CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 108

A COLLECTION OF CARTOGRAPHIC NOTES

BY

B. EDWARDS

OTTAWA

1965

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THE GEOLOGICAL CARTOGRAPHIC DRAUGHTSMAN

A list of desirable skills for a geological cartographic draughtsman and compiler.

As scribing and stick-up lettering came more and more into use, penmanship is becoming less and less important to the draughtsman, but there are many jobs, such as compiling, illustrating, three-dimensional diagrams, exhibits, and sketch-maps for which there is no substitute for good penmanship.

The ability to design can be subdivided into three main attributes. Layout design applies to all draughting and should be functional and easy to read; it must also be economical as wasted space is wasted money in printing. Colour design is a vital ability, though final colour design is only done by experienced cartographers. Again the design should be functional, easy to read, and be acceptable to the eye. The third type of design, is the aid given a geologist, when the draughtsman can grasp his ideas and then translate them into a diagram which portrays them.

A geological draughtsman and compiler must know at least enough geology to interpret correctly — just as a typist must know enough geological terminology to interpret bad hand-writing. He also needs a knowledge of geology to enable him to generalize information to scale requirements, the ability to learn new techniques, instrumentation, calculate and compute, and a knowledge of the tolerances and limitations of various printing methods.

MAPPING THE EARTH

Definition of a Map

A map is a picture or illustration showing the natural and cultural features of the spherical earth on a flat surface.

Maps are nearly as old as human culture, probably just as old as the first attempts one human being made to communicate ideas to another. Maps have been made on all types of materials, wood, stones, sticks, sea-shells, and our own Indians and Eskimos used birch-bark and animal skins.

In the nomadic hunting and fishing stage of human development, individuals were familiar with large areas over which they roamed. Their sense of direction and observation were highly developed and it has been found that Eskimos, Indians and Australian Aborigines can draw fairly reliable sketch maps of large areas in sand, snow or other mediums. However, these primitive cartographers could think in only one scale and if illustrating a long route he used enormous quantities of the medium he was working in. Primitive maps are not scientific, as they depend too much on the individual's sense of distance and direction.

Then, as we progress, we arrive at the settled civilizations of the Babylonians and Egyptians. These civilizations had reached the land ownership stage; and land ownership brought about land surveying to fix boundaries and property lines. To record these boundaries, maps were made on baked clay tablets; many are still preserved today and have been found to date back to 2,500 years B.C.

At this time and for many centuries following, the earth was pictured as a flat plate, floating in a surrounding sea and over this arched the vault of heaven, making a compact, boxlike universe. About the fifth century (B.C.), the Greek philosophers and mathematicians, advanced the concept of a round earth. The earliest written record is in Plato's, "Phaedo" in the year 399 B.C. A few years later Aristotle fully accepted the earth's roundness and advanced ideas to prove it. He had observed, during an eclipse of the moon, that the earth's shadow, as it advances across the moon, has a circular outline.

Although the Greeks had now accepted the idea that the earth was round, it was not until 150 years later that they were able to obtain a measurement of its circumference.

This feat was performed by Eratosthenes, a mathematical philosopher, who was librarian in the famous library of Alexandria, Egypt. As a mathematician, he wanted to develop an orderly basis for mapping. Up to this time there had been no way of relating one map to another and therefore maps had been of fairly crude nature. Before he could accomplish this orderliness, he had to obtain the size of the earth, to enable him to design a projection, within which he would be able to locate places in their correct relationship to one another.

Eratosthenes discovered that at Syene there was a deep well which was completely illuminated by the rays of the sun shining directly down it, one day in every year. This was at noon, on the 21st June, the summer solstice (longest day of the year). At that moment, vertical objects in Syene cast no shadow, but in Alexandria, 500 miles north, objects did cast a shadow. From this information he deduced that this difference was caused by the earth's curvature and he felt he could calculate the circumference of the earth, by finding out what fraction of a complete circle, this distance represented.

At Alexandria, on the 21st June, he raised a vertical pole, and at noon he measured the angle cast by its shadow (Figure 1). Using a simple geometrical theorem, "a line crossing two parallel lines makes the corresponding angles equal", he knew the measured angle would be equal to the angle of the well and pole if they were extended to meet at the earth's centre.

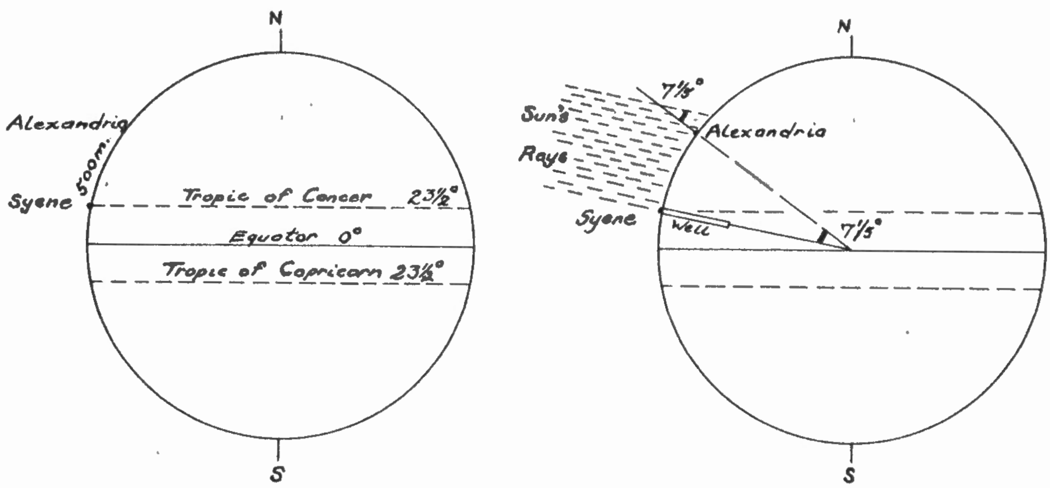


Figure 1

The angle of the poles shadow was 7 1/5°, or 1/50 of a complete circle (1/50 x 7 1/5 = 360°). Knowing that 1/50 of the earth's circumference equalled 500 miles, he obtained the full distance by multiplying 500 x 50 = 25,000 miles. This answer is remarkably close to the correct distance of 24,860 miles. Eratosthenes' world map extended from Thule to Ceylon and its scale was inaccurate as he used an irregular grid to fix his important points.

A century later (100 B.C.), Hipparchus, the inventor of trigonometry, criticized Eratosthenes irregular projection and invented parallels and meridians as they are used today. He also originated orthographic and stereographic projections.

Even though these great men believed the earth was round it was still not generally accepted until Columbus and Magellan completed their great voyages of discovery.

The news of these great voyages was astounding and rather bad news for the map-makers. They soon found it is impossible to show a true picture of a round world on flat paper. They tried making crude globes, but most people found a globe did not have enough detail on it, and if it was enlarged to show more detail, it was then too clumsy for everyday use.

These events led to the era of projections and the producing of many different ones.

PROJECTIONS

Definition

A projection is any regular system of parallels and meridians upon which a map can be drawn.

The first problem to confront cartographers when producing a world map is where to start. The earth is a ball which has no beginning or end; but, it is spinning and here lies the answer. By passing an imaginary line through the earth's centre, from north to south, the ends of this imaginary axis become the poles, and provide map makers with two fixed points from which can be started a system of parallels and meridians.

What are parallels and meridians? We have mentioned them several times.

Imagine a plane (Figure 1) passing through the globe, perpendicular to its axis and midway between the north and south poles. This plane would cut the earth at the equator — the zero parallel of Latitude. This line is known as a full circumference or great circle. Any plane cutting the earth's surface parallel to the equator, is also a parallel and is known as a small circle.

Concurrently, a plane passing through the north and south poles is a meridian of Longitude, and all meridians are great circles. The zero meridian of Longitude passes through Greenwich, England.

Latitude is measured from the equator 0°, north and south to 90° at the poles, and Longitude is measured east and west from Greenwich 0° to 180°.

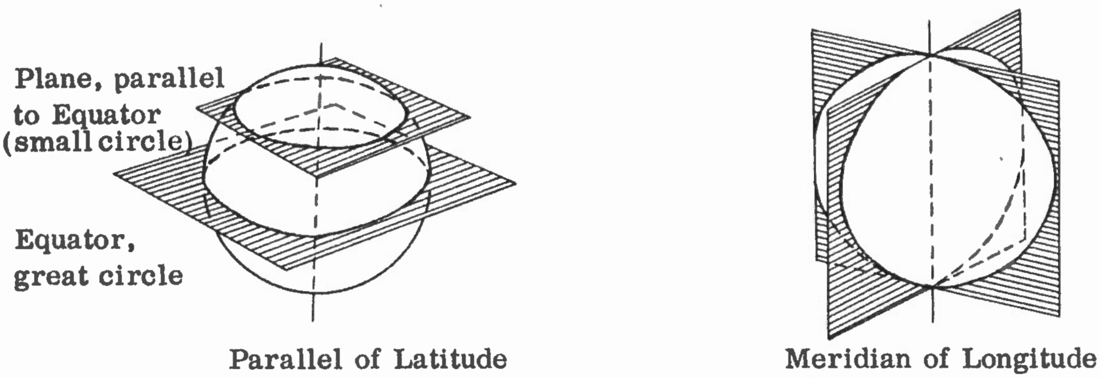


Figure 1

Many kinds of projections have been invented but the key to most of these are three geometric figures — cones, cylinders and planes (Figure 2).

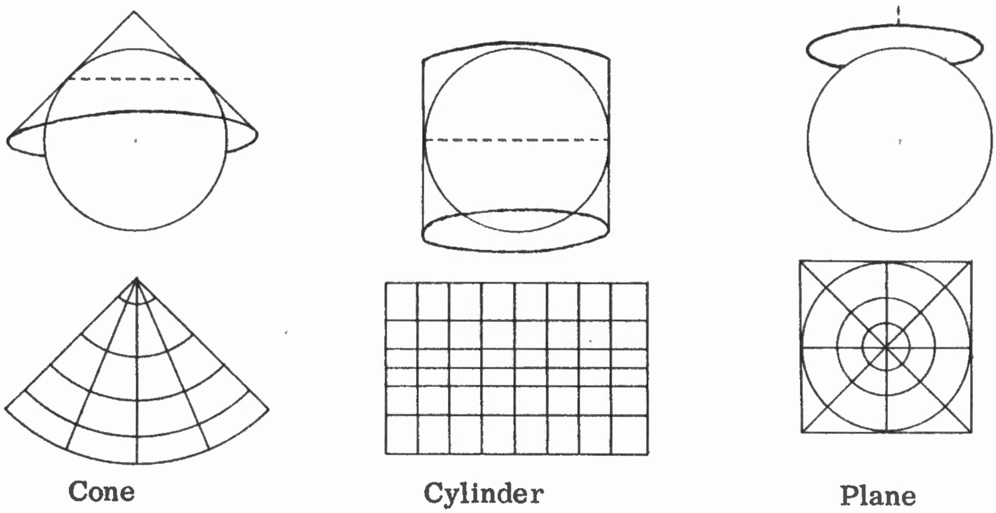


Figure 2

Although no portion of a sphere can be made to lie flat without distortion, these three figures do have flat areas which are called developable surfaces.

A cone will fit over a sphere, touching it along a small circle of latitude.

This line is called the standard parallel and along this line the scale of the projection is true. As the standard parallel approaches the equator the elements of the cone become more parallel until finally, when the equator is reached, the cone becomes a cylinder. If the cone is altered to fit the standard parallel on the sphere at higher and higher latitudes, the elements become flatter, until eventually the cone becomes a plane, touching the sphere at a single point, which has true scale. These are the principles followed by the majority of projections.

Unfortunately for cartographers there is no one projection which is better than all the others. A projection which is good for Canada is not necessarily good for Africa (due to different land mass shapes), and a different projection is used for a navigational chart than for a statistical map. Every projection has certain virtues and certain limitations.

The two main projections are 'equal-area' and 'conformal'. Inan equal-area projection, every part, as well as the whole, has the same area as a globe at the same scale. To accomplish this, the land shapes, and the angles of the parallels and meridians have to be distorted. A conformal projection is one on which any small area has the same shape as on the globe, and one point is in the true direction from any other as long as the points are close together. At any point the scale is the same in every direction, although it may change from point to point. In conformal projections the parallels are at right angles to the meridians, and in any small area the length of a degree of longitude is in true relationship to a degree of latitude.

Within the G.S.C., the majority of maps are drawn on two projections; Lamberts Conformal Conic projection and the Universal Transverse Mercator projection.

Lamberts Conformal Conic projection - from the title we can see that this is a conformal projection and that it is based on a cone. When originally devised, this projection had only one standard parallel (Figure 2). It has since been re calculated to have two standard parallels (Figure 3) and this is the projection in use at the present..

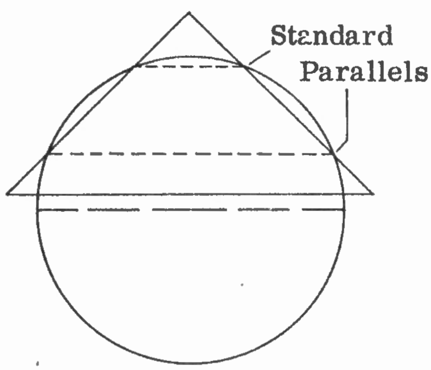


Figure 3

In this projection the meridians are straight lines, so that all the parallels are arcs of concentric circles, struck from the intersection point of the meridians, thus maintaining the right angled intersections. The two standard parallels are true to scale, the other parallels not true but they hold the same scale throughout their length. This means the area from the standard parallels to the centre parallel is a minus area (smaller) and the area from the standard to the bounding parallels is a plus area (larger). See Figure 4 for correct placement of standard parallels.

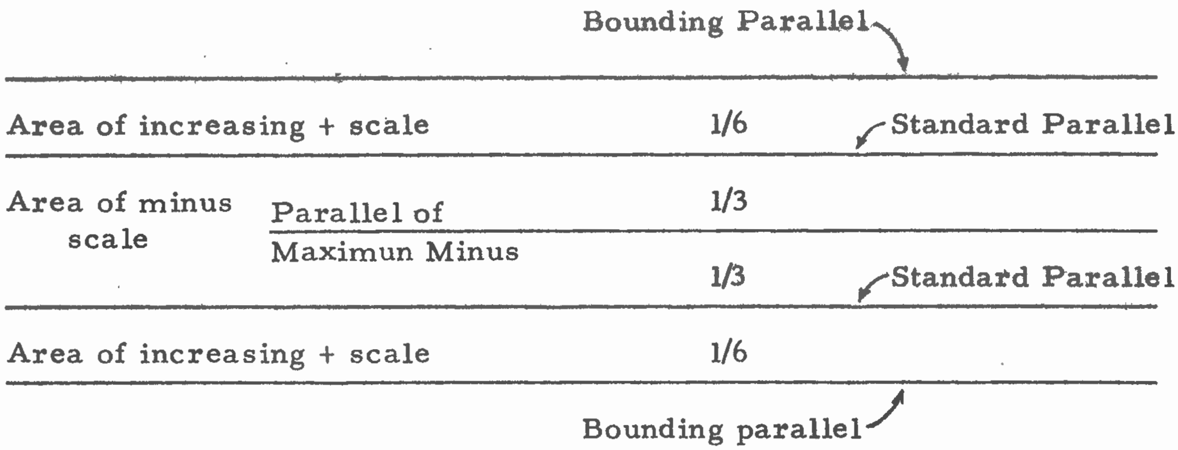


Figure 4

Therefore it is very important that the standard parallels be placed in relationship to the area being mapped, so as not to give excessive distortion at either the north or south map edges. In a map of Canada, the area extends from latitude 42° (bounding parallel) to latitude 83° (bounding parallel), but very little extends south of 44° and only a very small triangle south of 43°, while in the north, only the polar islands extend above 70°. Because of inaccurate mapping in the north, projection accuracy can be sacrificed to gain higher scale accuracy in the south where more detail is shown. To gain this higher scale accuracy in the south the standard parallels are placed at approximately 45°30' and 67°30' instead of 49° and 76° as would be the usual placement under Figure 4.

From this we can conclude:

1. The narrower the area of latitude, the smaller the scale error.
2. By varying the placing of the standard parallels we can obtain a small scale error at the southern end of a map at the expense of a larger scale error for the northern end, or a small scale error at the centre of the map at the expense of a larger scale error for the north and south.

Construction of Lamberts Conformal Conic Projection:

1. To construct from given data (i.e., x and y coordinates).
2. To construct from World Aeronautical Charts Projection Tables, Volume 1.

Construction of Lamberts Conformal Conic Projection

To construct this projection from given data (i.e., x and y coordinates, Fig. 2)

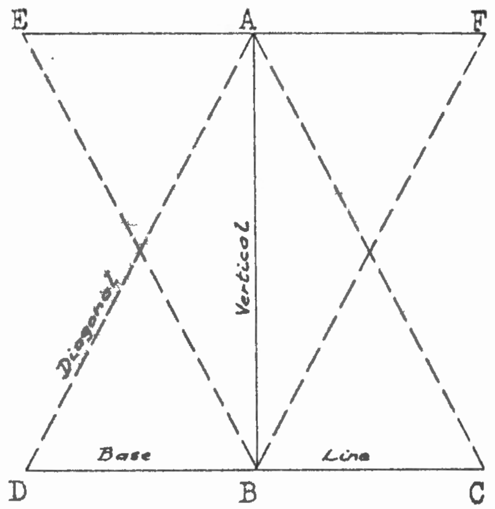


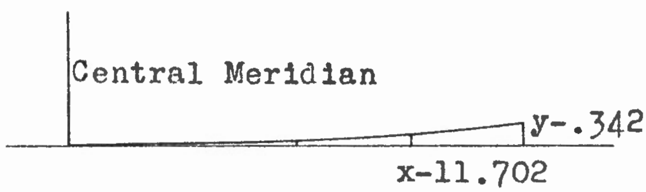
Figure 1

The x and y coordinates are given for only one side of the sheet from the central meridian and must also be plotted on the opposite side of the meridian at the same time.

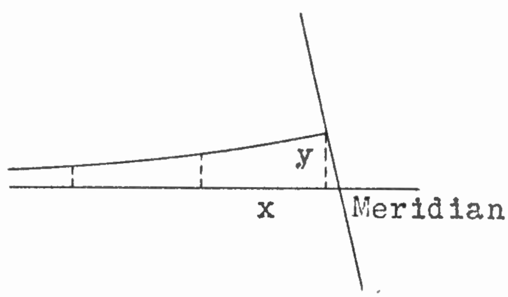
1. Lay down a base line and in the centre of it construct a vertical line. This should be checked by using the diagonal measurement between A-C and A-D (Fig. 1).
2. Now draw a line through A parallel to DBC. This again should be checked by diagonals B-E and B-F. This distance A-B should be the total distance between 60° and 65° (Fig. 2).
3. Divide line A-B into the measurements for each degree given on data sheet. Through these points construct lines parallel to the base line.

4. At each of these lines now plot the x coordinate distances. Remember to plot each measurement on both sides of the central meridian.

5. At each of these points you have now plotted on the lines parallel to the base line project vertical lines. On these vertical lines will be plotted the y coordinate measurements. By joining up each of these last points you have now plotted in a smooth curved line, you have constructed a line of latitude or a small circle.



6. The last step is to draw in the lines of longitude or meridian. This is done by joining up the y coordinates on each parallel. In this projection the meridians are straight lines so if all y coordinates join up you have correctly plotted your x and y coordinates. If not, a check should be made of the coordinates missed.



Lambert Conformal projection
Standard Parallels 47° 30' and 65° 30'

5° of longitude
Scale 1 inch to 10 miles

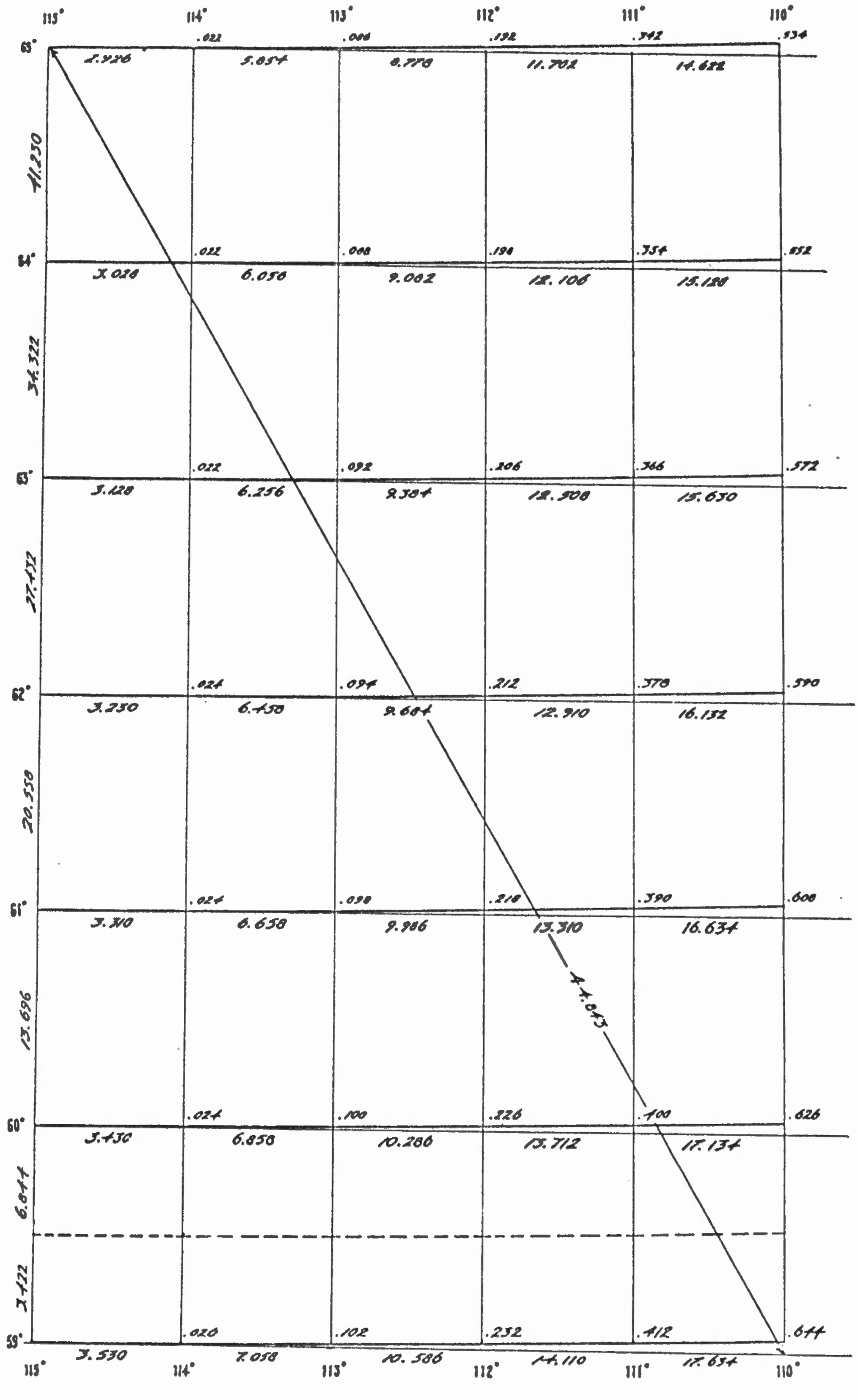


Figure 2

LAMBERTS CONFORMAL CONIC PROJECTION

To be constructed, from World Aeronautical Charts Projection Tables, Volume 1, a projection on Latitude 56° - 60°. Standard parallels for given latitudes are on page III. Position of standard parallels is 1/6 from top and bottom of map.

Calculation (Figures 1 and 2)

Find Central Meridian of sheet and construct Figure 1 as shown and write in values as follows. In part titled Projection Tables (pp. IV - X) find the radius values of 56°, 57°, 58°, 59°, and 60°.

Then in part titled Lambert Conformal Conic Projection Tables (pp. 1 - 133) in band 56° - 60°, find the a and b values of points a_1, a_2, a_3, a_4, a_5, e_1, e_2, e_3, e_4, e_5, and b values only of points b_1, c_1, d_1, etc.

Construct Figure 2 and show values reduced to map scale. In this example the figures are for a 1:500,000 map and are to be plotted in centimetres. Preferably for 1, 2, 4 and 8 mile maps it would be more advantageous to construct the projections on the metric system (1:50,000, 1:125,000, 1:250,000, 1:500,000), and reduce at final photography. Calculus will be simplified by multiplying natural distances by:

$\frac{2}{100,000}$ for 1:50,000

$\frac{8}{1,000,000}$ for 1:125,000

$\frac{4}{1,000,000}$ for 1:250,000

$\frac{2}{1,000,000}$ for 1:500,000

These answers will be in metres. To convert to centimetres multiply by 100

To calculate AE subtract radius values (A-E). Calculate B,C,D by subtracting their values from A. Calculate a and b values to map scale.

Construction

Draw baseline and on centre point raise AY. Figures will be plotted both sides of Central Meridian (AY). Measure on AY distances B, C, D, E and construct lines parallel to baseline through them. On baseline and EX measure a distances. Join these points with straight lines (meridians). From construction lines at A, B, C, D, E measure b distances on meridians. Join these points with a curved line (parallels of latitude).

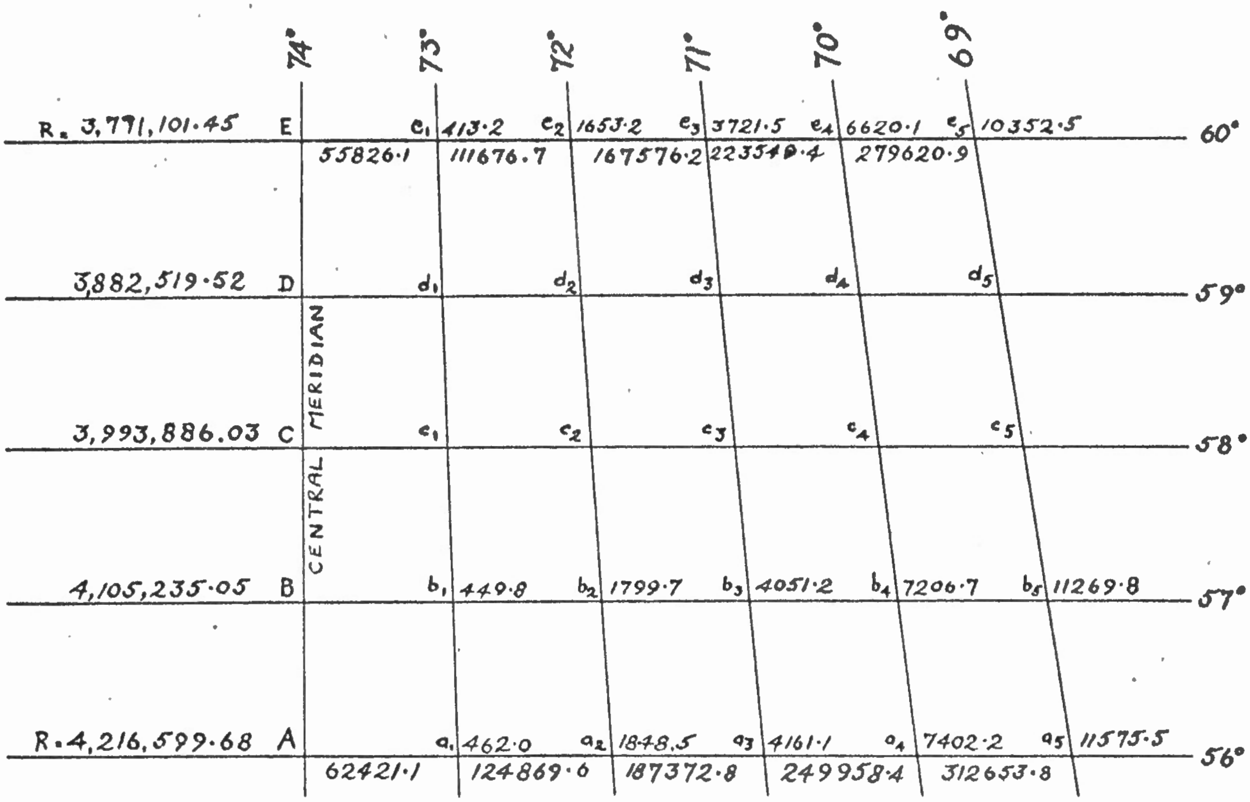


Figure 1. Showing values in natural metres.

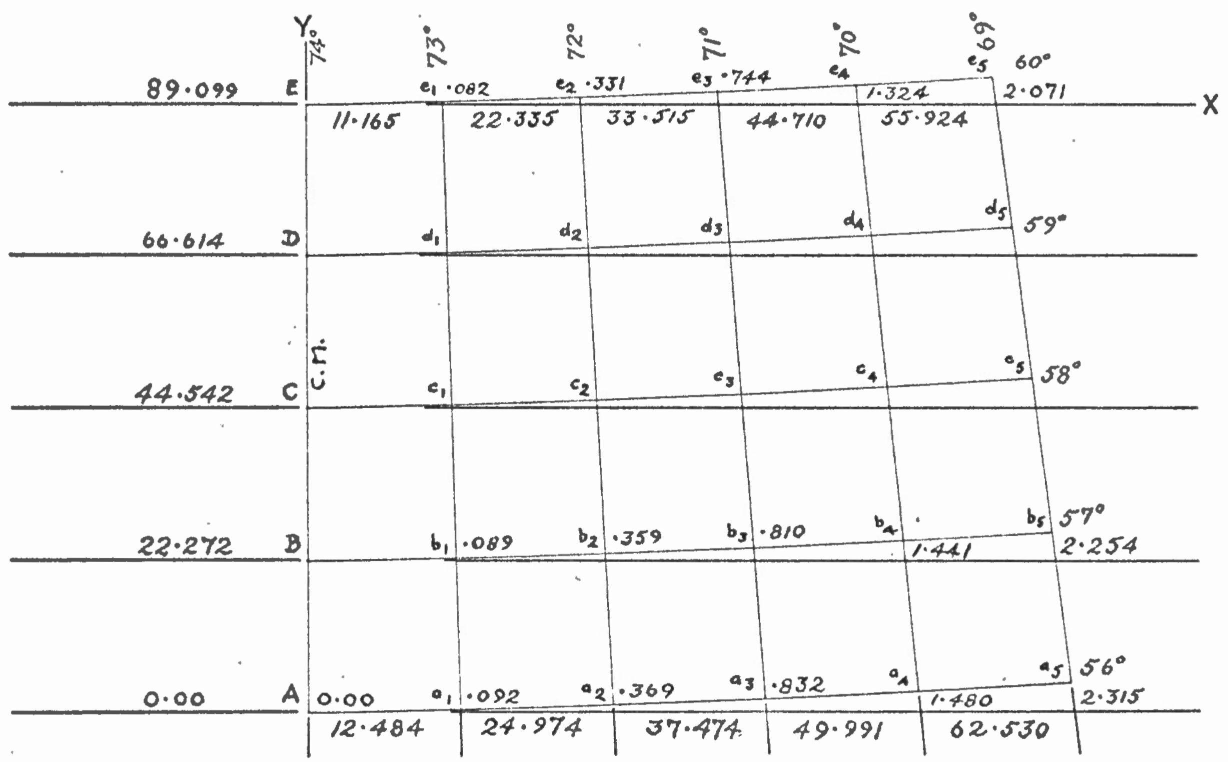


Figure 2. Showing values calculated to map scale in centimetres.

Mercator Projection:

This is one of the most famous projections in the world. In 1569, a Flemish mathematician and geographer, Gerardus Mercator, devised this projection. He was a man worthy to be called a cartographer, who did more towards converting maps from philosophical pictures into precision instruments. 'Mercator's Marine Chart', as it was called then, was devised for surface navigation and is still in use today.

This projection is based on a cylindrical figure (Figure 2), which gives it the property of having vertical meridians and horizontal parallels, both of which are straight lines and cross each other at right-angles. It is a conformal projection.

Proof that this is a navigation map can be obtained from the fact, that because its parallels and meridians cross at right-angles, any line drawn between two points on the map, gives the true compass direction.

It is interesting to note in a map of the world, the great distortion which occurs in the north and south regions. Greenland appears to have the same area as South America though it is actually only one tenth the size. This is the main reason why this projection, when accuracy is essential, can only be used for a maximum area of 20 degrees either side of the standard parallel.

On the equator (standard parallel) the meridians are true and the parallels are so placed that for any small area the scale along parallels and meridians is the same as the globe. Therefore, at latitude 60°, a degree of latitude is twice as long as a degree of longitude.

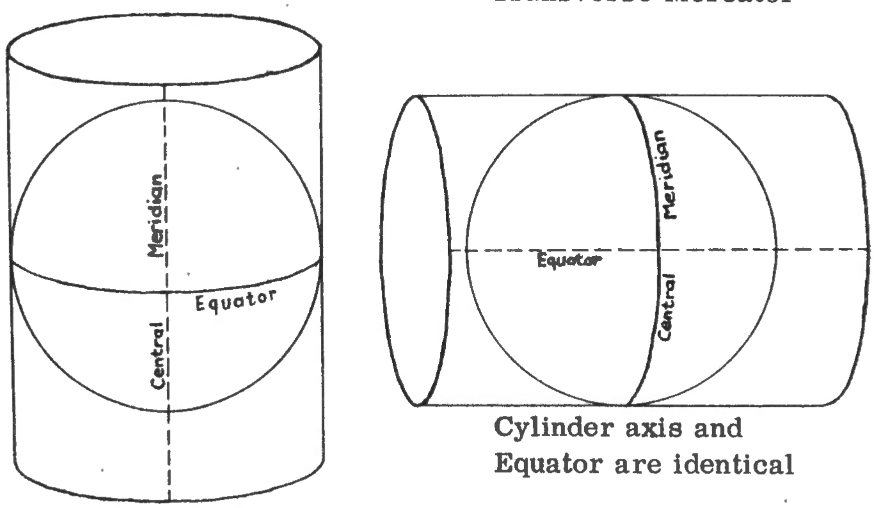
The Mercator projection is very popular for world maps, due to its easy construction and also as a rectangular projection it fills the page. The scale can be shown along the sides as one minute of latitude is equal to one nautical mile.

Today, the G.S.C. uses the Universal Transverse Mercator, plotted from "Clarke 1866 Spheriod" tables. The definition of the term 'transverse' is to turn a projection, any degree up to 90°, from its usual orientation in relation to the globe (Figure 5).

Relationship of basic cylinders to globe

Mercator

Transverse Mercator



Cylinder axis and
Equator are identical

Figure 5

Therefore the central meridian will be divided true to scale and the equator is divided according to the increasing scale. The "Clarke 1866 Spheroid" tables have been further modified to gain scale accuracy. The world has been divided into 60 - six degree zones and a map falling within a zone is calculated and plotted from the zones central meridian. Any map crossing the border between two zones cannot be plotted on the Transverse Mercator projection and the alternative is to use Lamberts Conformal Conic projection. Unfortunately, when the Mercator projection is transversed it loses the property of giving true compass direction.

Construction of Universal Transverse Mercator Projection:

CONSTRUCTION OF UNIVERSAL TRANSVERSE MERCATOR PROJECTION

To plot the projection first decide degrees of Latitude and Longitude then turn to Index Map (Clarke 1866 Spheroid) and decide on which ZONE the projection falls in and its position as to the Central Meridian of that zone.

Now construct diagram as in Figure 1 and write in coordinates of x and y (shown in red)

To calculate the projection coordinates. (Figure 2)

Distance A-a_5 = difference between their x coordinates
Distance A-B = difference between their y coordinates
Distance B-b_5 = difference between x coordinates of A and b_5
Distance B-b_1 = difference between x coordinates of A and b_1
Distance A-A_1 = difference between y coordinates of A and y coordinate of Central Meridian

Locate points A_2, A_3, A_4, A_5, B_1, B_2, B_3, B_4, B_5 in the same manner as A-A_1 by the difference between y coordinate of point and coordinate of Central Meridian.

NOTE:

These readings are natural distances in metres and must be converted to map distances in inches. This can be done by use of the conversion figure supplied below.

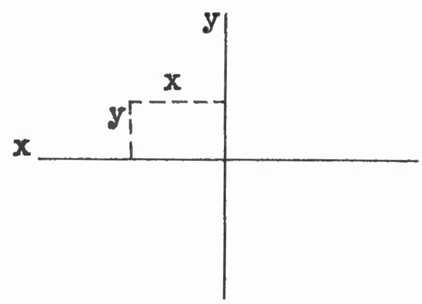
To convert natural distances in metres to map distances in inches:

Scale of Map	Multiplier	Log
1 Inch to 1/2 Mile	0.001,242,74	.094,381,4
1 Inch to .66 Miles	0.000,932,05	.969,441,7
1 Inch to 1 Mile	0.000,621,37	.793,351,5
1 Inch to 1.33 Miles	0.000,466,02	.668,404,6
1 Inch to 2 Miles	0.000,310,68	.492,321,5
1 Inch to 2.66 Miles	0.000,233,01	.367,374,6
1 Inch to 4 Miles	0.000,155,34	.191,291,4
1 Inch to 5.33 Miles	0.000,116,50	.066,344,5
1 Inch to 8 miles	0.000,077,67	.890,260,0
1/40,000	0.000,984,25	.993,105,4

To construct the projection

First draw baseline A-X. Then raise perpendicular A-Y.
Now measure A-B on A-Y and draw B-X_1 parallel to A-X.
Measure A-a_5 on A-X
Measure B-b_5 on B-X_1
Measure B-b_1 on B-X_1
Now divide A-a_5 and b_1-b_5 into four equal divisions. On these divisions erect perpendiculars. On these perpendiculars measure distances A-A_1, a_2-A_2 and so on until complete. Join these points to form the projection and subdivide to give intermediate intervals.

Eastings (E) measured east or west of Central Meridian (C.M.) correspond to X;Northings (N) correspond to Y



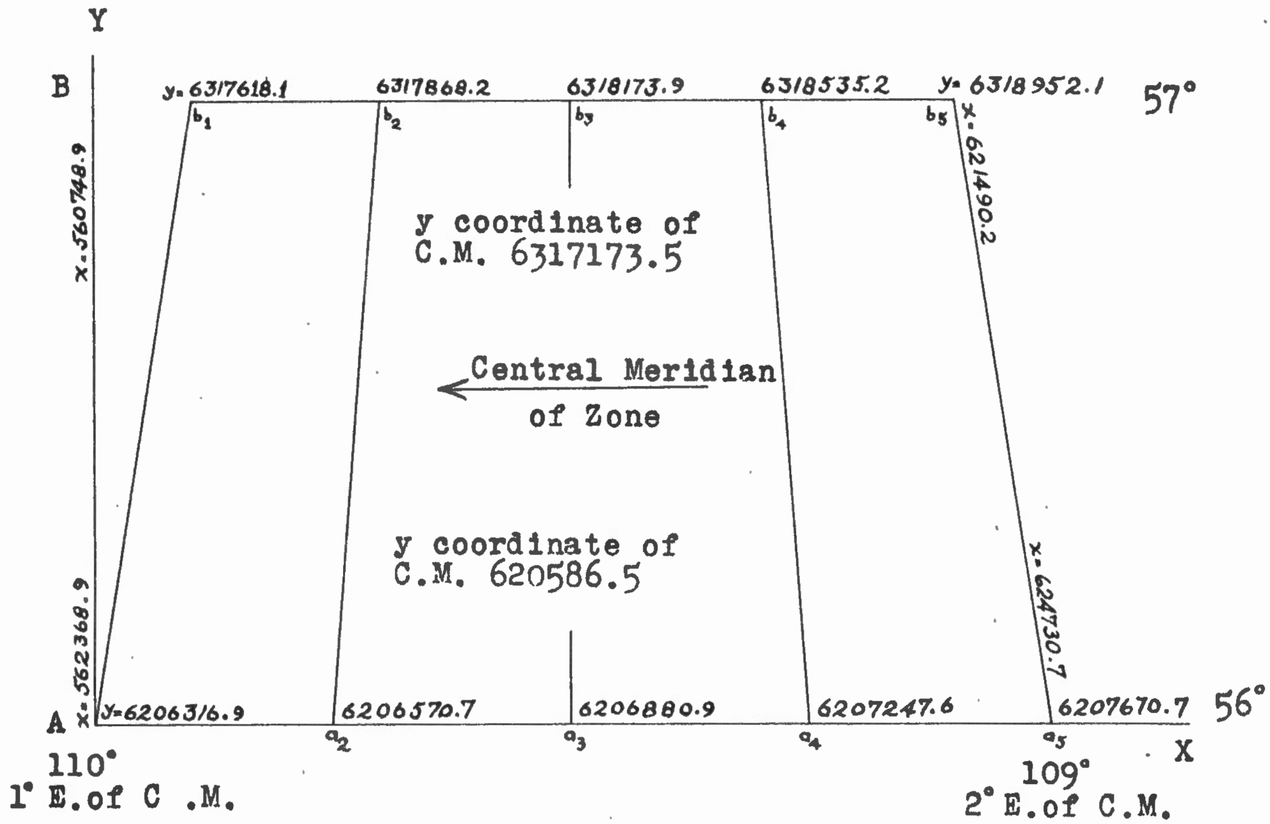


Fig.1. Showing coordinates for 1"-2mile sheet falling in ZONE 12

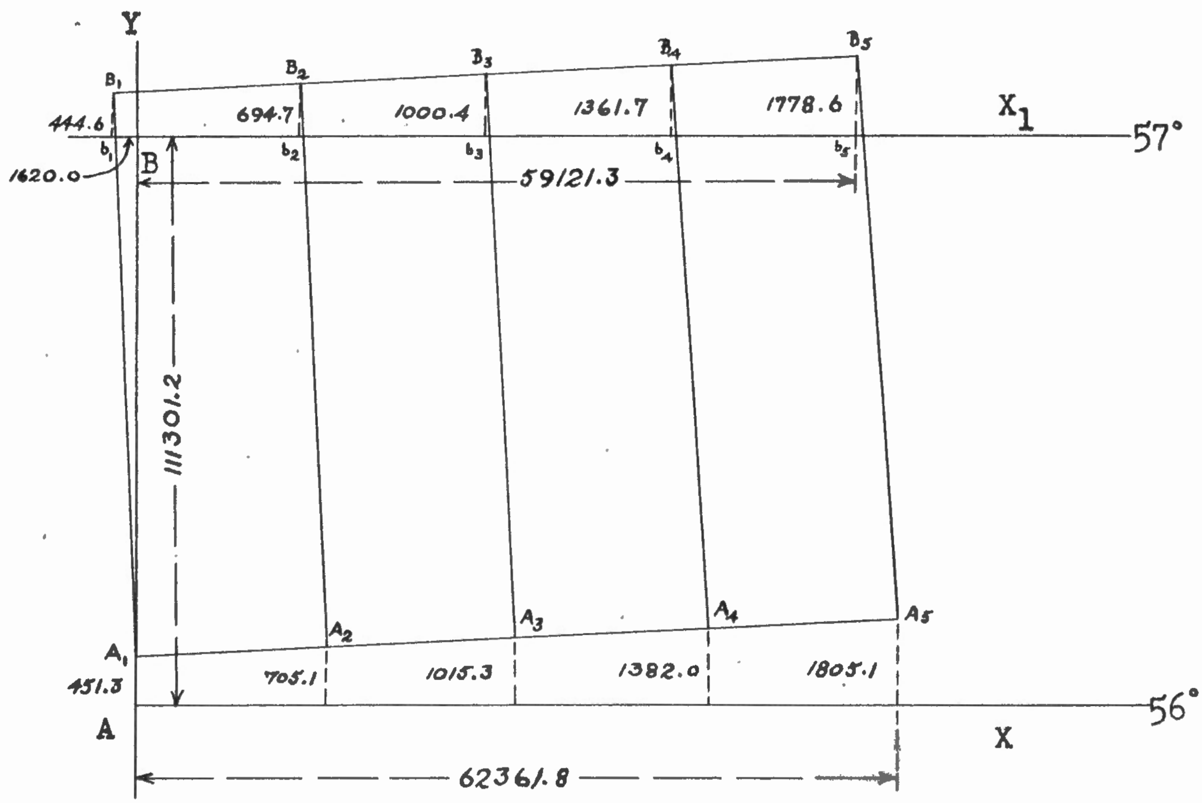


Fig. 2. Showing calculated distances in metres

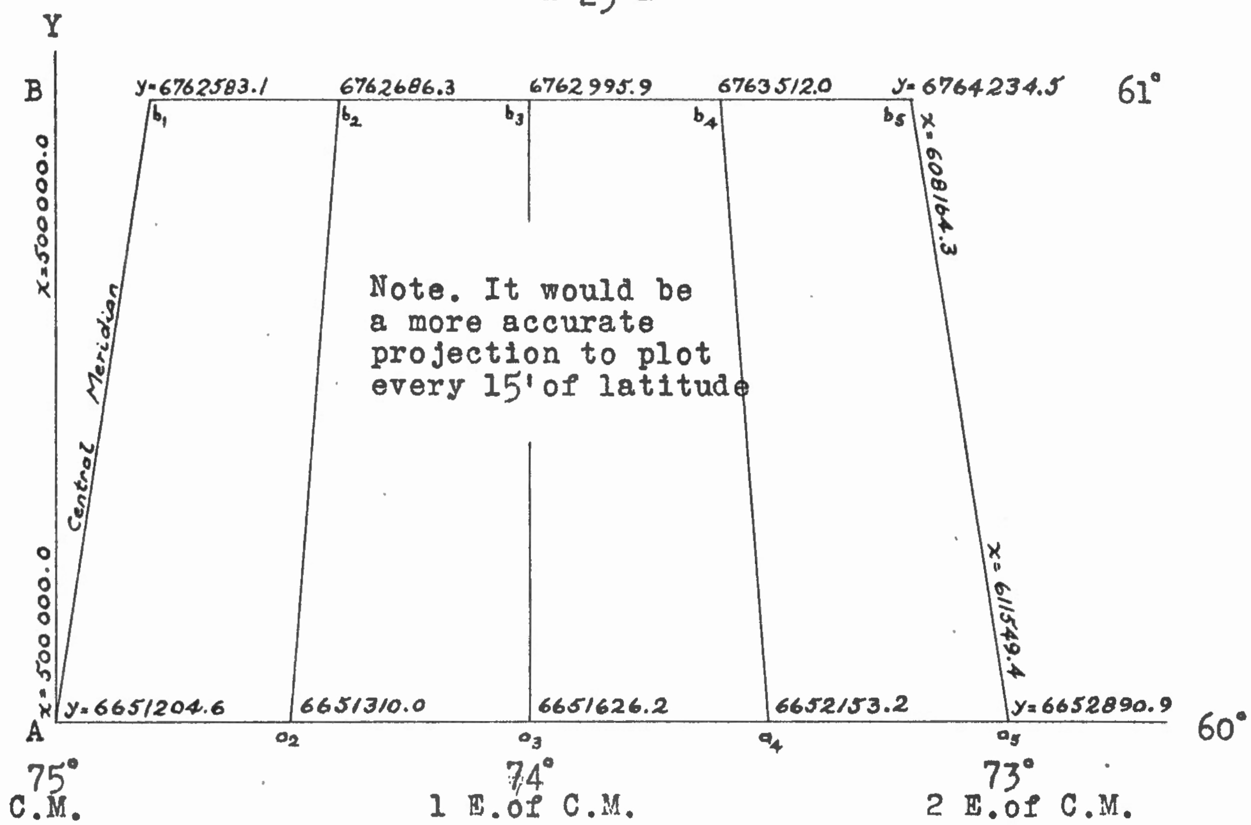


Fig.1a. Showing coordinates for 1"-4 miles sheet falling in ZONE 18

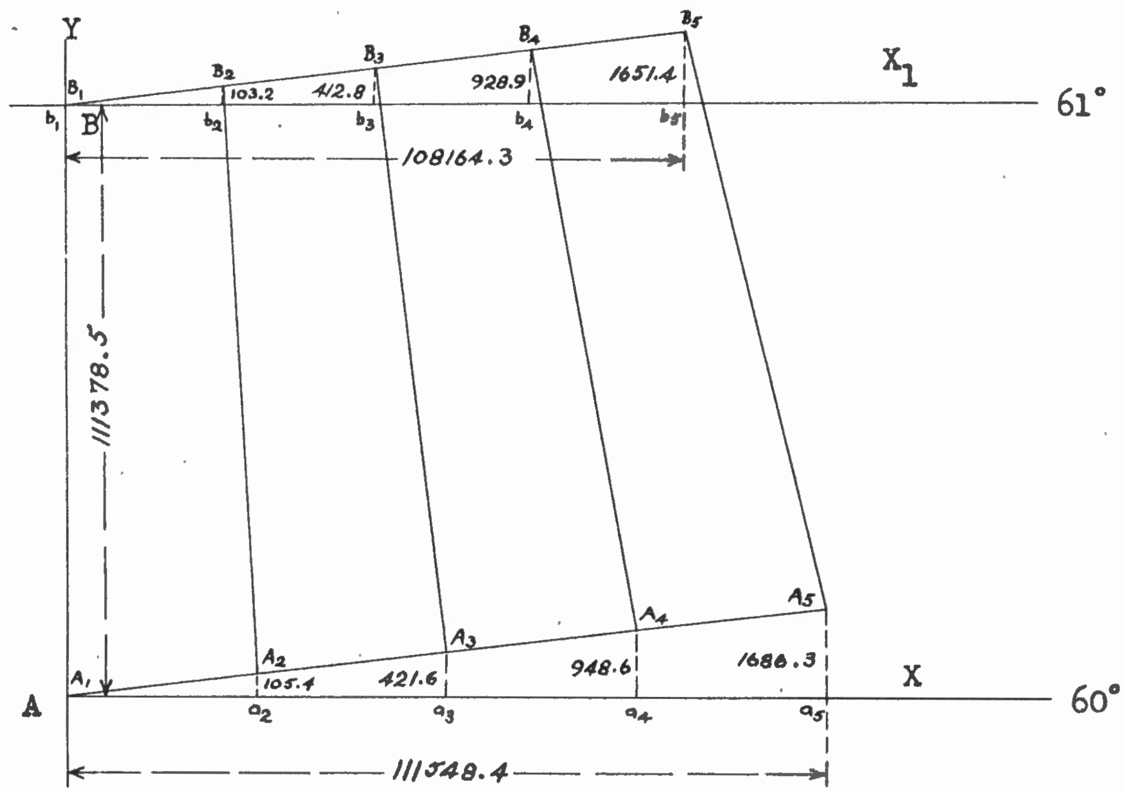
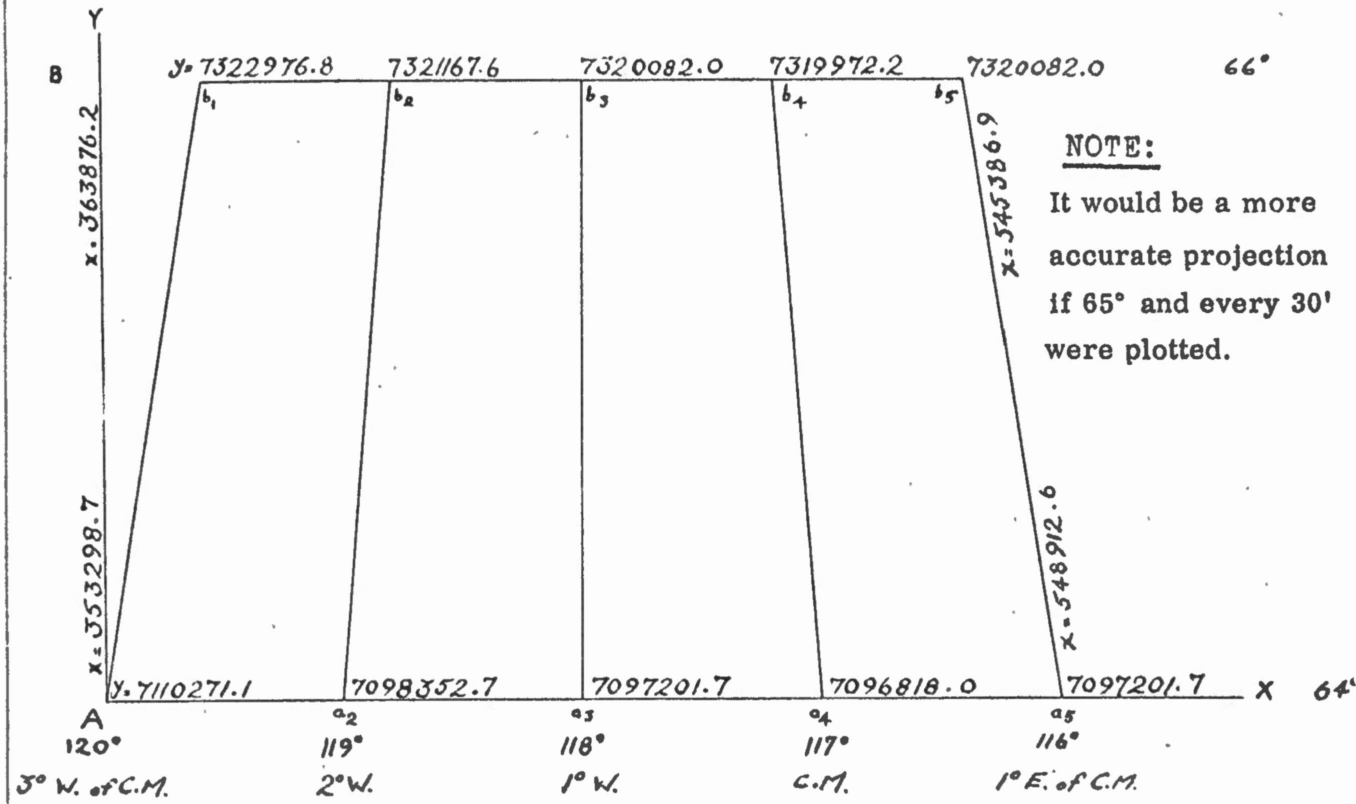


Fig.2a. Showing calculated distances in metres



NOTE:

It would be a more accurate projection if 65° and every 30' were plotted.

Figure 1b. Showing coordinates for 1 inch to 8 mile sheet falling in ZONE 11.

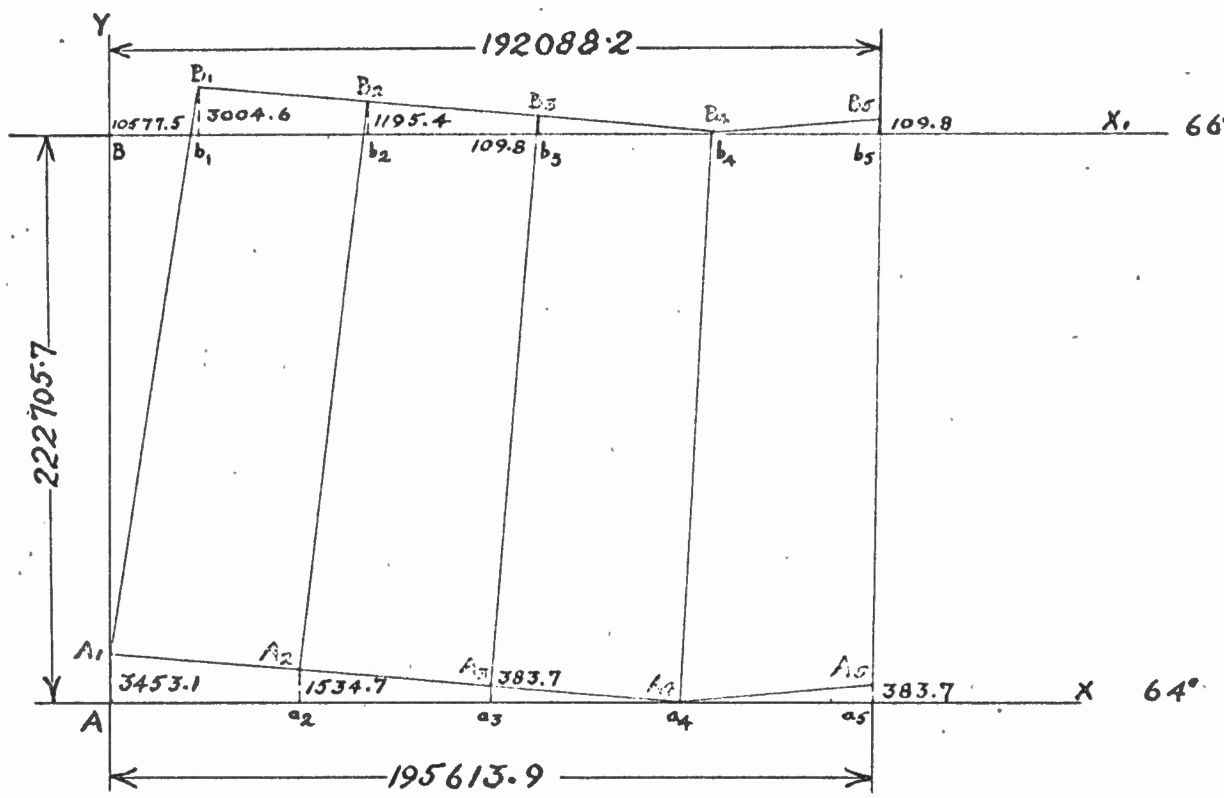


Figure 2b. Showing calculated distances in metres.

Dimensions of the Earth

Equatorial radius	6,378,206.4 metres	3,963.0 statute miles
Polar semi-axis	6,356,583.8 metres	3,949.5 statute miles
Radius of sphere of equal area	6,370,997.2 metres	3,958.5 statute miles
Area of earth (approx.)	510,900,000 sq. km.	197,260,000 sq. miles
Equatorial circumference	40,075 km.	24,899 miles

Lengths of degrees of Meridians

Latitude	Stat. miles	Km.
0-1°	68.703	110.567
9-10°	68.722	110.598
19-20°	68.781	110.692
29-30°	68.873	110.840
39-40°	68.986	111.023
49-50°	69.108	111.220
59-60°	69.224	111.406
69-70°	69.320	111.560
79-80°	69.383	111.661
89-90°	69.407	111.699

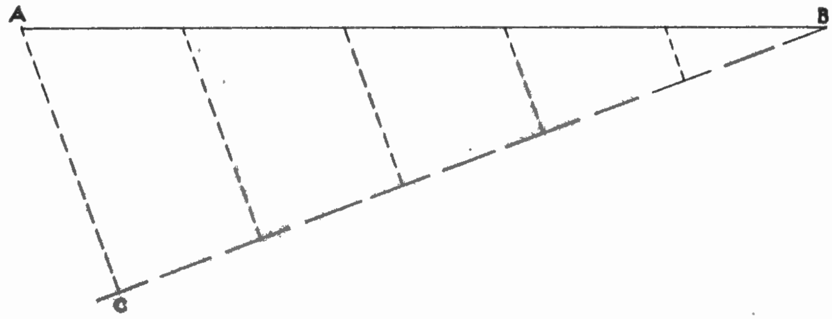
Lengths of degrees of Parallels

Latitude	Stat. miles	Km.
0°	69.172	111.321
5°	68.911	110.900
10°	68.129	109.641
15°	66.830	107.553
20°	65.026	104.649
25°	62.729	100.952
30°	59.956	96.448
35°	56.725	91.290
40°	53.063	85.396
45°	48.995	78.849
50°	44.552	71.698
55°	39.766	63.996
60°	34.674	55.802
65°	29.315	47.177
70°	23.729	38.188
75°	17.960	28.903
80°	12.051	19.394
85°	6.049	9.735
90°	0	0

For ordinary map use it is well to keep in mind the fundamental fact that the parallels are very nearly the same distance apart from pole to pole.

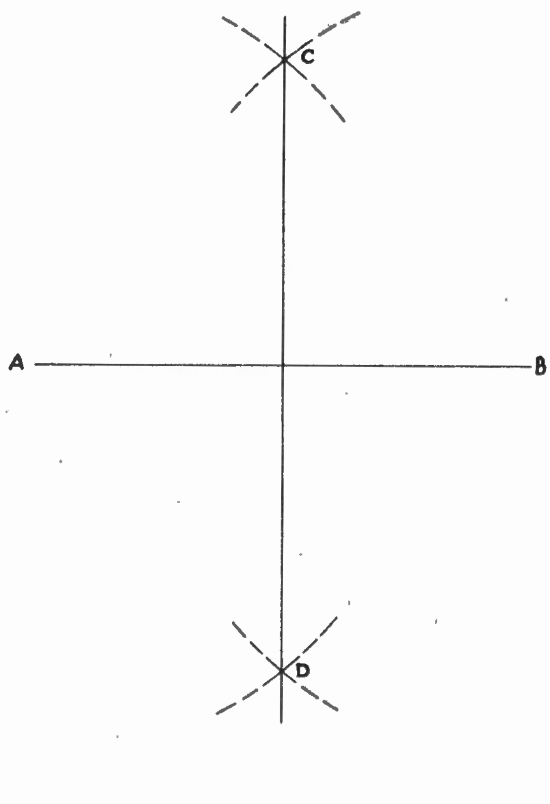
To divide line of odd length into equal parts.

Construct line CB (of indefinite length) at any angle to AB, the line to be divided. Starting at B, divide it into the number of equal divisions desired, using an approximate divider setting. Connect final division point (C, in example) with A. Lines drawn through the division points and parallel to AC will divide AB equally.



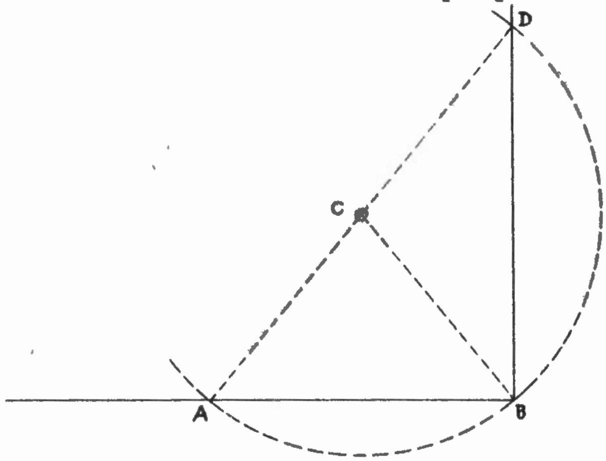
To erect a perpendicular at centre of a line.

Let AB represent any line. Using A and B (extremities) as centres, and with a radius greater than one-half AB, describe arcs above and below AB. Line CD, drawn through intersections of arcs, will be perpendicular to AB.



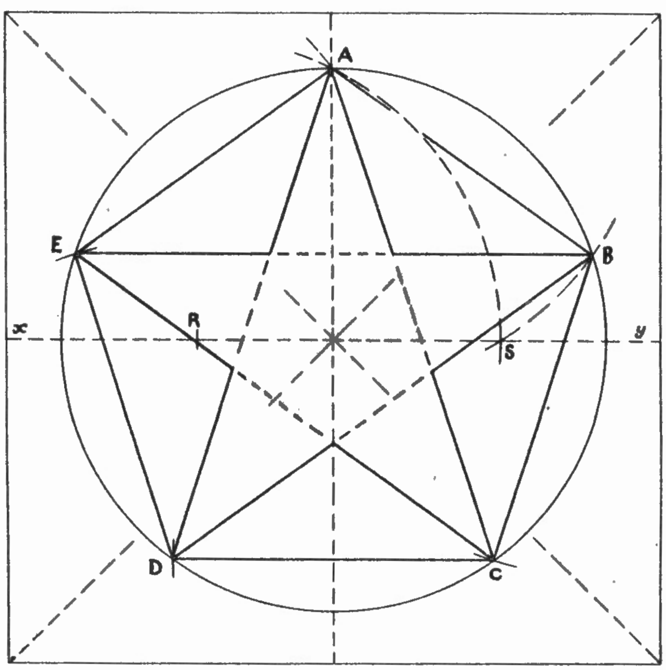
To erect a perpendicular at end of a line.

With any point C as centre, and with CB as radius, describe an arc similar to ABD. Join A and C, prolonging line until it intersects arc (D). A line drawn through B and intersection D will be perpendicular to line AB.



To construct a pentagon and a five-pointed star.

Draw intersecting diagonals through corners of square to locate centre point of circle. Describe circle and construct centred coordinate lines. With R as centre (half the radius of the circle), describe an arc with radius RA, intersecting axis xy at S. With A as centre, describe an arc intersecting S to establish point B and the length of one side of pentagon (AB). Construct pentagon and star within as illustrated



GRIDS

A grid is used for designating the exact location of a feature by the use of coordinates.

There are two main types of grids in use today, referred to as Geographic Grid and Plane Grid.

Geographic Grid - consists of a network of lines composed of an east-west system comprising the equator and parallels, and a north-south system consisting of meridians. Measurements are made in degrees, minutes and seconds north or south and east or west from the origin (commonly the intersection of the equator and prime meridians).

Plane Grid - are usually overprinted on the projection. They are rectangular in nature; intervals between grid lines are usually spaced that the sides of the rectangles are equal; that is, the coordinates form squares.

The Universal Transverse Mercator Grid is very popular and is standard on most military maps. This is a plane grid which is superimposed over the Universal Transverse Mercator projection. Within this projection and grid, the world is divided into 60 North-South zones each 6 degrees wide. On these maps a square kilometre grid is drawn, starting with the intersection of the equator and the central meridian. False origin is 500 km. west of the central meridian on the equator for the Northern Hemisphere and 10, 000 km. below this for the Southern Hemisphere (Figure 1). The polar regions have the Universal Polar Stereographic grid which is used north of 80 degrees.

References are given in three stages. First, the number of the zones 1 to 60, starting with 180 degrees; second we give them letters from C to X according to Figure 1. This reference is only used to define

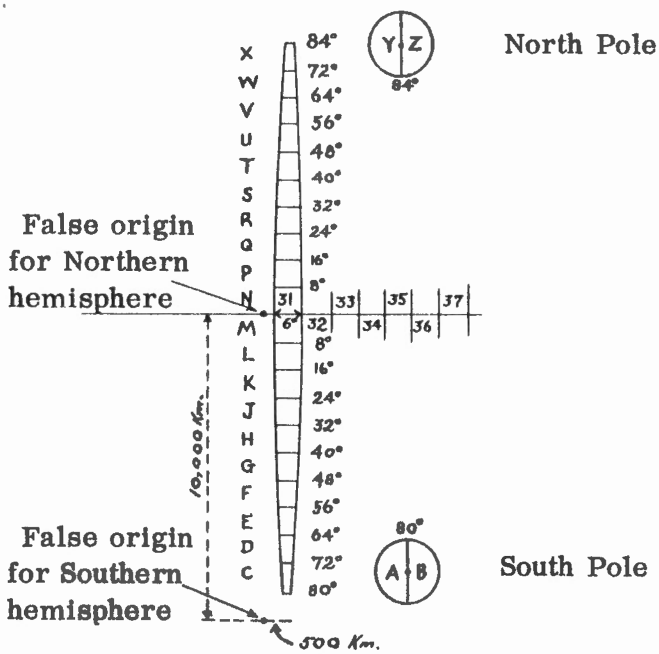


Figure 1

a point in world relationship and is usually omitted in limited operations.

A second reference is given by two letters which define 100 km. squares. The scheme of lettering is shown in Figure 2. This scheme of lettering repeats itself for every 18° of latitude and a little over 24° of longitude.

The third phase of reference is by numbers giving metres from the Southwest corner (within the 100 km. squares), always going right and up, as in Figure 3. Points are usually defined within 100 metres, which is sufficient for easy identification of most objects.

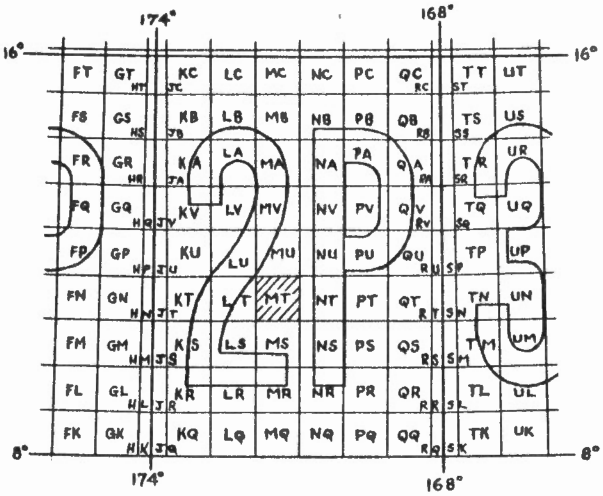


Figure 2

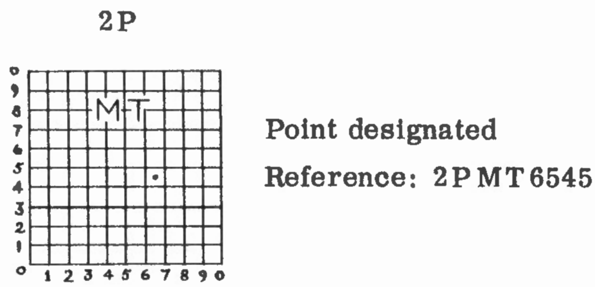


Figure 3

The Universal Polar Stereographic Grid - the polar areas from 80° to the pole are drawn on the stereographic projection, as this is a conformal projection which makes calculations easier. This is divided into 100 km. squares starting from 0° + 180° and 90°E - 90°W meridians. From there on reference is given in the same manner as before.

The British system is still found on many maps. It uses 5 x 5 = 25 letter squares. First one large letter will define 500 km. squares prepared for geographical units rather than systematic world coverage. A second letter will define 100 km. squares. Within these, the definition is by numbers, the first half of which is eastings, and the second half northings. Thus AG 64 12 defines to within 100 metres.

The World Geographic Reference (Geo-Ref) System. While the Universal Transverse Mercator System is well adapted to limited operations, it is not shown on most aeronautical charts. For long-range operations of planes, rockets, and missiles, spherical coordinates are still the best, and the Air Force returned to our latitude-longitude system of degrees and minutes, but with a simplified scheme of reference.

The world is divided into twenty-four 1 hour or 15° bands of longitude, lettered A to Z (with I and O omitted), starting at 180°. Similarly, twelve 15° belts of latitude lettered A to M start at the South Pole. Thus we have 15° quadrangles totalling 288, and identified by two letters. As before, we read to the right and up. Within each quadrangle, single degrees are marked with letters A to Q, starting at the lower left corner. Thus four letters like BGMQ will identify a 1° quadrangle, 60 nautical miles square. Each degree quadrangle is divided into 60' again, starting from the lower left, and referred to by numbers. The minute quadrangles can be further subdivided by tenths or hundredths by additional figures similar to the UTM system. The divisions, however, are not in kilometres, but in hundredths of minutes.

Scales

Maps are always drawn in a predetermined scale, which varies with the amount of detail to be shown.

A proficient map user first looks at the map scale. From this he can determine the amount of generalization and detail that will be shown. For example - if you wished to drive from Ottawa to Toronto you would not use a 1/50,000 map as this would require twelve sheets. All the required information can be obtained on one sheet at 1/1,000,000 scale.

Scale is illustrated by three main methods. The first is by natural scale or Representative Fraction (R.F.), shown thus $\frac{1}{63,360}$. This illustrates that one inch on the map is equal to 63,360 inches (1 mile) on the earth. The second is the written method, "One Inch to 1 mile", and the third is by the graphic method, a drawn bar scale.

Map scales are broken down into three groups; Large, Medium and Small scale maps. A scale larger than four miles to 1 inch (1/253,440) is a large scale map. Most basic topographic sheets, city maps, real estate (cadastral) and contruction plans are in this category. The map user realizes that in the larger scale maps he will obtain the maximum information for any area that can possibly be shown.

Medium scale maps are from 1/250,000 to 1/1,000,000 - 4 to 16 miles/inch. This map has to be strongly selective, symbolized and generalized. Auto maps, navigation charts and provincial maps fall in this category.

The third group, small scale maps, are from 1/1,000,000 upwards with no actual limit being set. These maps are found in atlases, books, and magazines, and show very little detail apart from major rivers, mountains, cities and international boundaries. By example, in a map scale of 1:150,000,000 one inch will represent 2,360 miles.

Calculating Scales

Below, I have listed five methods of calculating English and Metric scales.

To calculate the Representative Fraction of a map:

Scale: 6 inches to 1 mile.

$$\text{R.F.} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{6''}{1 \text{ mile}} = \frac{6''}{63{,}360''} = \frac{1}{10{,}560}$$

From the R.F. you can find what 1 inch or 1 metre represents on the map.

R.F. = 1:10,560	R.F. = 1:10,560
∴ 1" = 10,560"	1 m. = 10,560 m.
10,560 + 63,360 = .165 miles	10,560 + 1,000 = 10.56 kms.

1. To calculate a scale, 4 inches to 1 mile, showing 100's yds and approximately 6 inches long.

$$\text{R.F.} = \frac{4}{63{,}360} = \frac{1}{15{,}840}$$

As 4" equals 1 mile, 6" will equal 1 1/2 miles. Converting 1 1/2 miles to yards we find the nearest round figure is 2,500 yds.

$$\therefore \frac{2,500 \text{ yds}}{15,840 \text{ inches}} = \frac{2,500 \times 36}{15,840} = 5.675 \text{ inches.}$$

$$\therefore 5.675'' = 2,500 \text{ yds.}$$

2. To calculate a scale, at 1:25,000, showing 100's metres and approximately 6" long. The answer is in centimetres and must be converted to inches if necessary.

100,000 cms. in 1 Kilometre. 1" = 2.54 cms.

$$\therefore \frac{100,000}{25,000} = 4 \text{ cms.} \qquad 4 \text{ cms} = 1 \text{ Km}$$

4 cms. is approximately 1 1/2 inches. Therefore as 1 1/2" divides into 6", four times the scale will be 16 cms. long

$$16 \div 2.54 = 6.29 \text{ inches}$$
$$\therefore 6.29 \text{ inches} = 4 \text{ Kilometres.}$$

3. To calculate a scale, 4 inches to 1 mile, showing 100's yds and approximately 6 inches long

$$\text{R.F.} = \frac{4}{63,360} = \frac{1}{15,840}$$

$$1'' = 15,840 \text{ inches}$$
$$1'' = 15,840 \div 36 = 440 \text{ yds.}$$

$$\therefore 1'' = 440 \text{ yds} \qquad x = \frac{100}{440} = .227 \text{ inches} = 100 \text{ yds.}$$
$$x = 100 \text{ yds}$$

$$\therefore 2,500 \text{ yds} = .227 \times 25 = 5.675 \text{ inches}$$

4. To calculate a scale, 4 inches to 1 mile, showing 100's metres and approximately 5 inches long.

We know 1" = 15,840 inches
or 1" = 15,840 x .0254 = 402.336 metres
$\therefore$ 1" = 402.336 metres
x = 100 metres

$$x = \frac{100}{402.336} = .248 \text{ inches} = 100 \text{ metres}$$

$\therefore$ 2,100 metres = .248 x 21 = 5.208 inches.

5. To calculate a scale, 4 inches to 1 mile, showing 100's yards and approximately 6" long.

1" = 440 yds.
6" = 440 x 6 = 2,640 yds.

$$\therefore 2{,}500 \text{ yds.} = \frac{2{,}500 \times 6}{2{,}640} = 5.675 \text{ inches.}$$

5a. To calculate metric scale for above

5.675 inches = 2,500 yds.
5.675 inches = 2,500 x .9144 = 2,286.000 metres.

$$\therefore 2{,}100 \text{ metres} = \frac{2{,}100 \times 5.675}{2{,}286} = 5.208 \text{ inches.}$$

Plotting the Scale

A graphic scale may be plotted in the following manner. Draw horizontal line (AB) and measure it accurately (Figure 1). Raise line AC at any angle up to 45°. Now divide line AC by the desired number of divisions needed on AB. These divisions can be any convenient distance, i.e. 1/2", 1" etc. Now join AC_5 to B and parallel across all other points to line AB. AB is now divided equally.

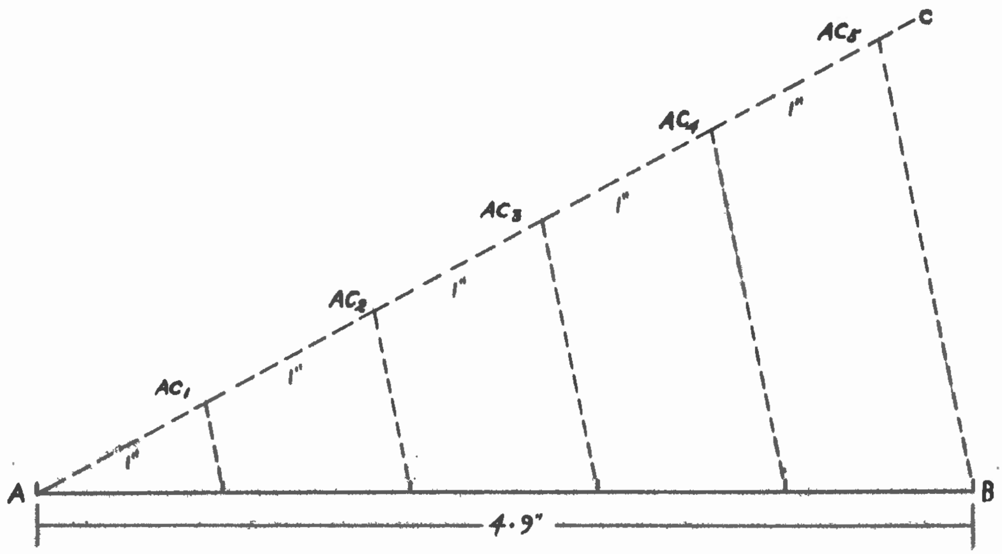


Figure 1

Common Map Scales and Their Equivalents

Map Scale	One Inch represents	One Centimetre represents	One Mile is represented by	One Kilometre is represented by
1:2,000	56 yards	20 metres	31.68 inches	50 cm.
1:5,000	139 yards	50 metres	12.67 inches	20 cm.
1:10,000	0.158 mi.	0.1 km.	6.34 inches	10 cm.
1:20,000	0.316 mi.	0.2 km.	3.17 inches	5 cm.
1:24,000	0.379 mi.	0.24 km.	2.64 inches	4.17 cm.
1:25,000	0.395 mi.	0.25 km.	2.53 inches	4.0 cm.
1:31,680	0.500 mi.	0.317 km.	2.00 inches	3.16 cm.
1:50,000	0.789 mi.	0.500 km.	1.27 inches	2.0 cm.
1:62,500	0.986 mi.	0.625 km.	1.014 inches	1.6 cm.
1:63,360	1.00 mi.	0.634 km.	1.00 inch	1.58 cm.
1:75,000	1.18 mi.	0.750 km.	0.845 inch	1.33 cm.
1:80,000	1.26 mi.	0.800 km.	0.792 inch	1.25 cm.
1:100,000	1.58 mi.	1.000 km.	0.634 inch	1.0 cm.
1:125,000	1.97 mi.	1.25 km.	0.507 inch	8.0 mm.
1:250,000	3.95 mi.	2.5 km.	0.253 inch	4.0 mm.
1:500,000	7.89 mi.	5.0 km.	0.127 inch	2.0 mm.
1:1,000,000	15.78 mi.	10.0 km.	0.063 inch	1.0 mm.

METRIC SYSTEM

10 millimetres (mm.)	=	1 centimetre (cm.)
10 centimetres	=	1 decimetre (dm.)
10 decimetres	=	1 metre (m.)
10 metres	=	1 dekametre (dkm.)
10 dekametres	=	1 hectometre (hm.)
10 hectometres	=	1 kilometre (km.)

	mm.	cm.	m.	km.
1 inch	25.4	2.54	.0254	.000,025,4
1 foot	304.8	30.48	.3048	.000,304,8
1 yard	914.4	91.44	.9144	.000,914,4
1 mile	1,609,300	160,930	1609.3	1.6093

	in.	ft.	yd.	mi.
1 millimetre	.0394	.003,281	.001,093,6	.000,000,621
1 centimetre	.3937	.03281	.010,936	.000,006,21
1 metre	39.3701	3.281	1.0936	.000,621
1 kilometre	39370.1	3,281	1,093.6	.621,37

Scale Conversion Factors

1/40,000 to 1/63,360	-	0.6313
1/63,360 to 1/40,000	-	1.5840
1/50,000 to 1/63,360	-	0.7891
1/63,360 to 1/50,000	-	1.2672
1/125,000 to 1/126,720	-	0.9864
1/126,720 to 1/125,000	-	1.0137
1/250,000 to 1/253,440	-	0.9864
1/253,440 to 1/250,000	-	1.0137
1/500,880 to 1/500,000	-	0.9864
1/500,000 to 1/506,880,	-	1.0137
1/1,000,000 to 1/1,013,760	-	0.9864
1/1,013,760 to 1/1,000,000	-	1.0137

DRAFTING EQUIPMENT AND USES

The Pencil - all drafting pencils are graded soft, medium and hard. The soft pencils range from 6B to 2B; the medium grades are F, HB and H; the hard range from 2H to 9H. There is little use for a pencil softer than HB in map drafting and numbers 2H to 6H will be found the most useful. Practically all drafting requires the long slender conical point. This can be obtained by the use of sandpaper or special pencil sharpeners. When using the pencil all lines should be fine, true and lightly drawn. As most lines are inked over needless pressure on the pencil damages most working surfaces and causes poorly drawn lines.

Scales - most office scales are divided from 1/10 down to 1/100. Learn to use accurately. In striking of measurements, learn to make a short light line that forms a continuation of the division mark on the scale.

Ruling Pens - used universally in making sharp clean lines consistent in weight throughout. It is always used in combination with a straightedge, triangle, or French curve as a guide. After adjustment of the set-screw to the weight of line desired, it is inked by inserting ink between the blades to about a maximum of 5/16 inch according to length of line to be drawn. Overloading will cause the pen to "flood". When drawing a line the pen is slightly inclined in direction of line being drawn. Clean by dipping the tip in water and wiping inside as well as out with a soft cloth. Sharpening pens should be demonstrated by a trained draftsman.

Contour Pens - same use as a ruling pen except that the pen is used freehand, that is, without a straightedge. The pen is used for drawing of streams, contours, etc. where the lines twist and bend a great deal. This pen needs a great deal of practice to follow a line accurately.

Compasses and Dividers - the compass is used for drawing circles and arcs (segments of circles) in pencil or ink. The divider is used for taking and transferring measurements accurately.

Drawing Pens - these pens are used for freehand lettering, inking irregular lines and symbols freehand. Gillott pen nibs are amongst the most popular. Three of them are: 170 (broad), 290 (fine, soft), 291 (fine, hard). You should experiment with these points in your early freehand work until you have learned their individual characteristics, differences, and limitations well enough to select the best pen for a specific task with little hesitation. In applying a pen to paper, do not grip the holder too tightly, but more as you would in ordinary writing. Tenseness causes ragged lines and induces fatigue. Most important of all, learn to apply a light consistent pressure on the working surface, it is the only way in which lines consistent in weight throughout can be drawn. It is better to control the amount of ink on the pen by applying it with the stopper quill to the under side of the nib rather than by dipping it into the ink bottle.

Triangles - these are used in conjunction with a straightedge for drawing parallel lines, raising right angles and in laying out type.

French Curves - drafting section equipment includes a wide variety of French curves. These curves serve the same purpose in guiding the ruling pen in curved line work that triangles serve in straight line drafting. Considerable practice is required in learning to fit them perfectly to the desired curve or plotted points.

Tracing Point - tracing and transferring detail are important tasks of the draftsman in which accuracy is of paramount importance. With a properly sharpened (preferably steel) tracing point that fairly glides over the paper, transferring can be simpler than penciling. The point should be sharp enough to produce a fine line through the special blue transfer paper, but not so sharp as to cut the working surface. Since the colour blue does not photograph in reproduction it need not be erased unless desired.

Aids to Draftsman

Leroy - a mechanical lettering device involving templates, scriber and special Leroy pens. A different template is necessary for each size lettering. The template is moved along a straightedge and the scriber traces the depressed letters of the template and reproduces them with the pen beyond the template.

Zip-a-tone - this is a commercially prepared pattern which can be used to designate a certain area. The patterns are available on thin transparent film coated with an adhesive. The material is placed over the area desired and is cut with a sharp blade to fit, then burnished to the drawing.

Proportional Dividers - can be used for enlarging or reducing.

Beam Compass - used to draw flat arcs or for measuring large distances in the plotting of projections.

Railroad Pen - used for drawing two lines at once. Works on a swivel the same as a contour pen.

Drop Compass - used for making small circles.

Electric Eraser - a rubber mounted on the end of a small electric motor which is used for erasing large areas of line work.

SCRIBING

Until a few years ago practically all maps were prepared for reproduction in the form of drawings made with black ink on metal-mounted paper to which was added supplementary details (stick up). The process of printing the blueline-base guide copy on the metal-mounted paper, required the paper to be submerged in water for developing; this damaged the surface texture of the paper so that ink could not be applied evenly or neatly. Various methods of coating the paper were used in an effort to restore or produce a suitable inking surface. The inking operation itself then became a highly developed skill among cartographic draftsmen. The preparation of the paper surface, the sharpening and care of pens and pen points, the consistency of ink, line-weight specifications, atmospheric humidity, were all items of significance. In spite of the care taken to keep the drawing clean and maintain line uniformity, negative retouching was required.

The actual date of beginning plastic scribing, in common with similar developments, is difficult to determine. The idea sought was a scribed negative from which the detail could be transferred onto the press plate by means of a single direct photographic process. The development of new, stable, transparent plastics, undoubtedly contributed to the development. Plastic sheets of 0.005, 0.0075, 0.010 inches thick have been used successfully. These sheets are coated on one side with an opaque paint by means of a whirler, roller, or sprayer. The paint must have the characteristics that will allow it to be removed by a scribing tool, in the form of a clear, clean line, and will include some degree of translucence. Either white, yellow or orange coatings are used, depending on how the copy is to be used. A small amount of paint is supplied to the draftsman in order to obliterate any possible imperfections in the coating, to delete errors, to make corrections or revisions. A grease pencil can also be used to obliterate a scribed line. To remove cutaway paint, a soft brush or kleenex can be used.

A special drafting table having a glass top and a light beneath is required for the scribing method, inasmuch as the draftsman working on an opaque coated plastic needs to see lines against an illuminated background.

Three cutting tools are used to scribe nearly all the map details on any sheet. These tools are the rigid scriber, the swivel scriber, and the pen type scriber. These scribers are made of plastic and metal, or all metal.

The Rigid Scriber - the base plate and handle rest on two ball-bearing feet about 1/2 inch long. These are attached to the rear of the base plate. A small chuck is fixed to the front of the base plate. The scribing points are placed in this chuck. Round scribing points are used in the rigid scriber in sizes from .003 to .012.

The Swivel Scriber - resembles the rigid scriber except that the cutting blade is on a swivel or castor arrangement like an ordinary contour pen. This tool is used for single, double and border line cutters and for scribing lines freehand. These cutters can be obtained in sizes from .005 to .050, plus various sizes in road and border cutters.

The Pen Scriber - this is a holder in which a scribing cutter or phonograph needle can be held for the touching up of lines.

These scribing tools enable the draftsman to remove the plastic coating by a cutting operation for the delineation of all details formerly executed in ink. Other types of scribing tools and templets have been developed for specialized use. The dotting device is an example. To remove the coating the chisel type bit is rotated in one spot making the required dot. Templets are used to reproduce special shapes such as circles, squares and triangles.

The object of scribing is to produce a negative from which can be made the printing plate. This is done by using one of the colour plastics. White coated sheets are photographed when used. The scribing can be done without a light table by laying a piece of black matte paper beneath the sheet. All the stick up information is also added. This is then photographed with a black background to produce a negative. In using one of the coloured plastics, this being a negative right away, the stick up information must be added on an overlay, changed to a negative by photography or contact negative and combined with the scribed negative at the plate stage.

In conclusion, it has been found that the quality of scribing is entirely satisfactory for reproduction, without major retouching, which was not so with ink drafting. It is a faster means of producing a map, which is very important in these days of high production and it maintains a uniform line from map to map.

MAP COMPILATION

Map compilation is the preparation of a new map up to the stage of "fair" drawing. This compilation is done by using all available material — such as air photos, existing maps of whatever scale, charts, field surveys and geologist data.

The compilation is the foundation of the map and a finished sheet can be no more accurate than its compilation, nor can it contain more information than the compilation contains. A large part of the responsibility for preparing a satisfactory map, therefore, rests with the Compiler. Apart from a few guiding principles, a compiler can be given few instructions to guide him in the selection and plotting of detail. He can only acquire with experience the knowledge of what should or should not be included. He should be familiar with all phases of cartography and allied subjects, map reproduction methods from the camera to the printing press.

A good compiler produces his final compilation in such a form that the draughtsman has no doubt in his mind of exactly what is to be shown and how. It is only with experience that he is able to develop a capacity for independent thought and decision.

In the selection of detail there is no problem in selecting the outstanding features of anarea (such as roads, railways, rivers, etc.). The problem of secondary features is more difficult. When the choice lies between several features, the rule applied is to choose the feature most readily recognizable in the field or the feature which seems to tie in with the geological data.

Plotting of data must be as accurate as source materials, sizes of symbols and instruments will allow. Great care must be taken while plotting features, since the fair draughtsman will copy them exactly as they appear on the final compilation. Every effort should be made to match the new compilation with existing sheets of the same scale, though in attempting to match borders, no errors should be introduced into the new compilation, as the latter sheets may be in error or out of date.

Compilations should be prepared on stable material and inks should be of such colour and density that they will photograph satisfactorily. Pencil lines should be sharp and black, and care should be taken not to smudge them. Coloured pencils should be applied lightly, so as not to interfere with photography.

As a guide to compilers there follows below a summary of facts.

1. A finished map can be no more accurate than the compilation.
2. The final compilation drawing must leave no scope for conjecture at the fair drawing stage.

3. All compilation symbols should occupy approximately the same space as on the fair drawing.

4. It must be possible to reproduce the compilation drawing by photographic means, both contact and camera.

5. The compiler should study the area before starting. Only in this way can he decide what is important.

6. The compiler must consider how his sheet falls into the general pattern and treatment of the adjoining sheets.

7. As scale decreases, generalization increases, but every effort should be made to retain shape and detail, to achieve legibility and clarity, with thought given to the capabilities of reproduction methods employed.

8. Check sheet edges and at the same time look a little way beyond.

GENERALIZATION

There are several definitions for the word "generalization". An appropriate one from Websters dictionary is, "to emphasize the general character rather than specific details of". Another definition of generalization might be, "the simplification of form, omission of non-essential information, combination of small forms, and the magnification of certain features essential to the map". This implies selection, judgment and retention of essential elements.

Modern methods employing aerial photographs give a high assurance that all significant features are detected during compilation. Prior to the use of aerial photographs in mapping, it was not uncommon for isolated features to go undetected by field surveys.

In this map generalization, we are referring to the preparation of maps from other published maps.

When is generalization required? A map drawn to the scale of the earth's surface would require no generalization, but a map of the earth drawn on a postage stamp would be generalized. This, of course, is an extreme example. Between these two examples some generalization is required at all scales.

Regardless of map scale, the items which must remain relatively unchanged are line width and type sizes. Map detail must change through generalization, to accommodate a scale change. It is best that generalization be done at the compilation stage, but unfortunately this is not always the case. "Compiling-drafting" is slow and wasteful since it necessitates draftsmen spending many hours eliminating work done previously by compilers.

At 1:50,000 scale the width of a fine line represents a distance of 25 ft. and at 1:1,000,000 scale the same line covers 500 ft. As scale is decreased, lines used for outlining objects increase in measured width and details must be omitted because to show them is to magnify them. Magnification must be accepted at times in order to depict information which is essential or desirable. Such magnification causes displacement of roads, buildings, and so on but this must be accepted in the interests of clarity. At progressively smaller scales, magnification of certain features becomes impractical and the use of a group symbol or outline becomes necessary. Thus, it can be said that scale is the predominant factor determining what can be shown.

Whenever generalization is carried progressively from one scale to a smaller scale several times over, without a check being made back to the original large-scale material, there is danger of eventually producing a map which is entirely incorrect. Reference to the original material must always be made in order to maintain the predominant characteristics of the area being generalized.

Generalization of Hydrography

Since hydrographic features retain a permanency of form, they provide the foundation to which relief, map detail, and in our case, geological information, is anchored. Features such as buildings and highways are subject to change, but the Indians traversed the same lakes and rivers as we see today. It is therefore necessary that the generalization of hydrographic features retain a higher integrity than other map features. On the other hand, it is important to avoid creating a false impression. The Koukdjuak River in Baffin Island is a good example. This river is two miles wide, but only 2.5 ft. deep, so instead of being shown as a double line river it should be shown as a single line river on a map.

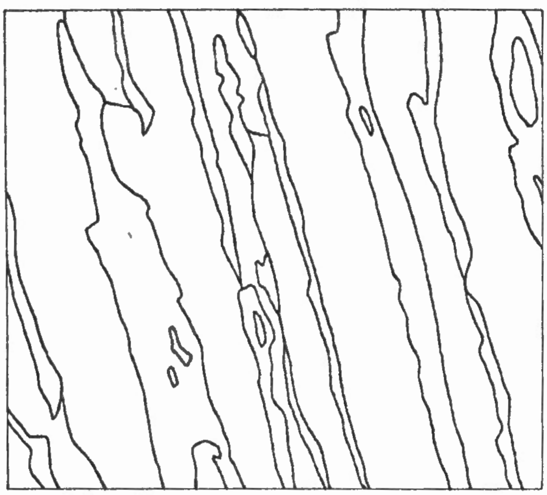
Therefore, the general aim is to retain shape and detail as much as possible, subject to the following rules:

a) The amount of detail retained must be related to the capabilities of reproduction methods employed.

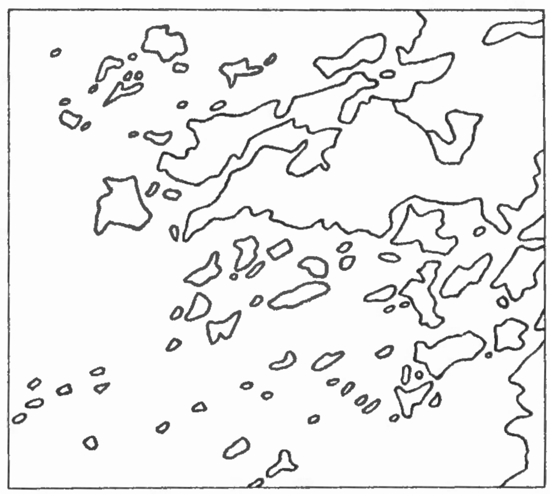
b) The result must achieve legibility and clarity.

These rules should discourage arbitrary "smoothing" of detail simply for convenience of drafting. As with finger-prints, there are no two lakes alike and, within reason, this should be maintained regardless of scale reduction. As a rule, features reduced to the point where identity cannot be maintained should be either omitted, combined, emphasized, or symbolized.

To illustrate the meaning of area or feature characteristics:



The striated formation of lakes caused by glaciation



A multitude of small islands

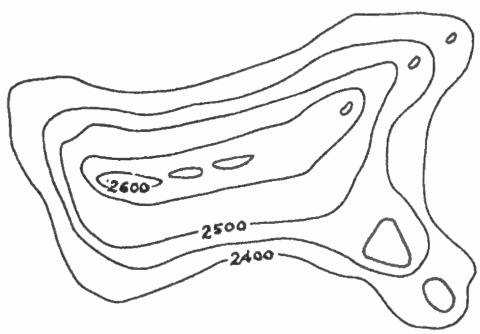
In generalizing areas such as those illustrated, the compiler must retain their characteristics through selection, simplification, emphasis and combination of features.

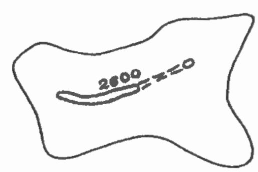
"Selection" refers to the choice of those features best representing the area characteristics.

"Simplification" refers to the smoothing out of detail to achieve de-emphasis or to cope with scale reduction. Scale reduction normally requires the simplification of small bays and irregular shorelines to avoid a confused depiction. It is important not to over-simplify to the point where original identity is lost.

Generalization of Relief

The contour line is the most widely accepted form of relief portrayed. Contours are usually generalized in far too casual a manner causing misleading representation of relief.





It can be seen from the above figures that a ridge is shown by four small isolated peaks. If generalization does not include all these peaks the size of the ridge would be approximately half. Therefore, the compiler should always try to visualize the appearance of any feature before generalizing it.

To obtain the clearest result in relief portrayal it is apparent that contours alone do not give the best results. One answer is layer tinting. If combined with contours, it has the advantage of indicating, more clearly, the shapes and relative importance of features, while at the same time reducing the requirement for a detailed study of contours. The second answer is hill shading instead of contours which could be printed in brown and combined with a geological map.

Generalizing of Names

This can be defined as simply omitting certain names. It must be remembered that names are a special information, as important as any other detail and should not be considered as a complication to map making which can be eliminated at will.

Through the use of colours (e.g. cultural names in black, hydrographic names in blue) more names can be shown without detriment to the clarity of the map.

In geological maps, all names appearing in the descriptive notes or memoir should be shown on the map. After these names have been shown it is up to the compiler to add sufficient names to make all other important features visible but at the same time retaining clarity.

SYMBOLS

The entire map is a symbol as well as its parts and it is not quite correct to designate only certain components as symbols. A coastline is actually a line of equal value (a contour) and has no existence at all, being but an imaginary line between water and land. This is one of the major ways in which a map differs from an air photograph. The data on a map are selected and symbolized in order to tell a story, to make clear one or a series of relationships. A photograph of a portion of the earth is a record, unsymbolized and unselected, which is "seen" by the camera. One of the major duties of the cartographer, then, is to understand the relations among symbols, their relative effectiveness, and their relative suitability for the purpose for which the map is being constructed. Symbols constitute a kind of code by which the cartographer can present the most effective story in the limited space available.

In the Geological Survey two types of symbols are used. Standard topographic symbols as laid down by Surveys and Mapping, and geological symbols. These symbols can be found in a "Guide for the Preparation of Geological Maps and Memoirs" by H.M.A. Rice and P. Harker (1961).

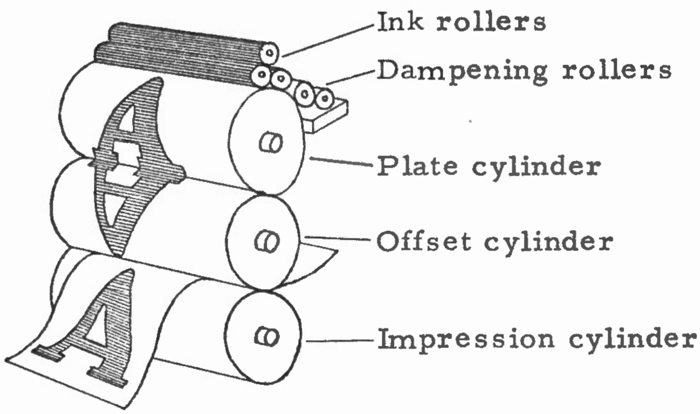
PRINTING AND ASSOCIATED PROCESSES

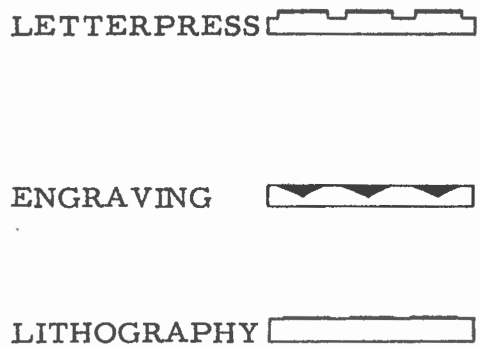
It is not necessary for the draftsman to have a detailed knowledge of printing, so the following pages will contain only an outline of printing and associated processes.

The earliest method of printing was done several thousand years ago by pressing a raised surface into clay. At a very early time, the Chinese carved block characters, inked the raised portion, and transferred the impression to paper. This is the kind of printing from movable type that subsequently was "invented" in the Western world and grew rapidly after the middle of the fifteenth century. Today printed material from a plate on which the printing surfaces stand in relief is known as LETTERPRESS.

Another method of reproduction involving ink and an uneven surface was ENGRAVING. Someone conceived the idea of cutting or engraving grooves in a metal plate and filling them with ink. The flat surface of the plate was then cleaned off and the plate with its ink-filled grooves was squeezed against a sheet of paper. The paper "took hold" of the ink and when removed from the metal plate the pattern of grooves appeared as ink lines. In a sense this process of engraving printing is just the opposite of letterpress printing, for the inking area is "down" instead of "up".

About a century and a half ago it was discovered that a drawing could be made on the smooth surface of a particular kind of limestone with oily ink or greasy crayon. The fats combined chemically with the elements in the stone to form a calcium oleote which had the property of repelling water. The unmarked portion of the surface could then be dampened and when a greasy printing ink which was repelled by the water was rolled across the surface, the ink would adhere to the oily marked areas but not to the clean dampened areas. Paper pressed against the stone would pick up the ink. Because of the use of stone in the original form, the process was named LITHOGRAPHY.





OFFSET LITHOGRAPHY

Today stone is no longer used except in rare instances. Although thin metal plates have been substituted it is still known as lithography. It is also frequently called offset because the image is offset by the press to a rubber roller which in turn prints it on the paper. Whatever printing surface prints directly to the paper, the printing surface will be "backwards". By offsetting to an intermediate roller which then prints to the paper, the printing plate will "read correctly". This is advantageous in processing and it allows delicate printing plates to have a longer life on the press since rubber is softer than paper. In any case it is a planographic process, that is, the surface of the lithographic printing plate is a plane having no significant difference in "elevation" between inked and the non-inked areas.

The three kinds of printing and printing surfaces, relief, intaglio (engraving), and planographic are still used, but most maps are printed by either letterpress or lithography. Larger maps are usually done by lithography and the smaller, such as figures for books, by letterpress.

Until the latter part of the nineteenth century the major problem in all three printing processes was that of obtaining the image (of the drawing which was to be printed) on the printing plate. There was no mechanical way to accomplish this, and as a consequence, arts such as engraving or drawing directly on the lithographic stone were highly developed and few possessed the necessary skill. Some idea of the problems involved may be gained from the simple fact that everything on the printing plate had to be backwards including the lettering.

With the rapid development of photography after approximately 1850, a fundamental change took place in printing. It was discovered that the image of the drawing could be transferred to a photographic emulsion which when developed resulted in a negative. By a variety of processes involving emulsions and etching compounds, a printing plate could be prepared directly by mechanical means. Today all ordinary printing plates are prepared by exposing a negative or positive to a light-sensitive printing plate which is then made ready for printing.

The introduction of the photographic process introduced two main problems: 1. the maintenance of exact size and fit with other drawings for multicolour maps (register, discussed later in this article); 2. the cost of time and money in photographic processes.

The four basic steps in the process of printing a map are:

1. Photographing the original.
2. Processing the negative and making the artificial negatives.
3. Making the printing plates.
4. Presswork.

Photographing the original drawing and processing the negative is discussed under "Photo-Mechanical Process in G.S.C.".

Line and Half-tone

All copy, that is, original drawings or anything else to be printed belongs to either of two classes, line copy and half-tone copy. The distinguishing characteristics that place a drawing in one or the other class is whether or not it contains any colour shading or grey tones. If it does, it is half-tone copy and must be dealt with in the reproduction process by a different (and more costly) procedure. The significance of this division results from the fact that the ordinary printing processes depend upon printing from a surface that is either inked or is not inked. There is no such thing in lithography and letterpress as "halfway inking".

It is possible, however, to make a printed area appear grey or shade from light to dark (continuous tone) as if the surface had more or less ink on it. The process, half-toning, is accomplished by transforming the tone area into a large number of small dots of different sizes depending upon whether it is to be dark or light. The dots print ink and the spaces between do not. The dots are so close together that the eye is unable to distinguish them easily so that the combination of inked spots and white spaces blends and appears as a tone.

The size of the printing dots relative to the white spaces between is dependent upon the darkness or lightness of the tones on the copy. It should be remembered, however, that unless special additional processing takes place, no part of a half-tone will be without dots. All lines and lettering will therefore have fuzzy edges. Pure whites on the original drawing will in ordinary half-toning be printed with a covering of very small dots and therefore a light tone, whereas solid areas will reproduce with small white areas rather than being completely solid. These effects can be removed by opaquing or scraping on the half-tone negative but this is difficult if the areas involved are complex. This is one of the reasons why half-toning is so expensive, as the use of a skilled operator is necessary for negative corrections.

A mapping office can obtain a similar result with line copy. The most popular method is with the use of Ben Day screens or equivalents which are either added to the negative or used at the plate-making stage by placing the screen between the negative and the plate before exposure. When developed the lines appear on the printing plate.

Other methods are: shading either uniformly or for continuous tone effect by hatching or stippling with pen and ink; use of air brush; aid by shading on a coarse rough surface.

Colour Reproduction

The reproduction of maps in colour does not differ from black reproduction except that different coloured inks are used. Each separate ink requires of course a separate printing plate, and thus a complete duplication of the steps in the whole process. Generally speaking, the costs of colour reproduction are many times that of the single colour (usually black) reproduction. There are, however, two basically different colour reproduction processes. The two are called "flat colour" and "process colour".

Flat colour is the method most often used for maps and involves a straightforward procedure that varies very little. For the flat colour procedure the map is planned for a certain number of coloured printing inks, and either a drawing or artificial negative is prepared for each colour. Of course, many combinations of line and half-tone effects are possible.

Process colour, or more properly four-colour process, is the name given to an essentially different procedure. This method is based on the fact that almost all colour combinations can be obtained by varying mixtures of red, yellow, blue, white and black. The copy consists of two pieces usually, the colour drawing and a black line plate. The black plate usually contains the border, lettering, projection, outlines, etc. and is the base for the blue-line. On the blue-line all colour work is done by painting, airbrush, etc. The colour copy is photographed three times, each time through an appropriate colour filter and a half-tone screen so that the three printing plates are half-tones of the varying amounts of the primary colours. The black plate is treated as a line drawing. When printed together again the half-tone dots and transparent inks merge and recreate the colours of the original drawing.

Process colour allows smooth gradations of hues and tints composed of mixtures of hues. The reproduction of coloured photographs and painted art works in popular magazines is done by process colour.

This explanation of the principal colour processes used in reproducing maps is greatly simplified in order that you can have an idea of the basic procedures.

More information can be obtained from:

The Reference Manual of the Graphic Arts
by Colton Press, New York, 1941

The Lithographers Manual
by W.E. Soderstrom, 1940

Map Registration

The basic mechanical problem of multicolour map preparation is registration. Registration involves: (a) preparing the individual drawings so that they fit one another exactly in all respects; (b) maintaining this perfect fit through the processing which results in the printed map. The first involves knowing precisely where to draft all lines and symbols, etc. on the different drawings to be combined, and the second requires that the materials maintain their size and shape while being processed.

Registration may be maintained by: (a) using a dimensionally stable drawing or scribing surface; (b) preparing carefully artificial negatives or negative separations. Whatever method is employed, great care must be taken to maintain as perfect registry as possible.

To facilitate register during the drafting and processing of the map, register marks are used. These are corner marks placed on every colour, or crosses placed in the centre of each side outside of the border, and lastly, when using scribing precisely punched holes in the edge of the plastic sheets which can be fitted over pegs on a registration bar causing each sheet to register perfectly. Corner marks and register crosses should be drawn in as thin a line as possible.

Colour Chart

Suggested guide for maps covering large regions. Numbers shown after each colour are taken from the "Geological Survey Colour Chart".

CENOZOIC - Yellow (1), Yellow-grey (1, 3).

MESOZOIC - Green (1, 5), Yellow-green (1, 6), Blue-green (2, 5), Grey-green (1, 3, 5).

PALAEOZOIC - Blue (5), Special Blue (7), Blue-grey (3, 5), Grey (3).

PRECAMBRIAN - Orange (1, 9), Yellow-orange (1, 10), Carmine-orange (2, 9), Grey-orange (1, 3, 9), Grey-carmine (3, 9), Purple (5, 9), Blue-purple (5, 10), Carmine-purple (6, 9).

INTRUSIVE ROCKS - Carmine (9), Display Red (11), Orange (1, 9), Grey-carmine (3, 9), Grey-display red (3, 11), Grey-orange (1, 3, 9).

PHOTO-MECHANICAL PROCESSES IN G.S.C.

All of the following processes take place in the Geological Survey.

Camera - The vacuum copy-board and the bellows and lens are suspended from an over head track, and the camera back is in the dark-room.

The camera is used for all photographic work related to the production of geological maps and is designed to produce negatives of the highest quality necessary for lithographic plate-making. The maximum size of negative is 40 in. x 48 in. and the range of the camera is from an enlargement of 1:7 to a reduction of 5:1.

In the print processing room a vacuum frame measuring 48 in. x 60 in. is used to produce vandyke prints, cronaflex (matt surface plastic) transparencies and positive films from the negatives made in the camera.

Also blueline prints, plastic colour proofs and stripping film negatives and positives. In all these processes exposure to light is the key.

Vandyke Prints - paper print made from negative or positive.

Cronaflex transparency - blackline or blueline print made from negative. Cronaflex is a translucent matt surface plastic material.

Positive and Negative Film

Blueline Prints - made on paper or plastic by sensitizing with ferro-prussiate blue solution.

Colour Proofs - made on grained plastic by sensitizing with watercote and exposing to light through various colour negatives and screens.

Negative retouching is done by covering imperfections in the film with an opaque paint.

Artificial colour negatives are produced by three methods. These are by dyrite, peelcoat and on film.

Dyrite - a combined positive of the black and blue negatives is made, then covered by transparent sheets of dyrite plastic, one for each solid colour and one for each half tone colour. The areas to be printed in each colour are opaqued on the appropriate plastic. The sheet is then dyed and the opaque is washed off. The result is an artificial negative in which only the areas requiring colour are "open".

Peelcoat - a combined positive is made from the black and blue negatives. This positive is exposed to sensitized sheets of peelcoat, again one sheet for each solid and half tone colour. The peelcoat is now a negative with an impression of the blue and black on it. The areas to be printed in colour are peeled out and all other lines are opaqued over thus giving an artificial negative.

Film - a combined positive of black and blue is made. This covered by a sheet of clear plastic on which all areas to receive colour are filled in. From this plastic are made negatives, the total of which is the same as the number of colours on the sheet. On this negative all colours are opaqued except the colour required. By adding ruling to the half tone areas a negative is produced which contains solid and half tone colour areas with a saving of 50 per cent on the amount of film used and an improvement in registration of 70 per cent which reduces press error.

PREPARATION OF SLIDES

Legibility of Standards

1. Use simple Gothic lettering such as produced by Leroy.

2. Express a minimum of ideas on any one slide.

3. Do not clutter with needless detail. Keep as simple as possible. Audience does not have time to digest a mass of information.

4. Arrange titles, legends, etc. in logical order and position in order to make slide easy to follow. Dispense with border around copy whenever possible, the mask fulfils this purpose.

5. To avoid unnecessary glare, use negative slides for graphs and other slides with large blank areas.

A standard lantern slide is 4" x 3 1/4" glass size, 3" x 2 3/4" work size; 35m slide is 2" x 2" glass size, 1 5/8" x 1 5/8" work size. To calculate work size if only one measurement is known, a ratio is needed. For 3" x 2 3/4" (work size) the ratio is 1:.92 and for 1 5/8" (work size) the ratio is 1:1. Therefore, in a 3" x 2 3/4" slide with a copy width of 17 inches, the ideal height would be approximately 15 1/2 inches.

In lettering a slightly wider than normal space should be used between letters. To calculate the minimum height of letters a formula of: .016 x base = height of type. If governed by the height a formula of: .023 x height = height of type. If typewriter type is to be used a maximum size of 7" x 6 1/2" should be used for the copy.

Other Rules:

To determine legibility of a slide it should be viewed at 7 to 10 times the horizontal dimensions.

12" slide = 12 x 7 = 84" or 7 feet

To calculate line weights

.0010 x width of copy in inches for minimum line

.0016 x width of copy in inches for drainage

.0300 x width of copy in inches for boundaries.

Minimum Sizes of Leroy Letters

Horizontal dimension		Vertical dimensions	
5 inches - 80	10-11 inches - 175	7 inches - 80	9-10 inches - 175
6 inches - 100	12-13 inches - 200	5 inches - 90	11-12 inches - 200
7 inches - 120	14-15 inches - 240	6 inches - 100	13-14 inches - 240
8-9 inches - 140	16-19 inches - 290	7 inches - 120	15-17 inches - 290
	20-22 inches - 350	8 inches - 140	18 inches - 350

GEOLOGY OF CANADA

by

Dr. A. Wilson

What is geology? Geology is the story of rocks of all kinds. It follows then, that the geology of Canada is the story of the rocks of Canada, how they were formed, where we find them, and what they contain. It is a story that goes back millions of years.

Long, long ago before man lived, before there was any animal on land, before there was a tree or a blade of grass, mountains covered a large part of this country of ours, but not where they now stand. These ancient mountains extended from Labrador to the centre of the continent, thence to the north. How far they stretched to the west we do not know. Their roots are covered. These ancient mountains looked east to the Atlantic, west to the Pacific, for, then, no mountains on the Gaspe and Maritimes, no Rockies on the west barred their view.

While the mountains were young, volcanoes studded the land. The lavas that poured out from them are still there. But not all were volcanoes. When mountain ranges are squeezed up molten rock wells up from far below. It cools slowly as it nears the surface. Each mineral crystal gathers to itself according to a mysterious law. These rocks then, are not volcanic. We call them 'crystalline rocks', and it is in the crystalline rocks of this ancient time that hold Canada's greatest wealth: gold, silver, nickel, radium, iron, and many other common and

Then, picture the land! Mountains and volcanoes! No trees! No birds! But in place there was water. How do we know?

Among the mineral bearing crystalline rocks are some that were formed in water. Some mineral matter dissolves in water, like salt, and is carried away by streams, distributed on land, or re-deposited in the sea. Such is limestone. Sandstone and shale is formed from the remaining sediments that will not dissolve in water.

But to come back to Canada! Think of this majestic, though barren land! For millions and millions of years it was thus! New volcanoes would burst out. Old ones would burn out. Changing levels of the land made new changes in the shores of the surrounding oceans, gulfs, bogs, lakes and rivers. So it went on and on.

But a change came. The sea invaded two wide troughs where our present mountains now stand on the east and on the west. The invading sea dropped its sediments - limestone,sand and clay. The country rose. The sea was drained out. After many years the country sank again, and again the sea came in. It happened again and again. Many times the sea spread beyond the edges of the two great troughs. Sometimes the water entered from the east, or from the west, sometimes from the north or from the south. Sometimes two long fingers met from north to south and almost covered the land, but not quite. How do we know?

Well, life began in the sea. At first it was a simple life, tiny one-celled forms. The cells multiplied by dividing themselves.

Then colonies of cells grew so large that work was divided. Some cells gathered food. Some cells produced young. So it went on and on, until both plants and animals became more and more complicated. At first they just floated, then they fastened themselves to plants or rocks taking their food from the surrounding water. As they developed they went after their food. This development first took place in the ocean water. When the creatures died their shells were buried in the sediments and preserved there. Each time the sea invaded Canada and then retreated it left in its sediments the shells that had been dropped there. Each invasion left more highly developed forms. So, the shells in the sediments are like the words in a book. They tell the story.

Then came the time when both plants and animals crept up on land. That began about the time the rocks of the Niagara scarp were formed. They had no water to bear them up, or to bring them food. The plants grew strong stems. The animals developed power to crawl or walk or run.

Thus from the shells in the sea-laid rocks we can count the invasions of the seas, and tell how far they covered the land.

The Parliament Buildings in Ottawa stand on a hill of limestone that was deposited during the second great period of invasion; and within the main building the walls are lined with rocks from Manitoba that were deposited towards the end of this same flooding. The Provincial Buildings of Manitoba are also made of it, as are many other buildings in both the east and the west.

The rocks over which Niagara Falls roar were laid during the third great period of invasion. There are others of the same age in both the east and the west. In western Ontario there is natural gas found in these rocks.

Perhaps the fourth great invasion was the most interesting. For, within its sediments are enclosed the oil of western Ontario - small oil fields compared to some but they have produced for many years, and new sources are still being tapped there. By this time great coral reefs had been developed; and now these coral reefs buried under later sediments are the reservoirs for the really great oil resources of the Prairie Provinces, particularly of Alberta.

As far as known the eastern central part of Canada has not been invaded or even the edges flooded since the fourth great period of invasion.

All this time the ancient central mountains were being worn down, year after year, hundreds of years after hundreds of years, even millions of years after millions of years.

By now, however, the mountains on the east were beginning to rise. On their margins were swampy lands. When the next invasion of the sea came it did not cover so much of Canada. But in the eastern marginal swamps, grew and died trees that gave us the coal of Nova Scotia. The next invasion left very little, comparatively speaking, and that on the far east and the far west. Then followed a long period of wearing down. But for more spectacular, the mountains on the west began to rise, at the southern end in the United States - the young Rocky Mountains.

On the west the sea again invaded during several long periods, from the Arctic, from the Pacific and even from the Gulf of Mexico and California. In high unflooded areas during one of these invasions grew the trees that now form the coal fields of Drumheller and elsewhere in Alberta. The dinosaurs, too, lived in the low swampy lands at the margins of these invasions, both in the United States and in Alberta.

Meanwhile the Rocky Mountains rose farther and farther to the north, higher and higher. West of them vast fields of granite welled up from below, and when tremendous pressures came from the west the granite was stronger than the rocks in the trough to the east of it that had been filled with less consolidated and weaker sediments. They crumpled. Look at any picture of the mountains now. Their rocks are twisted and torn, pushed over and under one another. It did not happen all at once, but through ages of time, until the mountains now stand almost as we know them. Immediately rains, rivers, frost and winds began to wear them down. In the valleys and basins between the mountains in British Columbia we find, not sea but land deposits, and in them plant and insect remains.

And then! Over all came the glaciers from the north, riding down over the central mountains — what was left of them — tearing off their tops, gouging out lakes which filled with melted water, dropping debris everywhere as they melted, and carrying our soil farther south — the soil that had weathered from the rocks during all these millions of years. The higher mountains, of course, have their own glaciers which work at reducing them all the time. But this was a great continental field of ice covering most of Canada. We find its marks almost everywhere.

So great was the weight of ice that Canada was depressed. Then the glaciers withdrew, Canada slowly rose, but not before the sea again entered up the St. Lawrence, and Ottawa valleys. Then this sea, too, withdrew.

So now we have Canada!

On the east lie the north end of the Appalachian Mountains in the Maritimes, eastern Quebec and Newfoundland — and, the coal fields on their margins, in Nova Scotia.

Along the greater valley of the St. Lawrence into western Ontario, on the western shores of Hudson and James Bays, and on some of the Arctic islands is the lower land formed of the sediments of the second, third, and fourth long periods of invasion, with the enclosed salt, gas, and oil of western Ontario.

From Labrador to the east shore of Lake Winnipeg, thence north to Great Bear Lake are the roots of the ancient central mountains, the backbone of the continent which we call the Canadian Shield. In these rocks, lies the great mineral wealth of Canada.

Under the more level Prairie Provinces lie the deposits of the later seas, and beneath them the coral reefs of the fourth great period of invasion with their oil reservoirs.

In the west we have the Rocky Mountains of western Alberta and British Columbia showing some of their history in the up-turned rocks from that ancient trough with its records dating back to the first invasion; and west of the Rockies lie the granites that welled up from below with their great mineral wealth.

This, then, is Canada.

GEOLOGY
(Explanation of terms)

Geology is the story of the rocks around us. Actually the solid earth underfoot is not as solid as it seems. It undergoes constant stirrings. Sometimes these take place before our eyes, as when volcanoes spurt out molten rock or earthquakes wrack the globe's thin crust. But usually the shifts are on a far slower and larger scale, as whole regions rise or subside, tilt or warp. In either case, no plain, no cliff is permanent. By studying the record of past change written on the face of the earth, geologists can not only trace the past but also infer what the future holds in store.

The basic fact about the earth's crust, whether above or below water, is that it is virtually all solid rock. This is not always apparent, as soil, vegetation and rock fragments (sand and gravel) are littered everywhere. But whereas this cloak of crustal debris is measured in feet or yards, the underlying bedrock is measured in miles.

This rock is broken down into three great groups; the igneous, the sedimentary and the metamorphic.

Igneous Rocks — were once molten and are believed to have come from deep in the earth, cooling at various rates and assuming various forms ranging from smooth basalt to grainy granite.

Sedimentary Rocks — as their name implies, are formed of layers of such materials as sand and clay washed down into lakes and oceans. These sediments, cemented together under pressure and often raised up again by later earth's movements, include sandstones, shales, limestones and dolomites. It is in these rocks, particularly in shales and limestones, that fossil deposits are found.

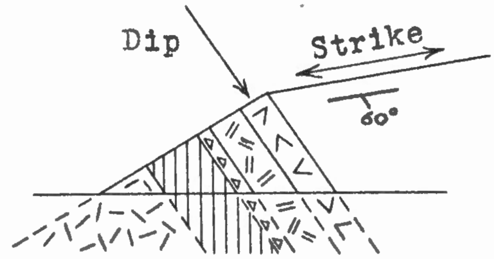
Metamorphic Rocks — are also aptly named: they are changed in form, reborn by heat and pressure during periods of deep burial. Thus slate was once clay, quartzite is a changed form of sandstone and marble is reconstituted limestone or dolomite.

Man's only direct experience with rock formation comes from active volcanoes — holes in the earth's crust from which molten rock, pours forth. This is the prototype of all igneous rocks. Lava does not always reach the surface by the volcanic route. Sometimes, it does not reach the surface at all. If it can find no outlet, or if there is not sufficient pressure behind it to force one, it may merely thrust it's way up into cracks or between layers of rock near the surface. Sometimes it forms underground lakes, pushing up the surface above like a blister but not breaking through. Often it runs along natural fissures. Sometimes into a vertical crack, hardens there like a wall and is called a dyke. They are often exposed millions of years later by erosion.

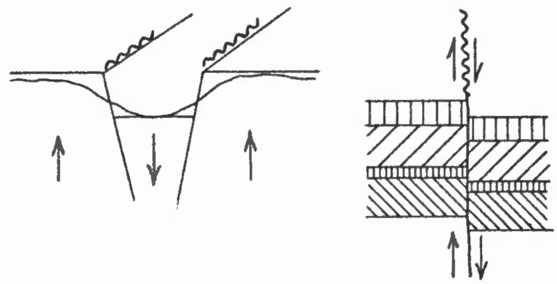
But the primary interest is in showing the relationship between the drawn geological map symbols and the features on the ground.

Lateral Moraine — rock and gravel on edge of glaciers, when two glaciers join, their moraines join and become a central moraine called a medial moraine.

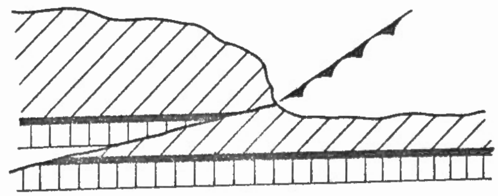
Bedding-measurement of rock outcrops for dip and strike.



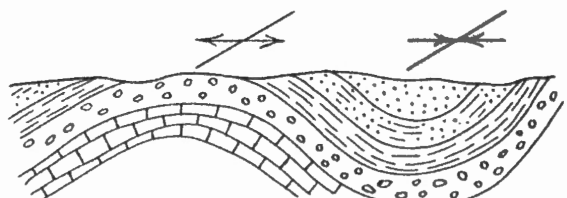
Fault-when rock layers are broken and shifted-- raised (squeezed up), subside, and horizontal movement.



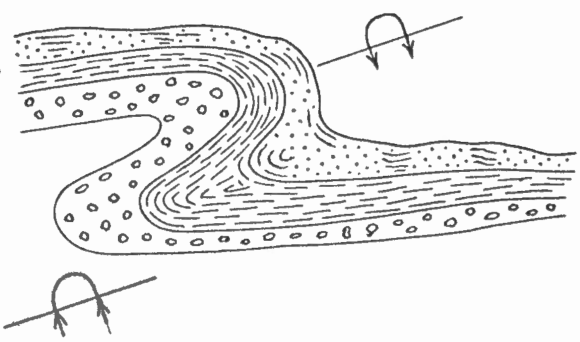
Thrust fault-severe folding with horizontal sliding (teeth in direction of dip)



Fold-strata buckled by compression, but not fractured forming ridges, which become anticlines and synclines.



Overturned anticline & syncline.



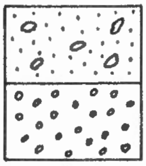
Further explanation of symbols can be obtained from "Prospecting in Canada", Econ.Geol.Ser.No 7.

PRINCIPAL PATTERNS

(Geological Maps & Figures)

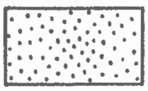
The following patterns are only suggested, and may be changed as the need arises.

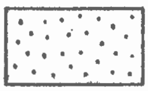
Sedimentary Rocks


Conglomerate

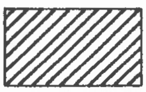

Limestone


Shale

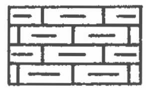

Drift

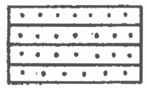

Siltstone or Sandstone

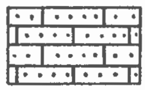

Dolomite

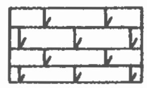

Slate

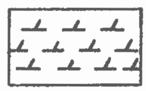

Gypsum or A nhydrite

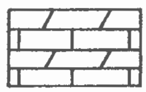

Shaly Limestone


Shaly Sandstone


Sandy Limestone

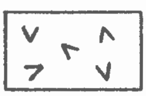

Dolomitic Limestone

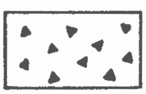

Dolomitic Shale


Dolomite & Limestone

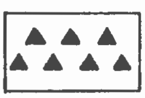

Vuggy or cavernous

Igneous Rocks

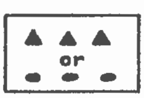

Granite or Granodiorite


Breccia


Greenstone

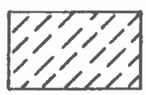

Trachyte,Rhyolite,Porphyry

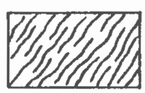

Porphyry

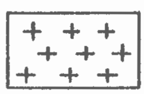


Chert

Metamorphic Rocks


Gneiss


Schist


Quartzite

GLOSSARY OF CARTOGRAPHIC TERMS

Altitude - vertical distance above datum, usually mean sea-level, to an object or point in space.

Altitude Tints - a sequence of colours usually varying from green to brown, marking zones of elevations between successive contour lines.

Ammonia Process (Diazo, Ozalid) - a positive printing process in which sheets are coated with a compound which decomposes on exposure to light. The unexposed lines will darken in ammonia fumes.

Azimuth - the angle, measured clockwise, in a plane tangent either to the spheroid or to the geoid, between a meridian and a point projected onto the plane.

Azimuthal Equidistant Projection - on which straight lines radiating from the centre or pole of projection represent great circles in their true azimuths from that centre, and lengths along those lines are of exact scale. This projection is neither equal-area nor conformal.

Bar Scale - a line or system of parallel lines divided at specified intervals to indicate distances on the map. Usually part of the marginal information.

Blueline - an image obtained by coating a surface with a light-sensitive iron salt which decomposes when exposed to a brilliant light. Exposed area turn blue when developed. The blue-line is non-photographic under controlled photographic processes.

Cartography - the art and science of making maps, charts, globes and relief models.

Central Meridian - the line of longitude occupying the centre of a projection. Generally the basis for constructing the projection.

Composite Print - reproduction from a successive series of images. A proof made by exposing the negatives of colour-separation sheets one after the other on a single sheet of black and white or blueprint paper which when developed, contains the images of all the negatives on a single sheet. Used in checking.

Conformal Map Projection - a projection on which the shape of any small area remains unchanged.

Conic Projections - a group of projections which are derived from the concept of projecting the parallels and meridians of a globe upon a tangent or secant cone and then developing the cone into a plane.

Contact Printing - a process which produces a print the same size as the original by lighting through the design, which is in direct contact with a sensitized sheet.

Contour - an imaginary line on the ground all points of which are at the same elevation above a specified datum.

Contour Interval - the constant difference in elevation between successive contours.

Coordinates - linear or angular quantities (usually two-dimensional) which designate the position which a point occupies in a given reference plane or system.

Plane coordinates: a system of coordinates in a horizontal plane, used to describe the positions of points with respect to an arbitrary origin by means of two distances perpendicular to each other.

Rectangular coordinates: same as plane coordinates (plane rectangular). Grid coordinates: a plane rectangular coordinate system based upon, and mathematically adjusted to a map projection in order that geographic positions (latitudes and longitudes) readily may be transferred into plane coordinates and the computations relating to them by the ordinary methods of plane surveying.

Culture - those features of terrain that have been constructed by man, such as roads, trails, buildings and canals; also boundary lines and all names and legends.

Cylindrical Projections - a group of projections with horizontal parallels and evenly set vertical meridians.

Datum - a reference element, such as a line or plane, to which the positions of other elements are related.

Declination, magnetic - the horizontal angle between the true north and the magnetic north.

Elevation - vertical distances above the datum, usually mean sea-level, to a point or object on the earth's surface.

Equal-Area (equivalent) Projections - a group of projections upon which any area, large or small, is the same as on a globe of corresponding scale.

Equator - an imaginary line around the earth which is everywhere equidistant from the poles.

Foreshore - that area which is bare or awash at low tide, but covered at high tide.

Form Lines - lines having the same appearance as contour lines but which have been sketched from visual observations to show the shape of the terrain rather than its elevation.

Gazetteer - a list of place names usually giving the geographic locations and grid references of places listed.

Geoid - the shape of the earth considered as a mean sea-level surface extended continuously under the continents.

Globe - a spherical body. In cartography it refers to a small sphere representing the earth.

Graticule - a system of lines upon a plane surface, representing latitude and longitude. The term "Projection" has a strictly geometrical meaning, while many of the systems of lines in common use for map-making have no such projectional basis for their construction.

Great Circle - a circle on a sphere produced by any plane which passes through the centre of the sphere.

Greenwich Meridian - the meridian passing through Greenwich, England, and designated as the zero or standard meridian on maps made in Britain, North America, and many other countries.

Grid System - a systematic network of regularly spaced lines, intersecting usually at right angles, upon which coordinates are based and to which the map features are referenced.

Grid Values - numbers appearing in the margin of and on the face of a map labeling grid lines. Those in the margin at the four corners are complete; the others are usually abbreviated.

Grid Zone - a column, 6° in latitude, whose grid coordinates are based on the same origin. In the Universal Transverse Mercator Grid system, the zones are numbered from 1 to 60, beginning at 180° and progressing eastwards.

Hachuring - a method of relief representation on maps by short lines which run parallel to the dip of the slope. The steeper the slope the heavier the line.

Halftone - a shade between black and white, reproduced by the use of halftone screens.

Hydrography - the representation of water features on maps.

Intermittent River or Lake - a river or lake which is dry for three months or more, on the average.

Isometric Diagram - a drawing of a three-dimensional body related to three axes. The dimensions parallel to the axes are true to scale. One of the axes is usually vertical.

Isogram - any line which connects points of equal value. Derived from the Greek prefix 'Iso' meaning equal.

Isobars - lines of equal barometric pressure values.

Isobath - lines of equal depth below water values.

Isobase - lines of equal value for places that have been raised the same amount since some certain time, as the glacial epoch.

Isocrymes - lines of equal frost values.

Isogenic - lines of equal magnetic declination values.

Isograd - lines showing metamorphic rocks of equal age, or amounts of heat and pressure.

Isohyets - lines of equal rainfall values.

Isohels - lines of equal sunshine values.

Isohypses - lines of equal elevation (contours) values.

Isopach - lines on a map drawn through points of equal thickness.

Isopleth - lines of equal quantitive values.

Isotherms - lines of equal temperature values.

Latitude - a plane passing through to globe perpendicular to its axis and midway between the north and south poles would cut its surface on the equator, the zero parallel of latitude. Any plane parallel to the equator is also a measurement of latitude.

Legend - an explanation of symbols on a map.

Longitude - any plane passing through the north and south poles of the earth is a meridian of longitude.

Loxodrome - a line on the map which crosses the successive meridians at constant angle. Also called a "rhumb line".

Map - a selective, symbolized, and generalized picture on a much reduced scale of some spatial distribution of a large area, usually the earth's surface.

Map Projection - any regular set of parallels and meridians upon which a map can be drawn.

Mean Sea Level - the average height of the sea for all stages of the tide.

Meridian - the trace of plane on the earth's surface which passes through the poles. Meridians are in a North-South direction.

Metre - unit of length derived from 10-millionth part of the arc distance between the equator and poles. It is 39.37 in. long.

Mosaic - several air photos mounted together to form a continuous picture of a larger area.

Neatline - the line which surrounds the map itself. Differs from margin in that the margin is outside the neatline.

Origin of Grid Systems - a point from which the grid lines are laid out, usually in the centre of the grid zone. 'False Origin' is a point west and south of the grid zone from which grids are actually numbered to avoid negative values.

Overlay - a record on a transparent medium to be superimposed on a drawing.

Parallels - lines on the earth's surface cut by planes parallel to the equator. In cartography they are regarded as circles. Parallels are in a East-West direction.

Photogrammetry - the science and art of preparing map from photo's.

Planimetre - instrument for measuring the area of a plane surface.

Profile - a vertical section along a straight or curved line.

Proportional Divider - an X-shaped divider, formed by jointing a pair of two-pointed arms, which is used for enlargement and reduction.

Registration Marks - points on four sides of the map, by which the colour-separation drawings are fitted to each other.

Reproduction - the summation of all the processes involved in printing copies from an original drawing.

Representative Fraction - map scale giving the ratio between any small distance on the map and the corresponding distance on the ground (1:63, 360).

Rhumb Line - see loxodrome.

Scale - the ratio of distance measured on a map to the corresponding distance on the ground. Different from representative fraction only in that scale can be expressed in other than fractional form; that is, such as an equation with different units of measurement on each side.

Scribing - engraving lines, symbols and windows in a scribe coating, usually for the preparation of a negative for map reproduction.

Sepia Print - a photographic reproduction obtained by the use of a surface with a light sensitive iron and silver salt in a gelatin coating, which after exposure to brilliant light will turn brown when developed. Also known as Van Dyke.

Small Circles - any other circle of latitude whose centres lie somewhere within the globe but not at the centre.

Sphere - a body of space bounded by one surface, all points of which are equally distant from a point within called its centre.

Spot Height - a point whose elevation is noted on a map.

Symbols - designs on maps used to represent various features.

Structure Contour - lines drawn to represent the surface of any single bed or top of a formation below the earth's surface.

Three-Colour Process - a method of colour reproduction using filters and half-tone screen.

Tick - short lines perpendicular to the neatline marking grid systems.

Topographic Map - a general map of large to medium scale showing all important features, including relief.

Transverse Projections - a map projection turned up to 90 degrees from its usual orientation in relation to the globe.

Vanishing Point - the point in perspective where parallel lines meet.

Vertical Exaggeration - enlarging the vertical component on a profile, relief model, or block diagram to make it more apparent.

Zip-a-tone - adhesive-backed cellophane on which symbols for maps are printed.