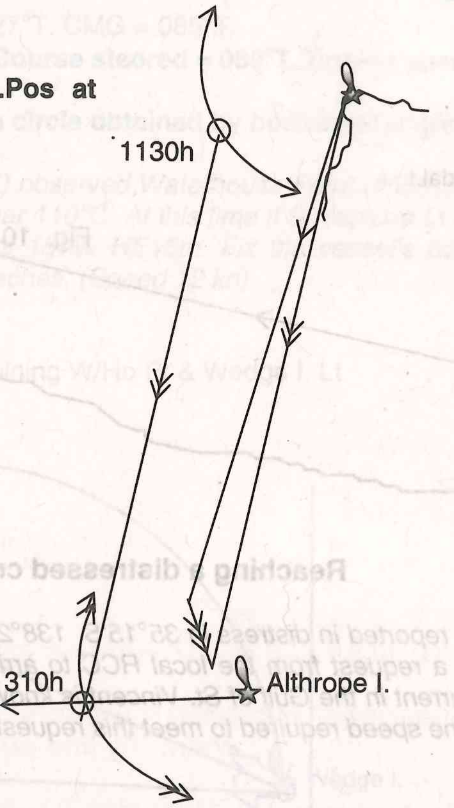


Fig. 11

Using bearing line to steer a course & maintaining a given distance from a point

Q. 12 A vessel heading 170°T on the west side of Wedge I. obtains a bearing of Wedge I. peak (298) as 117.5°T. If the visibility deteriorated thereafter & no further fix could be obtained, explain how this position line could be used to keep 5 M off when passing Althrope I. LtFl.7s (35°22'S 136°52'E). State what time you would alter your present course to achieve the above & your new compass course to steer. (2nd Mate / NWKO). Chart: Gulf of St. Vincent & Approaches,

Hint.
Draw a circle of radius = 5 M with Althrope Lt as centre.
Draw a line // to original bearing line viz. 117.5°T so that its tangent on '5 M-circle'.
Distance between original bearing line & its // line drawn as above along course i.e.170°T = 9.1M.
Steer on original course for 45.5 min & thereafter alter course to 117.5°T.(i.e.along tangent line).
(Refer to the description on the use of single bearing line, chapter 16)

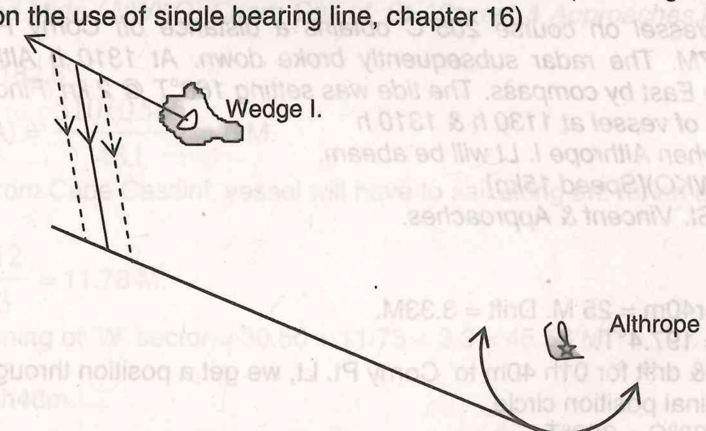


Fig. 12

Fix by horizontal angle & 1 bearing

Q.13 A vessel following the traffic Separation Scheme off Skerries observes the following bearings: Skerries Lt (53°25'N 04°36'W) 173°C. Ynas Pt. (53°25'N 04°17.5'W) 103°C. Find the position of the vessel at this time. (2nd Mate / NWKO) Chart: Burrow Head to Liverpool.

Hint.
Draw the position circle given by horizontal angle = 70°
Part of position circle passes over traffic seperation. scheme.
Ship's true heading must be same as the direction of traffic lane.
Find compass heading using deviation card.
Direction of lane = ship's head = 083°T
Var = 22.5°E, Mag. head = 60.5°
Aprox. Dev (seen for 60.5°) = 11.3°W giving aprox compass head = 71.8°
Dev for 71.8°C = 12.4°W giving Compass error = 22.5°~12.4° = 10.1°E.
Deviation corresponding to the compass head is applied to one of the bearings to get true bearing. Thus
True Skerrries Lt bearing = 173°+10.1 = 183.1°

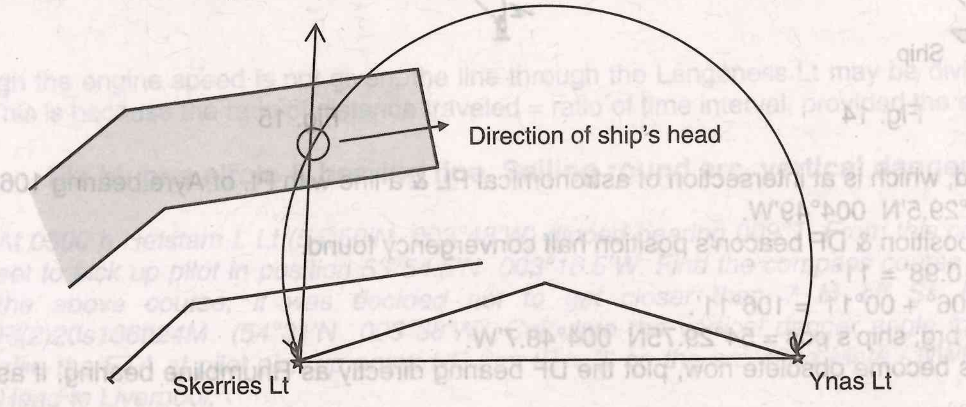


Fig. 13

Ans. Pos ≡ (53°29.6'N 004°36'W)

Given DF bearing, to find Mercator bearing. To find out direction & rate of tidal stream & apply the same to find course to steer

Q.14 At 1600 h in DR 54°34'N 004°45'W an observation of the Sun gave an intercept of 3' away on an azimuth of 078°T. At the same time a DF bearing of Pt. of Ayre (54°25'N 004°22'W) was 106°. Find the position of the vessel allowing for the possibility of half convergency. From this position, find the course to steer counteracting a tidal stream running at position "E" (54°32'N 004°37'W) so as to pass Pt. of Ayre 5M off. High Water (spring tide) at Liverpool is at 1500h (2nd Mate / NWKO) Chart: Burrow Head to Liverpool.
Note: Concept of DF bearings is obsolete now but student may learn from the other part of this question.

Hint.
Plot PL as given by astronomical observation.
To find Mercator bearing:

Aprox Mercator bearing to be plotted may be found by applying half convergency to true DF bearing which is a great circle bearing. This correction is directly proportional to d'long (between ship & the transmitter). & to the Sine of mean Latitude.

Half convergency (in minutes) = $\frac{D'long(\text{minutes})xSineM'lat}{2}$

Whether to add or subtract the correction will depend on;
1. Whether direction of bearing has E or W component.
2. Whether N or S hemisphere.

In all the cases however, the sign may be found by drawing DF bearing & Mercator bearings as shown in the diagrams above. DF bearing is plotted with convexity towards pole.

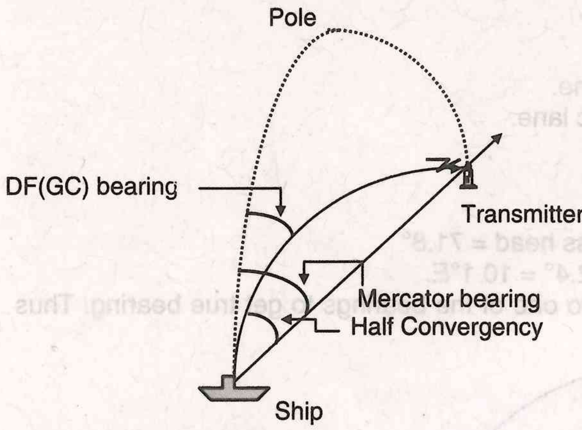


Fig. 14

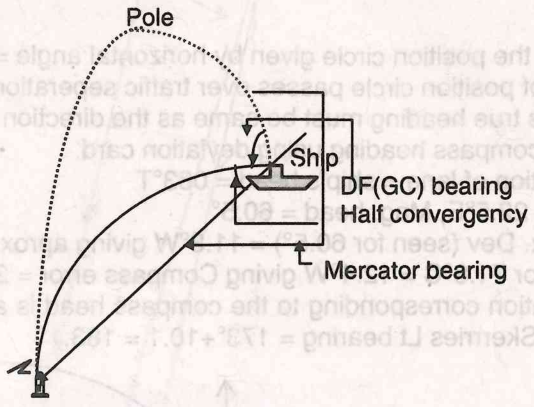


Fig. 15

Approx position found, which is at intersection of astronomical PL & a line with Pt. of Ayre bearing 106°T.
Approx position ≡ 54°29.5'N 004°49'W.
Using approx ship's position & DF beacon's position half convergency found.
Half convergency = 10.98' = 11'.
Mercator bearing = 106° + 00°11' = 106°11'.
Plotting the Mercator brg; ship's pos = 54°29.75N 004°48.7'W.
Note: Since D.F. has become obsolete now, plot the DF bearing directly as Rhumbline bearing, if asked in the examination.

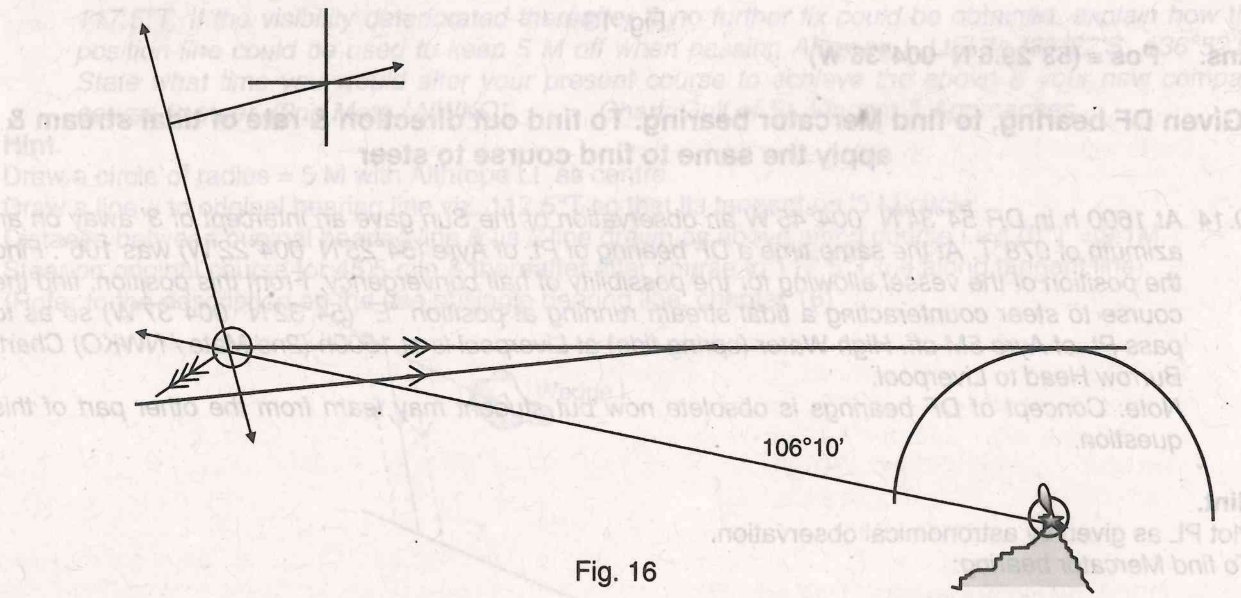


Fig. 16

To find direction & rate of tidal stream:
HW Liverpool = 1500h
Pt. of Ayres is to be passed 5'off. aprox DTG till then = 16 M.
It is not stated as to what time the vessel commenced steaming, nevertheless assume that the ship is able to start without undue delay.

Following is the data provided for position E taken from tidal data provided on the chart. Thus

At 01 h after HW	tidal stream Dir = 243°	rate = 1.8kn (Sp)
At 02 h after HW	tidal stream Dir = 248°	rate = 3.1kn(Sp)
At 03 h after HW	tidal stream Dir = 251°	rate = 3.4kn (Sp)

Make the best estimation of the average tidal stream applicable for about 1.5h of sailing. e.g. in present case we may assume the tidal stream to be setting along 248°T @ 2.8 kn.
Alternately we may plot Co-steered-CMG triangles for each hour of steaming.
Course to steer may thus be found out.

Ans. Course to steer = 083°T.

Bearing of an object from three positions at known interval (speed of ship not given)

Q.15 While steering a course of 217°T, engine speed unknown, the following bearings of Langeness Lt (54°04'N 004°38'W) were obtained: 1400h 180°, 1415h 150°T, 1445h 090°T. If the current was known to be setting 135°T@ 2 kn. Find CMG, Eng speed & pos at 1400h (2ndMate / NWKO) Chart: Burrow Head to Liverpool.

Hint.
Although the engine speed is not given, the line through the Langeness Lt may be divided in the ratio of time. This is because the ratio of distance traveled = ratio of time interval, provided the speed is steady.

Fix by pos circle & bearing line. Sailing round arc, vertical danger angle

Q.16 At 0500 h Hetstam I. Lt (54°50'N 003°48'W) dipped bearing 009°T. From this position course was set to pick up pilot in position 53°54.5'N 003°16.5'W. Find the compass course to steer. While on the above course, it was decided not to get closer than 7 M off St. Bees Hd. Lt, Gp Fl(2)20s136ft24M (54°31'N 003°38'W). Calculate the vertical danger angle to set on sextant & also the ETA at pilot pick up point. HE 5m. IE = 3' on the arc. (2nd Mate / NWKO) Chart: Burrow Head to Liverpool.

Hint.
It is stated that the light dipped which means that the visibility is good enough for the light to be seen at its GR. & since the met. visibility is not given the candidate may take the liberty of assuming that the visibility was sufficient & probably better than normal. Thus

$$7 = \frac{Ht.inFtx0.565}{Obs.Alt.(\min utes)} \quad \therefore \text{ Obs alt} = 10.97' = 11' \qquad \therefore \text{ Sext alt} = 00°14.0'.$$

ETA pilots will be given @ 12kn Distance to cover at this speed = X+Y+Z.
(Assume no reduction of speed while sailing round the arc).

$$Y = \frac{RadiusxAngle}{57.3}.$$

Ans. Sext alt = 00°14'

Vertical sextant angle at a tide level other than MHWS

Q.17 While steaming off Isle of Man, Longness Pt. (54°04'N 004°38'W) bore 315°C & Douglas Hd. (54°10'N 004°28'W) bore 065°C. At the same time the vertical sextant. angle of Longness Pt. was found to be 00°10', IE 2.0' off the arc. HE 12m & water level has fallen 2m below MHWS. Find the ship's position & compass error(2nd Mate / NWKO). Chart: Burrow Head to Liverpool.

Hint.
Ht to be used in formula = charted ht. + 2m., because the heights given on the chart are above MHWS level.
A second pos circle is found using horizontal angle = 110°

Centre of this pos circle is on the non shipward side of line joining the two lights.
True bearing of Longness Pt. is read on the chart from the fix thus obtained. It is compared with compass bearing to find error.

Ship steered a Co allowing leeway & assuming a certain value of Set & rate of Drift. Set & Drift being different, to find actual value

Q.18 From a position with Little Basses Reef Lt (06°24'N 081°44'E) bearing 000°T distance 10M, find the compass course to steer to pass Sangama Kanda Lt.(07°01'N 081°52'E) 8M off counteracting the following:
i. An estimated leeway of 5° due to an Easterly wind.
ii. An estimated current setting 270°T x 4 kn.
After 2 h of steering, Little Basses Reef Lt bore 226°T distance 12 M. Find the actual Set & Rate of current (2nd Mate / NWKO). Chart: Ceylon South Part. (Ship's Speed 12 kn)

Hint.
Co to MG = 020.5°T. Co to Steer to counteract current = 039°T.
Co to counteract current & leeway = 044°T.
The fact is that the helmsman steered a course of 044°T by compass.
It is implied that the leeway estimation is correct. If leeway is considered to be 5° as estimated & the current is assumed to be zero, the ship will reach a position somewhere along 039°T, from initial position.
Mark off a position along 039°T at a distance of 24M from initial position. Call it A.
Plot observed pos after 2 h Call it B.
AB is Set & Drift in 2 h.

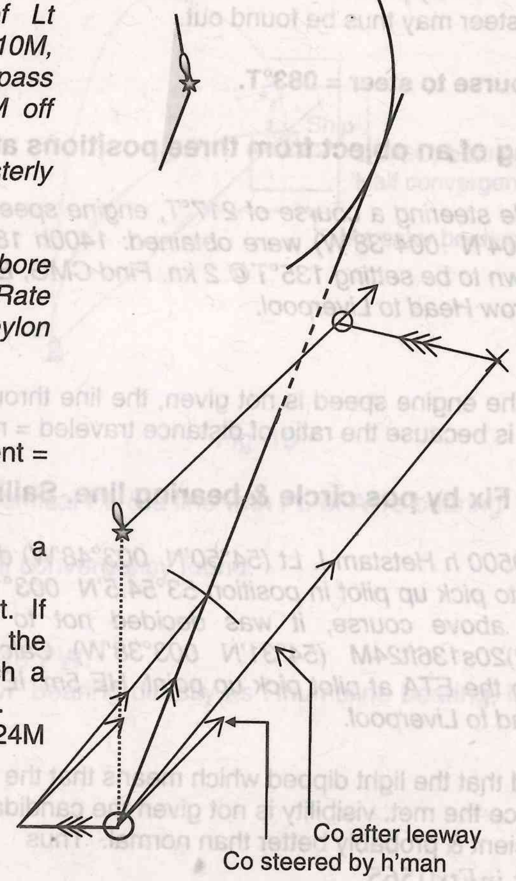


Fig 17

Raising a Lt right ahead in prevailing current

Q.19 At 2100 h Dondra Hd. Lt (05°55'N 080°36'E) bore 004°M distance 8.25 M. Find the true course to steer to raise Great Basses Rf Lt (06°11'N 081°29'E) right ahead counteracting a current setting SE @ 3 kn. What time will Great Basses Lt be abeam on this course? HE 15M. (2nd Mate / NWKO) Chart: Ceylon South Part.[ship's speed 12kn]

Hint.
It is implied that the light is expected to be raised which means that the visibility is good enough for the light to be seen at its GR. & since the met. visibility is not given the candidate may take the liberty of assuming that the visibility was adequate for the purposel.
Thus, HE = 15m., Ht. of Lt 34m. GR = 20.2 M.
Draw circle of radius = 20.2 M round the G.B.Rf Lt.
Engine distance of 20.2 M will be covered in 101min. Drift in 101 min. = 5.05 M.

Or $\dfrac{\text{Distance x rate}}{\text{speed over water}}$ = drift vector to be applied at light house

Draw drift vector, SE x 5.05 M from G.B.Rf Lt., call it B.
Let initial pos be A. Line AB represents CMG line. This line intersects 20.2 M arc at C.
C to pos of Lt 'D' is Co to steer.

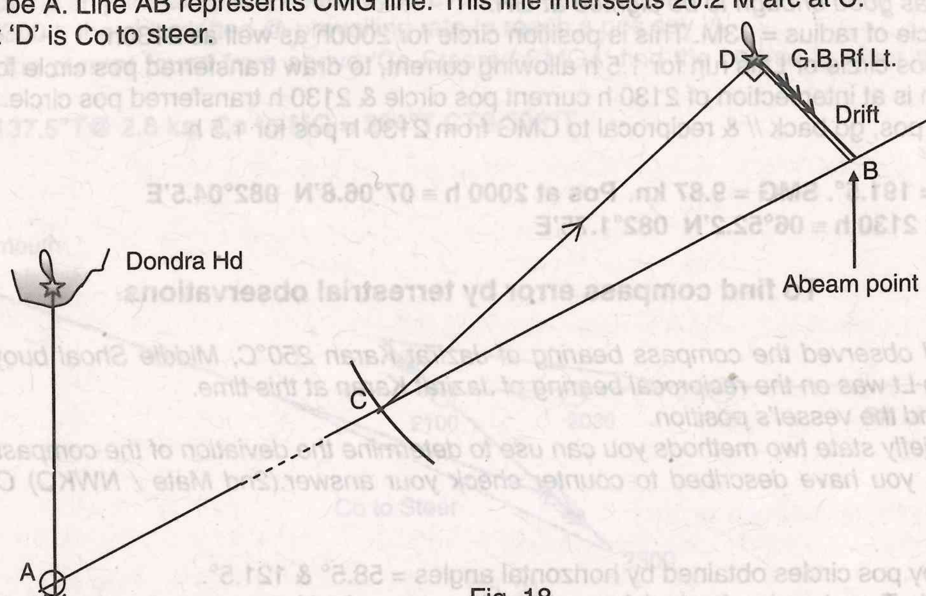


Fig. 18

$$\text{SMG} = \frac{60x21.8}{101} = 12.95 \text{ kn.}$$

DTG to beam point = 59.1 M ∴ time taken = 04h 34m.

Ans. True Co to Steer = 057.5°T. CMG = 70.5°T. G.B.Lt abeam at 0134 h

Running fix of position circles rising / setting dist of same light used for this purpose

Q. 20 A vessel steering 180°T observes Sangamakanda Lt Ho, Fl5s.25ft10M to rise at 2000h & same Lt.dipped at 2130h During this period current was setting 320°T @ 3 kn. Find the CMG & SMG by vessel, pos at 2000h & 2130h(HE = 12m Eng spd 12 kn. (2nd Mate / NWKO) Chart: Ceylon South Part.

Hint.

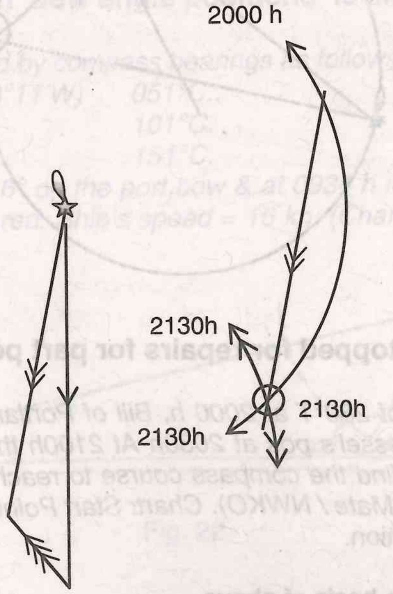


Fig. 19

In the present problem its specifically stated that the light was seen rising & dipping. *Indirectly it is implied that visibility was good enough to be sighted at GR.*
Draw a pos circle of radius = 13M. This is position circle for 2000h as well as 2130h.
Centre of the pos circle or Lt is run for 1.5 h allowing current, to draw transferred pos circle for 2130h.
2130 h position is at intersection of 2130 h current pos circle & 2130 h transferred pos circle.
To find 2000 h pos, go back // & reciprocal to CMG from 2130 h pos for 1.5 h

Ans. CMG = 191.5°. SMG = 9.87 kn. Pos at 2000 h ≡ 07°06.8'N 082°04.5'E
Pos at 2130 h ≡ 06°52.2'N 082°1.75'E

To find compass error by terrestrial observations

Q. 21 A vessel observed the compass bearing of Jazirat Karan 250°C, Middle Shoal buoy 308.5°C. Al Arabiyah Lt was on the reciprocal bearing of Jazirat Karan at this time.
(a) Find the vessel's position.
(b) Briefly state two methods you can use to determine the deviation of the compass & use these methods you have described to counter check your answer.(2nd Mate / NWKO) Chart: Persian Gulf.

Hint.
(a) Find fix by pos circles obtained by horizontal angles = 58.5° & 121.5°.
(b) Method 1: True bearing is read from chart & compared with compass bearing of any one of the three to get error & hence deviation.
Method 2: True direction of line joining Al Arabiyah Lt & Jazirat Karan can be found from chart. Its compared with compass direction i.e. 250° - 070° to find compass error & hence deviation.

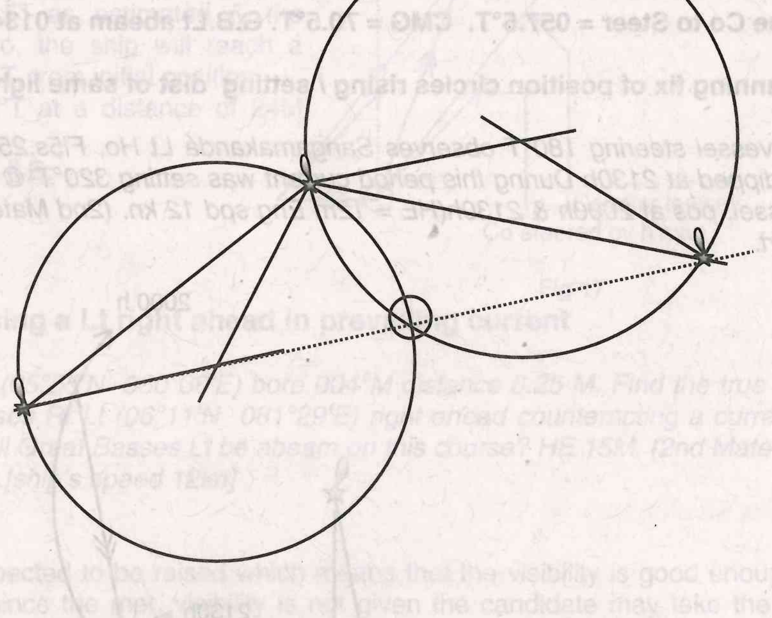


Fig. 20

Vessel stopped for repairs for part period. To find EP

Q. 22 While steering a course of 280°T at 2000 h, Bill of Portland Lt bore 090°T x 8M. At 2030h it bore 090°T x 13M. Find the vessel's pos at 2030h At 2100h the main engine stopped for repairs up to 2300h From 2300h pos, find the compass course to reach Exmouth pilot station counteracting the current experienced.(2nd Mate / NWKO). Chart: Start Point to Needles.(Ship's Speed 12 kn)
Hint. Plot 2000 h & 2030 h position.

Deduce the pos at 2100 h on the basis of above.

Make 'Co Steered-CMGΔ' for 60 min.
Assume that the ship instantly lost headway at 2100 h
2100 h to 2300 h the ship drifted @ prevailing rate to reach a pos say 'A'
At A using the current found from above 'Co Steered-CMGΔ' find the course to steer to reach Exmouth pilot station.
Ans: Set 137.5°T@ 2.8 kn, Co to MG = 294°T CTS 300°T

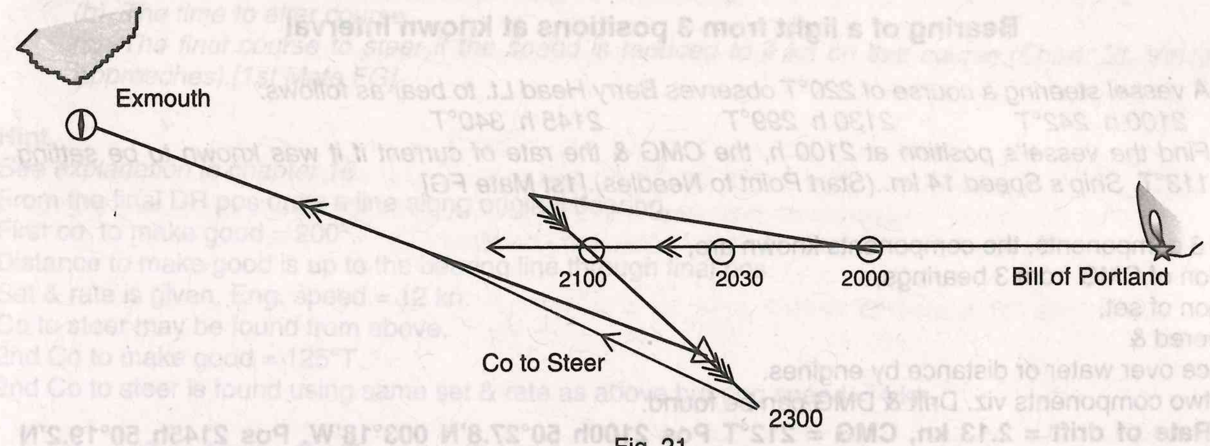


Fig. 21

To find the CMG after current & leeway. The time when light would be abeam

Q. 23 A vessel in position 54°33.5'N 003°55.5'W was steering 156°C through a tidal stream setting 030°T @ 4 kn & experiencing a leeway of 5° due to an E'ly wind. Determine the time & position when Bees Head Lt, (54°31'N 003°38'W) will be abeam. Use Dev card 1. Var= 4°E. (Chart: Burrough Head to Liverpool).(1st Mate FG)

Hint.
True co. = 156° + 4°-1.9° = 158.1°T.
To prepare Co steered - CMG Δ, plot co. steered along 158.1°+5° = 163.1°T.
Mark the position on CMG line when Bees Hd. Lt bears [158.1(+/-)90]°T.

To find the beam distance of a light when distance traveled between 2 known 'bow angle positions' is known

Q. 24 At 0900 h the position was fixed by compass bearings as follows:

Lune Fl(2)R buoy (53°56'N 003°11'W)	*051°C..*
Blackpool tower (conspic)	*101°C.*
Nelson Fl(3)R buoy	*151°C.*

If at 0904h, Nelson buoy was 16° on the port bow & at 0934 h it was 53° on same bow, determine the compass course being steered. Ship's speed = 16 kn. (Chart: Burrough Head to Liverpool).[1st Mate FG]

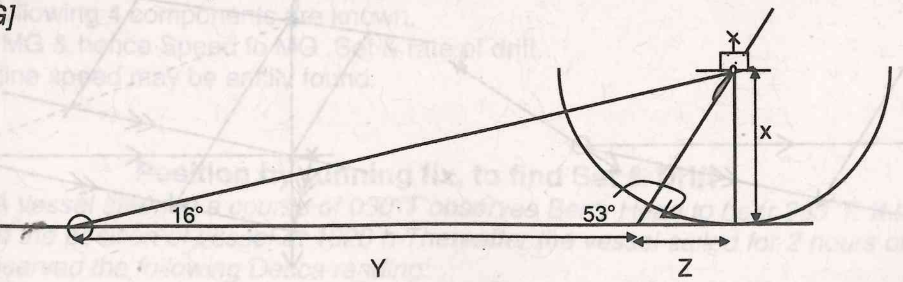


Fig. 22

$$\text{Cot. } 16° - \text{Cot } 53° = \frac{y+z-z}{x} = \frac{y}{x} = 2.73.$$

Y is distance traveled in 30 min = 8 M.

$\therefore x = 2.93$ M.

Draw a circle of radius = 2.93 M around Nelson Buoy.

Bearing of a light from 3 positions at known interval

Q. 25 A vessel steering a course of 220°T observes Berry Head Lt. to bear as follows:

2100 h 242°T   2130 h 299°T   2145 h 340°T

Find the vessel's position at 2100 h, the CMG & the rate of current if it was known to be setting 113°T, Ship's Speed 14 kn. (Start Point to Needles).[1st Mate FG]

Hint.

Of the 6 components, the components known are,

Direction of CMG from 3 bearings,

Direction of set,

Co steered &

Distance over water or distance by engines.

Other two components viz. Drift & DMG can be found.

Ans Rate of drift = 2.13 kn, CMG = 212°T Pos 2100h 50°27.8'N 003°18'W. Pos 2145h 50°19.2'N 003°26.2'W.

Running fix of astronomical PL with a terrestrial PL (with current)

Q. 26 At 0900 h while on DR pos 01°40'N 105°00'E, a sun sight gave an intercept of 10' towards a bearing of 030°T. The vessel then steered a course of 214°G. GE 1°Low. After one hour the engines were stopped for repairs. At 1130 h the vessel resumed her original course at full speed. At 1230 h Horsburgh Racon (01°20'N 104°24.6'E) bore 225°G. Find the pos of the vessel at 1230 h, if the current was setting 270°T at 2 kn (Chart no. 5118)[1st Mate FG]

Hint.

Pick up any point on PL, allow Co & speed for 2 hours.

Allow drift due current 3.5 hours to get a point from where to transfer PL.

Intersection point of this PL & 1230 h bearing line is the fix at 1230 h.

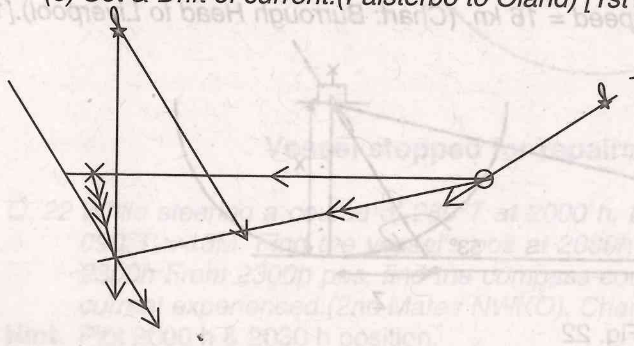
Given, fix + 2 bearings. All at known intervals, to find CMG, SMG & current

Q. 27 A vessel steering 270°T observed Utklippan Lt. bearing 057°T & 8 M off. After running 16M by engines on her course Hano Lt. bore 328°T & after running another 8 M by engines it bore 000°T. From the above observations find:

(a) Ship's position at the time of final bearing.

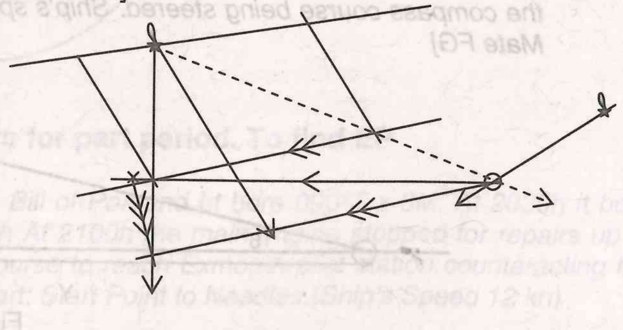
(b) Course & speed made good.

(c) Set & Drift of current.(Falsterbo to Oland) [1st Mate FG]



Distance ratio method

Fig. 23



Implied 3 bearing method

Fig 24

Using a single PL to clear a danger in fog

Q. 28 While steering a course of 200°T, at 2100 h, a single bearing of Wedge Island Lt. (35°11'S 136°29'E) was observed to be 125°T. The vessel then encountered a patch of fog. It is intended to anchor the vessel 5M SW of Althrope Lt. & the current is setting 270°T @ 2 kn. Find:

(a) The 1st compass course to steer.

(b) The time to alter course.

(c) The final course to steer if the speed is reduced to 4 kn on this course.(Chart: St. Vincent & Approaches).[1st Mate FG]

Hint.

See explanation in chapter 16.

From the final DR pos draw a line along original bearing.

First co. to make good = 200°.

Distance to make good is up to the bearing line through final pos.

Set & rate is given. Eng. speed = 12 kn.

Co to steer may be found from above.

2nd Co to make good = 125°T.

2nd Co to steer is found using same set & rate as above but eng speed = 4 kn.

To steer a Co To get a light at particular bow angle at given distance

Q. 29 At 2000 h T. Berakit Lt. was first sighted bearing 270°T when the meteorological visibility was 10. Find the ship's position & the compass course to steer to have Horsburgh Lt. 4 points on port bow 8 M off.(Chart 5118).[1st Mate FG]

Hint.

Draw a pos circle with radius = 1st sighted range which is smaller of PLR & GR.

Draw a circle with Horsburgh Lt as centre & radius = 8.Sin 45° M.

Draw course line tangenting this circle & keeping the Lt on port beam.

To find Set & rate of current. To find spd to steam at to maintain ETA

Q. 30 While proceeding towards Karlskrona Pilot point, following Decca readings were obtained at 2100 h J30, A05. The vessel was steering 090°T. At 2200 h Decca readings changed to H30, A10. Find course & speed to reach the above point at 0030 h assuming the current remaining throughout the same. Ship's speed = 12 kn. (Chart: Falsterbo to Oland).[1st Mate FG]

Hint.

A10 is Red & J30 is Green lattice, as Red lattice are numbered from 0 to 24. Also Green lattice are numbered from 30 to 48.

Find Set & Drift encountered between 2100 h & 2200 h

For the 2nd part following 4 components are known,

Co to MG, Dist to MG & hence Speed to MG, Set & rate of drift.

Co to steer & engine speed may be easily found.

Position by running fix, to find Set & Drift

Q. 31 At 0930 h A vessel steering a course of 030°T observes Berry Head to bear 333°T. It bore 270°T at 1020 h Find the position of vessel at 1020 h Thereafter the vessel sailed for 2 hours on a course of 095°T & observed the following Decca reading:

Purple E 56.2

Red F 5.8

Find the set & drift.(Chart: St. Georges Channel).[1st Mate FG]

Hint.
Pos is found at 1020 h by ordinary running fix without current.
Current comes in to picture only after 1020 h.

Bearing of a light from 3 positions at known interval. To get a light at certain bow angle at given distance

Q. 32 A vessel steering 180°T observes Arklow Lt Vessel to bear as follows.

At 2000 h 205°T
At 2030 h 270°T
At 2054 h 312°T.

If the current was known to set 040°T @ 3.8 kn, find the pos at 2000 h & at 2054 h From 2054 h pos, find the course to steer so as to ensure Tuskar Rock Racon is 30° on starboard bow when 8 M off, counteracting the current.(St. Georges Channel).[1st Mate FG]

Hint. See chapter 20, answer to Q.20.7

H-102 (Feb 1998)

HYDROGRAPHIC NOTE

(for instructions, see overleaf)

Date ....

Ref. No. ....

Name of ship or sender: ....

Address of sender: ....

....

....

Tel/Fax/Telex No. of sender (if appropriate): ....

General locality ....

Subject ....

Position. Lat .... Long ....

British Admiralty Charts affected .... Edition dated ....

Position of fixing system used .... Datum set ....

Latest Weekly Edition of Notice to Mariners held ....

Publication affected (Edition No., ... date of latest supplement, page and Light List No. etc.)

....

Details:-

A replacement copy of Chart No .... is required, but see 4 overleaf.

Signature of observer/reporter ....

HYDROGRAPHIC NOTE

Instructions:

1. Mariners are requested to notify the Hydrographer of the Navy, UK Hydrographic Office, Admiralty Way, Taunton, Somerset, TA1 2DN, United Kingdom, when new or suspected dangers to navigation are discovered, changes observed in aids to navigation, or corrections to publications seen to be necessary. The mariners Handbook (NP100) Chapter 8 gives general instructions. The provisions of international and national laws should complied with when forwarding such reports.
2. This form and its instructions have been designed to help both the sender and recipient. It should be used, or followed closely, whenever appropriate.
   Copies of this Form may be obtained gratis from the UK Hydroaphic Office at the above address or principal Chart Agents (see Annual notice to mariners no.2)
3. When a position is defined by sextant angles or bearing (true or magnetic being specified) more than two should be used in order to provide a check. Distances observed by the radar and the readings of Loran, Decca, etc., should be quoted. Latitude and Longitude should only be used specifically to position the details when they have been fixed byastronomical observations or GPS and a full description of the rthod, equipmen and datum (where applicable) used should be given.
4. A cutting from the largest scale chart is the best medium for forwarding details, the alterations and additions being shown thereon in red. When requested, a new copy will be sent in replacement of a chart that has been used to forward information, or when extensive observations have involved defacement of the observer's chart. If it is preferred to show the amendments on a tracing of the largest scale chart [rather than on the chart itself] these should be in red as above, but adequate details from the charts must be traced in black ink enable the amendments to be fitted correctly.
5. When soundings are obtained The Mariners Handbook (NP 100) should be consulted. The echo sounding trace should be marked with times, depths, etc., and forwarded with the report. It is important to state whether the eco sounder is set to register depths below the surface or below the knee; in the latter case the vessels draught should be given. Time and date should be given in order that corrections for the height of the tide ma be made where necessary. The make, name and type of should also be given.
6. Modern echo sounders frequently record signals from echoes back after one or more rotations of the stylus have been completed. Thus with a set whose maximum range is 500m, an echo recorded at 50m may be from depths of 50m, 550m or even 1050m. Soundings recorded beyond the nominal range can usually be recognized by the following:-
   (a) the trace being weaker the normal of the depth recorder,
   (b) the trace passing through the transmission line,
   (c) the feathery nature of the trace.
   As a check that apparently shoal soundings are not due to echoes received beyond the sets nominal range, soundings should be continued until reasonable agreement with charted soundings is reached. However, soundings received after one or more rotations of the stylus can still be useful and should be submitted if they show significant differences from charted depths.
7. Reports which cannot be confirmed or are lacking in certain details should not be withheld. Shortcomings should be stressed and any firm expectation of being able to check the information on a succeeding voyage should be mentioned.
8. reports of shoal sounding s, uncharted dangers and navigational aids out of order should, at the mariners discretion, also be made by radio to the nearest coast radio station. The draught of modern tankers is such that any uncharted depth under 30 meters or 15 fathoms may be of sufficient importance to justify a radio message.
9. Port information should be forwarded on Form H.102. Form H.120.a lists the information required for Admiralty Sailing Directions and should be used as an *aide memoire.* Where there is insufficient space on the form an additional sheet should be used.
10. Reports on ocean currents should be made on Form H.568 (Sea surface current observations) in accordance with The Mariner's Handbook. This form is obtainable from the UK Hydrographic Office, Taunton, or principal Chart Agents.

Note: An acknowledgement receipt will be sent and the information then used to the best advantage which may mean immediate action or inclusion in a revision in due course. When a notice to Mariners is issued, the senders ship or name is quoted as auhority unless (as sometimes

H-102a (Feb 1998)

HYDROGRAPHIC NOTE FOR PORT INFORMATION

(To accompany Form H.102)

Name of Ship or sender: ....

Address: .... Ref. No. ....

.... Date: ....

....

1. NAME OF PORT	
2. GENERAL REMARKS Principal activities and trade. Latest population figures and date. Number of ships or tonnage handled per year. Maximum size of vessel handled. Copy of Port Handbook if available.	
3. ANCHORAGES Designation, depts, holding ground, shelter afforded.	
4. PILOTAGE Authority for requests. Embarkation position. Regulations.	
5. DIRECTIONS Entry berting information. Tidal Streams. Navigational aids.	
6. TUGS Number available and max.hp.	
7. WHARVES Names, numbers or positions. Lengths. Depts alongside. Heights above Chart Datum. Facilities available.	
8. CARGO HANDLING Containers, lighters, Ro-Ro etc.	

9.CRANES

Brief details and max. capacity.

10.REPAIRS

Hull, machinery and underwater.
Ship and boat yards.
Docking or slipping facilities.
Give size of vessels handled or dimensions.
Hards and ramps.
Divers.

11. RESCUE AND DISTRESS

Salvage, lifeboat, Coastguard, etc.

12. SUPPLIES

Fuel with type and quantities available.
Fresh water with rate of supply.
Provisions.

13. SERVICES

Medical.
De-ratting.
Consuls.
Ship Chandlery,
Compass adjustment, tank cleaning, hull painting.

14. COMMUNICATIONS

Road, rail and air services available.
Nearest airport or airfield.
Port radio and information service with frequencies and hours of operating.

15. PORT AUTHORITY

Designation, address and telephone number.

16. SMALL CRAFT FACILITIES

Information and facilities for small craft (eg yachts) visiting the port.
Yacht Clubs, berths, etc.

17. VIEWS

Photographs (where permitted) of the approaches, leading marks, the entrance to the harbour, etc.
Picture postcards may also be useful.

Signature of observer/reporter ....

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