CHAPTER SIX

NAVIGATION.

Every navigator should try to cultivate 'navigational sense'. This means keeping tight hold on your sense of direction. Learning to estimate distance and not being deceived by appearance, seizing opportunities, and not giving way to panic.

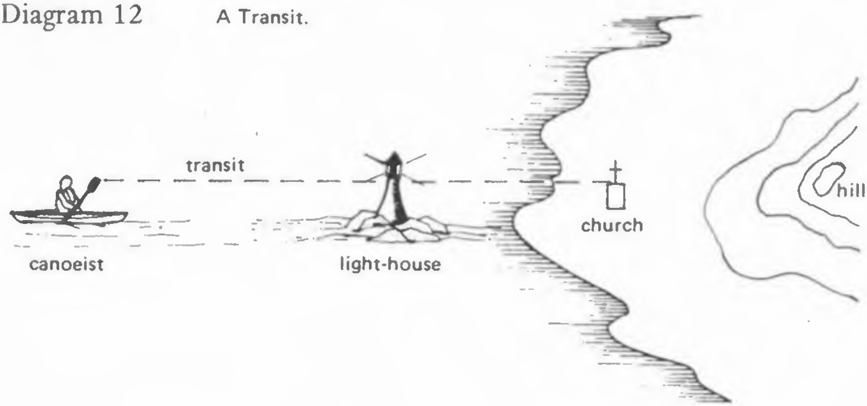
A sense of direction does not necessarily mean relying on instinct. It means remembering simple things such as; the sun rises in the East and sets in the West, and at noon bears South (in the Northern hemisphere) and that the Pole Star always bears North, and that if you are lost in the middle of the English Channel you have only to paddle northwards long enough to find land somewhere! !

Equipment.

1. A good table top to work on. As all navigation work for sea canoeing has to be done before the trip, the kitchen table should suffice.
2. Parallel rules. These are used for drawing or 'laying off' on the chart the course and bearings.
3. Dividers are required for measuring distances on the chart.
4. Pencils and rubber.

All the planning and accumulation of information necessary for a trip must be achieved before undertaking the trip. It should be checked by each member of the party for accuracy.

Diagram 12 A Transit.



THE USE OF COMPASS.

I have briefly mentioned some types of compasses available under the heading of Equipment. I will now say a little more on the use of a compass.

In about the 17th century it was discovered that the Earth itself is a vast magnet whose poles attracted one end of a magnetised needle. The 'south' end of the needle points to the north pole and the 'north' end to the south pole. This is in accord with the rules of magnetism which say . . . unlike poles attract, like poles repel.

Since the 17th century it slowly became obvious that the magnetic poles could not be in the same place as the geographical poles, and furthermore that the magnetic poles were not stationary, but changing their position over long periods of time. This accounts for the compass needle not pointing accurately to the geographical north but instead to the magnetic north. This difference is known as VARIATION. Magnetic meridans are the lines in which the compass needle lies and they do not run geographically north and south. In other words the compass needle does not point directly towards the geographic North, but at an angle with it which varies in different localities, and also slightly with time. This is known as the ANGLE OF VARIATION.

Modern techniques and the vast store of information garnered over the years enables the variation to be predicted accurately for any given place and time. At the present time the variation in the U.K. is changing annually by about 8 minutes of arc.

To the modern navigator variation is no mystery. Allowances must of course be made for it if an accurate TRUE course is to be steered at sea. If magnetic north lies to the west of true (geographical) north it is a WESTERLY VARIATION and an EASTERLY if it lies to the East.

Compass Rose is a compass drawn on a chart. The variation is usually shown inside the rose, together with the amount by which it is increasing or decreasing annually. The Compass Rose on a chart consists of two concentric circles graduated in degrees. With the aid of the rose and parallel rules, courses and bearings can be laid off on the chart. The North point of the outer (True) circle is aligned with the meridian and therefore indicates True North on the chart. The North point of the inner (Magnetic) circle is aligned to Magnetic North and this is correct at the date the chart was printed. You should therefore check the variation value written inside the compass rose, correct it for the annual change since the chart was published.

Apart from Variation as already described there is yet one other correction to be made in order to be sure you are steering Magnetic North. This correction is caused by the compass DEVIATION. Deviation is the error due to magnetic disturbance within the craft. It should not effect us as canoeists apart from remembering not to show metal articles too close to your compass. Any angle of deviation on a particular heading is defined as the angle between Compass North and Magnetic North and will vary as the canoe alters course.

Compass graduation. Nowadays most compass cards are graduated from 0° to 359°, the 360° of a circle. Thus 0° is North - 090° East - 180° South and 270° West, and back again to North or 360°. Modern compasses also display the Cardinal and Quadrantal points - NE SE SW NW, usually marked inside the degree graduation. To set a particular course, the appropriate graduation on the card is brought opposite the Fore-and-Aft mark on the compass bowl, (known as the Lubber line). You should make sure that this Lubber Line is truly aligned fore and aft, i.e. parallel to the keel of the canoe.

The TOTAL COMPASS CORRECTION is a combined allowance for the errors caused by VARIATION and DEVIATION.

As I have already said, deviation need not worry us over much so long as we keep metal articles stowed away from the compass. This is not the case for VARIATION, so let us now derive a simple rule for converting True directions into Magnetic directions, and vice versa.

In Fig (a), OA is a direction (a course or bearing) which is 60° from the True meridian and 50° from the Magnetic meridian, the Variation being 10° East.

In Fig (b), OA is again 60° from the True meridian, but it is 70° from the Magnetic meridian, because the Variation is 10° West.

We therefore derive our rule as follows:

VARIATION WEST,
MAGNETIC BEST.
VARIATION EAST,
MAGNETIC LEAST.

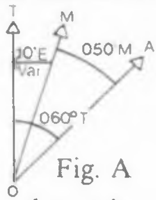


Fig. A

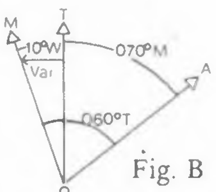


Fig. B

It is important to note that, when using this rule, the directions must always be expressed in three figure notation, or the rule will not work properly in every case. i.e. for Fig (b), 060° T, Var. 10° W = 070° M, and for Fig (a), 050° M, Var. 10° E = 060° T.

The Dead Reckoning Position (Deduced Reckoning).

The Deduced Reckoning or D.R. position is arrived at by allowing for the canoe's true course and speed through the water since leaving a known point.

The Estimated Position.

The estimated position allows for the best estimate of tidal stream and leeway being applied to the dead reckoning. In other words, it is the best estimate of the canoe's position over the ground allowing for course, speed, tidal influence and leeway since the last known position of the canoe.

Fixing by Transit and Bearing.

A transit bearing simply consists of taking two prominent landmarks and lining them up and keeping them in line so that you paddle the required course. The great advantage of a transit is its certainty. If the charted marks, tower, lighthouse etc., are visible in alignment then the canoe must lie on the extension of the line joining them.

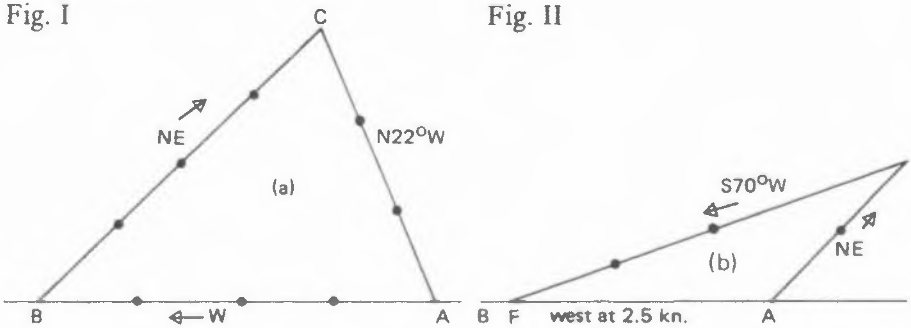
If a second transit bearing can be established simultaneously then a reliable fix is obtained. A fix is one's position in time on the water. This is difficult to ascertain from a canoe. Transits are not always available when needed. However, an intelligent glance at the chart will often show that if a suitable back mark can be found that is visible over a wide range of bearings, an assortment of front marks are often available. By lining up on a transit and then sitting the canoe without paddling, the set and drift of the tide may be found. This is always useful information.

Laying off a Course.

1. Effects of Currents. When setting a course across a known current or tidal stream adequate allowance must be made for its effect. In a canoe this can be considerable. This is best demonstrated by a parallelogram of forces diagram from which a course to paddle to counteract the stream, or the effect of it if not counteracted, can be calculated or measured. In fact only half the parallelogram is used in each of these cases - a triangle of forces rather than a parallelogram.

In Fig. I of Diagram 13 the first triangle (a) shows the effect of a 4kn NE current on a canoe being paddled at 4kn steering west.

Diagram 13



Paddling towards B at the end of an hour the canoe has made good a track of N 22° W and a speed over the ground of 3 knots. A similar triangle can, of course, be constructed for any course or interval of time. It can also be used to determine the set and drift of the current.

N.B. Track is the distance actually made good over the ground.

Course is the direction steered.

Set is the direction of stream or current.

Drift is the speed or distance of the current.

2. Countering a current

Refer to Figure II of Diagram 13, triangle (b) in which the navigator anticipates a current setting N.E. at 2 knots but requires to get from A to B so wishes to counteract.

Lay off the track line A.B. From any point on it, to scale, lay off an hours current effect.

From the point so reached, E, with a distance equal to the speed of the canoe at the same scale, with the dividers cut the track line at F. The distance of A.F. represents the speed the canoe will make along the track i.e. 2½ knots. The line E.F. represents the course the canoeist must steer to make good the track A.B.

A PRACTICAL APPLICATION.

So far we have learnt a little about compasses, compass roses, charts, tides, laying off, estimated positions, etc.

Now let us see how all the foregoing knowledge can actually allow us to plan an expedition in terms of navigation.

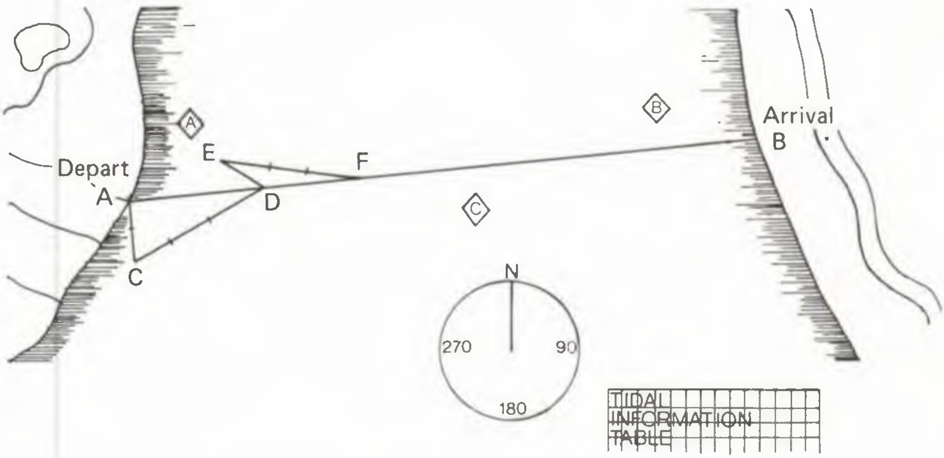
There are basically two types of expeditions, - coastal 'hopping' and sea crossings.

Coastal trips.

As you are to be following the coast you are less likely to get lost. Your most useful aid will probably be an ordnance survey map. Study this well for prominent land marks, escape routes, beaches fit for landing, roads, telephones, habitation, etc. Ensure that your trip allows you to make the best use of the tides, and away you go.

Sea Crossings.

Let us assume that you wish to cross an open area of water which is 20 Nautical Miles wide



Draw a line from your point of departure, A, to your point of arrival, B. We have already determined that it is 20 N M. long.

Next decide on your estimated speed over the water, i.e. the speed at which you paddle. A strong group should be able to maintain a speed of between 3 and 4 knots. For the sake of this exercise we will agree on a speed of 3 knots.

FIRST HOUR. Close to your departure point you will see a ⟨A⟩ . By reference to column A on the tidal information table you will find, for the sake of this example, that the tide flows 180^{o} at 2 knots Spring and 1 knot Neaps. As we are, again for the sake of example, half way in time between Springs and Neaps we must extrapolate to determine that the tide is running at 1.5 knots.
Using your parallel rules draw a line from departure point A in the direction of 180^{o}.Now set a pair of dividers by using the scale at the

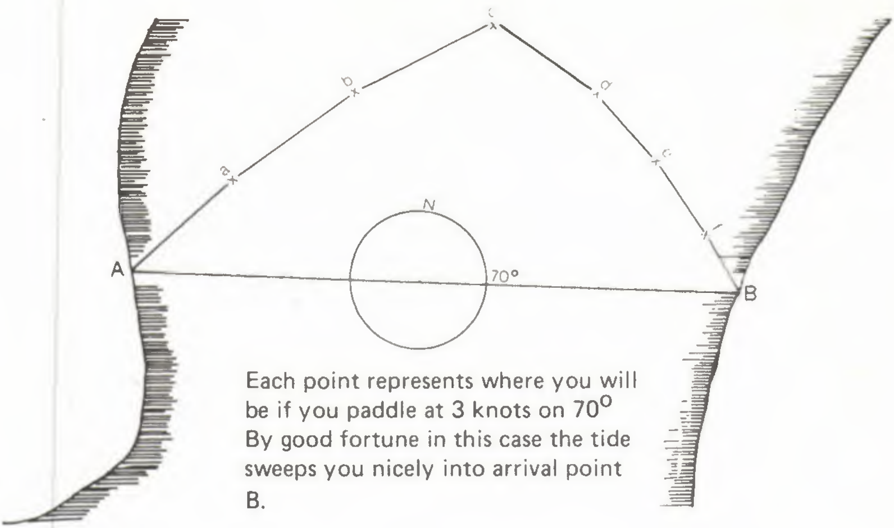
SIDE of the chart. (The latitude scale of the Mercator's chart is used to measure distances. Because the latitude scale varies on the chart as one goes North or South, you must always use that part of the chart scale of latitude which is abreast of the distance to be measured). In this case set the dividers at 1.5 N.M. and mark the spot along this line to give the line AC.
Take a pair of dividers, space them to the scale of 3 N.M. (estimated speed per hour). Put one point on C and where the other point crosses the line AB make the mark D. The direction of line CD is now determined by use of the parallel rules and the compass rose. We find that it is 45^{O}. This is the True bearing we must steer from point A to arrive at point D one hour later.

SECOND HOUR. Again from ◇A we discover that the tide has now changed for the second hour out and is running at 1 knot in direction of 315^{O}. From point D draw a vector line in direction of 315^{O}, 1 N.M. in length as previously described to give the line DE. Using the dividers draw a line 3 N.M. long to cross AB at F. The line EF represents the True bearing to steer and the point F is the point reached after the second hour. This procedure is repeated until you reach your destination at point B. Remember to use the different ◇ as they appear in the area of your calculations.

The calculations show the trip should take seven hours. To avoid having to remember the different compass headings hour by hour, add the seven headings up and divide by seven. This will give an average bearing which, all things being favourable, should take you to your arrival point B.

Another method of navigating open waters that I have favoured in the past consists of working out the tidal influence over seven hours as if you do not intend to counteract the tide as you paddle. For example, if the tides run one way for half the time and the opposite way for the other half, paddling on one compass heading should bring you right on to arrival point B.

If the tide runs longer in one direction than the other, you may find that by adjusting your departure time you overcome this problem. By repeated plottings, varying the start time you will find which time of departure allows you to make the best use of the tides to successfully bring you to your destination.



If the tide runs one way for six hours out of the seven, you end up by completing an extended 'ferry glide'. This is not making the best use of the tides.

In the foregoing explanations I have not mentioned converting True readings to Magnetic readings. DO NOT FORGET THIS.

THE SEA & NAVIGATION - A GLOSSARY

KNOT	A speed of one nautical m.p.h.
A NAUTICAL MILE	is one minute of latitude, is 6076 ft.
A CABLE	is 1/10th of nautical mile
ERROR OF COMPASS	is the angle at any place and time between magnetic North and true North - South Meridian (also known as declination).
VARIATION	Is due to the fact that the earth's magnetism does not lie in the direction of the true North-South axis. The magnetic pole lies 1,000 miles away from geographical North.

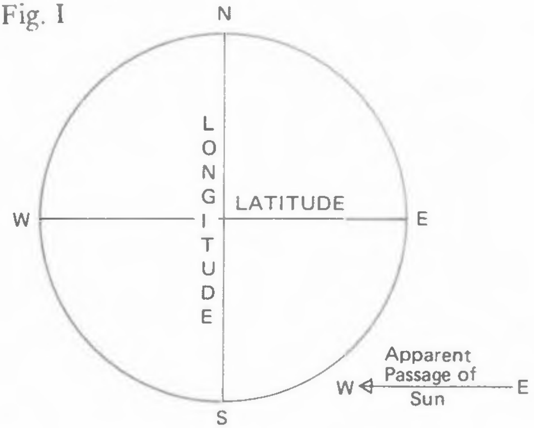
DEVIATION	is the error due to magnetic disturbance within the ship or from near by external objects.
TIDES	Spring Tides occur at times of full and new moon (Full and change of the moon) Neap Tides occur at the moon's quarters.
Tidal Streams	are a local phenomenon. They are the flowing of water in various directions and at varying rates due principally to the rising and falling of the tides, but directed also by the conditions such as the shape of the coast, estuaries, islands, the inclination of the sea bottom. They are generally strongest in narrow and shallow waters.
Tide Rises & Falls	On an average the tide rises for 6hrs 13 minutes and then falls for 6hrs 13 minutes. Thus there are two high and low tides in every lunar or tidal day of 24hrs. 52mins. It must be emphasised that this tidal interval is an average. The variations may be considerable with time and place. Also on average the tide times becomes 51 minutes later each day, but the actual increase in time may be anything from 15 mins. to 1½ hrs.
Priming	When this increase in time is less than the average the tides are said to be priming (i.e. they come earlier than expected).
Lagging	When the increase in time is more than the average the tides are said to be lagging.
Making	When the amount of rise and fall of tide is increasing, it is making.
Taking Off	As Neap Tides approach they are said to be taking off.
The flow or flood	= Rise)
The ebb	= Fall) of the tide

Slack Water	Occurs at the interval between ebb and flow.
Spring tides	Occur at 14 day intervals, so do neaps at the alternate weeks. Thus a tide is making for seven days and 'taking off' for seven days.
LINE OF POSITION	A single bearing gives a Line of Position
A FIX	If two lines of position are established at the same time; the point of intersections is your position. Method of obtaining a fix is by CROSS BEARING.
SET	is the direction of the current
DRIFT	is the speed or distance of the current
DEAD RECKONING (D.R.)	is deduced reckoning. It means estimating your position from some previously determined position, allowing for course steered, speed maintained and all known effects of winds, currents etc.
THE SUN	(a) sets in West and rises in East because earth rotates on its axis in an easterly direction (i.e. anti-clockwise). (b) Annual movement NORTH & SOUTH between the parallels of 23½^{o}S and N (The Tropics).
AZIMUTH	Sun's bearings.
AMPLITUDE	Sun's bearings at the moment of rising or setting.
SOLSTICE	The sun's passage across the equator.
DECLINATION	Is the latitude of the sun - to be found for any date and time G.M.T. in the nautical almanac.
RELATIONSHIP BETWEEN LONGITUDE AND TIME	(a) The earth rotates on its own axis once in 24 hrs. (b) The sun appears to cover 360^{o} of longitude every 24 hrs. (c) covers 15^{o} in 1 hr. covers 1^{o} in 4 mins. covers 1′ in 4 secs (1′ of arc = 1 nautical mile)

Hence lines of longitude can be considered as lines or as an arc. As the sun crosses each meridian of longitude on its westward path, the LOCAL time is noon on that meridian. The sun appears to take 5 hrs. to travel from Greenwich to New York: noon occurs 5 hrs later at New York.

Meridian of longitude form angles at the poles. The angle at the Pole of the meridian of Greenwich and that of New York is 75^{o} (as 15^{o} in 1 hr = 5 hrs). Such angles are known as HOUR ANGLES.

Fig. I



ZENITH Is the point at which the sun is immediately overhead. (This is tabled in Nautical Almanacs).

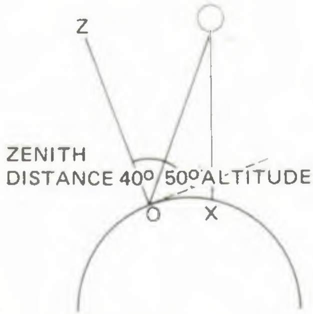
The Zenith Distance (See Fig II) = is the distance of the sun from the subjects own zenith.

It is the complement of altitude or the angular distance of a body (e.g. the sun) from the zenith of the observer

It is possible to reduce the zenith distance to NAUTICAL MILES.

i.e. 1′ of arc measures 1 nautical mile therefore an angular zenith distance of 40^{o} reduced to the surface becomes 2,400 miles. i.e. 40^{o} = 2400′ of arc
= 2,400 nautical miles.

Fig. II



CIRCLE OF EQUAL ALTITUDE

using the zenith distance as a radius, a circle is described around the point immediately beneath the sun. At any point on its circumference we should obtain the same altitude of the sun because the complement of the altitude - the zenith distance - has been used as radius.

Such a circle has a very large radius, so large that any small part of its circumference may be regarded as a straight line. This is important.

POSITION LINE

Any radius of a circle meets the circumference at right angles.

If we find the true bearing of the sun we can say that a line at right angles to it (drawn at a distance equal to the zenith distance from the sun) is a small part of the circumference of our circle of equal altitude.

A position line is a line at right angles to the true bearing of a celestial body, a small part of a circle of equal altitude round the body, at some point on which the observer must be

MAGNETIC COMPASS

The earth's magnetic field has two components a horizontal force and a Vertical Force, the vertical force being maximum at the Poles and zero at the equator, the horizontal force zero at the Poles and maximum at the equator.

1) Variation

Variation is the angle between magnetic North and True North. Variation Charts are used as a means of correcting the compass heading. Variation in Britain is changing annually by about 8′ of arc. Is defined as WESTERLY variation if Magnetic North is to west of TRUE and Easterly if Magnetic North is East of True North.

2) Deviation — or angle of deviation of a particular heading is defined as the angle between compass North, and magnetic North and is caused by metal too near to compass position.
The deviation of the compass on all headings must be found. This is normally done by 'swinging the ship' i.e. swinging the boat slowly through N.E.S.W. through 360°.

ISOGONIC LINES — Are two lines, joining places of equal variation.

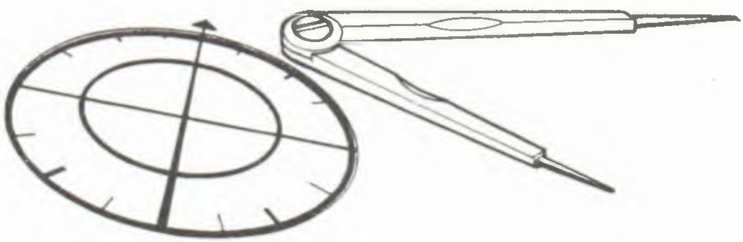
LUBBER LINE — Is the fore and aft mark on the compass - must be carefully aligned i.e. parallel to the boat's keel.

THE RULE — If going from magnetic bearings or courses to True bearings or courses subtract Westerly and add Easterly variation. The converse applies if going from true to magnetic.

C.A.D.E.T. — COMPASS ADD EAST TO GET TRUE.

DISTANCE, COURSE, SPEED, DIRECTION — You must have - a compass
- a chart

DISTANCE — 1 nautical mile = 6076.115 ft = 1′ of arc = 1852 metres = for general purposes 2000 yds divided into 10 cables of 200 yds apiece.
(N.B.) 1 statute mile = 1,760 yds, = 0.87 nautical mile



SPEED

A knot = 1 naut. mile per hour

Distance (D) = Speed (S) x Time (T)

Example — Distance (D) = 10 miles
Time (T) = 40 minutes

$$10 = S \times \frac{40}{60} \text{ (mins)}$$

$$S = \frac{40}{60} \div \frac{10}{1}$$

$$= \frac{40}{60} \times \frac{1}{10} = \frac{40}{600} = 15$$

ANS = 15 knots

The Six Minute Rule.

Six minutes = 1/10 of an hour

Travel .2 miles (2 cables) in 6 mins.
Speed = 2 knots
Travel .5 miles (5 cables) in 6 mins.
Speed = 5 knots
Travel 1 mile (10 cables) in 6 mins.
Speed = 10 knots

Portion of chart showing a Compass Rose