CHAPTER 6

MAP REFERENCES

SECTION 1 - GRID REFERENCES

601. General Principles

1. A grid is a rectangular system of lines superimposed on a map, within which any point can be defined and located by reference to the lines enclosing the square within which the point falls. The principle of all systems of grid reference is the same.

2. Maps are normally printed so that north is approximately at the top of the sheet when the writing is the right way up. Therefore, the rectangular lines of the grid are drawn so that one set of lines runs approximately north-south, and the second set of lines runs approximately east-west. The position of each point within a square is thus indicated by its distance east of a north-south line and north of an east-west line.

3. North-south lines are given values called "Eastings" according to their distances east of an origin failing at the south-west corner of the grid system; similarly east-west lines are given values called "Northings" according to their distance north of this origin.

602. How to Give Grid References

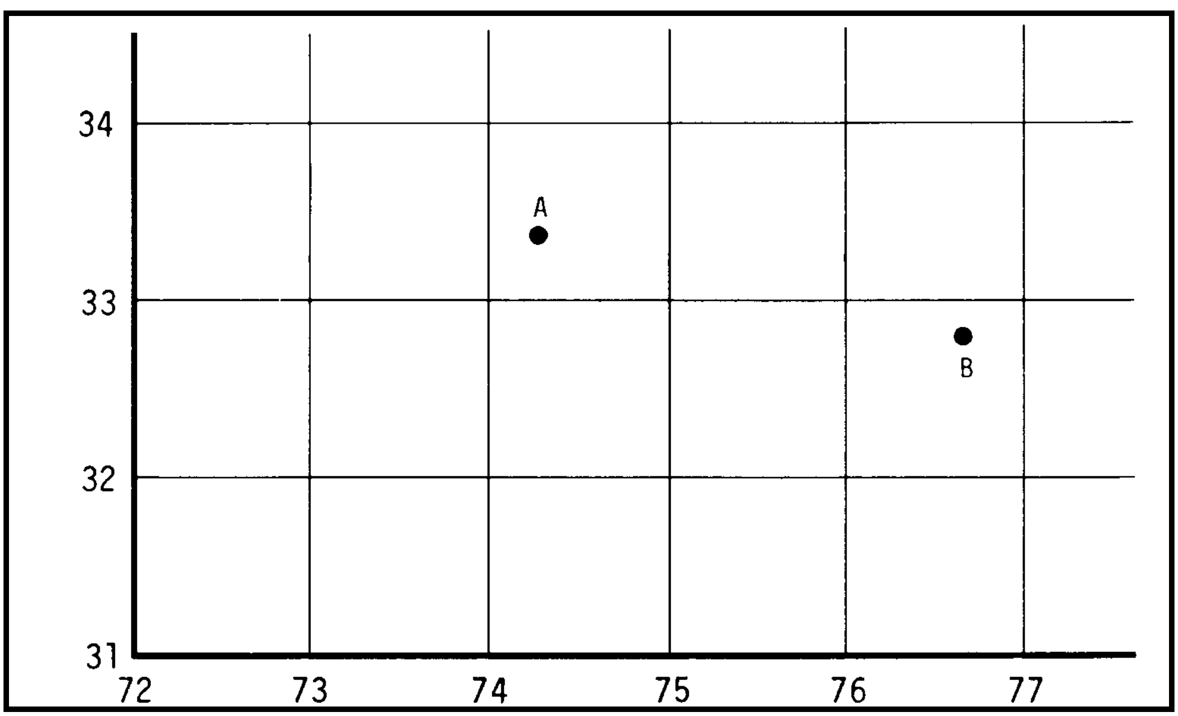

Figure 6-1 Grid Squares

1. Figure 6-1 illustrates a part of a typical grid system with the north-south lines given eastings of 72 to 77 units while the east-west lines are given northings of 31 to 34 units. A and B are two points on the map of which grid references are required.

2. Grid references are always given with the casting value first followed by the northing value. The grid reference of the intersection of easting line 74 with northing line 33 is therefore 7433.

3. When giving a grid reference to a square, the reference is always to the south-west corner of the square. Thus the reference to the square in which "A" falls in Figure 6-1 is 7433. Similarly, "B" falls in square 7632.

4. A reference to a grid square is only adequate if accompanied by a brief description, eg, the village in square 7433. When, however, the reference is to an item of which there is more than one in the square, eg, a bridge, it is necessary to give a more precise reference if the correct bridge is to be identified. This technique is described in art 603.

603. Grid References Within a Square

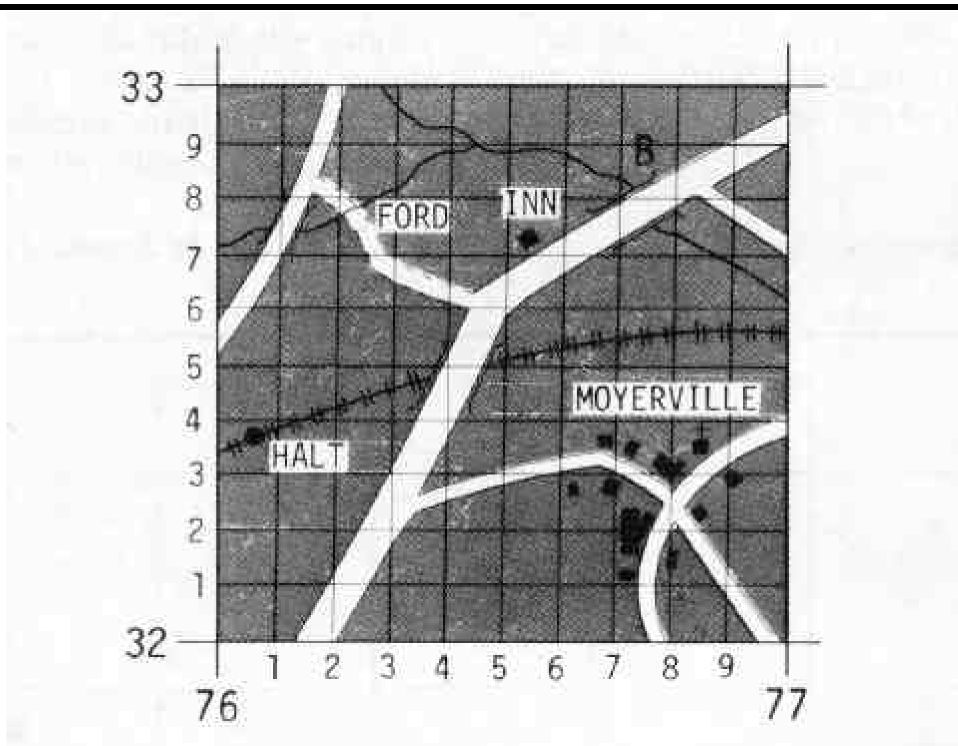

Figure 6-2 Grid Reference Within a Square

1. Figure 6-2 shows the detail within the square 7632 which contains point "B", a bridge. To provide an accurate rid reference to a point of such detail, it is necessary to break up the grid square shown on the map into 10 subdivisions in each direction as shown in the figure.

2. The centre point of this bridge is in the small square whose south-west corner is 7/10 east of casting 76, and also 7/10 north of northing 32. Its casting is thus 76.7 and its northing 32.7 units. Omitting the decimal points, the grid reference is thus written as 767327.

3. The two other bridges within the square are at 761327 and 764324. Similarly, the church is at 768323 and the railway station is at 760323.

4. In Figure 6-2, the breakdown of the grid square into tenths has been drawn to help describe the method. In practice, the tenths of a unit are estimated, or may be measured with a romer as described in art 610.

5. Should it be necessary to indicate a position even more accurately, the same method of estimation may be extended another stage by dividing each of the small squares again into further tenths and by adding a fourth figure to each of the eastings and northings. The fourth figure represents one hundredth of a unit. The reference to the railway station in Figure 6-2 could be written as 76053232, but such a reference is only required when a six figure reference is not precise enough to define the point without any doubt.

6. Important points to remember are that:

   a. All the casting figures are always given before the northing figures, ie, the first half of any grid reference is the casting and the second half the northing.

   b. Grid reference figures are never rounded up to the nearest figure, but are always given to the reference lines west and south of the point. The six figure reference to the railway station is thus 760323 and not 761324.

604. Grid Square Units

The grid references described in art 603 have all been expressed in terms of "Units", as the principle is the same whatever these units may be. In practice, in most grids used by the military (see Sect 2) the grid unit is the metre, but grids using the yard may still be found on some maps. The grid unit is always stated on the map. All examples given in this publication are in metres.

605. Sizes of Grid Squares

The spacing of the grid lines to define the sizes of the individual grid squares depends on the map scale. It is desirable to have a square which is small enough to enable the user to estimate tenths by eye, but which is not so small as to make the frequency of the grid lines overpower the map. The following may be taken as a general guide:

1:25,000 and 1:50,000	1000 metre squares
1:250,000 and smaller	10,000 metre squares

606. Accuracy of Grid References

1. As explained in art 603.4, the normal grid reference to a point of detail is made by estimating tenths of i square. Based on the square sizes in art 604, the accuracy to which such a reference can be given is therefore one tenth of the square size, viz,

1:25,000 and 1:50,000	scales 100 metres
1:250,000 and smaller	1000 metres

2. Using references to a further decimal place as in art 603.5, the references can be given to the nearest 100 metres, 10 metres, and metre respectively. For survey purposes, even more precise references may be given.

607. Grid Letters

Most grid systems use letters to identify the 100,000 metres squares: this is further explained in Sect 2. To avoid all possible error, a full grid reference must include the grid letter as well as the grid reference in numbers since the grid figures will recur at intervals of 100,000 metres. When using maps of 1:250,000 scale and larger, the use of the letters is, however, necessary only when a 100,000 metre line falls in the sheet, and in such a case, the grid letters are shown on the face of the map in the borders on either side of the junction line. On maps of 1:500,000 scale and smaller the grid letters are shown in the body of the map in the centre of the 100,000 metre square to which they refer.

608. Grid Values

Grid values (easting and northings) are written in full on the grid lines nearest to the SW corners of the sheet and may be written in other corners also. Grid values to the other grid line are usually shown by one, two, or three figures (depending on the scale) omitting the final zeros which represent decimals of the grid square. For grid reference purposes, the map user need normally use only those grid values which appear in large type against the grid and are repeated within the body of the sheet.

609. Grid Reference Box

As stated in art 210, each map carries a panel in the lower or side margin explaining how to give a grid reference. The panel shows any grid letter applicable to the sheet, and explains in detail a grid reference to a selected point of detail within the sheet. On some maps, the grid reference example may not necessarily apply to a point on the map.

610. Romers

1. A romer is a device for measuring the position of a point within a square instead of estimating the tenths. See Figure 6-3. To use the romer put the corner against the required point with the edges parallel to the grid lines. The distances east and north within the grid square can then be read against the west and south grid lines of the square. Clearly, a different romer must be used for each scale of map.

2. Romers for 1:25,000 and 1:50,000 scales in metres are included on the Protractor C2 illustrated in Figure 6-4: similar romers in metres are included on the Silva compass (Chap 8, Sect 3). If such romers are not available, a romer may be made easily from a piece of paper or card, marking off the appropriate sub-divisions of a grid square from the scale on the map.

SECTION 2 - GRID SYSTEMS

611. Purposes of Grid Systems

1. In addition to the purpose of providing a reference system as described in Sect 1, a grid system in mapping has the following important purposes:

a. to provide a rectangular framework within which all control points may be computed and plotted in rectangular coordinates, thus simplifying the calculation for bearings and distances;

b. to simplify the layout of standard sheets and the joining together where necessary of neighbouring sheets; and

c. to provide a map framework within which distortion due to various causes can be measured simply and effectively.

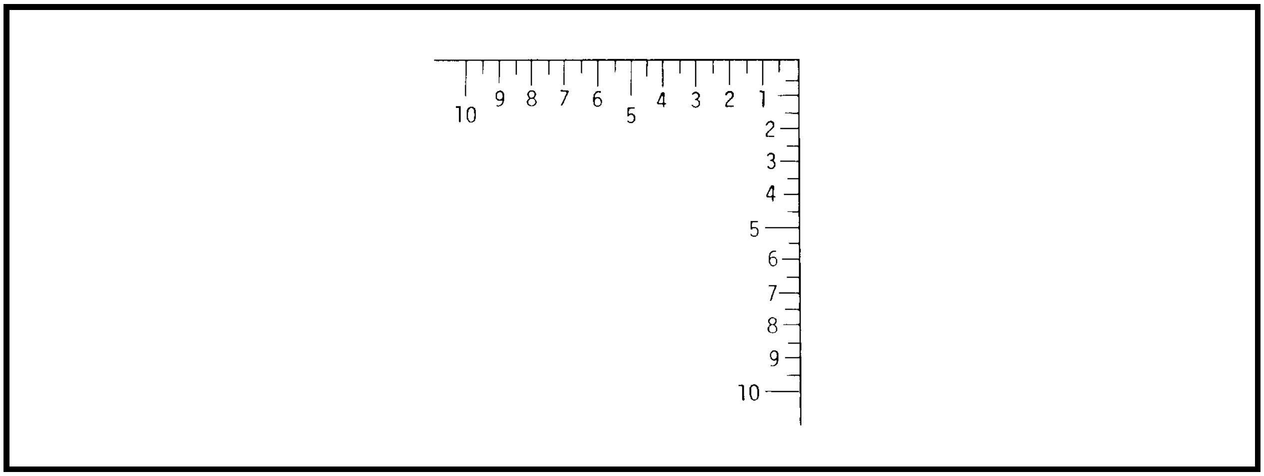

Figure 6-3 Romer

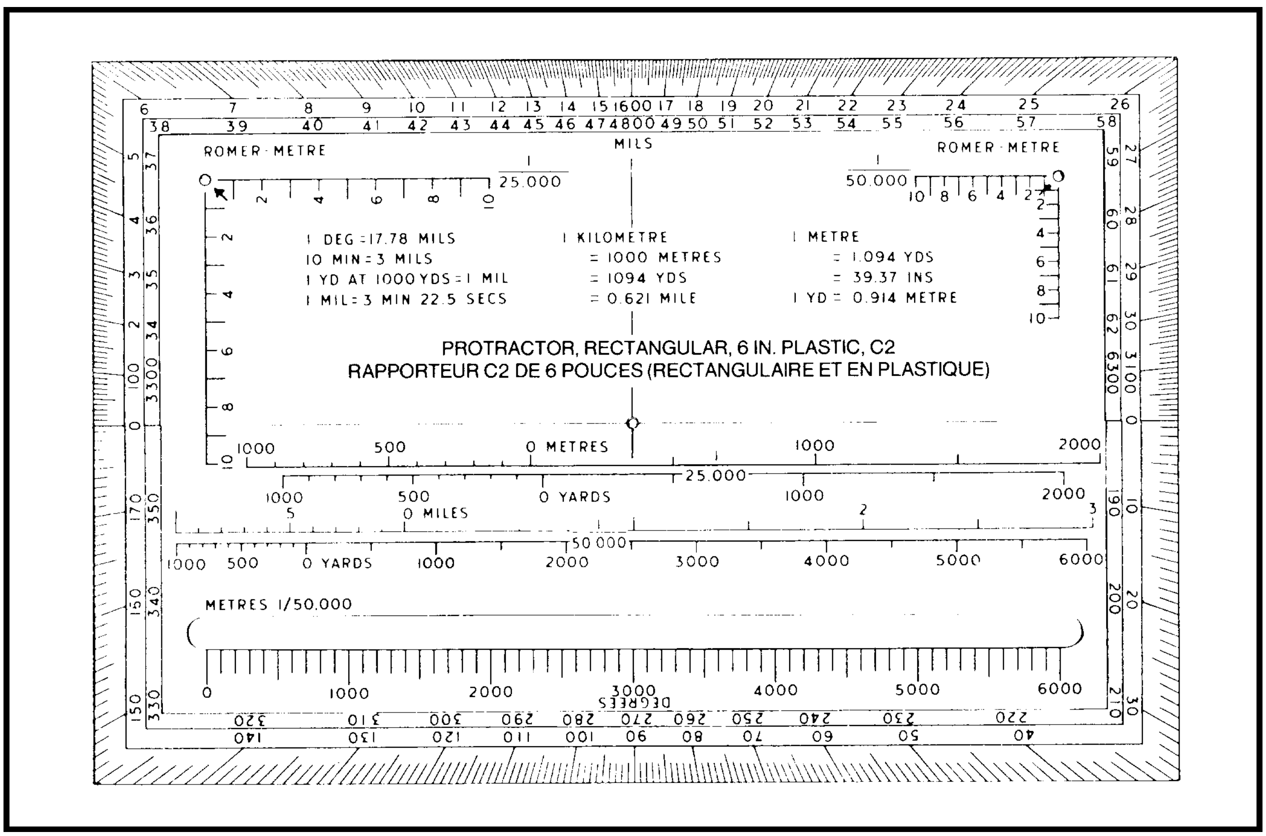

Figure 6-4 Protractor C2 6" Mils/Degrees/Metres

612. Relation of Grid to Projection

As explained in art 611, a grid is not merely a reference system but is also an important technical element in map making and use. A grid is desirably based on and closely related to the projection used for the map, so that the combined system may provide as true a representation of the earth's surface (which is spherical) as is possible by a rectangular grid on a flat piece of paper. Clearly, it is impossible to make this representation 100 per cent accurate over a wide area, and projections and grids are therefore designed to make the best fit within the scope of the publication to explain projections and grids in great technical detail, but it is important that tolerable limits of accuracy over limited areas. It is not within the scope of the publication to explain projections and grids in great technical detail, but it is important that users should understand that map grids are not just a set of grid lines which can be continued indefinitely as straight lines, regardless of the scale and area covered. For a more comprehensive coverage of the subject see CFP 306, Field Artillery, Vol 17, Artillery Survey.

613. Universal Transverse Merecator Grid System

1. Most military mapping is now based, or is being based, on the universal transverse mercator (UTM) system. It is a universal grid system which can cover the world except for the polar regions, and is based on 60 separate modified transverse Mercator projections, each six degrees of longitude wide and extending from 80°S to 84°N latitude.

2. The UTM grid is divided into "Zones", each covering six degrees of longitude and eight degrees of latitude (except for the most northerly band from 72 ° N to 84 °N which covers twelve degrees of latitude). The 60 longitude bands are numbered and the 20 latitude bands are lettered, each grid zone thus being one rectangle of the grid pattern established by their bands and designated by the figures of the longitude band followed by the letter of latitude band, eg 14U. See Figure 6-5.

3. Each grid zone is subdivided into 100,000 metre squares, vide Figure 6-6. Each column and each row is identified by a letter which are combined to identify the 100,000 metre square, eg, ML which falls within grid zone 14U making its full references 14UML. Whilst the pattern of the letters is repeated at intervals, the distance between similar letters for 100,000 metre squares is very great (normally 18° longitude), and where there may be a risk of error in identification, the use of the zone designation avoids this.

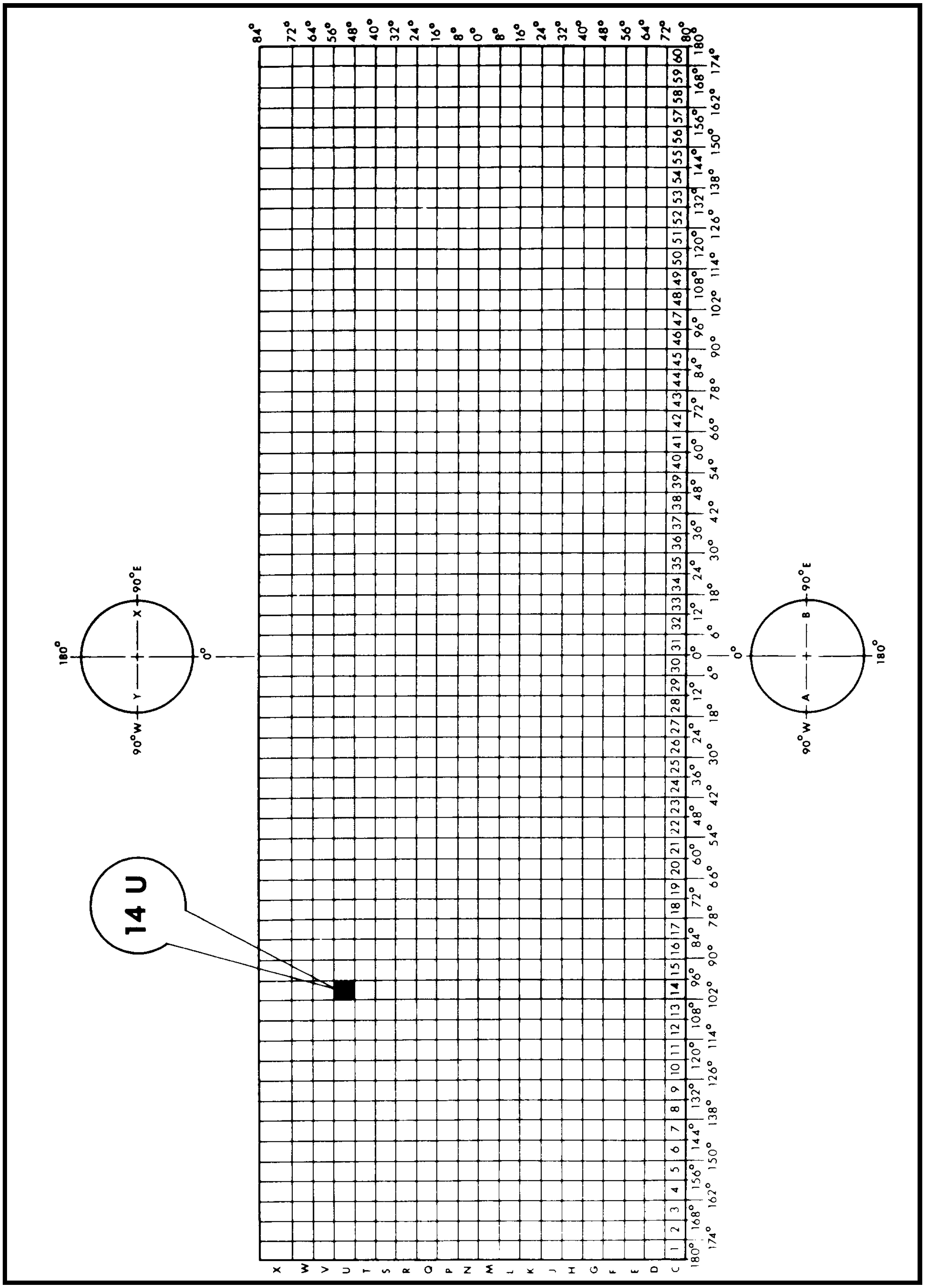

Figure 6-5 UTM Grid Zones

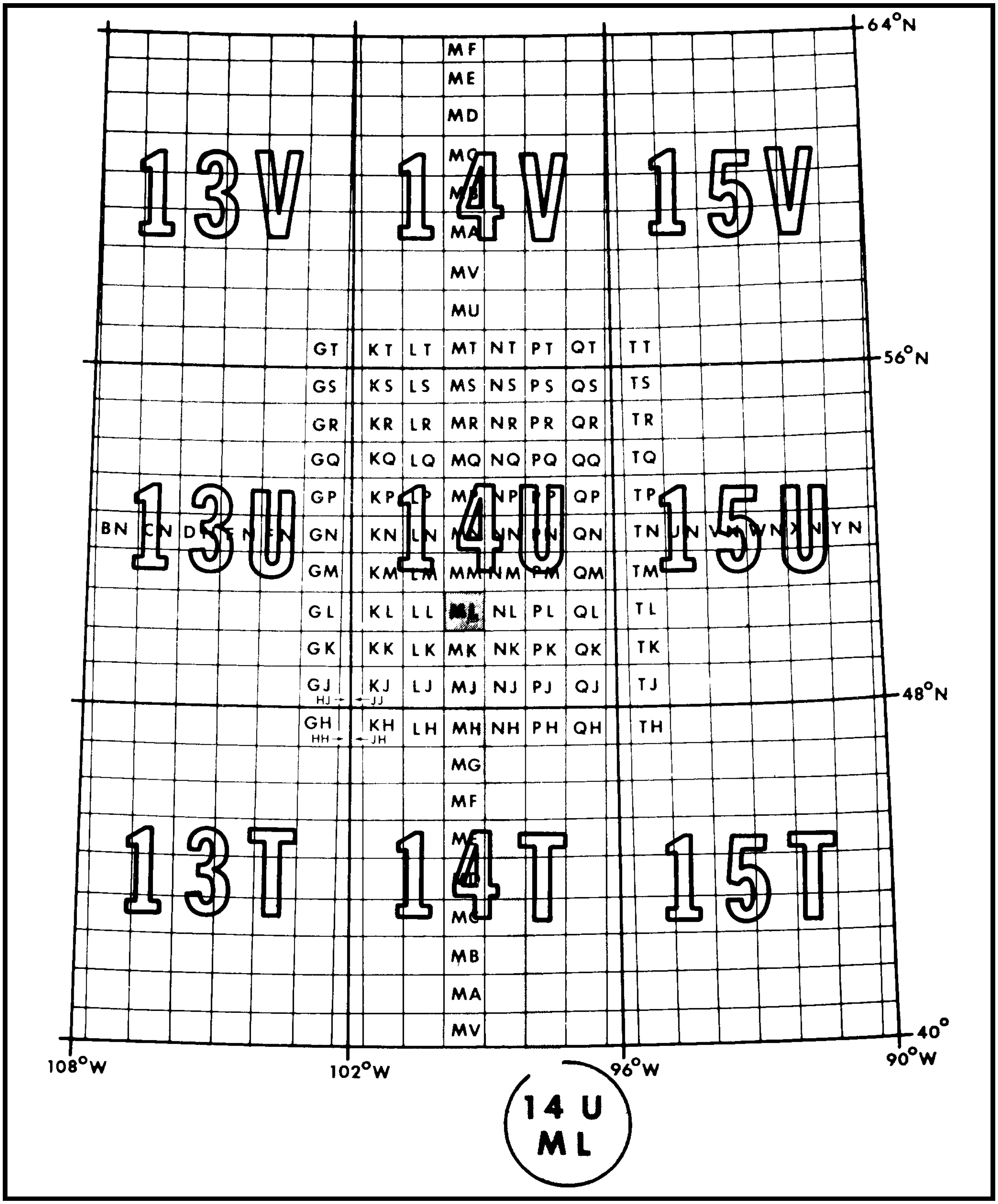

Figure 6-6 Layout of 100,000 Metre Squares

4. Grid references on the UTM grid are given on the same principle as explained in Sect 1, starting normally with the 100,000 metre square letters as shown in Table 6-1.

Scale of Maps	**Normal Interval Between Grid Lines in Metres**	**Normal UTM Grid Reference**	**Locates a Point Within**
1/1,000,000	100,000	ML 90	10,000 metres
1/500,000	10,000	ML 9507	1,000 metres
1/250,000	10,000	ML 9507	1,000 metres
1/50,000	1,000	ML 957075	100 metres
1/25,000	1,000	ML 957075	100 metres

Table 6-1 UTM Grid References

If the grid zone designation is necessary to avoid ambiguity, it is added before the 100,000 metre letters, eg, 14 UML 90. This, however, is not normally required.

SECTION 3 - GEOGRAPHICAL COORDINATES

614. Graticules

1. A "Graticule" is the network on a map of lines of longitude and latitude (meridians and parallels). Some maps, particularly on scales of 1/1,000,000 and smaller, only have a graticule and no grid. Maps on larger scales may be bounded by gratictile lines, eg, degree squares, and also carry a grid superimposed on them. Other maps may be based on grid lines, but carry cutting marks and values of the graticule so that a graticule could be drawn LIP if desired.

2. Thus, by various means, almost all maps carry the necessary information to enable a user to find out the latitude and longitude of any point of the map.

615. Geographical Coordinates

1. The latitude and longitude of a point constitute its geographical coordinates. Both values are expressed in degrees, minutes, and seconds: latitudes are north or south of the Equator; longitudes are east or west of the meridian of Greenwich.

2. Geographical coordinates are used as map references for a wide variety of purposes, but generally only in small scale mapping (1/1,000,000 or smaller), and when considering large areas in extent. They are particularly used in air and sea operations, and on all charts designed for those types of use.

3. A reference system called GEOREF using geographical coordinates in a similar way to grid coordinates is used by air forces and for some other purposes, but it is not normally required by land forces and is therefore not described in this manual. Details on the use of GEOREF may be found in CFP 198, Manual of Pilot Navigation.

(616 to 699 not allocated)

CHAPTER 7

DIRECTION

SECTION 1 - DESCRIBING DIRECTION

701. The Points of the Compass

1. North, East, South, and West for the four cardinal points of the compass. There are in all 32 points of the compass, but only 16 of them are normally used in map reading for the description of direction. These are the four cardinal points and twelve intermediate points shown in Figure 7-1.

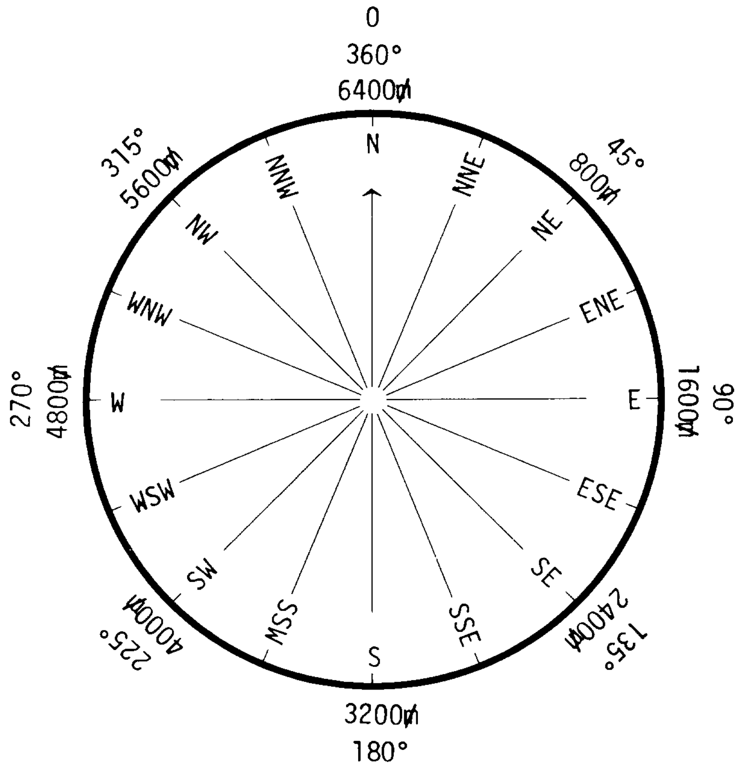

Figure 7-1 The Points of the Compass

2. In Figure 7-1, the letters N, E, S, and W stand respectively for North, East, South, and West. In the intermediate points these letters are combined, eg, SE is South East, NNW is North North West, etc. These points describe directions only to within one-sixteenth of a full circle. For a more precise indication of direction it is necessary to use sub-divisions of the circle called mils or degrees, as described in subsequent paras.

702. The Mil System

The standard military system is to divide the circle of the compass into 6,400 mils, the zero being at the North point. The four quadrants of the circle are each 1,600 mils, and so the East, South and West points fall at 1,600, 3,200, and 4,800 mils respectively. See Figure 7-1. Angles are expressed in mils and decimals of a mil. The symbol normally used for mils is ;K; on German maps it is shown thus: 200-.

703. The Degree System

1. The degree system is used principally by air and naval forces, and is used on maps to express geographical coordinates and for some angular measurements. References to angular measurements in this manual are normally given in mils.

2. In the degree system, the circle is divided into 360 degrees, each quadrant being 90 degrees. Each degree is sub-divided into 60 minutes, and each minute into 60 seconds. Degrees are marked thus “ minutes and seconds".

704. Conversion Between Mils and Degrees

1. Where it is necessary to convert from degrees to mils or vice versa, the following conversion factors may be useful:

a. 1° = 17.8 mils (18 mils approx);
b. 1° = 0.3 mils; and
c. 1 m i 1 = 3.4'.

705. The Grade System

A further system of angular measurement found on German and some other continental maps is the grade system. The circle is divided into 400 grades, each quadrant being 100 grades. Each grade is divided into 100 centigrades. The abbreviations are g and c respectively.

Thus 100 g = 90° = 1600 m
1 g = 54'= 16 m
1 m = 0 g 6.3 c

706. Bearings

1. A bearing is the angle, measured clockwise, that a line makes with a fixed zero line. The zero line is always North, unless some other zero line is stated. If one stands at point P, and says that the bearing of A is 700 m, it means that the line PA makes an angle of 700 m with the North line: see Figure 7-2 (a). If one says that the bearing of A is 300 m from a zero line PB, it means that the angle between PA and PB is 300 m, measured clockwise; see Figure 7-2(b).

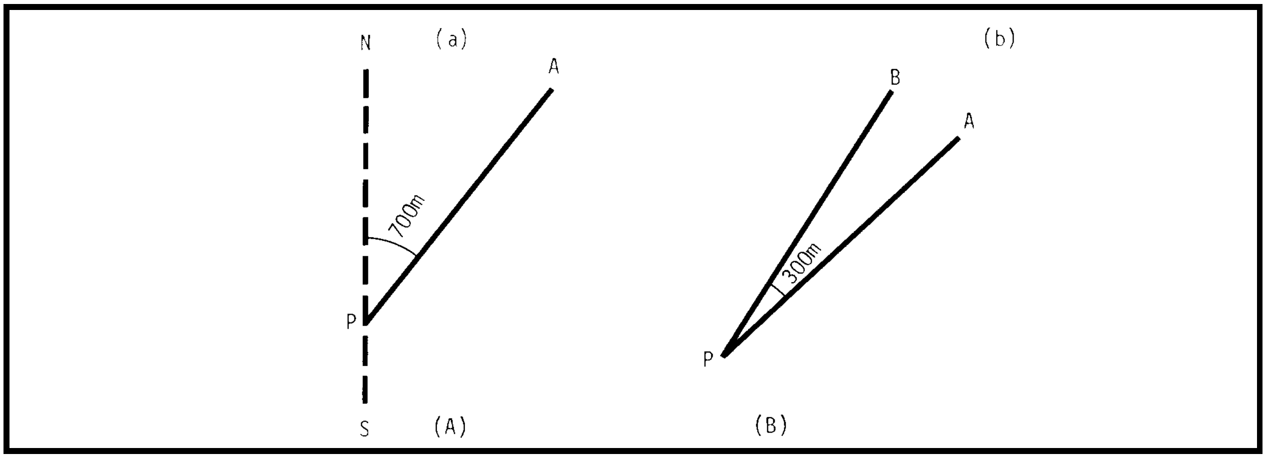

Figure 7-2 Bearings

2. The essential point to remember is that bearings are always measured clockwise from the zero line. This zero line is normally North, and therefore bearings of any direction to the east of the North-South line fall between 0 and 3200 m. Bearings of any direction to the West of the North-South line fall between 3200 pa and 6400 z. Figure 7-3 emphasizes how the angle of the bearing is always measured clockwise.

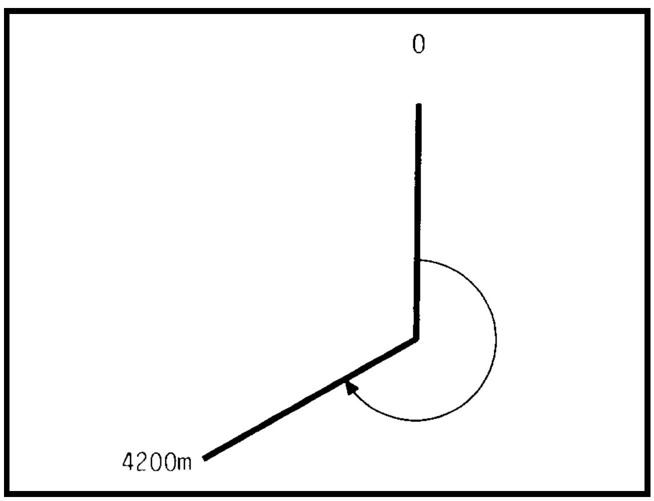

Figure 7-3 Bearings

707. Back Bearings

A bearing gives the direction of a line from the point of observation P to a point A. A back bearing gives the direction from the point A back to the point of observation P.

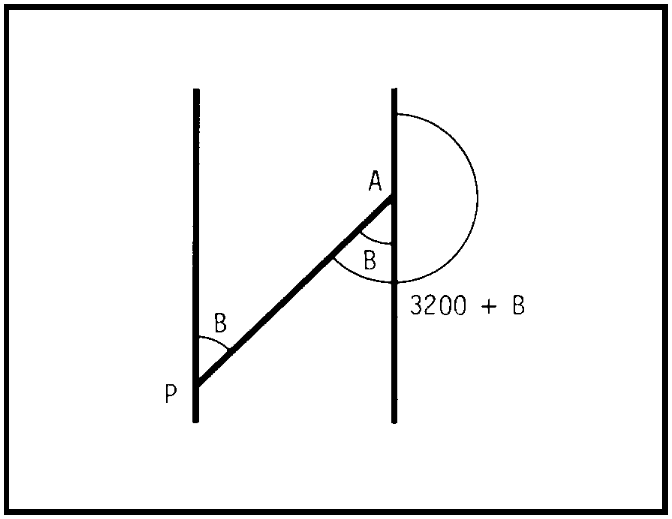

Figure 7-4 Back Bearings

Figure 7-4 illustrates that the difference between a bearing and its back bearing is 3,200 mils. Therefore, given the bearing, to find the back bearing add 3,200; or if the bearing is more than 3,200 m subtract 3,200. Service protractors give the values of both the forward and the back bearings along the same line. Examples:

Forward Bearing	Back Bearing
450 m	3650 m
4000 m	800 m

SECTION 2 - TRUE, MAGNETIC, AND GRID NORTH

708. Definitions of North

1. In Sect 1 it is explained that directions are measured by bearings, and that bearings are the angles measured clockwise from a zero line which is normally the direction of North. There are, however, three types of north, each of which differs by a small amount. These are:

   a. True North;
   b. Grid North; and
   c. Magnetic North.

2. True North is the direction of the North Pole. On a map the direction of True North is shown by the lines of longitude (meridians). Bearings measured from True North are called "True" bearings; these are not normally used by map readers.

3. Grid North is the northern direction of the north-south grid lines on a map. As explained in Chap 6, Sect 2, a grid system being a rectangular system imposed on a curved surface cannot exactly fit the lines of longitude and latitude. There is, therefore, except along the "Standard" meridian on which the grid is based, a small angle between the direction of grid north and true north. This angle increases with the distance east or west from the standard meridian. The grid lines on a map provide the most useful and normal reference for measuring bearings on a map; such bearings measured from Grid North are called grid bearings and are the bearings most commonly used in map reading.

4. Magnetic North is the direction in which a compass needle points when free from error or disturbance. (arts 803 and 804 refer). This direction is to the magnetic pole which differs from the North Pole. Its position varies slightly from year to year (see art 710). Bearings measured from Magnetic North are called magnetic bearings; these are the bearings read on a magnetic compass.

709. Angles Between North Points

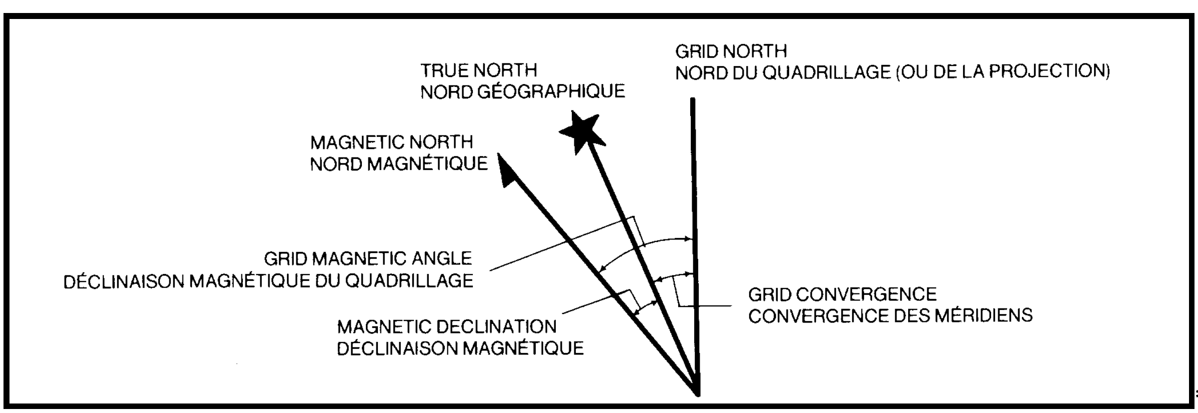

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Figure 7-5 North Points

1. Figure 7-5 illustrates the angle between the three north points. They are defined as follows:

a. magnetic declination - the angle between Magnetic and True North at any point;
b. grid convergence - the angle between Grid North and True North; and
c. grid magnetic angle - the angle between Grid North and Magnetic North. This is the angle required for conversion of magnetic bearings to grid bearings or vice versa.

2. It must be realized that the relative direction between the north points will vary in different parts of the world and on different grid systems. The definitions of the angles, however, remain constant. For the practical application of these angles in map reading, see Sect 3.

710. Annual Magnetic Change As stated in art 708, para 4, the magnetic pole varies in position. The amount by which its direction changes annually, ie, the annual change in the grid magnetic angle, is called the annual magnetic change. This must be taken into account when converting magnetic bearings to other bearings or vice versa. See Sect 3.

SECTION 3 - PLOTTING, READING, AND CONVERTING BEARINGS

711. Plotting and Reading Grid Bearings

1. The plotting and reading of grid bearings on a map may be done by using either an artillery protractor illustrated at Figure 6-4 or a Silva compass described in Chap 8, Sect 3.

2. If an artillery protractor is used to plot a bearing, a north-south line parallel to the grid must first be drawn through the point from which the bearing is to be plotted. The protractor is then placed with its zero line on this north-south line, and with the centre point of the zero line on the point from which the bearing is to be plotted. If the bearing to be plotted falls between 0 and 3,200 mils, the protractor should be placed so that the mils scale lies on the east side of the north-south line (see Figure 7-6); if the bearing falls between 3,200 and 6,400 mils, the mils scale must be placed to the west of the north-south line.

3. To measure the grid bearing of a line drawn on the map, place the artillery protractor with the zero line along any convenient north-south grid line which is cut by the bearing line, with the centre of the zero line at the cutting point of the bearing line and the grid line. The mils scale is to be placed east or west of the grid lines as required in accordance with para 2 above. The grid bearing is then read off the protractor on the appropriate scale. See Figure 7-7.

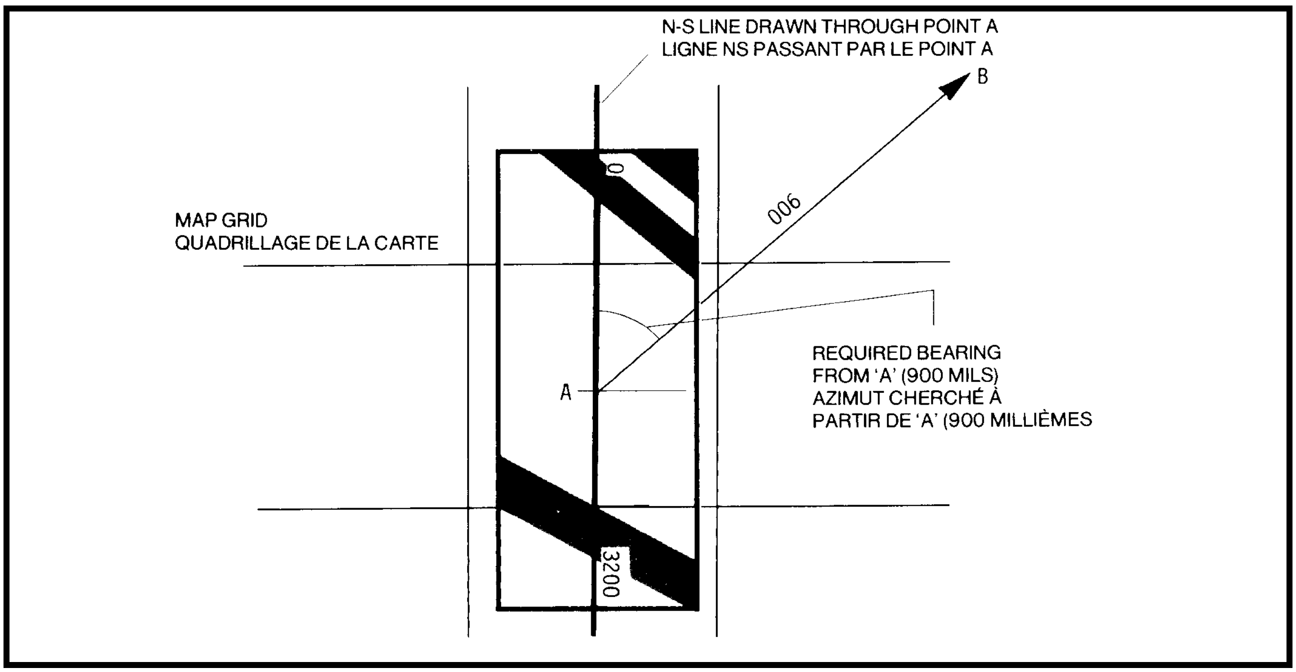

Figure 7-6 Plotting a Bearing on a Map from Point A

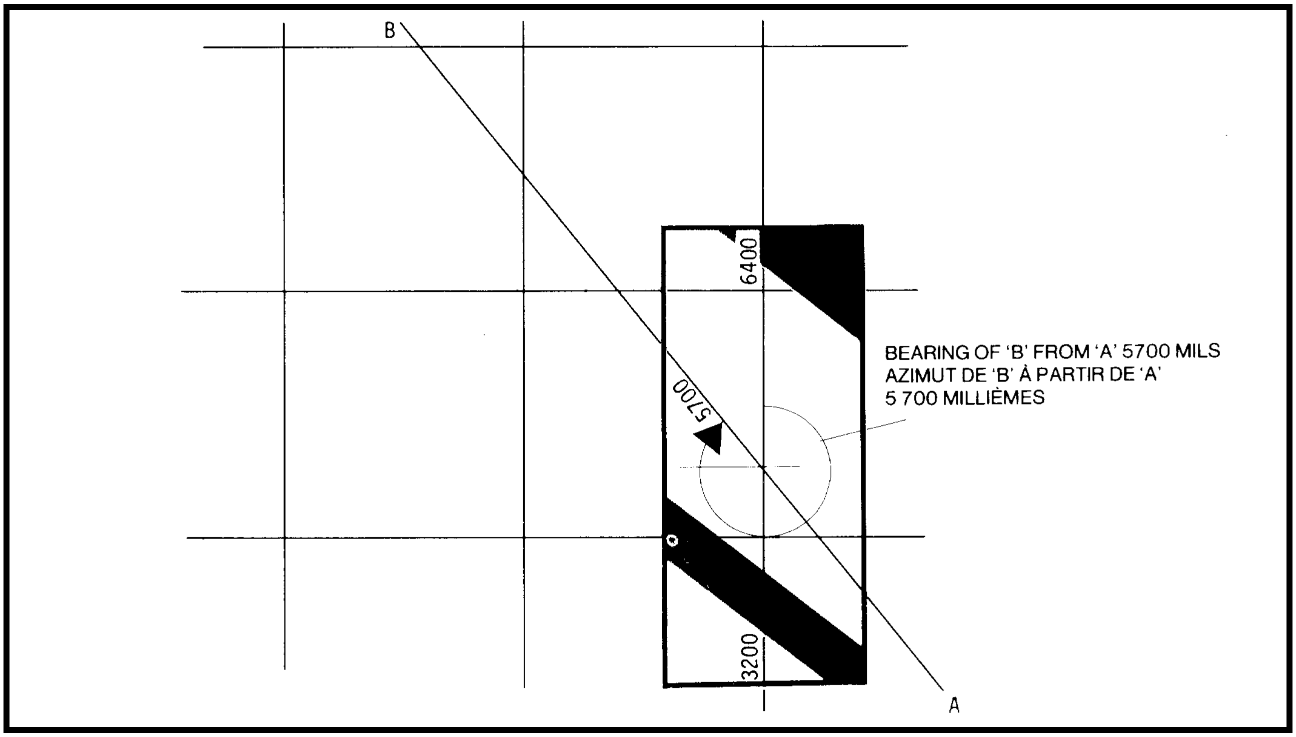

Figure 7-7 Reading a Bearing from a Map

4. If a Silva compass is used, the procedure for measuring the grid bearing of a line on the map is described in art 807. If it is desired to plot a grid bearing from a point A, the required bearing should be set against the line of travel by twisting the compass dial. Then place the compass with a long side against point A, and twist the whole compass until the base lines are parallel to the north-south grid lines (with the "N" arrow pointing to the North). The long side is then set on the required bearing in the direction of the line of travel.

712. True Bearings and Magnetic Bearings All bearings on a gridded map are best plotted as grid bearings. If, therefore, it is necessary to plot or to read a true bearing or a magnetic bearing, it is better to convert these to grid bearings before plotting; this conversion is explained below. If, however, the map is ungridded and if the lines of latitude and longitude are shown or can be established from the data given on the map, it will be possible to plot true bearings in a similar way to grid bearings. In any case, a magnetic bearing must first be converted either to a grid bearing or to a true bearing as required.

713. Conversion of Bearings

To convert a bearing from one sort to another, it is only necessary to add or subtract the appropriate angle between the two north points concerned. The necessary information about these angles should always be given in the margin of the map. On maps prepared under NATO and ABCA agreements, the information is given in the form of a diagram showing the north points with annotations as reflected in Figure 7-8. On other maps it may be given in written form only. See art 716.

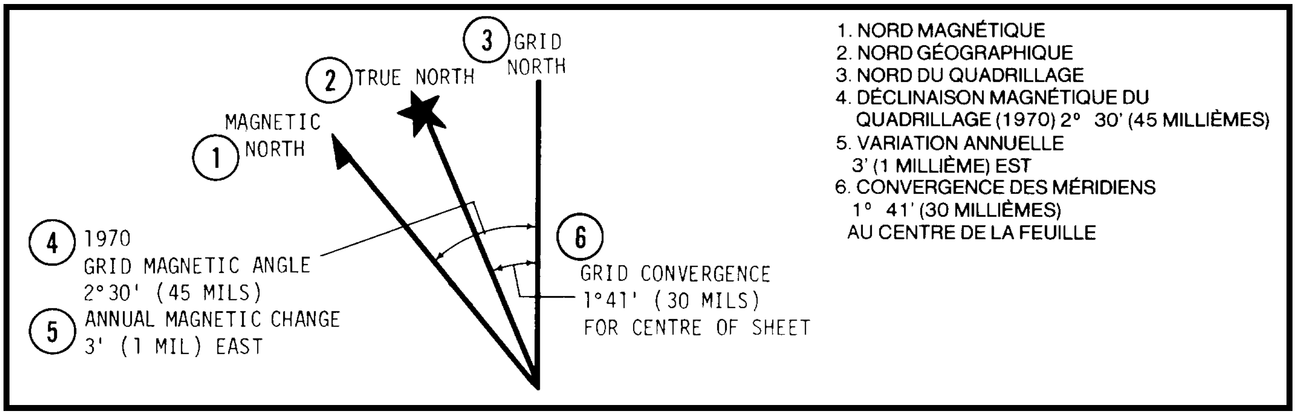

Figure 7-8 Conversion of Bearings

714. Grid Bearings/Magnetic Bearings

1. To convert a grid bearing to a magnetic bearing, or vice versa, the essential information is the Grid Magnetic Angle at the date of observation of the magnetic bearing. For example, using the values given in Figure 7-8, if the observation is made in 1975, the grid magnetic angle at that date would be calculated as follows:

Change in angle from 1970 to 1975
= 5 X annual change
= 5 X 1 mil
= 5 m EAST

ie, Magnetic North has moved 5 m towards the East, and therefore, in this case, the grid magnetic angle has become smaller by this amount. Hence, the grid magnetic angle in 1975 was 45 - 5 = 40 mils.

2. Remembering that all bearings are measured clockwise from their north point, it is clear from the above example that a magnetic bearing will be greater than the corresponding grid bearing by the amount of the grid magnetic angle. Therefore, to convert 1975 a grid bearing to a magnetic bearing, one had to add the grid magnetic angle of 40 mils to the grid bearing. Conversely, to convert a magnetic bearings to a grid bearing, one had to subtract 40 mils from the magnetic bearing. See Figure 7-9.

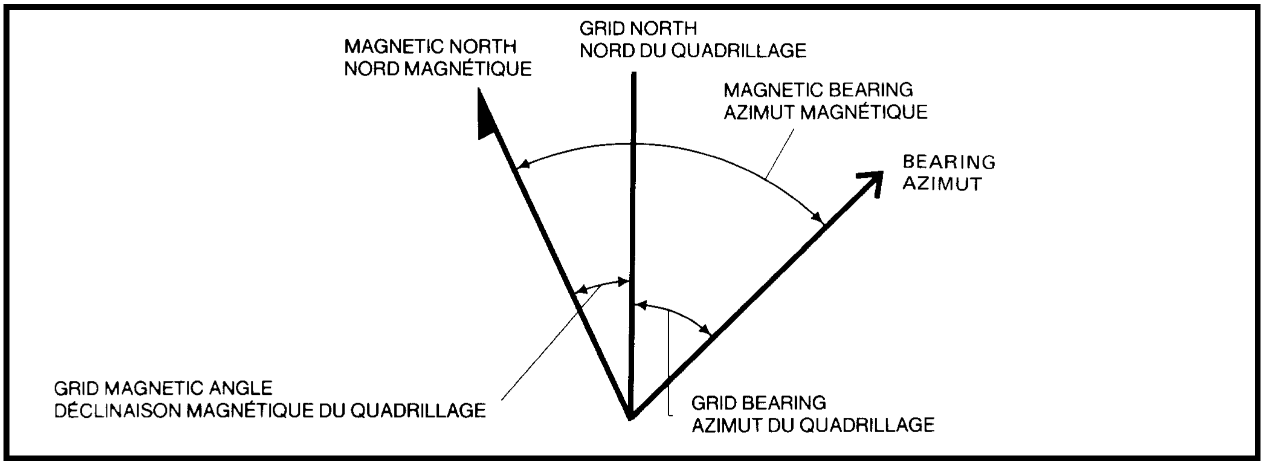

Figure 7-9 Grid Bearing = Magnetic Bearing - Grid Magnetic Angle

In this case, on maps which conform to NATO and ABCA agreement, a note such as that which follows is added on the map adjacent to the diagram in Figure 7-8:

> TO CONVERT A MAGNETIC BEARING TO A GRID BEARING SUBTRACT GRID MAGNETIC ANGLE.

3. Where the magnetic north is East of grid North, this note reads "ADD" in lieu of "SUBTRACT". See Figure 7-10.

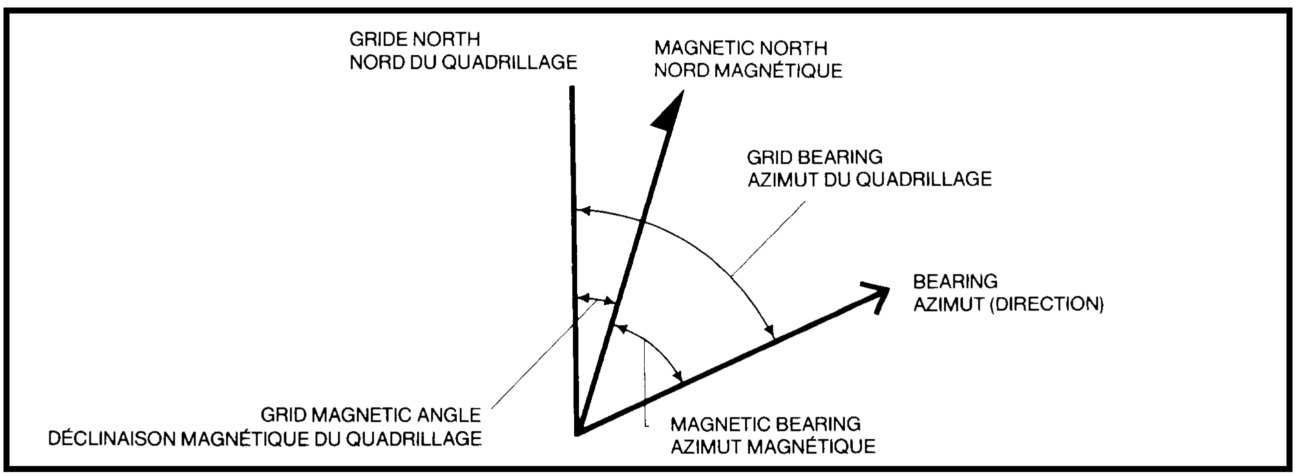

Figure 7-10 Grid Bearing = Magnetic Bearing + Grid Magnetic Angle

4. The information on the map is given in degrees as well as in mils and the same principles apply. In the example given in art 714.1, the grid magnetic angle in degrees in 1975 is 2° 30' - 5 X 3' = 2° 15'. This is added to the grid bearing in degrees or subtracted from the magnetic bearing in degrees as in para 1.

715. Conversions to/from True Bearings

1. In converting grid bearings to magnetic bearings and vice versa, the grid convergence does not enter into the calculation. It is, however, an essential factor for any conversion between true bearings and either grid or magnetic bearings. In Figure 7-8, it is clear that to convert a grid bearing to a true bearing it is necessary to add the grid convergence (30 mils) to the grid bearing; similarly, to convert a true bearing to a grid bearing one subtracts 30 mils from the true bearing. This relationship is constant and is not affected by the date.

2. To convert a magnetic bearing to a true bearing it is first necessary to determine the grid magnetic angle at the time of observation as in art 714.1. It is then possible to determine the value of the angle between Magnetic North and True North at that time by, in this case, subtracting the grid convergence from the grid magnetic angle in 1975, ie, 40 - 30 = 10 mils. Thus, to convert a true bearing to a magnetic bearing one adds 10 mils to the true bearing. To convert a magnetic bearing to a true bearing one subtracts 10 mils from the magnetic bearing. This relationship is of course not constant. It changes

3. It should be noted that the grid convergence is normally given only for the centre of the sheet. This implies that it is adequate for conversion to or from true bearings throughout the sheet. If, in certain special cases, this single value is not accurate enough, extra values are given for the east and west sides of the sheet, and the value appropriate to the position of the line of bearing on the sheet should be used. This difference is unlikely to affect any use other than for specialist purposes.

716. Conversion Information Not Shown in Standard Form

1. There are, however, a large number of maps in current use in which the essential information is given but not in the standard NATO form previously described. There may, for instance, be no diagram to illustrate the relative positions of the north points, and the terms in which the angles are described may be different.

2. However, in whatever form this information is ,given, it is essential for the map user to construct a diagram of his own on the lines of Figure 7-9 or 7-10, as appropriate, to show the relative positions of the north points and to insert the values of the angles from the information supplied. It is vitally important to place the north points in their correct positions relative to each other to accord with the map information supplied. The relative positions vary and are not always as shown in Figure 7-8. Once a correct relative diagram has been made and the values inserted, the conversion of bearings is straightforward.

SECTION 4 - FINDING TRUE NORTH FROM SUN OR STARS

717. Introduction

When you have no map, or when map reading without a compass, it is often useful to find the approximate direction of True North (or South). The methods described in this section will give adequate results for this purpose, but are not sufficiently accurate for reading bearings or for other precise measurements.

718. Finding True North from a Watch

1. Since the sun rises in the east, moves (in the northern hemisphere) through the southern sky, and sets in the west, the position of the sun, when it is visible, is always a rough guide to the direction of north. Calculations must be based on local Standard Time.

2. Lay the watch flat with the hour hand pointing to the sun. In the northern hemisphere, True South will then be midway between the hour hand and twelve o'clock on the watch. See Figure 7-11.

3. In the southern hemisphere, lay the watch with twelve o'clock pointing to the sun; True North then lies midway between the hour hand and twelve o'clock.

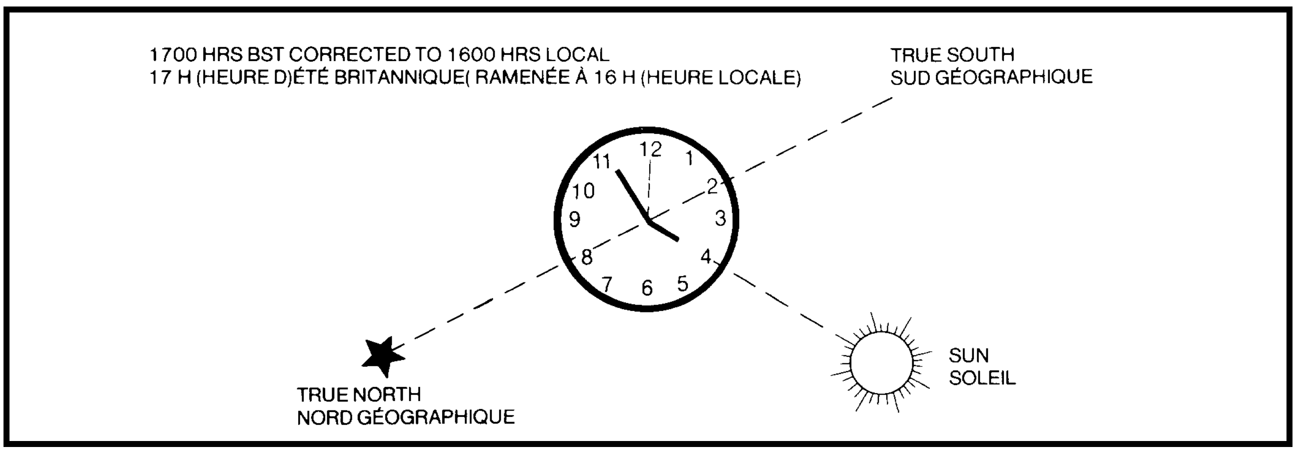

Figure 7-11 Finding True North from a Watch

4. When the sun is high up in the sky, this method cannot be used with much success. In any case, the result is unlikely to be accurate to better than about five degrees.

719. True North by the Movement of the Sun

1. If you have no watch or if the sun is high in the sky, True North can be found by observing the shadow of a vertical stick stuck in the ground, see Figure 7-12. This is more accurate than the watch method.

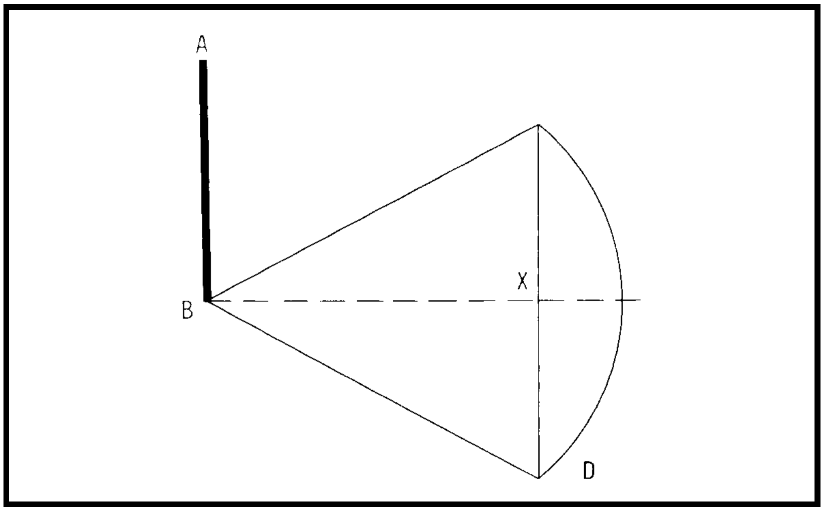

Figure 7-12 Finding True North by the Movement of the Sun

2. Choose a piece of level ground free from shadow, where one can easily make marks on the ground surface, eg, plain earth. Plant a straight stick (AB) vertically in the ground, the longer the stick the better. About two hours before midday, mark the position of the end of the stick's shadow C, and with the aid of a string tied to the foot of the stick B, mark on the ground the arc of a circle with radius BC in the direction of movement of the stick's shadow. The shadow will grow shorter until midday and the end of it will recede from the marked circle. After midday it will lengthen, and eventually (about two hours after midday) it will reach the circle again. Mark the point where it does so D. Find and mark the point X midway between C and D. The line joining X and B is then the true north-south line.

720. True North by the Stars (Northern Hemisphere)

1. In latitudes less than 60°, Polaris (north polar star) is never more than about 40 mils away from True North. The position of Polaris is indicated by the "Pointers" of Ursa Major, the Great Dipper. See Figure 7-13. All stars revolve round Polaris and the Great Dipper may be either below it, down near the horizon and "Right Way Up", or above it high in the sky and "Upside Down", or in any position in between. If the Great Dipper is obscured or below the horizon, Cassiopeia which is shaped like a "W" and is on the opposite side of Polaris from the Great Dipper, may be visible: Polaris is the nearest bright star within the arms of the "W".

2. Above 60° latitude Polaris is too high in the sky to be a good guide to North. At the North Pole it is vertically overhead.

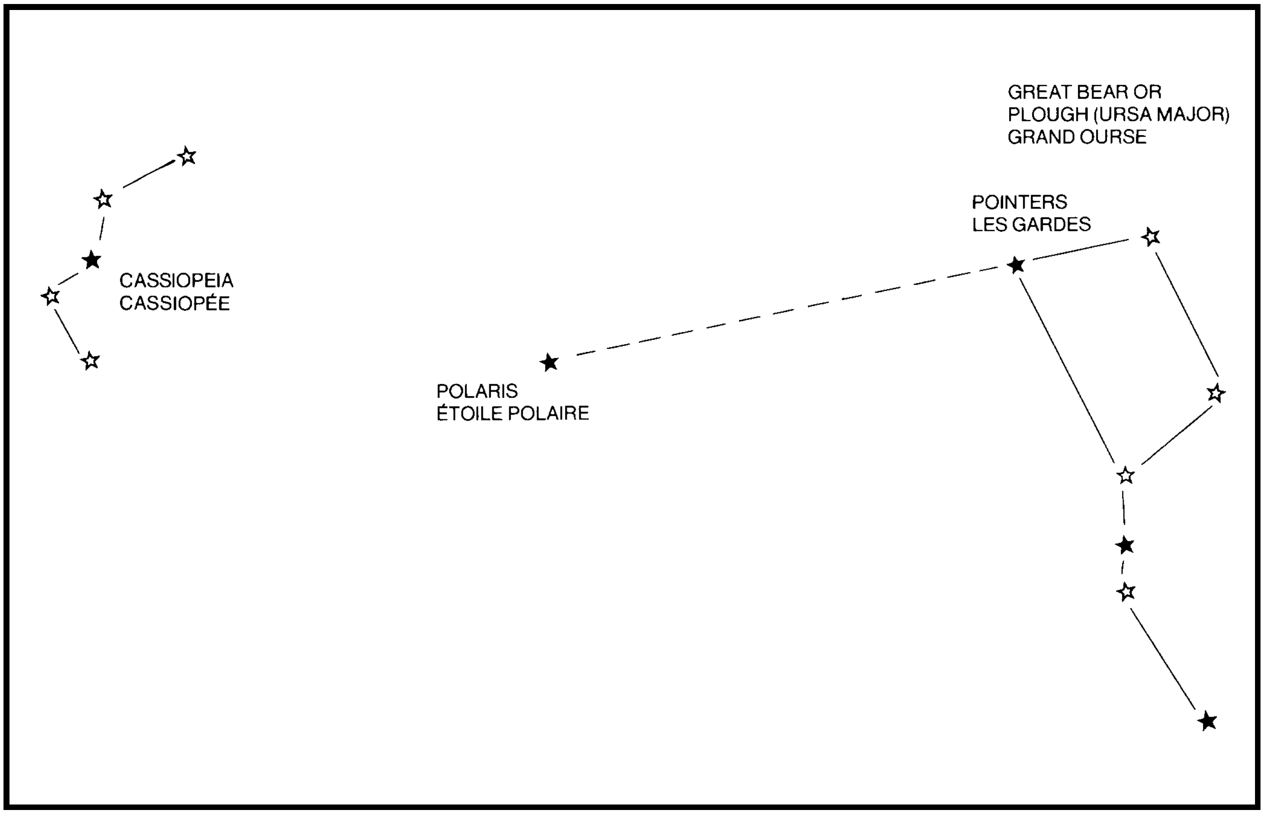

Figure 7-13 Finding True North by the Stars (Northern Hemisphere)

721. True North by the Stars (Southern Hemisphere)

1. The Southern Cross (see Figure 7-14) is not so convenient a guide as Polaris, because it may be appreciably off south. To find South, consider the Southern Cross as a kite. Extend the greater axis about 4 1/2 times in the direction of the tail, and the point reached will be approximately True South.

2. To find South rather more accurately, continue the line fo r another two lengths of the greater axis and you A,ill reach a bright star in the constellation of Hydra. When this star and the tail star of the Southern Cross are vertically one above the other, they are very nearly True South.

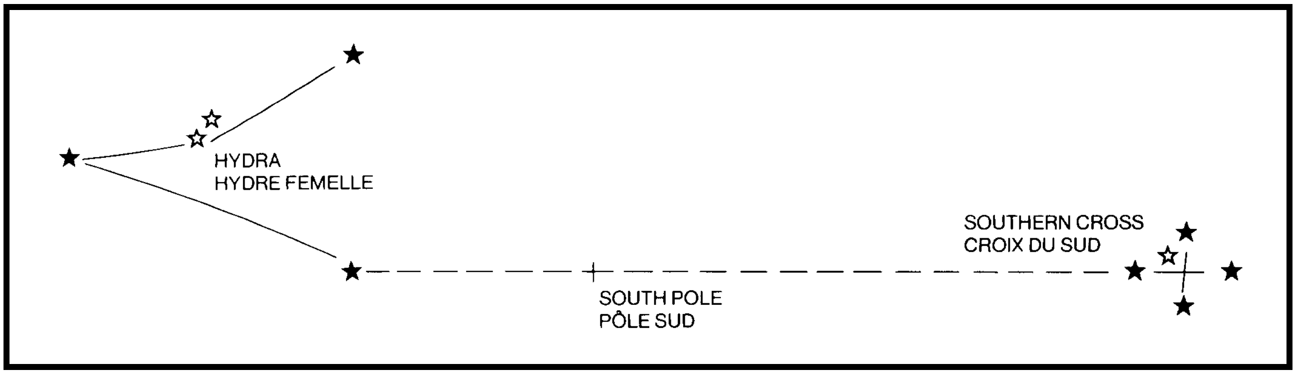

Figure 7-14 Finding True North by the Stars (Southern Hemisphere)

(722 to 799 not allocated)