MILITARY SKETCHING

AND

RECONNAISSANCE

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BY

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PREFACE

THIS book is intended to be instructive, and in order that it may be so I have endeavoured to describe everything as simply as possible, not hesitating to indulge in constant repetitions where I have deemed them necessary. The reader is considered to be a beginner, and he is taken through the subject from start to finish. By studying the earlier chapters, by putting into practice what he reads, and by working on the lines recommended in the later chapters, I feel confident that any British officer may become (even without personal instruction) a thoroughly efficient military sketcher. I would go further, and say that he may become a trained observer, an expert scout, and a man capable of developing in others their latent powers of observation.

Many men imagine that they are unable to draw or to produce good topographical work, and that consequently the study of Military Sketching is for them a waste of time. This is a fallacy. The worst draughtsman may, on service, produce invaluable work, and furnish information of the greatest importance, provided that he has trained himself in the allied branches of military science, and knows what to look out for and how to report it. Map-making and map-reading are in reality but a small part of what is sometimes termed 'Military Topography,' for the latter includes also an acquirement of knowledge inseparable from and indispensable to the study of tactics, field engineering, military history, &c.

It is, perhaps, unnecessary to add that it is hoped that the following pages contain sufficient information on the subject to enable any officer—Regular, Militia, or Volunteer—to pass the required examinations up to the rank of Lieut.-Colonel, and that nothing in the book is contrary to the rules and principles officially laid down in the *Manual of Field Sketching and Reconnaissance*, 1903.

Military Sketching & Reconnaissance

By Lieut.-Col. A. F. MOCKLER-FERRYMAN.

ADDITIONS AND ALTERATIONS, 1907.

THE official *Manual of Map-Reading and Field-Sketching*, published in 1906, has introduced a few changes of a technical nature which should be known to students preparing themselves for the examinations in Military Topography.

In order to bring *Military Sketching and Reconnaissance* into line with the official *Manual*, the following alterations are necessary :

COLOURED PLATES.

All masonry, such as buildings, bridges, etc., should be in black, not red. Main roads should be coloured brown, not yellow. The conventional signs for marshes, wells, windmills, lighthouses, etc., should be altered, as explained below.

CHAPTER I.

Main roads to be coloured brown.

If a red line is used to denote a railway, the word "railway" should be written along it.

A marsh is all in blue, with the word " marsh " in black.

A well is represented by a small blue circle, with a blue **W.** beside it.

All masonry to be in black.

A lighthouse is represented by a small black dot, with **L. H.** written by it.

A windmill is a circle with a cross above it.

The nature of cultivation, etc., should be written in in black.

The width of a river should be written by its side.

Mounted Infantry is represented by the sign for cavalry, with **M. I.** written close to it.

P. stands for post office; **T** for telegraph office; **S. P.** for sign-post.

CHAPTER III.

In this chapter and elsewhere the new term *Ruling-point* may be considered to be synonomous with the term *Station*. A ruling-point, however, has a somewhat wider meaning, being selected not only for purposes of triangulation, but also with a view to the simultaneous sketching-in of hill-features.

[P.T.O.

CHAPTER VI.

Page 63, Fig. 14. The word "magnetic" is now written along the magnetic meridian.

CHAPTER VII.

Page 73, Fig. 18. A new pattern of the Luminous Prismatic Compass has been introduced. The card has a double set of figures, those on the outer circle being reversed for use with the prism, those on the inner circle being as on the card of an ordinary compass.

CHAPTER VIII.

The *Manual* does not use the term "contour" in connection with field-sketching.

"Form-line" (or sketch-contour) is the new term.

CHAPTER IX.

Page 88. After "Brow" insert "or Crest."

The following is the new definition of Watershed: "A ridge of high land separating two drainage basins; the summit of land from which water divides or flows in two directions. A watershed does not necessarily include the *highest points* of a chain of mountains or range of hills."

N.B. The general method of field-sketching set forth in the *Manual* deals with hill-features from the outset. Certain ruling-points are selected on the ground, on account of their suitability both for triangulation and for aid in obtaining the shape and levels of the ground. In other words, the system laid down in the *Manual* is a simultaneous combination of the methods described in Chapter III. and on pages 94–97 of *Military Sketching and Reconnaissance.*

CHAPTER XV.

Page 149, footnote. For "1902" read "1905."

APPENDIX IV.

BROW.—Add "or Crest."

NORMAL SYSTEM OF CONTOURING.—The rule quoted in the latter part of this paragraph has been modified, *e.g.* sketches on a scale of four or six inches to one mile may have Vertical Intervals at 20 feet.

RULING-POINTS.—Insert the following: Ruling-points are such objects on the ground as the sketcher selects as likely to be of value to him in making his sketch. Their positions and heights are fixed and determined by instruments, and are laid down on the paper as accurately as possible. A ruling-point is therefore a fixed station, or intersected point, the height of which, with reference to an assumed datum (or a known level) has been worked out by means of a clinometer and the Triangle of Reference formula.

WATERSHED.—See definition given above.

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APPENDICES

ILLUSTRATIONS

(1) *PLATES*

(2) *TEXT DIAGRAMS*

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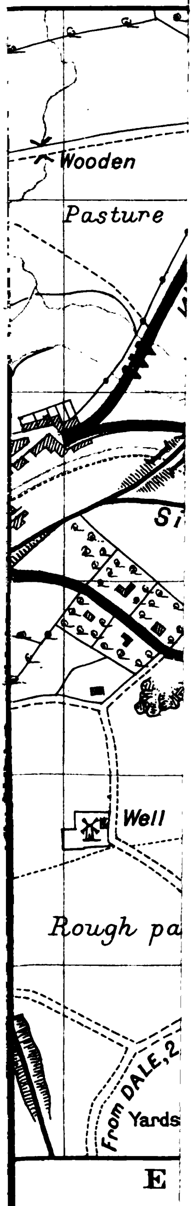


MILITARY SKETCHING

AND

RECONNAISSANCE

CHAPTER I

INTRODUCTION

Definitions—Map—Plan—Surveying—Survey—Topographical Survey—Military Survey—Military Sketch—Drawing—Printing—Copying Maps—Enlarging and Reducing—Examples—Finishing Sketches—Pacing Yards—Conventional Signs.

OF all branches of military science Military Sketching and Reconnaissance is perhaps the most practical. A man must set to work in the field as soon as possible, but, of course, he must study the theory of the subject before he can practise it.

DEFINITIONS:—A MAP is the representation on a plane of the surface of the earth, or of a portion of it. It is the actual drawing (indoors) compiled from the work of surveyors in the field.

A PLAN of a portion of country or of any object is the delineation of their outline as seen from a position vertically over them (*e.g.* from a balloon).

SURVEYING is the art of measuring, and representing in plan at a reduced scale, the shape and size of a portion of the surface of the earth. The result is called a SURVEY, and if is added a delineation of the heights of the features, and various other details, it is called a TOPOGRAPHICAL SURVEY (*e.g.* the contoured Ordnance Maps).

A MILITARY SURVEY is a topographical survey (usually of limited extent) made for military purposes.

(N.B.—Surveys are made, with the best possible instruments, by trained civilian or military surveyors.)

A Military Sketch is made with portable, or pocket, instruments or sometimes without instruments (see Chapter X.), by any officer or non-commissioned officer.

The main point to remember is that in military sketching one tries to get as near to actual topographical surveying as is possible with portable instruments, bearing in mind always that particular attention must be paid to features likely to be of importance for military or tactical purposes. Thus a fold in the ground that the civilian topographer might overlook might be of vital tactical importance, as affording cover to a body of troops, gun-teams, &c. Above all things, the military sketcher should be able to represent things faithfully and without exaggeration, for his sketch is intended for those who have never seen the country depicted. He must be accurate, clear, and neat in his drawing, as well as in his writing.

By drawing is not meant *freehand* drawing, but the simple process of drawing lines and the detail usually shown on maps, which can readily be acquired by anyone. The best practice is to take the conventional signs shown in Plates I. and II., and copy each one neatly and to the same size as on the original. Copy also some of the printed matter, for unless the sketcher writes a clear copper-plate hand it will be much easier for him to learn to print in italics, and in block, than to attempt to write small and neatly.

The most convenient size for printing is *Italics*, $\frac{\frac{3}{60}\text{ inch}}{\frac{4}{60}\text{ inch}}$, the capitals and long letters being the full $\frac{7}{60}$ inch; **SMALL BLOCK**, $\frac{7}{60}$ inch; and **LARGE BLOCK** $\frac{10}{60}$ inch. Parallel lines at these intervals apart should be ruled with the Marquois Scales; for *italics* occasional sloping lines should also be ruled to guide the eye; and for all block-printing it is essential to make each letter fit into a square, leaving the space of half a square between each letter. With a little practice the eye becomes so trained that very fair printing can be done without ruling lines at all. The whole of the printing on a sketch should be in *italics*, except names of places, which should be in **SMALL BLOCK** (*i.e.* capitals), and the title of the sketch, which should be in **LARGE BLOCK**; and all printing should be parallel to the top and bottom of the sketch, except names of rivers and mountain ranges, tactical and explanatory notes, and names of villages, &c. (off the sketch), to or from which roads or railways run.

If after considerable practice a man finds that he cannot *print* to his satisfaction, let him *write* clearly and legibly, for inability to print will not prevent his executing valuable topographical work. At the same time it may be mentioned that, as far as officers of the army are concerned, there is not one man in a hundred who writes better than he prints.

Finally, before commencing sketching, it is as well to make an accurate copy of some good sketch of a piece of ground containing plenty of detail, or of a portion of a large-scale map. This should be reproduced either the same size (*i.e.* on the same scale), or reduced, or enlarged, to a different scale.

It may frequently be useful to be able to copy a map, and there are several ways of doing so. If a simple reproduction is required, the map can be traced off up against a window, or, if on too thick paper (*e.g.* card), a tracing taken off on thin paper and then transferred to the drawing-paper with transfer (or carbon) paper.[1] But for general purposes the method of squares is the handiest; this consists in ruling squares of convenient size on the original, and then ruling on the drawing-paper squares the length of the sides of which bear to the length of the sides of the squares on the original the proportion between the scale of the proposed copy and the scale of the original. Thus, supposing the copy is to be on the same scale as the original, the sides of the squares on each would be of

[1] As a rule carbon paper is greasy and dirty. The best plan is to make the tracing, and then go over the back of it with a soft (BB) pencil.

the same length. If a reduction were required, say, to half the scale, then the size of the squares on the drawing-paper would be drawn half the length of the sides of the squares on the original. Similarly, if an enlargement, say, to three times the scale, were to be made, then the sides of the drawing-paper squares would have to be three times the length of the sides of the original squares. (Examples will be found in Appendix III.)

Having ruled the squares of the correct size on the original and on the drawing-paper, number each to correspond, then copy (freehand) as accurately as possible on to each square of the drawing-paper the detail shown in the square (of the same number) on the original. (Plate I.)

With regard to actual drawing: draw everything in pencil first, working with a light hand, with a pencil the marks of which will rub out easily (HB), and keeping always a fine point to your pencil. A piece of sandpaper (or even a pebble picked up when out of doors) is useful for maintaining a fine point. Now proceed to ink in, using a fine pen, but in an ordinary-sized holder, so as not to cramp the hand; use well rubbed-up Indian ink, or prepared waterproof ink. When everything has been inked over, clean out all pencil lines with bread or soft indiarubber.

It is customary to finish field-sketches either in ink (as above) or in pencil. When finishing in *ink*, any detail requiring colour is *painted*; in *pencil* finishing, colour is applied with *coloured chalks*. To produce a neatly finished pencil sketch is more difficult than to ink in a sketch. The following is recommended as likely to give good results. Place a couple of sheets of blotting-paper under your sketch; with a hard pencil (HHH) go over everything, as if you were finishing in ink. The blotting-pad causes the pencil to work deep into the paper, and lines thus drawn cannot be rubbed out, so you can clean up thoroughly with indiarubber or bread. Coloured chalks should be applied the last thing of all, after cleaning up; otherwise they are liable to smudge. The greatest care is required in their use: the point must be kept fine, and the pencil should be worked round in the hand as it is being used. The beginner is inclined to put on his colour much too dark, thus killing the general effect of the drawing; when, for instance, a lake has to be coloured with blue chalk, this should be done with thin horizontal lines about $\frac{1}{16}$ inch apart, and not by rubbing blue chalk all over the lake.

Accuracy and clearness come first, neatness and finish next. An inaccurate sketch, however artistically produced, is valueless for military purposes. To attain accuracy it is necessary to be proficient in handling one's instruments, and to be able, when sketching on foot, to *pace yards correctly.* The importance of the latter cannot be over-estimated; and before attempting field-work the sketcher should religiously practise his pacing over a known distance, until he finds himself proficient. A smart, even step, at the rate of at least four miles an hour, is necessary to produce reliable results. Check the stride down-hill, increase it up-hill; and keep a record of distances by closing a finger for every hundred yards. With very little trouble anyone can learn to pace yards with an error of less than 3 per cent.

CONVENTIONAL SIGNS.—These are laid down 'by authority,' and must be strictly adhered to. They have been fixed on, after due consideration, for convenience, and they are understood by every military man.

In many cases the sign represents the object in plan (*i.e.* as seen from above), drawn approximately to scale.

It is not necessary to explain each sign, as a study of Plates I. and II. will show the sketcher exactly what is required. There are, however, one or two things which may not be quite clear:

Roads are drawn with dotted lines (if possible, the correct distance apart to scale) when unfenced—*e.g.* a road crossing an open common; with continuous lines when fenced in any way (hedge, bank, rails, wall, &c.). The words 'metalled' or 'unmetalled' should be written by the side of the road, and *main roads* should be coloured yellow.

Roads are officially classed as follows:

1*st class*, good road, metal more than 14 feet wide.

2*nd class*, good road, metal less than 14 feet wide.

3*rd class*, indifferent metalled road.

4*th class*, unmetalled road.

A *Path* along which a waggon or cart cannot go is shown by a single dotted line.

At the ends of all roads, paths, and railways should be printed, in the margin of the sketch and parallel to the direction of the road &c., the name of the nearest village or town, as well as its distance. In printing these names, '*From*' should be put before all names on the *left* and *bottom*, '*To*' before all names on the *right* and *top* of the sketch. To keep this in your mind, remember that all your ordinary writing—the writing of all Western languages—runs from the left-hand to the right-hand, so you write *From left; To right;* or remember that the place is situated to the left of the *F* when you use *From*, and to the right of the *o* when you use *To*.

A *Railway* should have the words 'single' or 'double' written along it here and there. A single red line, or a black line with cross-pieces.

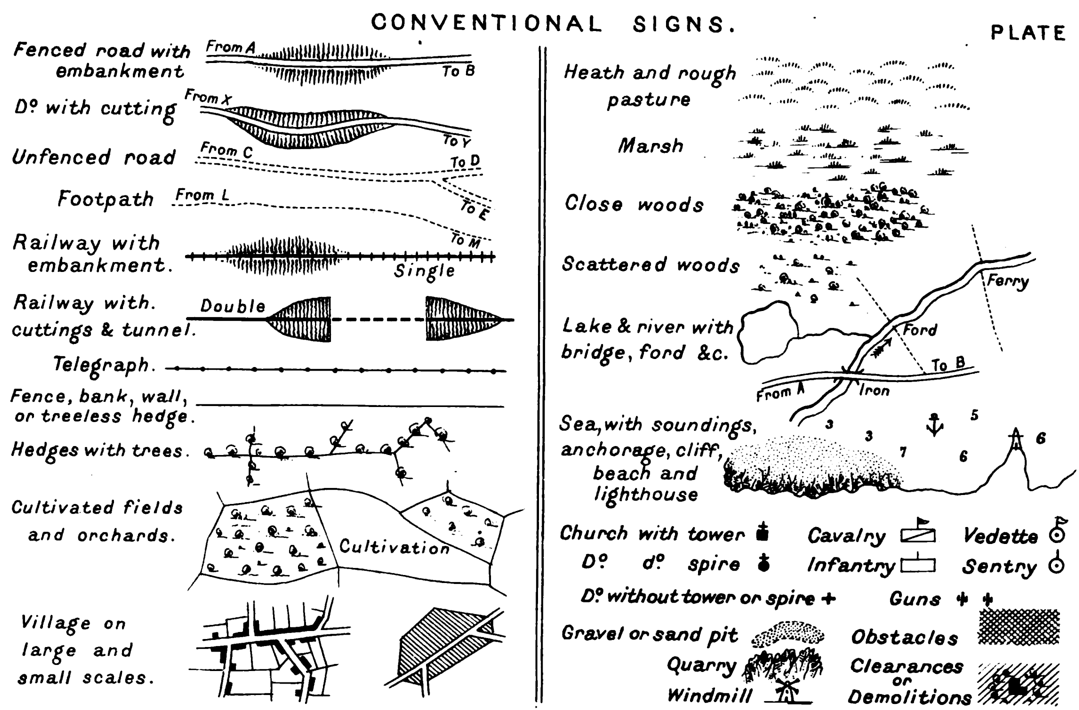
A *River* or *Stream* is shown by a single blue line if under 15 feet wide; double lines (with colour between) if over 15 feet wide. The name of the river should be written along its bank. A black arrow with feathers should be drawn by the side of the river to indicate the direction in which the water is flowing.

N.B.—A *River* contains running water at all seasons; a *Torrent* dries up in the summer or dry season; *Rivulets* and *Brooks* are small *Streams*.

The banks of a river are described as *Right* and *Left* in accordance with the direction in which the river is flowing. A person sitting in a boat drifting downstream, and facing the way he is going (*i.e.* towards the mouth), has the *right* bank on his right hand, and the *left* bank on his left hand.

The *Rate* at which a river flows is generally described as so many miles per hour; and the *Fall* (*i.e.* the slope of the bed) as so many inches or feet per mile.

PLATE II.


CONVENTIONAL SIGNS.
Fenced road with embankment
From A
To B
D° with cutting
From X
To Y
Unfenced road
From C
To D
Footpath
From L
To E
Railway with embankment.
To M
Single
Railway with. cuttings & tunnel.
Double
Telegraph.
Fence, bank, wall, or treeless hedge.
Hedges with trees.
Cultivated fields and orchards.
Cultivation
Village on large and small scales.
Heath and rough pasture
Marsh
Close woods
Scattered woods
Lake & river with bridge, ford &c.
Ferry
Ford
To B
From A
Iron
Sea, with soundings, anchorage, cliff, beach and lighthouse
3
3
7
5
6
6
Church with tower
D° d° spire
D° without tower or spire
Cavalry
Infantry
Vedette
Sentry
Guns
Gravel or sand pit
Quarry
Windmill
Obstacles
Clearances or Demolitions

Marshes are drawn as shown in the Plate, in black, with some blue horizontal lines here and there to represent the water among the rushes or grass.

Woods are all drawn in the same way; but the nature of the trees, and whether affording cover to troops or not, should always be written in. A wash of green paint, or horizontal green lines in chalk, may take the place of the Conventional Sign.

Ordinary Military Sketches should, when possible, be drawn with the top to the north; in the case of a scheme, with the top towards the enemy; while the starting-point of a Route Sketch should be at the bottom of the paper.

Every Military Sketch should have on it: (1) A descriptive heading or title, (2) North Point,[1] (3) Scale, (4) if contoured, Scale of Slopes, (5) Signature (with rank and regiment) of the sketcher, (6) Date when executed.

The appearance of a sketch is always improved by trimming—*i.e.* cutting off the waste edges and making the corners rectangular.

COLOURS to be used (light shades) in finishing up sketches:

Blue, water (enemy's troops, when shown).

Green, woods (when trees are not represented by the Conventional Sign).

Yellow (ochre), main roads (1*st* and 2*nd Class*).

Brown (burnt sienna), contours, and form lines.

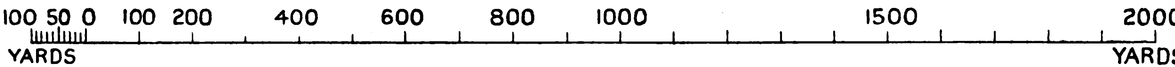
Red (crimson lake), masonry, contours (as an alternative for brown), base and intersected points (stations), railways, intrenchments, (British troops, when shown).

Black, everything not mentioned above (iron or wooden buildings or bridges should be distinguished by the material being written in).

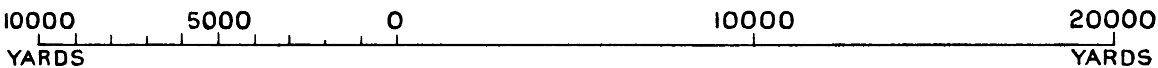
[1] See page 63. The North Point should never be drawn in the left-hand top corner, otherwise it may be concealed if the sketch is fastened to other papers.

PLAIN SCALES

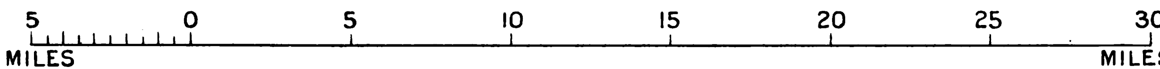
Scale $\frac{1}{12672}$ or 5" to 1 mile

(Fig. 1) 

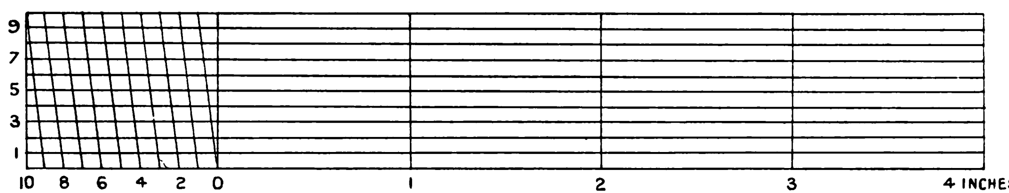
Scale $\frac{1}{190080}$ or 3 miles to 1 inch

(Fig. 2) 

Scale $\frac{1}{380160}$ or 6 miles to 1 inch

(Fig. 3) 

DIAGONAL SCALE OF INCHES

(Fig. 4) 

CHAPTER II

SCALES

Simplicity of Scales — Definition — Representative Fraction — Rapid Measurements—Rules for Calculations—Plain Scales—Examples—Scales for various Plans.

A MAP must, of course, have a scale attached to it, otherwise it is impossible to tell the distance from one place to another; therefore the man who would make a military sketch must be able to draw a scale for his sketch. Now, this matter of scales is often considered by beginners as an almost insurmountable difficulty. Whole volumes have been written on the subject, and the embryo military draughtsman imagines that he must master all the intricacies of scale-making before he can make a start with actual sketching. For the trained surveyor a considerable knowledge of scales is a necessity, but the practical military sketcher—*i.e.* the ordinary British officer—need not trouble his head about anything more than what is contained in this chapter and in Chapter XI.

The scale of a map (or sketch) is the proportion which it lineally bears to the actual size of the ground represented—that is to say, it is the proportion between lines on paper and lines in nature. For instance, on a map drawn at a scale of 1 inch to 1 mile, a line an inch long on the paper represents a line a mile long in nature.

In England it is usual to name the scale of a map in two ways:

1. So many inches to the mile, or so many miles to the inch.

2. The fraction representing the linear proportion between the map and the ground. This is called the REPRESENTATIVE FRACTION, which means that a line on the map is drawn the named fraction of the length of the line which it represents on the ground.

The scales drawn on military sketches should always be headed in both the above ways, because the number of inches to the mile, or miles to the inch, is readily comprehended by everyone,[1] and the Representative Fraction is useful for comparing the sketch with other sketches or maps (whether English or foreign) of the same piece of ground drawn at different scales.

This Representative Fraction consists of 1 for the numerator, and for the denominator the figures showing the proportionate measurement of a line with reference to, and in the same terms as, 1. Thus R. F. $\frac{1}{10000}$ means that one linear inch on the plan represents 10,000 linear inches on the ground; or 1 foot on the plan represents 10,000 feet on the ground. So with foreign maps, the above R. F. would mean, for instance, 1 metre represents 10,000 metres, and so on according to the nationality of the man who made the map.

In order to save labour in working out scales, it is recommended that the following should be learned by heart:

63,360 inches = 1 mile.
5,280 feet = 1 mile.

Scale of 1 in. to 1 mile = R. F. $\frac{1}{63,360}$

" " 6 in. " = " $\frac{1}{10,560}$

[1] Most people can estimate the length of an inch by eye, but everyone should be able to measure off distances on a map rapidly with his fingers. Register the following: Which joint of which finger is the nearest approach to 1 inch; the width across the knuckles of the hand when laid flat on the table; between the tip of which finger and the tip of the thumb 8 inches can be just measured at the widest extension of the fingers. Note, also, that the diameter of a halfpenny is 1 inch.

Scale of 8 in. to 1 mile	=	R. F. $\frac{1}{7,920}$
,, ,, 2 miles to 1 in.	=	,, $\frac{1}{126,720}$
,, ,, 5 ,, ,,	=	,, $\frac{1}{316,800}$
,, ,, 10 ,, ,,	=	,, $\frac{1}{633,600}$
R. F. $\frac{1}{10,000}$	=	6·34 inches to 1 mile.
,, $\frac{1}{100,000}$	=	1·58 miles to 1 inch.
,, $\frac{1}{250,000}$	=	3·95 miles to 1 inch.
,, $\frac{1}{500,000}$	=	7·89 miles to 1 inch.

Rule 1.—*Given the number of inches to the mile, to find the R. F.*: Divide 63,360 (inches in 1 mile) by the number of inches to the mile of the scale; place the quotient as the denominator and 1 as the numerator—*e.g.* scale of 4 inches to 1 mile, $\frac{63360}{4} = 15,840$; R. F. $= \frac{1}{15840}$.

Rule 2.—*Given the number of miles to the inch, to find the R. F.*: Multiply 63,360 by the number of miles to the inch of the scale; the result gives the denominator as before —*e.g.* scale of 4 miles to 1 inch, $63,360 \times 4 = 253,440$; R. F. $= \frac{1}{253440}$.

Rule 3.—*Given the R. F., to find* (1) *the inches to the mile, or* (2) *miles to the inch, of the scale*: (1) Divide 63,360 by the denominator of the fraction; or (2) divide the denominator of the fraction by 63,360.

$$e.g.\ \text{R. F.}\ \frac{1}{12,000},\ \frac{63,360}{12,000} = 5{\cdot}28 \text{ inches to 1 mile;}$$

$$e.g.\ \text{R. F.}\ \frac{1}{200,000},\ \frac{200,000}{63,360} = 3{\cdot}15 \text{ miles to 1 inch.}$$

For purposes of military sketching it is only necessary to be able to construct what is known as a *plain scale*. Diagonal scales (which are employed for showing small measurements) are never used on an ordinary sketch, and all that need be known of their use is how to take off, from the diagonal scale of inches on the PROTRACTOR (*vide* Chapter VII.) a measurement running into two places of decimals. Suppose it is required to measure 3·68 inches; place the point of one leg of the dividers on the vertical line numbered 3 at the bottom and at its intersection with the horizontal line numbered 8 on the left, open the dividers until the point of the other leg is at the intersection of the diagonal line numbered 6 at the bottom with the horizontal line numbered 8 on the left. The total distance thus measured is 3·68 inches. (Plate III., fig. 4.)

With regard to the construction of the *plain scale* which is to be shown on the sketch, it is customary when the scale is 'inches to the mile' to make a scale of yards, and when 'miles to the inch' a scale of miles.

The beginner will usually be working on what may be called a large scale—*i.e.* a certain number of inches to the mile—and for convenience he will generally employ one of the scales marked on his protractor or ruler. The scales so marked are generally 6 inches to 1 mile and 8 inches to 1 mile, from which (by multiplying or dividing) scales of 1, 2, 3, 4, 12, 16, 24 inches, &c., can be readily obtained. When using one of these scales, there is no trouble in drawing the scale on the plan, as it can be copied or adapted straight from the protractor. When, however, a sketch is ordered to be made on a scale not shown on the protractor or ruler, or when the sketcher does not happen to be provided with a protractor or scaled ruler, then he must be able to make a scale for himself.

EXAMPLE I.—*Construct a plain scale of yards, 5 inches to 1 mile.*—First, work out the R. F., as it will have to be shown in the heading of the scale. This will be found to be $\frac{1}{12672}$. Then, remembering that the *unit of measure* is in this case *yards*, and that the scale must be divided throughout into hundreds of yards (*primary divisions*), with the left-hand hundred subdivided into tens of yards (*secondary divisions*), decide how many yards altogether it will be best to show. The scale must not be unduly long or short; between 5 and 6 inches is usual. Here 5 inches will show 1,760 yards, and 6 inches would show 2,112 yards; so take a round sum, and show 2,000 yards in the main portion of the scale, and another 100 yards for the subdivided left-hand portion—*i.e.* you decide to have a line which will show altogether 2,100 yards. Now work out a simple calculation: If 6 inches represent 2,112 yards, how many inches will represent 2,100 yards?

$$2{,}112 : 6 :: 2{,}100 : x.$$

$$x = \frac{2{,}100 \times 6}{2{,}112}$$

$$x = 5{\cdot}96 \text{ inches.}$$

Measure off 5·96 inches, and draw a line that length. Divide the line into 21 equal parts, each of which will show 100 yards. Subdivide the left-hand hundred into 10 equal parts, which will show tens of yards. Name the scale, and draw it as in fig. 1, Plate III.

EXAMPLE II.—*You have a map which you are comparing with the ground; the scale has been torn off the map, and in order to draw a scale for it you pace the distance between two objects, which are shown on the map as* 2·75 *inches apart, and which you measure as* 550 *yards.*

Here 2·75 inches represent 550 yards; so 1 inch represents $\frac{550}{2{\cdot}75}$ yards, or 200 yards (taking *yards* as the *unit of measure*).

The R. F. of the scale would therefore be $\frac{1}{200 \times 36}$ —*i.e.* $\frac{1}{7200}$.

You know that your scale is to be between 5 inches and 6 inches long, and you see at a glance that 5 inches will show 1,000 yards, and that 6 inches will show 1,200; you therefore decide to show 1,000 yards in the main portion, and 100 yards in the subdivided left-hand portion, or 1,100 yards in all, which, without any calculation, you see will be represented by $5\frac{1}{2}$ inches.

Draw a line 5·5 inches long. Divide it into 11 equal parts, representing 100 yards each ; subdivide the left-hand hundred into 10 equal parts.

Figure the scale similarly to that shown in Example I., and write above it the usual heading, which will be Scale $\frac{1}{7200}$, or 8·8 inches to 1 mile.

EXAMPLE III.—*Construct a plain scale of yards for a map drawn at* 3 *miles to* 1 *inch.*—The R. F. will be $\frac{1}{63{,}360 \times 3}$, or $\frac{1}{190{,}080}$.

Proceed as in the previous examples, with *yards* as the *unit of measure.* 5 inches will show 15 miles, or 26,400 yards, and 6 inches will show 18 miles, or 31,680 yards. It is obvious that on a small scale like this it would be useless trying to show in any portion of the scale divisions of less than 1,000 yards ; but, as 10,000 yards is a good round figure, you decide that this shall be the main, or primary, division of the scale, that you will show 20,000 yards in the main portion of the scale, and subdivide 10,000 yards in the left-hand portion, so as to show thousands of yards.

Calculation.—If 6 inches represent 31,680 yards, how many inches will represent 30,000 yards?

$$31{,}680 : 6 :: 30{,}000 : x.$$

$$x = \frac{30{,}000 \times 6}{31{,}680}$$

$$x = 5{\cdot}68 \text{ inches.}$$

Draw a line 5·68 inches long, and divide it up as in fig. 2, Plate III.

Such a scale attached to a map would be useful principally for artillery ranges.

EXAMPLE IV.—*Construct a plain scale for a map drawn at* 6 *miles to the inch.*—For a scale of this size yards cannot be wanted, and the most that is necessary will be to show in the subdivisions halves of miles, *miles* being the *unit of measure.*

Here 5 inches will represent 30 miles, and 6 inches will represent 36 miles; therefore show altogether 35 miles.

Calculation.—If 5 inches represent 30 miles, how many inches will represent 35 miles?

$$30 : 5 :: 35 : x$$

$$x = \frac{35 \times 5}{30}$$

$$x = 5{\cdot}83 \text{ inches.}$$

Draw a line 5·83 inches long, and divide it up as in fig. 3, Plate III.

Most elementary books on Military Sketching go out of the way to create difficulties in the matter of scales, by giving examples of no practical value. The British officer sketching on foot need never use a scale other than one of yards or one of miles. Feet, links, chains, furlongs, and such-like measurements are quite outside all practical military sketching. On horseback or on a bicycle, &c., when sketching with the Cavalry Board, it is necessary to be able to construct a scale of time, of horses' paces, or bicycle revolutions; but these, as well as scales when sketching without instruments, will be dealt with later on in the book.

If it is left to the sketcher to select his own scale, he should bear in mind the object of the sketch; if much detail has to be shown, he must draw on a large scale. In short, the scale of the sketch depends entirely on the amount of detail required to be drawn in, and the time available.

ROUGH RULE.—*Towns or Villages* (to be placed in a state of defence, &c.) large scale, say 4 in. to 12 in. to 1 mile.

Positions, 2 in. to 4 in. to 1 mile.

Route Sketches, 1 in. to 3 in. to 1 mile.

Sketches of large Tracts of Country, 1 in. to 1 mile, or smaller.

The larger the scale, the longer it will take to make the sketch. How much detail it is necessary to show is a matter requiring great judgment, for absence of sufficient detail in a map may cause a disaster to troops in the field.

The amount of detail that *can* be drawn on a small-scale sketch can be judged of by studying a map like the 1-inch Ordnance Map, but the ordinary military sketcher must beware of overcrowding his sketch with unimportant detail.

CHAPTER III

THE FOUNDATIONS OF A SKETCH

General Principles—Triangulation, or Intersection of Stations—Base—Choice of Base—Stations—How to select them—Artificial Objects—Summary—Extension of Triangles—Advice to the Student.

MAP-MAKING is like building a house. Unless good foundations are laid, the whole structure will eventually collapse. No matter what instruments are used, the general principles on which a military sketch of an area is executed are exactly similar to those of a great trigonometrical survey of a country—which means that the country is divided up into a number of imaginary triangles, for the purpose of assisting the draughtsman in his step-by-step process of accurately drawing-in its features.

Suppose that you are taken out and shown a square mile of country, with boundaries roughly marked; and you are told that you have to sketch this on a scale of 4 inches to 1 mile. You know that the square mile of country will occupy on your paper a space 4 inches square, and that within that square of 4 inches you must draw in plan everything that is in the square mile of the ground, placing each object in its proper position relative to other objects. Now, in order to do this, you must get some sort of framework on to the paper, as a foundation whereon to build up the whole sketch.

This framework is obtained by what is termed TRIANGULATION (*i.e.* the making of triangles all over the paper), or, as it is also called, the INTERSECTION OF STATIONS, STATIONS being the name applied to conspicuous objects (such as noticeable trees, chimneys, church spires, &c.), in different parts of the piece of ground to be sketched. Each of these stations has to form the apex of a triangle, and the object of triangulation is to obtain the exact position of the apex of each triangle—*i.e.* the exact position of each station (fig. 3, page 23).

A triangle, as everyone knows, must have a base, and the first thing, therefore, to be done, before commencing the arrangement of triangles, is to select the position on the ground for making a start—in other words, to select the site for the Base, on which will afterwards stand the first and main set of triangles.

This base is the most important thing in the whole sketch, and it requires to be selected and measured with the greatest care, for it is to be a base common to several triangles.

Four principal considerations should be taken into account in the choice of the position of the base—viz.:

(1) Fairly *central* situation, with noticeable objects at each end.

(2) On tolerably *level* ground.

(3) A *good view* of the country from each end.

(4) Its *length* should be in proportion to the area to be sketched, the nature of the country, &c.

The *central situation* is important, as will be obvious to everyone, because, if the base is not somewhere near the centre, the stations or points which you wish to fix must on one side lie a long way off; and, of course, the farther they are from the base, the greater the liability to inaccuracy in determination, for they must either be fixed direct from the base ends by an acute intersection, or they would have to be fixed from what is termed a Subsidiary, or Secondary Base, which is not likely to be as accurate as the original or primary base.

The reason why the base should be on *level* ground, and unobstructed, is to obtain greater accuracy of measurement, for naturally one can pace with more reliable results on level ground than on undulating ground, also on smooth ground than on, say, ridge and furrow.

With regard to the third consideration, it need only be said that, since the whole sketch is to depend on the base and the triangles built up on it, the apex of each triangle (*i.e.* the point or station which has to be drawn on the paper in a position relative to that of the base) must be visible from the ends of the base.

As a rule, the longer the base the better, because from a short base the intersection of distant stations would be acute and unreliable (which will be referred to presently). For ordinary military sketches a base would seldom be less than 800 yards long.

It is not often possible to find for the base a site fulfilling all the above conditions. Something will probably have to give way; for instance, the centre of the ground to be sketched may be covered with a dense wood, or it may be most uneven.

Remember the conditions for the situation of a thoroughly satisfactory base, and if you have to give up one of them, pay greater attention to the fulfilment of the others—*e.g.*, if you cannot place the base in the centre, see that its ends are well defined, and that you can measure it with great accuracy, and perhaps make it rather longer than usual.

Before dismissing this question of the base, let us consider how it may be possible to overcome the difficulty of not being able to get a level and unobstructed central situation for the base; and this is best illustrated by an example (fig. 1).

The centre of the ground to be sketched is a deep wooded valley; a stream flows through the wood from north to south; outside the wood, on the east, a keeper's cottage stands on high ground overlooking the whole of the surrounding country; while on the west there is a tall solitary fir-tree growing on a knoll. The chimney of the cottage and the high fir-tree are ideal base ends, as they are everywhere visible, but the wood and the uneven ground between them make it impossible to pace their distance apart. You find that, though unpleasant, it is quite feasible to pace along the bed of the stream; and from points in the bed of the stream outside the wood, on the north and on the south, you can see the cottage chimney and the tall fir-tree, but you cannot see much of the surrounding country. You decide to use the stream as a SUBSIDIARY BASE, from each end of which to fix the positions of the cottage chimney and the tall fir-tree; these two points, when thus fixed, become your true base ends, from which you continue the TRIANGULATION, as will now be described.

Having settled on the site for your base, you have got rid of the most important thing, and you have, so to speak, laid the foundation-stone of your sketch. Now carefully measure

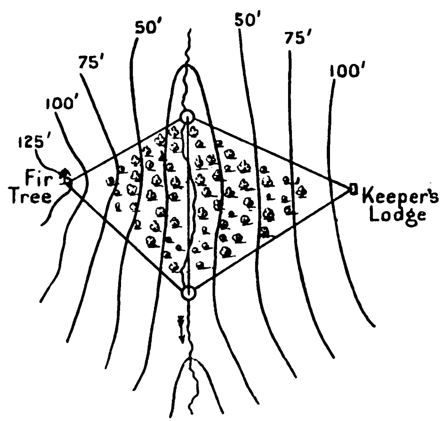


FIG. 1.—A BASE IN A WOODED VALLEY

the base, pacing it two or three times, if necessary, and if you can afford the time; and draw it to scale on your paper (fig. 2).

Standing at one end of the base, hold the paper so that the line you have drawn points in the direction of the other end of the base on the ground, and draw lines (technically termed *rays*) from the mark on the paper representing your position on the ground towards the principal conspicuous objects round about you.

Proceed to the other end of the base; arrange the paper so that the line representing the base points to the end that you have just left; and again, from the mark on the paper representing your position on the ground, draw lines to the same conspicuous objects as before.

Wherever these lines cut or *intersect* their corresponding lines from the other end of the base is the exact position of each of the conspicuous objects that you decided to fix on your sketch. You have now obtained their positions by INTERSECTION—by TRIANGULATION—for you started with a base, and what you have been doing in drawing the lines from each end of the base is simply making a number of triangles, the apex of each being a STATION, or point the position of

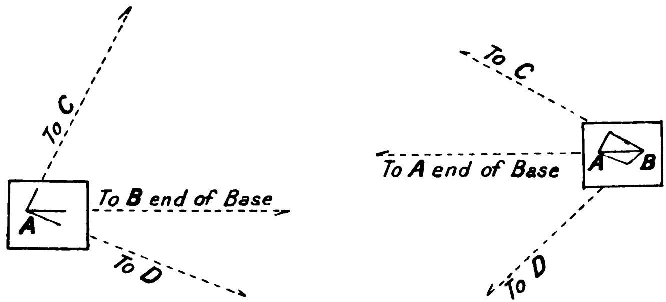


FIG. 2.—THE FOUNDATIONS OF A SKETCH

which with reference to other points or objects you wished to lay down on your paper.

Such is an outline of the method of forming the groundwork of a military sketch, whatever instruments are used. But, as with the selection of the base, so in the matter of stations, there are certain things that must be borne in mind—that is, when there is a great choice of objects.

Remember the principal uses of accurately fixed stations—viz. to serve as starting-points from which to sketch-in the surrounding detail; to check the work as it progresses—*i.e.* to check your pacing; and to enable you to find your position anywhere on the ground by what is termed *resection* (which will be fully explained farther on).

HINTS FOR SELECTING STATIONS.—(1) Let them be *conspicuous* and easy of identification. Do not let there be any chance of your mistaking one object for another when seen from different points of view.

(2) The distance of the stations from the base should not usually be greater than the length of the base; it is best to get the triangles as nearly as possible equilateral, because the *intersections* of the stations is thus more likely to be accurate. (Theoretically 90° gives the best intersection; practically anything between 45° and 80° is good enough, and triangles whose angles are within these limits are called WELL-CONDITIONED TRIANGLES.)

(3) Keep the stations within lines drawn at right-angles to the ends of the base.

(4) Do not have too many stations, but make certain that those that you select are correctly fixed and well distributed. Try to get stations about two to three inches apart all over your plan, no matter what scale you are using.

Sometimes you may find any number of conspicuous objects all over the ground to be sketched; at other times there may be no natural objects at all. In the latter case, you must put up a few objects of some kind—flags, poles, a piece of paper on a stick, &c.; but in doing this have regard to the background, so that the object may be visible at a distance.

The above suggestions assume that time is unimportant; but if time is a consideration it will be impossible to put up artificial objects, and you must then place greater reliance on your ability to pace correctly, though it will generally be found possible to check your work in some way. Should there be no possibility of checking, your sketch cannot be very reliable, and it is advisable always to add a note to this effect, so that anyone eventually using your sketch may not be deceived by it. Impress on yourself that the sketch that you are executing is for the benefit of the British Army, not for your own glorification. Sacrifice the latter for the former; for a miscalculated range of 300 or 400 yards may result in the loss of a battle.

Let us sum up what you have done so far in the making of a sketch.

(1) You have been shown the piece of ground to be sketched.

(2) You have decided on the scale that you will use.

(3) You have carefully measured a base, and laid it down to scale on your paper.

(4) You have fixed certain points or stations by *intersection*, and have thus arranged on your paper a network of triangles, of each of which the apex is an intersected point or station and the base a common one, viz.—the base that you measured.

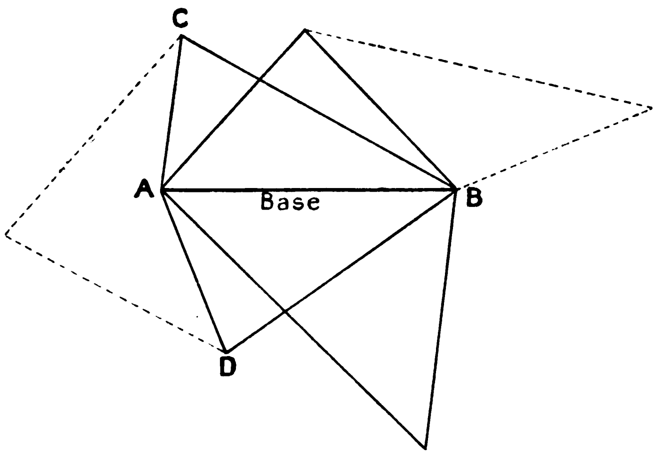


FIG. 3.—BASE AND TRIANGULATION

Now you have to extend your system of triangles; because if you have adhered to the rules laid down, you will have no stations on your paper outside the ends of the base. This, however, is a simple matter; since, if your stations have been carefully fixed, any two of them will be as good to work from as the original ends of the base. Say that you have fixed C and D from A and B (fig. 3); draw a line from C to D on your paper, and consider C—D as a fresh base, from which you can extend your triangulation, working as before.

This extension of the sketch requires the greatest care, for a trifling error in the original base and intersection of stations will cause a very considerable error in the position of stations fixed from a secondary base.

Having covered the paper with stations or intersected points in the above manner, the foundations of the sketch have been laid. It remains only to get in the detail, such as roads, streams, watercourses, houses, fences, &c., to complete the uncontoured plan of the piece of ground. This after-process will be dealt with later on.

So far we have treated only of such general principles as refer to every military sketch of an area, and we have made no mention of instruments. Before proceeding further, it will be necessary to describe the different instruments generally used by the military officer, and the beginner is recommended to study at first only such parts of the following chapters as relate to the particular instruments which he proposes to use. Let him master one instrument or one set of instruments before going on to another, and let him leave the clinometer and its use until he has learned to make the ground-plan of a sketch, and is about to commence hill-sketching.

CHAPTER IV

SOME PORTABLE INSTRUMENTS

Three usual methods of Sketching—Plane Table—Prismatic Compass —Cavalry Sketching Board—Appliances necessary—Abney Level— Watkin Mirror Clinometer—Description—How used—Its adjustment.

THE varieties of portable instruments that have been invented are innumerable, but it requires a knowledge of only a very few to be able to make a military sketch.

There are three practically distinct methods of executing the groundwork of a sketch (with instruments) that every officer is supposed to know, in addition to sketching without instruments, which will be dealt with separately (Chapter X.). The three methods are :

1. *Plane-tabling.*
2. *Prismatic-compass Sketching.*
3. *Cavalry Sketching-board work.*

Of these, Plane-tabling and Sketching with the Cavalry Board have much in common, but Prismatic-compass work has little connection with either. With all three, however, contouring is carried out by the same process, and it is necessary to have a clinometer, or an aneroid barometer.[1]

For *Plane-tabling* the following instruments are used : Tripod, Plane Table-top, a Magnetic Compass (trough or other), Alidade or Sight-vane Ruler.

For *Prismatic-compass work* it is necessary to have a

[1] It must be remembered that an aneroid is useless for sketching purposes in unsettled weather.

prismatic compass, a drawing-board of some kind, and a protractor.

The *Cavalry Sketching Board* is complete in itself, with attached compass and scaled ruler.

Without at present going into the methods of sketching with each set of instruments, we will say something about each instrument:

PLANE TABLE.--This consists of a tripod, to which the table-top is so fitted that it is capable of being revolved at will, and clamped in any required position. Any tripod (such as a camera-stand) will do, as long as it is firm when set up. There are, of course, many patterns of tripods.

The *Table-top* should be of convenient size, and fitted with some description of mechanism for attachment to the tripod.

The *Sight-vane Ruler* has flap sights at either end, and scales of yards marked on its edges.

The *Magnetic Compass* should be of a pattern enabling the sketcher to adjust it quickly to a line drawn on the paper coinciding with an imaginary line running through the centre of the length of the needle. That known as the trough or box compass is the simplest to work with, as it contains a long needle, and the greater sides of the box are parallel to the axis of the needle.

PRISMATIC COMPASS.—This is an ordinary circular magnetic compass, fitted with a flap sight-vane, and a prism, the slit in the prism and the hair of the sight-vane being in a straight line with the central or pivot point of the needle. The card of the compass is graduated in degrees, marked (so as to be read by reflection through the prism) in the reverse way to an ordinary compass-card.

There are one or two different patterns, but the general principles are the same.

The *Drawing-board* can be of any description and convenient size (a plain piece of wood, &c.), and the paper on which the sketch is to be drawn must be prepared with parallel lines (each of which represents a magnetic north and south line).

The *Protractor* is graduated in degrees, the outer figures showing from 0° to 180°, the inner figures 180° to 360°. It is also provided with useful scales of yards, &c.

The CAVALRY SKETCHING BOARD is intended primarily for use on horseback, and consists of a light wooden board with a surface of about six or seven inches square, having at each end a roller to hold the paper. A small circular compass is fixed to one side of the board, the glass being movable and having marked on it a straight line passing over the central or pivot point of the needle. Beneath the board is a strap for fastening the instrument to the horseman's left forearm.

The *Ruler* for sighting purposes is a narrow wooden one with various scales of yards marked on the edges, and is sometimes attached to the board by a hinged arm.

Two indiarubber bands are supplied with the board to keep the paper flat, and to prevent the ruler (when not attached to the board) being accidentally dropped.

Besides the above-named instruments, the sketcher must be acquainted with the use of some description of *Clinometer*.

The ABNEY LEVEL is now a *service* instrument, and is considered more accurate to work with than the Mirror Clinometer (page 29). The pattern shown in fig. 4 is the latest, and is an improvement on the original pattern. The diagram sufficiently explains the shape and appearance of the instrument, and it will be noticed that at the top (immediately under the milled head of the screw) is a spirit-level, with glass above and below; in the centre of the top of the rectangular metal box is an opening, the object of which is that, when the observer looks through the eyehole of the telescope, he shall be able to see the spirit-bubble in a reflector within the metal box. The graduated arc is a fixture, while the spirit-level and index-arm move together by turning the screw (or wheel). In the diagram the arrow on the index-arm is shown opposite to O on the graduated arc, therefore the instrument is set at zero—*i.e.* for taking a level. To discover what objects in the country are on a level with your eye, hold the instrument (set at zero) in the hand, and, looking through the telescope, slightly raise or lower the front of the instrument until the centre of the bubble comes to rest exactly on some distant object which is also cut at the same time by the horizontal wire within the metal box. The object so found is on a level with your eye.

To read a Slope.—Hold the instrument in one hand; look through the telescope, and direct the horizontal wire on to the

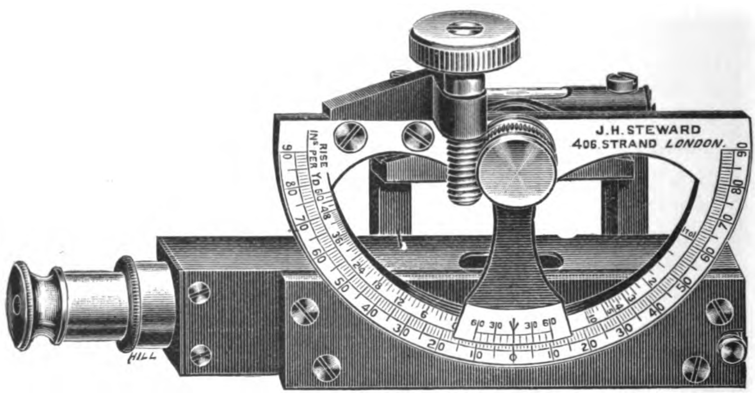


FIG. 4.—ABNEY LEVEL

object the elevation or depression of which is required. Now, with the other hand, gently turn the screw (or wheel) until the centre of the spirit-bubble is cut by the horizontal wire. Take the hand away from the screw, and read, off the arc, the figure opposite the arrow on the index-arm, which gives the slope of the object.

On each side of the arrow on the index-arm is a Vernier, by means of which readings to one-sixth of a degree can be made, but such extreme accuracy is seldom necessary in military sketching.

The WATKIN MIRROR CLINOMETER was for many years an 'article of store,' and is still in general use in the army.

This instrument is designed for levelling and observing slopes (either up or down); the mechanism will be best understood by looking at fig. 5, and comparing it with a mirror clinometer from which the cover has been removed.

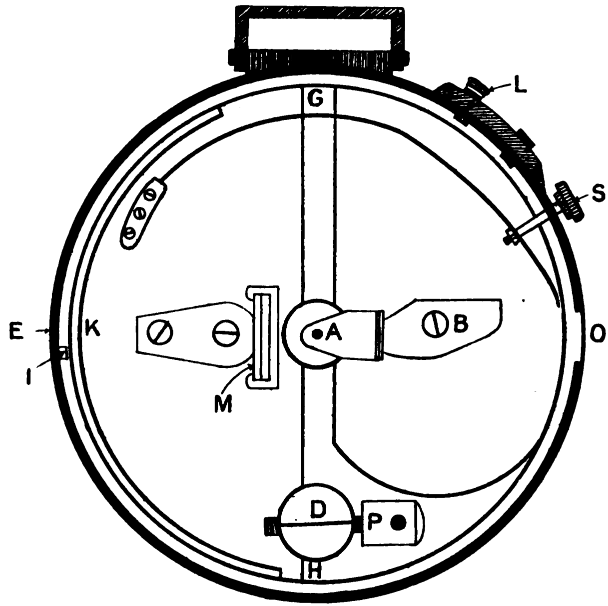


FIG. 5.—WATKIN MIRROR CLINOMETER (INTERIOR)

E is a small circular *eyehole* in the outer case; O a rectangular *opening* in the outer case; and I is the *index-bar*.

L is the *locking-stop*, used for locking the *stud* S when travelling; A is the *pivot-pin*, in the centre of the box, and held in place by the metal piece A B.

G H is a flat bar, with a hole in its centre to take the pivot-pin A, and attached to it at G and H is a circular rim, the circumference of which is slightly less than that of the case of the clinometer. The plan of the edge only of this rim is seen in the sketch, but on looking at the instrument itself it will be noticed that it is rather more than one-eighth of an inch in depth, and that to the inner side of one half of it (viz. G K H) is affixed a thin strip of ivory, graduated to show single degrees. The graduations are made in both directions, 0° being in the centre with *red* figures on one side of it and *black* figures on the other side.

At one end of the bar G H is attached a drum-shaped weight D, and into it there screws another weight P (for purposes of adjustment, as will be explained later on).

M is a mirror screwed inside the case, so as to face the eyehole (E), and enable the observer to read off the figures on the graduated arc.

The principle of most clinometers is this :

The slope of an object is the number of degrees that the object is out of the horizontal ; or, in other words, it is the measurement (in degrees) of the angle contained by a straight line drawn from the observer's eye to the object and a horizontal line passing through the observer's eye. This angle is measured by a clinometer.

Now a straight line from the observer's eye to the object can be easily obtained, and the only difficulty is to get a truly *horizontal* line. A spirit-level provides the best method, and some clinometers are fitted with one (*e.g.* Abney Level, just described). But if a truly *vertical* line be obtained, we have a line at right-angles to a horizontal line ; and a vertical line can always be obtained by means of a freely suspended weight (*i.e.* a plumb-line), which is the system adopted in the Watkin mirror clinometer.

If this clinometer be held up edgeways, so that the eyehole (E) be brought to the observer's eye, and the reflection of the index-bar (I) aligned on the object whose slope is required, then a straight line from the observer's eye to the object is obtained.

This straight line passes through the centre of the clinometer (A), and at this point it intersects a truly vertical line represented by the axis of the bar G A H.

G A H swings into its vertical position by reason of the weights D, P, and the graduated arc swings with it; thus the figure which comes opposite the eyehole, when the arc comes to rest, is the slope of the object.

The above is a description of the latest pattern; earlier patterns differ slightly in minute details. At one time the figured arc was a fixture, and the mirror made to swing; the size of the window in the cover has varied at different times; the arrangement for releasing the swinging arc has been altered; but, whatever pattern the sketcher may find in his hands, the method of use is the same.

To use the Mirror Clinometer.—Release the locking-stop (L). Hold the instrument up edgeways (window to the right) between the thumb and fingers of the left hand, placing the forefinger on the stud (S). Look through the small circular eyehole, and get the index-line on to the object the depression or elevation of which you wish to observe. Press the stud and keep the finger on it, so that the arc swings to the pendulum or weight. When it stops, read off the number of degrees reflected in the mirror, remembering that red figures are degrees of elevation, black figures degrees of depression (fig. 6).

When it is required to use the instrument for levelling purposes—*i.e.* to find about the country objects on the same level as your eye [1]—proceed as above; and when the arc comes to rest with the index-line reading 0°, observe what object is cut by the index-line.

In using the clinometer it is always advisable to get your eye as near to the ground as possible; otherwise, at short distances, the height of your eye (for instance, when standing) would make a considerable difference in the slope observed.

Occasionally it is found that the mirror clinometer is not

[1] Technically termed *Reference-points.*

in proper adjustment (though this is the fault of the makers), and it is as well to test your instrument when using it for the first time. To do this, put up two sticks, say fifty yards or so apart. Let one stick be about five feet high, and the other about three feet high. From the top of the higher stick observe the angle of depression to the top of the lower stick; then go to the latter and observe the angle of elevation from its top to that of the higher stick. If both readings are the same, then the clinometer is in proper adjustment. But suppose

FIG. 6.—THE MIRROR CLINOMETER IN USE

you found the angle of depression to be 2° and the angle of elevation to be 1,° the correct angle would be $1\frac{1}{2}$°.

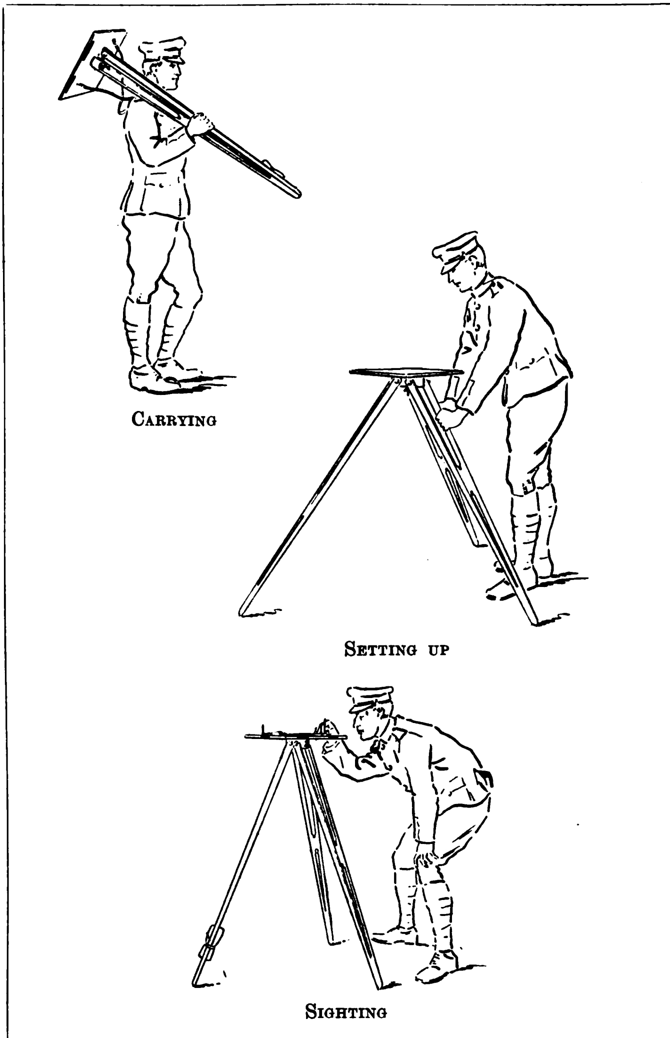
To adjust the instrument, take off the cover, and shift the centre of gravity of the plumb (P) by screwing it in to or out of (as required) the drum (D), until you get the instrument to read aright.

If the error is, however, a large one, you will probably not be able to alter the centre of gravity sufficiently; and you must then either get an instrument-maker to correct the position of the index-line, or you must, whenever you use the instrument, allow for the known error. Thus, suppose when observing an angle of depression you find it to be 3°, and when observing the same angle the other way you find it to be 5°, the correct angle is 4°; therefore, whenever you observe an angle of depression you must *add* 1°, and whenever you observe an angle of elevation you must *deduct* 1°.

Another way of testing the clinometer is to observe a known level surface (*e.g.* the water of a large lake), and notice if the clinometer reads 0°. The amount of error, and whether depression or elevation, will be seen at once.

For a description of a makeshift clinometer see p. 83. Other useful instruments are described in Appendix II.

PLATE IV.



THE PLANE-TABLE

CHAPTER V

PLANE-TABLING

The Plane-table — Description — Sight-vane Ruler — Compass — Pin — Setting up the Board—Hints—Making the Sketch—'Setting'—Drawing Detail—Traversing—Recapitulation—Resection.

THE Plane-table is by far the most satisfactory instrument for purposes of military sketching, provided that the sketcher is not pressed for time and is prepared to carry about a somewhat cumbrous tripod.

As Plane-tables differ in pattern, it is advisable, when purchasing one, to get the maker to explain how the table-top is fitted to the tripod, &c.; but the heavy pattern most generally in use shall be described:

Table-top, or Board.—This is usually about 15 × 10 inches, with top fitted with a sunken brass rim, for tightening and securing the paper. It is important that there should be no projections (*e.g.* drawing-pins) above the surface of the board, as they would interfere with the free use of the ruler.

Underneath the board is centred a brass pivot-plate with hole and slit like a keyhole; this is let into the board, and is so contrived that it will receive the head of a bolt in the tripod block, and hold it in a collar.

Tripod.—The legs of the tripod are hinged to a solid wooden block by long brass pins, with fly-nuts at the sides for tightening. In the centre of the wooden block is bored a hole having a narrow slit cut on one side, and into this hole there fits (loosely) a pivot pin or bolt, on one side of which is a narrow metal flange, of a size that will allow of its dropping into the slit in the block. The pivot-pin is about an inch and a half longer than the thickness of the block, and is provided at the lower end with a screw and fly-nut; while at the upper end is a flat-headed circular piece of metal about one-eighth of an inch in thickness.

To fit the Top to the Tripod.—Set up the tripod; unscrew the fly-nut of the pivot-pin as far as it will go; with the first finger of the left hand push the pivot-pin up through the block. Take the table-top in the right hand, paper side uppermost; place the circular hole in the pivot-plate over the head of the pivot-pin; draw the table-top to one side, so that the pin runs to the end of the slit in the pivot-plate; and, with the table-top lying flat on the tripod-block, allow the pivot-pin to drop. Now screw up the pivot-pin fly-nut, until it is fairly tight. This results in the head of the pivot-pin being held in the collar of the pivot-plate, and thus prevents the possibility of the top falling off the tripod, though it is free to revolve. By screwing up the fly-nut quite tight, the top can be clamped to the tripod, and the flange on the pin fitting into the slit in the block prevents the pin itself from turning round.

To remove the Top from the Tripod.—Reverse the above operations, without applying any force.

A little practice in fitting and removing the top is necessary. If force is used, the pivot-plate is apt to become bulged, which is detrimental to its rigidity. Another source of bulging is the upsetting of the table (by wind or carelessness); but the plate can generally be flattened again, without displacing the screws holding it in position, by a few taps of a hammer or of a heavy stone.

Besides the table-top and tripod it is necessary to have (as was mentioned in the last chapter):

(1) An *Alidade* or *Sight-vane Ruler*, which is a flat ruler twelve or fifteen inches long provided with flap sights at either end. One of the sights has a vertical hair or wire down its centre, and the other has a narrow vertical slit down the centre,

the hair and the slit being exactly in the centre of the ruler and parallel to its longer edges. On the edges of the ruler are marked scales of yards—generally 8 inches to 1 mile, and 6 inches to 1 mile.

(2) A *Magnetic Compass* of a pattern enabling the sketcher to draw accurately on his paper a line parallel to or coinciding with the axis of the needle.

(3) A long pin with a fine point and a big head. An ordinary glass-headed steel pin will do, though needles with wooden handles are specially made for plane-tabling. [The beginner is recommended always to work with a pin. In time he will be able to dispense with the pin, and substitute for it the point of his pencil held upright.]

Such is the equipment. Now for the method of using it for making a sketch; but first let us make a few preliminary remarks. (See Plate IV.)

Having fixed the table-top to the tripod, get into the habit of setting up the table ready for work as rapidly as possible. The top must always be fairly level; surveyors employ a spirit-level for the purpose, but the military sketcher must level his board by eye.

See that the side fly-nuts of the pins hinging the tripod legs to the block are not screwed up too tight; then take a tripod leg in either hand, and throw the third leg away from you. With practice, you will soon be able to set the two legs down so that the table-top comes approximately level. Screw up the side fly-nuts. Step to one side of the table, and see if the board is level, adjusting the legs until it is. Do not perch up the board too high; remember that it should be a convenient height for drawing, and incapable of being blown over by the wind. When working on a slope, one leg of the tripod should be up the slope and the other two down below (fig. 7). Lastly, in moving about whilst drawing, be careful not to knock against the legs of the tripod after it is in position.

After the table is set up, it will sometimes be found that the top is not rigid. This is probably caused either by the pivot-plate having become bulged, or by the side fly-nuts not being screwed up tightly enough.

All that was said in Chapter III. (' Foundations of a Sketch ') is applicable to plane-tabling, and by following the instructions about to be given you will have no difficulty in making an uncontoured sketch with the plane-table.

Having been shown the limits of the ground to be sketched, and told the scale on which to draw it, select the position for the BASE.

Proceed to one end of the base, set up your board, and level it. Take a good look over the ground, and revolve the table-

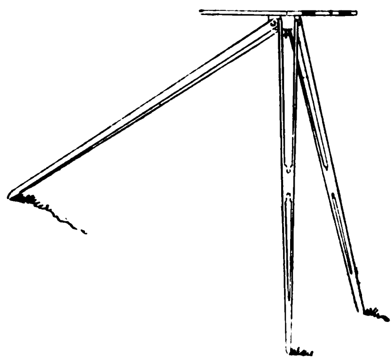


FIG. 7.—PLANE-TABLE ON A SLOPE

top until it is so placed that everything within the limits of the ground to be sketched will come on to the paper when drawn to scale. This, of course, requires a certain amount of judgment; you must estimate from the end of the base the distance to outlying points, and you must make a careful study of the scale that you are to use. Clamp your board, by placing the fingers of the left hand firmly on its top, and screwing up the fly-nut with the right hand.

With your pencil make a small mark on the paper to represent the end of the base at which you are standing. Draw a small circle round it, and name it, say, A. Stick the pin upright into the centre of the circle.

Take out your sight-vane ruler; lay it down carefully on the table, with sights raised, and with the slit sight nearest to you. Pivot the edge of the ruler against the upright pin, and align the sights on the other end of the base, by placing your eye close behind the slit and directing the hair-sight on to the object.[1] Hold the ruler firmly, and draw a line from the pin along the edge of the ruler. This is the base-line, so write BASE along it.

Now, select STATIONS to be fixed by intersection; and, without moving the board, pivot the ruler up against the pin, and draw a line or *ray* towards each object which you decide to make a station. You must give a name to each station, and write it along its ray.

(N.B.—It is as well to keep the same edge of the ruler up against the pin throughout a sketch; for choice, the edge that bears the scale that you are using. Although the sights are in the centre of the ruler and the rays are drawn along its edge, this does not affect the accuracy of the sketch, which is thereby thrown equally to one side of its actual position.)

Before leaving A, reverse the position of the ruler, still keeping its edge against the base-line, and observe some conspicuous object in prolongation of the base (*i.e.* behind you). Note the object carefully. This gives you a good long line against which to place the ruler afterwards.

Put away the ruler; gather up the legs of the tripod, so that it may be carried on the shoulder; and pace carefully to the other end of the base.

[1] Some people find a difficulty in quickly picking up the object through the sight-slit. One or two pin-holes drilled here and there, so as slightly to widen the slit, are a great aid to rapid sighting. When sketching in mountainous country, where sights have to be aligned on objects considerably above the sketcher, it is a good plan to stretch, from top to top of the two sights, a piece of thread, which then takes the place of the fore-sight.

On reaching the second end of the base (say, B), set up your board roughly; unclamp; mark off along the base-line (by means of the scale on the ruler) the number of yards that you made it by pacing. Mark the spot on the paper; draw a small circle round it, and name it B. Take out the pin from A and put it in at B.

Lay the ruler against the pin and with its edge along the base-line and its prolongation, the hair-sight pointing to A. Revolve the board gently, so as not to displace the ruler, until the latter is aligned on the first end of the base, A, and the object beyond that you noted. Clamp the board, which is now said to be 'set,' or *oriented.*

With the ruler pivoted against the pin, draw rays from B to each of the stations to which you drew rays from A. The point of intersection of each new ray with its corresponding ray drawn from A is the required station. Put a small circle round the point of intersection, and write-in the name of the station. Rub out all the rays, leaving only the base-line and the small circles representing stations.

Before moving the board, which is now 'set,' take out your compass and lay it on the paper. Turn the compass round slowly until the needle comes to rest, with its north and south ends exactly opposite the north and south points marked in the box. If you are using a trough compass, rule a line along the edge of the box; if you are using a circular compass, mark the position of the north and south points shown on the box carefully on the paper, and join them by a straight line. At the north end of the line thus obtained draw an arrow-head. This line is the magnetic north and south line, or magnetic meridian, and is called the *zero-line* of the sketch.

If you consider it necessary to get on to your sketch other stations than those that can be fixed from the base-ends, you must extend your triangulation as explained in Chapter III. For this purpose you can consider that any of the stations already marked on your sketch are reliable enough to make a fresh start from. Go to one of these stations; set up your board; put the pin into the centre of the circle representing the station, and proceed to *orient* or 'set' your board; place your compass so that the edge of the box (assuming that you are using a trough compass) is against the magnetic meridian, and that the north mark in the box is in the same direction as the arrow-head on the magnetic meridian. Revolve the board gently until the compass needle comes to rest with its axis parallel to the magnetic meridian. Or you can 'set' the board by laying the ruler from the pin to one end of the base, then revolving the board until the ruler is aligned on the end of the base. Clamp the board. Put away the compass, and, with the sight-ruler pivoted against the pin, draw rays (as before) to any objects which you wish to fix.

Repeat the operation from other selected stations shown on your sketch, until you have fixed as many stations as you require.

Remember always to move the pin to the position on the sketch representing the spot where you are standing, and to 'set' the board by means of the compass, or by one end of the base, before drawing rays.

The groundwork of your sketch is now completed. The base and the stations are all in their proper positions, relative to each other and to the magnetic meridian, or zero-line. Rub out all lines that you have no further use for, and endeavour to keep your sketch as neat and as clean as possible.

The next thing to be done is to draw-in all the detail, such as roads, railways, streams, fields, woods, houses, &c.; and knowing that these things have to be drawn on your sketch, you will have endeavoured to make some of your stations of real value for this after-work. For instance, if you have fixed (by intersection) the positions of two bridges crossing a river, you can afterwards draw-in the river from bridge to bridge by eye, without the necessity of taking your plane-table along the river-bank. Similarly, corners of woods and fields accurately fixed will save considerable trouble in drawing the boundaries of the woods and fields (fig. 8). But all this comes with practice, and after making a sketch or two you will find that you will have acquired a rapid grasp of the situation, and will see at once what objects it is advisable to fix with a view to filling-in the detail of the sketch. At first the beginner must be content to plod along steadily, and gain his experience as he goes.

Two distinct processes are followed in the systematic sketching-in of detail, viz.: Traversing, and Resection. *Traversing with the plane-table* is employed for drawing the

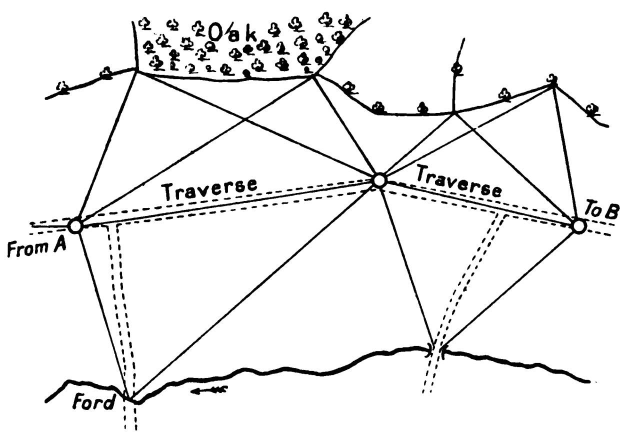


Fig. 8.—Traverse and Intersection

direction and windings of such things as roads, rivers, fences, &c., but only when you cannot get them on to your sketch in any other way. Before commencing, have a good look all round, decide where you will make a start, and how you will go over the ground so as to avoid visiting any part of it twice. You should begin traversing from or near a fixed station (*i.e.* an intersected point), and you will probably find one on some road; so begin traversing the road at that station.

Set up your board; put the pin in at your position on the sketch ; 'set' the board by the compass. Now align the sight-ruler on some object ahead situated at the point where the road changes direction ; draw a ray (termed a *forward ray*) ; pace the distance to the object ; measure it to scale ; mark the spot, and put the pin in at it. Draw at once the portion of the road along which you have come in double lines, the proper width apart (in accordance with the conventional signs).

'Set' your board at the new position (or *traverse-station*) either by the compass, or by what is termed the *back angle—i.e.* by laying the ruler-edge along the ray from your starting-point, and then turning the table-top round until the ruler is aligned on the spot (or *traverse-station*) that you have just left. Of the two methods, setting by the compass is the more accurate, while setting by the *back angle* or *back ray* is the quicker. The general rule is that the compass should be used for traversing roads, &c., with constant changes of direction, and in enclosed country; *back-angle* traversing being more suitable where the rays are long [1] (though an occasional check, by applying the compass to the zero-line, is always advisable).

Having 'set' the board, and clamped it, draw a forward ray and continue as before, until you have laid down the whole of the road. Then go to another fixed station, and start a fresh traverse.

As you cannot afford the time to go over ground a second time, you should, while running a traverse, draw-in all minor detail as you go along. Put in all houses near the road according to the distance paced from the last stopping-point ; draw the hedges perpendicular or otherwise to the road, the trees, and the direction of the watercourses, as well as other things which you consider of importance (more particularly from a military or tactical point of view). But the boundaries

[1] When a ray drawn on a sketch is short, it is a good plan to make a mark in prolongation of it several inches away. This is termed a *repere* mark, and is of great assistance afterwards in adjusting the ruler-edge accurately to the ray.

of large fields, and the like, may have to be traversed separately when sketching an important position on a large scale.

The position of such objects as houses, woods, trees, marshes, &c., at a distance from your traverse-line can be obtained either by fixing them (in the usual manner) from two known points on the traverse-line, or by the *Offset* process. By an *offset* is meant a line *set off* at right-angles to a traverse-line; along this line you pace or estimate the distance to the object whose position you wish to get on to your sketch, and then mark it off to scale. In many cases the

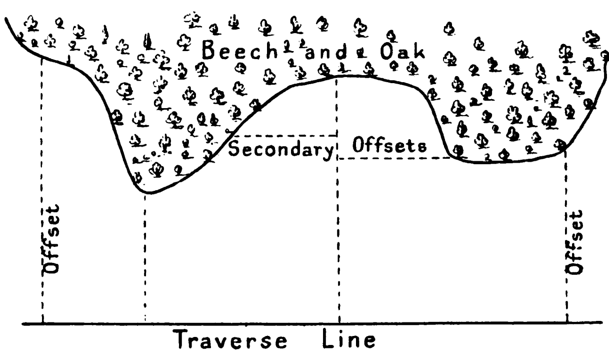


FIG. 9.—THE METHOD OF OFFSETS

employment of this method of filling-in detail will save considerable labour. Suppose, for instance, that, while running a traverse along a straight road, you find the irregular edge of an extensive wood at a little distance to one side of your traverse-line; by taking two or three *offsets* and an occasional *secondary offset*, you can draw-in the edge of the wood without having actually to pace along it. This will be understood by looking at fig. 9.

The accuracy of a traverse executed as described depends on three things—viz. the 'setting' of the board, the direction in which the forward rays are drawn, and the pacing of the distance from one traversing-station to another. There are, therefore, three sources of error, but with plenty of fixed stations the accuracy of a traverse can be periodically checked by drawing a ray to a fixed station, or by the process of RESECTION. Before going into this, let us recall the various steps taken in traversing with the plane-table:

(1) Start from a known point on the sketch; put the pin into it; 'set' the board by the compass.

(2) Clamp the board, and draw a forward ray.

(3) Pace the distance to the new position, and measure it (to scale) along the ray.

(4) Move the pin to the new position; unclamp the board.

(5) 'Set' the board at the new position by compass, or by back angle, and clamp it.

(6) Draw a new forward ray, and so on.

(7) On arriving at the last traverse-station check by drawing a ray to a fixed station (this ray is termed a *Closing Angle*).

Resection with the Plane-table.—If you have a compass, and can identify two stations that have been fixed on your sketch, you can discover your exact position on the sketch, wherever you may be, in the following simple manner:

'Set' your board by the compass; if more than two stations are visible, choose two so situated that rays from them will give a good intersection when drawn to the spot at which you are standing.

Place the pin at one of the selected stations; pivot the ruler against the pin, and align it on the station; draw a ray towards you. Move the pin to the other station, and do the same thing.

The intersection of the two rays fixes your exact position on the sketch.

The method of resection usually adopted by *expert* plane-tablers, and recommended by the *Manual of Field Sketching and Reconnaissance* (1903), is entered into fully in Appendix III., TRIANGLE OF ERROR.

While traversing you should be always on the look-out for fixed stations from which to resect; for, remember, your pacing is always liable to error, but in resection from satisfactory stations there should be no error. In open country, where stations are always visible, it is possible to traverse without any pacing, resecting the position at each change of direction of the traverse; and this is, of course, by far the most accurate method.

The different methods of *resection without a compass*, and '*setting*' *the sketch without a compass*, will be found described in Chapter XIV., and such methods will have to be employed in a country where local attraction (*e.g.* iron ore) makes it impossible to use a compass.

With all roads, streams, fences, &c., carefully traversed, and with the minor detail filled-in by the various methods described, the uncontoured sketch is now practically completed—at any rate, as far as field-work is concerned. All that remains to be done, in the way of finish in ink or pencil (in accordance with the suggestions contained in Chapter I.), can be carried out, if necessary, after returning to quarters.

CHAPTER VI

THE MAGNETIC COMPASS

Trough or Box Compass – Mariner's Compass—Terrestrial Magnetism—Compass-card—Points of the Compass—Bearing—Degrees—Conversion of Points into Degrees—Examples—Dip fully explained—Declination or Variation—Magnetic Meridian—Geographical Meridian—Longitude—The Sun—Finding the True North—The Pole-star—Variation from a Map—Compass-error—Locking-stop—Check-stop—Uses of the Compass.

THE needle of the compass used for sketching and other military purposes is enclosed in either a circular or a rectangular box with a glass top. The latter form of compass is known as the *Trough* or *Box Compass*, and consists of a needle about three inches long floating on a pivot-pin, with a central mark (or INDEX) inside the box, so placed that, when the point of the needle is opposite the mark, the axis of the needle is parallel to the longer sides of the box. One end of the needle is bright and the other blue, to distinguish the north end from the south end. This trough compass is used only for Plane-tabling.

The circular (*i.e.* the pocket, or hand) compass is merely a mariner's compass in a portable form, and as such is used by military officers for a variety of purposes; it is therefore necessary to master its details thoroughly, though it may be mentioned that a sketcher working with the plane-table and using a trough compass need know nothing whatever about the *bearings, points of the compass*, &c., which are now about to be discussed.

As everyone is aware, one end of the compass-needle (suspended at its centre of gravity) points to the North Magnetic Pole—said to be due to terrestrial magnetism (about which little is at present known).

This is the case with every magnetised bar ; for, when freely suspended, it will be found that one end of the bar is always seeking the North Magnetic Pole, and the other end the South Magnetic Pole ; and it was the discovery by the ancients of these properties in the lodestone that led, many centuries ago, to the invention of the mariner's compass.

In the mariner's compass the needle is fixed underneath a circular card, on the upper surface of which are marked the *points of the compass*, a line drawn from north to south being exactly over the axis of the needle. In the centre of the bottom of the box stands a finely pointed pin, and into the centre of the needle is fitted a small cap with a top of some hard smooth substance, such as iridium ore or agate. The cap being placed on the pin-point allows the needle to float horizontally.

This is the principle of all the portable circular compasses in military use, though in some patterns the card is fixed at the bottom of the box and the needle floats above it. As a rule, the card shows both *points of the compass* and *degrees.*

THE COMPASS-CARD.—Everyone should be able to draw a compass-card, and place the points of the compass in their proper positions. This is quite simple if you understand that you are supposed to be standing in the centre of the card, and that from that position you draw lines to the circumference (or outer edge) of the card in thirty-two different directions, all the angles made by any two adjacent lines, where they meet at the centre of the card, being equal. Thirty-two points originated solely from convenience in dividing-up.

To draw the card and learn the points, proceed as follows :

Draw a circle on a piece of paper. Through the centre of the circle draw a straight line from top to bottom ; at the top end write N., at the other end S. Draw a second line through the centre of the circle, and at right-angles to the first line; at the right-hand end write E., at the other end W. (fig. 10).

You now have the Four Cardinal Points—viz. N., E., S., W. Bisect each of the four right-angles, and draw lines from the centre to the circumference; this gives you four more points.

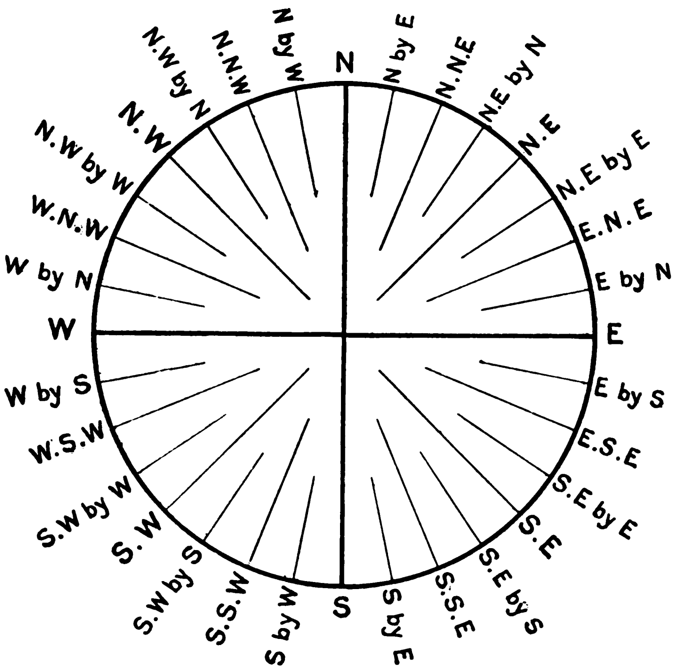


Fig. 10.—The Points of the Compass

Name these points according to their situation, and by joining the names on either side of them; thus the point between N. and E. is called N.E., that between E. and S. is called S.E., and so on.

Thus your second set of points are N.E., S.E., S.W., and N.W., and you now have eight points of the compass.

Again bisect each of the angles at the centre of the circle, and draw lines, as before, to the circumference, thus producing another eight points. The names of these new points are derived from the names of the points on either side of each of them; so, the point between N. and N.E. becomes N.N.E.; the point between N.E. and E. becomes E.N.E.; and so on all round the circle, the rule being that, in uniting the names of the two adjacent points to give a title to the new point, the name of the nearest of the Four Cardinal Points is always put first.

The new eight points thus arrived at are N.N.E., E.N.E., E.S.E., S.S.E., S.S.W., W.S.W., W.N.W., and N.N.W.

Repeat the operation of bisecting all the angles already drawn, and draw lines from the centre to the circumference, to obtain the last sixteen points. These sixteen points are known as the *by*-points, because each of them contains the word *by* in its title.

The method of getting the names for the *by*-points differs from that previously followed, because to write (for instance) N. and N.N.E. would give a clumsy combination of letters. The word *by* has therefore been introduced to simplify matters, and a further simplification has been introduced as follows:

Each of the *eight* principal points is allotted two satellite or *by*-points, to which it first gives its own name, and then adds the word *by* and the name of the nearest of the Four Cardinal Points.

Start from N. and name these sixteen *by*-points.

The points adjacent to N. are named N. by W., and N. by E.; the next of the eight principal points is N.E., and its *by*-points are called N.E. by N., and N.E. by E.; then comes E., its *by*-points being E. by N., and E. by S. In a similar way, name all the by-points with reference to the eight principal points and the Four Cardinal Points. In this manner you get for the last sixteen points the following titles: N. by E., N.E. by N., N.E. by E., E. by N., E. by S., S.E. by E., S.E. by S., S. by E., S by W., S.W. by S., S.W. by W., W. by S., W. by N., N.W. by W., N.W. by N., and N. by W.

This completes the drawing of the compass-card, with the names of the thirty-two points. You should get these well into your head, and should be able to name all the points of the compass in the proper order straight off, and in any order (called by seamen *boxing the compass*).

Now, having made a compass-card, if you can place it so that a prolongation of the line drawn from the centre to N. on the circumference points towards the Magnetic North Pole, you will be able to discover what is termed the *bearing* (in points of the compass) of all objects visible in the country round about you.

Practise yourself in taking the bearings of objects in this way, and remember that if the object is not in prolongation of any of the lines running through one of the thirty-two points, you must name it to the nearest quarter-point. Thus, halfway between N. and N. by E. would be N.½E.; halfway between N. by E. and N.N.E. would be N. by E.½E.

DEFINITION.—The Bearing of an object is the horizontal direction of the object with reference to Magnetic North; or, which is the same thing, it is the measurement of the horizontal angle formed by a line drawn from the centre towards Magnetic N. and a line drawn from the centre towards the object. The *True Bearing* of an object has reference to True N. in the same manner.

The next matter to be dealt with is the compass-card divided up into *degrees*, enabling more exact bearings to be taken to objects.

The circumference of the card is divided into 360 equal parts or degrees, the numbering commencing at N. and going round by E., S., and W. (like the hands of a watch).

You will remember that in drawing the previous compass-card, the Four Cardinal Points were obtained by getting four right-angles at the centre of the circle. Now, as a right-angle contains 90°, and as the whole circle is divided up into 360°, if you start numbering from N. or 0°, E. will be 90°, S. will be 180°, W. will be 270°, and N. again will be 360°. By dividing each of these quadrants into 90 equal parts, you will get divisions of one degree the whole way round the circle; or, in other words, each adjacent pair of lines that you draw from the centre to the circumference will form an angle at the centre of the circle of 1° (fig. 11).

To divide the circumference of the circle into 360 equal parts would be a tedious geometrical operation, but it can be

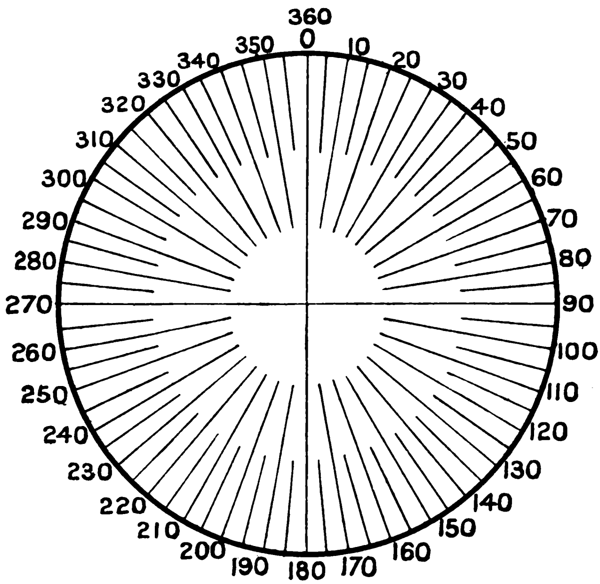


FIG. 11.—COMPASS-CARD SHOWING DEGREES.

done quite simply with a PROTRACTOR, and it will therefore be advisable to defer the actual making of a compass-card showing degrees until you come to the description of the protractor (in the next chapter). For the present it will be sufficient to know the direction in which the degrees are numbered from 0° to 360°.

With this knowledge, it is easy to understand how the bearing in degrees of an object is found. Place the compass-card so that the line from the centre to N. or 0° points towards magnetic north—*i.e.* *orient* or 'set' it; then imagine yourself to be standing in the centre of the card, and observe the number written at the end of the line that points towards the particular object whose bearing you wish to find. Or, to use the compass practically, hold it so that the index-mark (or *lubber's line*) points in the direction of the object. The north end of the needle will, of course, swing round to magnetic north, and the figure on the card which rests opposite the *lubber's line* will be the bearing of the object.

It will be noticed that the bearings of objects lying to the east of the N. and S. line must be between 0° and 180°; the bearings of those lying to the west of the N. and S. line must be between 180° and 360°.

It is often necessary to be able to convert *points of the compass* into *degrees*, and *vice versâ*. Remember that the Four Cardinal Points are N. 0° (or 360°), E. 90°, S. 180°, and W. 270°, and that, as there are 32 points of the compass to 360°, each point must be equal to $11\frac{1}{4}$°. Therefore, all that you have to do in order to convert points into degrees, or degrees into points, is to calculate from the nearest of the Four Cardinal Points.

EXAMPLE I.—*What is the equivalent in degrees for E.N.E.?*

E.N.E. is, as you know, two points north of E.; E. is 90°; for each point you allow $11\frac{1}{4}$°; so, as E.N.E. lies in the first quadrant, you deduct $22\frac{1}{2}$ from 90, and the answer is $67\frac{1}{2}$°.

EXAMPLE II.—*What is the equivalent in points of the compass for a bearing of* 315°?

Think, first of all, whereabouts 315° will come. W. is 270°, and N. is 360°: so it falls in the fourth quadrant. Deducting 315 from 360, you find that the required point is 45° on the west side of north; and 45 divided by $11\frac{1}{4}$ is 4; therefore 315° is four points west of north—*i.e.* N.W.

Of course, in this particular case you would see at a glance that, as 315° is 45° short of 360° or N., and also 45° beyond 270° or W., it must be midway between W. and N., and the midway point you know to be N.W.

It is now necessary to deal with two matters—viz. the DIP OF THE NEEDLE, and the VARIATION OF THE COMPASS. Each may appear to present a certain amount of difficulty to anyone who knows nothing about a compass, and if, after reading the following few pages, the novice fails to get an understanding of the subjects, he is recommended to neglect them altogether for the time being. Let him accept the fact that DIP and VARIATION exist; let him use a compass whose needle he can see floats horizontally in the part of the world where he is using it; let him, by making inquiries, or by consulting a variation chart, find out the local variation; and let him take it for granted that his compass is in proper adjustment. Ignorance of the cause and effect of either DIP or VARIATION will not, in nine cases out of ten, prevent his producing a good military sketch, or using his compass for other purposes, and he can master the subjects later on. But he is warned that they *may be* of vital consequence, and cannot be altogether disregarded.

THE DIP OF THE NEEDLE.—It was said just now that the needle of a compass is so balanced on the pivot-pin that it floats horizontally. If it did not do so, it, or the card attached to it, would, in the case of a pocket compass, be liable to come in contact with the glass top of the box, and thus not swing properly.

Now, as a matter of fact, a magnetised needle, when freely suspended at its centre of gravity, only floats absolutely horizontally near the equator; in all other parts of the world one end of the needle points downwards. This tendency is called the DIP or INCLINATION OF THE NEEDLE, and, like VARIATION, it is caused by terrestrial magnetism.

The simplest way to explain the effect of terrestrial magnetism on a compass-needle (or any other magnetised bar) is to assume that within the earth there lies a huge magnetic mass possibly resembling a bar ; that one end of the bar is situated vertically under the North Magnetic Pole (70° N. latitude and 96° 46′ W. longitude), and the other end vertically under the South Magnetic Pole (about 76° S. and 168° E.). Of every magnetised bar, as was said before, one end is south-seeking and the other end north-seeking; and if you place two freely suspended magnetised bars (such as compass-needles) in proximity, you will find that the north-seeking end of one will attract the south-seeking end of the other—*i.e.* the two bars will settle down with, so to say, the head of one against the tail of the other. Similarly, if you bring a freely suspended magnetised bar near a fixed magnetised bar, the former will swing round until its north-seeking end is opposite to what would be the south-seeking end of the latter if it were free to move.

Accepting the hypothesis of the magnetic bar within the earth, what is termed the North Magnetic Pole is the nearest spot on the surface of the globe to the south-seeking end of the earth's magnet ; that is to say, it is the spot where the north-seeking end of a freely suspended magnetised bar will come to rest pointing downwards. So, the South Magnetic Pole is the spot where the south-seeking end of a freely suspended magnetised bar will come to rest pointing downwards.

The north end of a compass-needle, therefore, is not only attracted horizontally towards the North Magnetic Pole, but it is attracted, at the same time, in a bee-line towards the south-seeking end of the earth's magnet (*i.e.* a spot within the earth vertically under the North Magnetic Pole). Thus it is said to *incline* directly towards the North Magnetic Pole. In the same way the south end of the needle *inclines* towards the South Magnetic Pole (the north-seeking end of the earth's magnet), and the DIP, or extent to which the needle inclines out of the horizontal, can be calculated, with special instruments, for all places on the earth.

At the magnetic equator there is no DIP, because the influence from each end of the earth's magnet is equal; but, coming northwards from the equator, the north end of the compass-needle will be found gradually to increase its dip downwards until in England at the present time (for it is always changing a little) it is about 70° out of the horizontal, and, finally, on reaching the North Magnetic Pole it stands perpendicularly (N. end downwards). Again, in travelling southwards from the equator the south end of the compass-needle will be found to dip or incline towards the South Magnetic Pole, eventually standing perpendicularly over that spot.

This is a somewhat lengthy explanation of a matter which may appear to be of little consequence, but its importance will be understood when it is known that an ordinary pocket compass bought for use in England will not work accurately in, say South Africa, until it has been corrected for Dip. For whereas in England the *north* end of the needle dips about 70° out of the horizontal, in South Africa the *south* end dips about 55°; so that the north end will have changed its position by about 125° between, say, London and Cape Town.

[N.B.—The above is *theoretically* accurate; the instrument known as the Dip Needle (in which the needle is suspended so as to move in a vertical plane) will show these degrees of dip. But *in practice* the Dip of an ordinary box-compass needle is found to be nothing like as great.]

Every compass-needle, therefore, should be corrected in some way, unless it is for use near the equator. Look at your compass and see for yourself what would happen in England if the needle had not been corrected by the makers; the north end would approach the bottom of the box, and the south end would approach the glass. Now open your compass and lift up the card, and you will notice that underneath it the makers have placed a drop of sealing-wax, so as to counteract the dip. If you wished to use this same compass in South Africa, you would have to scrape off this sealing-wax, and perhaps put another drop on the opposite end of the needle, shaving it down with a knife until you got the needle to float horizontally. Of course, two or three little bits of gum-paper would serve the purpose as well as sealing-wax.

In large compasses without cards the horizontal position of the needle is usually preserved by some sort of sliding brass weight, capable of being adjusted as required. The dip is counteracted in cheap toy compasses by the metal of one end of the needle being made heavier than the other end, which renders them practically useless for work in latitudes far removed from the place of their manufacture, unless one end is filed down or the other end weighted in some way. The needle can, however, be kept fairly horizontal by slightly tilting the box—a method not to be recommended, as the needle is thereby thrown more or less off the pivot-pin.

THE VARIATION OF THE COMPASS, also called the DECLINATION OF THE NEEDLE, and MAGNETIC DECLINATION.—The north end of the needle points to *Magnetic North*, which in few parts of the world exactly coincides with *True North*. The angle made by a line drawn towards the Magnetic North Pole and a line drawn towards the True North Pole, measured in degrees, is the Variation of the Compass at the particular spot where the observation is made.

The two lines thus drawn are known respectively as the *Magnetic Meridian* and the *Meridian* (True Meridian, or Geographical Meridian).

DEFINITION.—(1) The *Magnetic Meridian* at any place is the line coinciding with the axis of the needle of the compass set up at that place—*i.e.* it is a Magnetic north and south line.

(2) The *Meridian*, *True*, or *Geographical Meridian* at any place on the surface of the earth is the line that passes through that place and through the poles of the earth—*i.e.* a True north and south line.

This word *Meridian* means simply *midday*, so named because all places on the same meridian have midday, or noon, at the same moment. So when, for instance, a place is said to be on the meridian of Greenwich (or, geographically speaking, having the same longitude as Greenwich), such place has midday at the same time as at Greenwich. It is obvious that meridian lines, or lines of longitude, can never be parallel. Take a globe, stretch a string from the North Pole tightly over the surface to the South Pole, and this will give you a meridian line ; repeat this on another part of the globe, and you will see at once that the lines thus obtained are not parallel.

Now with a compass you can always find the Magnetic Meridian, and, knowing the meaning of the word, you can find the Meridian (True or Geographical Meridian) of a place, if you can discover when it is exactly midday at that place. There are, of course, accurate instruments for determining this, but for the military sketcher it is sufficient to note the direction of the sun-thrown shadow of a vertical object at the moment when that shadow is shortest.

In the Northern Hemisphere the sun at noon is True South, therefore the shadow of a vertical object will point to True North.

In the Southern Hemisphere the sun at noon is True North, therefore the shadow of a vertical object will point to True South.

By 'setting' a true north and south line drawn on a piece of paper, and by centering a compass over the line, it will be seen whether the north end of the needle points to the right or left (*i.e.* to the east or west) of true north, and the angle made by the axis of the needle and the true north and south line can be measured off in degrees. This measurement gives the variation of the compass, and the variation is said to be west if the magnetic needle points to the west of the true north, east if the magnetic needle points to the east of the true north.

The only difficulty is to set up an object exactly vertical, so as to get the shadow ; and then, when this has been done, to discover when the shadow is at its shortest. If you hang up a thread or string with a weight at the end, it must be vertical ; so, make a rough plumb-line of this kind, and suspend it from the end of a pole, the other end of which you stick into the ground at an angle of about 45°—if necessary, supporting the pole by a couple of sticks lashed together, as shown in fig. 12. The head of the pole should be placed roughly towards the north in the Northern Hemisphere, and towards the south in the Southern Hemisphere. Now, to the north of the pole (if working in the Northern Hemisphere), place on the ground some flat surface (such as a camp-table-top); or, at any rate, smooth and level the ground. Mark a spot (*a*) vertically under your plumb-line, and, at about half an hour before your estimated time of noon, draw, from this spot (*a*) as centre, an arc

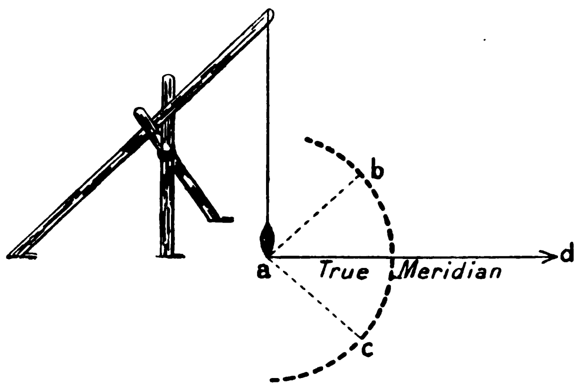


FIG. 12.—TRUE NORTH BY THE SUN

with a radius of the length of the shadow of the pole. Note the exact spot (*b*) where the shadow cuts the arc. Watch the shadow, and you will see it gradually getting shorter, then, after a while, it will grow longer again. Wait until it cuts the arc again, and mark the spot (*c*). If you bisect the angle *b a c*, the line of bisection (*a d*) will be the true north and south line. This is known as the method of *equal altitudes*.

The above method of determining the meridian depends on the sun being visible, and consequently on the absence of clouds, fog, &c. Another method, which also requires a clear sky, is that of observing the Pole Star; but it can only be employed in the Northern Hemisphere, as, of course, the Pole Star is not visible in the Southern Hemisphere.

The first thing is to make certain that you can identify the Pole Star (or North Star, as it is sometimes called). Most people know the constellation of the Great Bear (*Ursa Major*), with the two stars at the head known as the *Pointers*; a prolongation of a line passing through these two stars almost touches the Pole Star (see fig. 13). The different stars forming a constellation are known by a Greek letter prefixed to the name of the constellation; thus, the sixth star from the head of the Great Bear is called ζ *Ursæ Majoris* (Zeta of the Great Bear), zeta being the sixth letter of the Greek alphabet. This star is the last but one of the tail, and can be easily identified.

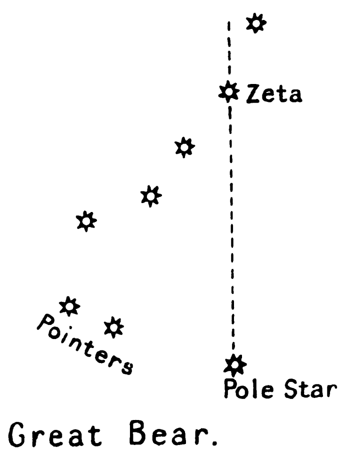


FIG. 13

Without going into matters of astronomy, it must be explained that the Pole Star always appears in the same place in the heavens, and that the other stars appear to revolve about it. If the Pole Star itself were exactly over the True Pole of the earth, to obtain the direction of true north it would only be necessary for the observer to draw a line towards the Pole Star whenever it was visible. But the Pole Star is *not* exactly over the True Pole of the earth; it is 1° 9′ to one side of it.

As the stars make a complete revolution round the Pole in twenty-four hours, there will be two different occasions in the twenty-four hours when a given star will be similarly situated with relation to the Pole Star; one occasion on one side of it, the other occasion on the other side of it.

It is known that when the star Zeta of the Great Bear is observed to be vertically above or below the Pole Star, the latter and the True Pole of the earth are in the same vertical plane. Therefore, if you can get Zeta of the Great Bear and the Pole Star vertically above or below each other, and if you then draw a line in the direction of the Pole Star, that line will also be in the direction of the True Pole of the earth—*i.e.* the line so drawn will be a true north and south line.

A good way of finding true north by this method is as follows : Hang up a plumb-line in some convenient place, so that by its means you will be able to see when the two stars mentioned are vertically above or below each other. You must select your night and the time for the observation (for, of course, this differs every night). Then, with the aid of an assistant (who should be provided with a lantern and a long pole), you watch for the moment when the two stars are in the same vertical plane as the plumb-line, and immediately send the assistant forward and dress his pole between the plumb-line and the Pole Star. When dressed, the pole is set up in the ground, or a picket driven in at the spot, while another picket is driven in vertically under the plumb-line.

In daylight it will be easy to lay down a piece of paper and draw a line on it corresponding with the direction of a line joining the two pickets; this line on the paper is the true north and south line (Meridian, True or Geographical Meridian). As before, centre the compass over this line, and you will obtain the variation of your compass at the particular spot.

If you have to work alone, the best plan is to hang the plumb-line in a northern window, and then, with a piece of paper fixed to a table well back in the room, as soon as the two stars are covered by the plumb-line, stick into the paper a pin aligned on the plumb-line and the stars. A line drawn from the pin towards the plumb-line will be a true north and south line.

(N.B.—Observations of the Pole Star cannot be made in very low or very high latitudes.)

The other method of observing the Pole Star—*i.e.* when it is due east or west of the Pole—is difficult to work out accurately, and is not recommended to the beginner. In fact, it is open to doubt if, with the ordinary pocket compass generally in use, any of these methods are worth troubling about. The bearing of the Pole Star *whenever visible* is quite good enough for all practical purposes.

Lastly, if you have a reliable map (such as the Ordnance map of Great Britain) the upright margins of which are true north and south, you can find the variation of your compass, without the Sun or the Pole Star. All that you have to do is to look on the map for two easily identified objects, a straight line joining which will be parallel to the upright margins of your map. Go to one of these objects on the ground; lay a ruler from one object to the other on the map; turn the map round until the ruler is aligned on the far object, and the map is then 'set.' Now centre your compass over this true meridian line, and observe where the needle points. If you have a PROTRACTOR (see next chapter), you can select *any* two objects, and measure the true bearing of one object from the other. Then proceed as before, and measure the magnetic bearing of one object from the other. Compare the two bearings, and you obtain the variation.

To sum up what has been said about variation:

(1) It has been defined as the angular distance between Magnetic North and True North; or, in other words, the number of degrees contained by the angle made by the Magnetic Meridian and the True Meridian.

(2) The Magnetic Meridian is obtained and laid down on paper by means of the magnetic compass, a line drawn through and in prolongation of the axis of the needle being a magnetic north and south line.

(3) The True Meridian is found either by observing the shadow of the Sun at noon, or by observing the Pole Star when vertically above or below Zeta of the Great Bear. (The Pole Star is then said to be 'on the meridian.')

(4) If, when the Magnetic Meridian and the True Meridian are laid down on paper one over the other, the Magnetic Meridian is to the east

of the True Meridian, then the variation is said to be East; if the Magnetic Meridian is to the west of the True Meridian, then the variation is said to be West.

These Meridians should, whenever possible, be drawn on every military sketch in the form of what is termed a NORTH POINT (fig. 14). It is advisable to draw this exactly as here shown, making the lines of equal length from the point of intersection to the ends; writing in the angle the number of degrees of the variation, and whether E. or W.; and placing at the head of the Magnetic Meridian a plain arrow-head, and at the head of the True Meridian an eight-pointed star.

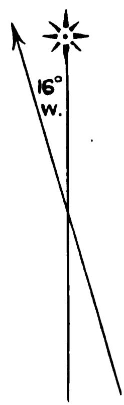


FIG. 14

The variation of the compass is always changing in nearly every place on the earth, and charts of the world showing 'Lines of Equal Magnetic Variation' are compiled each year. In a few places (on these irregular lines) the Magnetic Meridian coincides with the True Meridian—*i.e.* there is no variation, but these places are never the same two years running.[1]

Roughly speaking, at the present time (1903) the variation is West between a line passing through Canada, the United States, and the eastern portion of South America, and a line passing through Finland, the Black Sea, the Persian Gulf, the South of India, and Western Australia. Everywhere else the variation is East, except within an oval enclosing a portion of Siberia, the greater part of China, and the whole of Japan. A knowledge of the situation of these lines is, however, of no practical value to the military sketcher, though it may interest him to know that at London the magnetic variation in 1576 was 11° E.; that it gradually diminished, until in 1660 there was no variation; that it then increased westward, reaching 24° 20′ W. in 1815; and that since then it has been

[1] For definitions of *Annual Variation*, *Diurnal Variation*, and *Positional Variation*, see VARIATION, Appendix IV.

diminishing again, and has now (1903) been reduced to about 16° 20′ W.

It is important to discover the variation of your compass before making a sketch in out-of-the-way parts of the world, and especially when making a combined sketch with other officers, in order that a true meridian may be obtained for the general comparison of different sketches. Moreover, with a true meridian on it, a sketch is good for all time. Otherwise, the variation is quite immaterial, and the beginner desirous of getting on with practical sketching need not bother himself with abstruse problems connected with the variation of the compass.[1] In England he will always be able to find some one who will tell him the variation where he is going to sketch, so that he may be able to put a north point on his sketch; and all that he need do is to satisfy himself that his compass is in adjustment, by having it compared with a standard compass. But even if he cannot discover the variation, let him draw a Magnetic Meridian on his sketch, and write alongside of it the date.

Of course, no compass out of adjustment should ever be sold, but very frequently a compass will be found to have an error (called the *initial error of the compass*), which is the fault of the maker. Errors arise in the following ways :

(1) Pivot-pin not accurately fixed, or having too blunt a point.

(2) The 'magnetic axis' of the needle (*i.e.* the direction of the magnetism of the needle) not coinciding with a line drawn throughout the centre of the needle.

(3) Needle not fastened exactly under the meridian line on the card.

(4) The 'lubber's line' incorrectly placed.

(5) In Trough compasses, the outer edge of the box not parallel to the magnetic axis of the needle when the latter is at rest opposite to the 'lubber's line.'

But still, if you are working alone and use the same compass throughout, an error will not affect the accuracy of your sketch, as such error will usually be constant.

[1] For questions on Variation see Appendix III.

Most compasses have an arrangement, known as a 'locking-stop,' for raising the needle off the point of the pivot-pin when the compass is not in use. This preserves the fineness of the pin-point. A 'check-stop' is also sometimes provided for the purpose of arresting the revolutions of a sensitive needle.

An ordinary magnetic compass, as distinguished from a prismatic compass, is used for the following, among other, military purposes, though it must be remembered that, owing to *local magnetic attraction*, in some parts of the world (*e.g.* certain districts of South Africa) it is impossible to use any form of compass :

(1) Plane-tabling.
(2) Cavalry Sketching-board work.
(3) Finding the way.
(4) 'Setting' a map.
(5) Marching on a compass bearing.

Of these, Plane-tabling has already been explained, and the others will be dealt with in separate chapters, in which also will be described the prismatic compass and the magnetic (luminous) compass.

FIG. 15.—OBSERVING A BEARING WITH THE MAGNETIC COMPASS (OFFICERS' PATTERN)

CHAPTER VII

SKETCHING WITH THE PRISMATIC COMPASS

Advantages and Disadvantages—Description of Prismatic Compass—Graduations of the Card—Observing Bearings—The Protractor—Plotting Bearings—Making the Sketch—Traversing—Offsets—Resection—Summary—The Field-book—Traversing with a Field-book—Plotting from a Field-book.

ALTHOUGH the Plane-table is always to be preferred to any other instrument for accurate military sketching, its bulky nature sometimes renders its use inconvenient. For this reason, at one time the Plane-table was superseded (in the army) by the Prismatic Compass. Now, however, it has come to be recognised that Prismatic-compass work is only applicable in exceptional circumstances and under certain conditions.

The principal advantages of the Prismatic Compass are that the instrument is distinctly portable, and that (in wet weather) with it observations can be made in the field and recorded in a note-book, so that the sketch can be drawn indoors afterwards. But it is not as accurate to work with as a Plane-table, it is difficult to manipulate in cold or windy weather, and it has the great disadvantage that the sketcher is always working more or less in the dark, so that he is deprived of the benefits resulting from military sketching—viz. the study of ground, the acquirement of an eye for country, &c. &c.

A PRISMATIC COMPASS (figs. 16 and 18) is an ordinary circular magnetic compass having attached to it on one side a prism with a slit in it, and on the other side a sight-vane (with hair or wire). An imaginary line drawn from the prism slit to the hair or wire passes through the centre (*i.e.* the pivot-pin) of the compass. This arrangement is to facilitate the reading of *bearings* of objects. With an ordinary compass, in order to observe the bearing of an object, as was explained in the last chapter, the *lubber's line* is directed on the object, and then the number of degrees (or points) marked on the card which is shown opposite the lubber's line gives the bearing of the object.

It is not possible to take very accurate bearings in this way, but with the sighting arrangement on a prismatic compass the accuracy is considerably increased, the observer being able to read the bearing without taking his eye off the sights and the object. This is brought about by means of the prism, which brings in front of the eye the figure on the card immediately beneath it. Now in order to do this it is necessary to have the compass-card figured in the reverse way to an ordinary compass-card; so that, for instance, if you are observing an object due east of your position (*i.e.* 90°), the figure 90 on the card must be immediately under the prism and your eye; and if there is a *lubber's line* marked in the box, it will be found that the figure 270 is opposite the lubber's line.

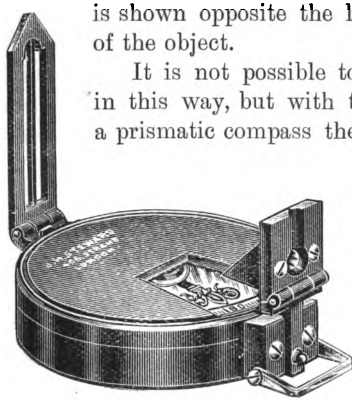


FIG. 16.—PRISMATIC COMPASS (OLD PATTERN)

Therefore, remember that the card of a prismatic compass is graduated in the reverse way to the card of an ordinary compass; so, if you open the prismatic compass and examine the card, you will find that 180° is over the North end and 360° over the South end of the needle.

Whatever pattern of prismatic compass is available, the method of observing a bearing is the same. Hold the compass, prism towards you, in a horizontal position, firmly between the fingers and thumb of the left hand, all the fingers spread out round the case, and one finger opposite the *check-stop* (supplied for arresting the card). With the forefinger and thumb of the right hand hold the ring of the compass in order to steady it. Having raised the prism and sight-vane, close the left eye, and, standing square to the object to be observed, with the right eye look through the slit of the prism and align the hair-sight on the centre of the object. If the card swings too freely, check it by applying the finger gently to the *check-stop*; and when the card has come to rest, read off the figure which appears exactly in line with the object and the hair-sight. This is the bearing of the object.

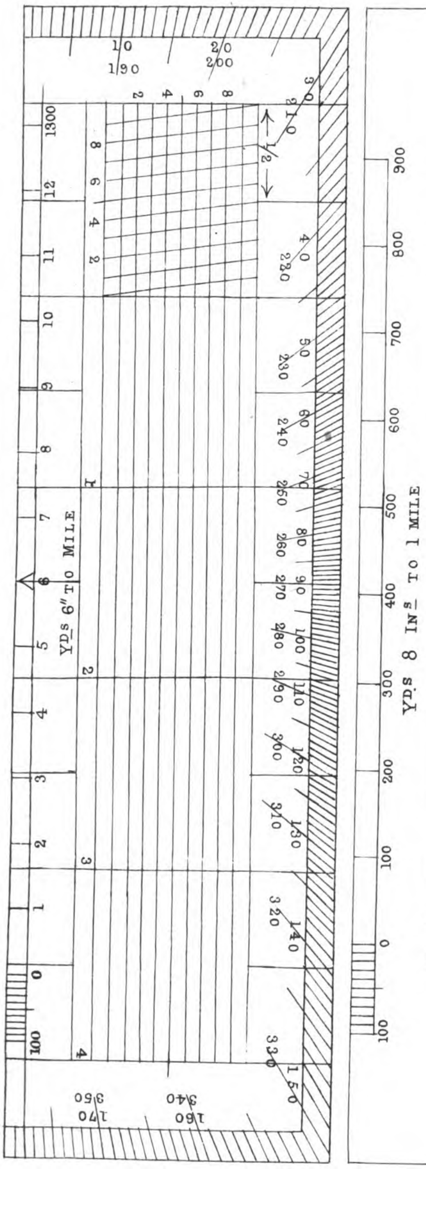
(N.B.—Be careful to keep the compass horizontal while taking a bearing, otherwise the edge of the card may touch the lid and be checked.)

There is nothing more to be said as to the method of observing bearings with the prismatic compass, though a certain amount of practice is necessary to be able to use it quickly. The next thing to be discussed is the manner of drawing the observed bearings on paper, for the purpose of making a sketch. This entails the employment of a PROTRACTOR, and paper ruled with parallel lines.

The PROTRACTOR (Plate V.) generally used is a thin strip of ivory or hard wood, about six inches long and two inches wide. At the centre of one of its longer edges is an arrow-head, and from this mark radii are engraved to the other three edges, each radius, or line, being distant one degree from the next one.

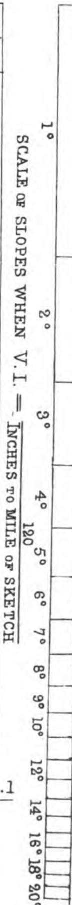
The protractor is nothing more than half a compass-card, for if you take an ordinary compass-card, remove the needle and cap, and cut it in half along the north and south line, the centre of this line where the cap fitted on the pivot-pin represents the arrow-headed mark on the protractor; then if you cut off the rounded portions of the card, and convert the

PLATE V.



H.E. IN YDS		
D	15′	20′
1	286	382
1½	191	255
2	143	191
2½	115	153
3	95	127
4	72	95
5	57	76
6	48	63
7	41	54
8	36	47
9	32	42
10	28	38
11	26	34
12	24	31
13	22	29
14	20	27
15	19	25
16	17	23
17	16	22
18	15	21
19	15	19
20	14	18

$$H.E. = \frac{V.I. \times 19.1}{D}$$



semicircle into a rectangle, you have a protractor showing bearings for half the circle (0° to 180° if you have taken the eastern half, 180° to 360° if you have taken the western half). (Fig. 17.)

It is obviously unnecessary to have two protractors, for the two halves of the compass-card are similarly divided, though differently figured; and one protractor can be made to do the

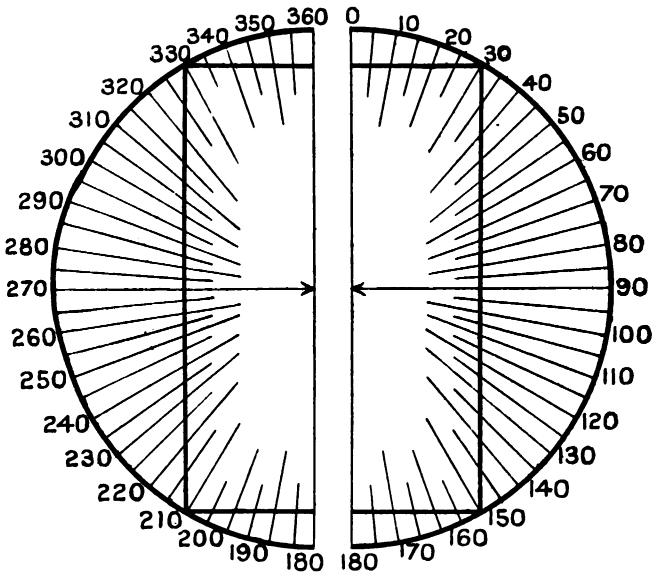


FIG. 17.—THE FORMATION OF A PROTRACTOR FROM A COMPASS-CARD

work of two by putting on it a double set of figures. Thus, the protractor (Plate V., left hand) is engraved on the outside of the edge with degrees numbered from 0° to 180°, and on the inside of the same edge from 180° to 360°.

Remembering that the protractor is only the half of a compass-card, it will be at once understood that, when held with the arrow-head (*i.e.* the centre of the card) to the left, the figures on the edge refer to bearings between 0° and 180°; when held with the arrow-head to the right, the figures refer to bearings between 180° and 360°.

Circular and semicircular protractors are also sold, but the oblong form is preferred for military sketching, as it enables scales of yards, and other information, to be engraved on one side, thus economising space.

Now, the use of the protractor is this: When making a sketch with the prismatic compass, you first take the bearing of an object with the compass, and then you have to draw this bearing in its proper situation on your paper (called *plotting* the bearing). To do this it is necessary to prepare your paper with parallel lines, ruled a convenient distance apart, or to use paper ready ruled. Each of these lines is considered to be a magnetic north and south line, or *Magnetic Meridian* line, and any one of them is, therefore, a *Zero Line* of a sketch. At one end of one of these lines put an arrow-head to represent Magnetic North.

To plot the bearing, place the *inner*, or arrow-headed, edge of the protractor up against, or parallel to, one of the lines on your paper. If the bearing is between 0° and 180°, place the graduated edge to the right; if between 180° and 360° place the graduated edge to the left. Then, with a pencil, mark on the paper the position of the arrow-head on the inner edge of the protractor, and also mark on the paper the position on the graduated edge of the protractor of the number of degrees of the bearing to be plotted. Remove the protractor. Draw a straight line from one mark to the other, and this is the bearing of the object drawn from the spot (represented by the arrow-head mark) from which it was observed.[1]

[1] It may sometimes happen that the point from which a bearing has to be plotted lies so near the edge of the paper as to render it impossible to lay the protractor on the proper side of the point. In this case, lay the protractor on the *wrong* side of the point, mark the *reverse* bearing, and produce the line (thus obtained) through the point. (*Cf.* Resection with the Prismatic Compass, page 75.)

(N.B.—The line thus drawn should be described as a *bearing* (*vide* definition, page 51), and not as an *angle*. It has reference to the magnetic north and south line—*i.e.* the lines on your paper, or the inner edge of your protractor.)

Before proceeding to execute a sketch with the prismatic compass, it is advisable that the beginner should make certain that he thoroughly understands how to plot the bearings that he takes with his compass. Examples for practice are given in Appendix III.

You now know how to handle a prismatic compass and take the bearings of objects, how to prepare your paper with parallel lines, and how to plot with the protractor each bearing that you observe. So you are ready to execute a sketch with the prismatic compass and protractor. Refresh your memory as to the general principles of making a sketch by glancing at Chapter III., and apply the principles set forth.

You are to make an uncontoured sketch of a piece of ground, and you are provided with a drawing-board on to which is fastened the drawing-paper prepared with parallel lines. You have also (besides pencils, indiarubber, &c.) a prismatic compass, a protractor, graduated as above described, and with scales of yards on the reverse side.

You decide which scale on the protractor you will use, and you then take a good look over the ground to be sketched.

Select the position of the BASE.

Select STATIONS for intersection (*Triangulation*).

Now go to one end of the base—call it A; hold your board in your hand, so that the parallel lines run approximately towards the north, the position of which you will generally be able to judge by looking at the sun and the time of day; draw an arrow-head at the north end of one of the lines; and settle whereabouts on the paper to mark a point representing the A end of the base, taking into consideration the limits of the ground and the scale of the sketch. Put a small circle round the point.

Lay aside the board, and take out the prismatic compass.

Face the other end of the base and observe its bearing. Take up the drawing-board and, placing the arrow-head of the protractor up against the point representing A, the edge of the protractor being laid parallel to the lines on the paper, mark on the sketch a spot opposite to the figure on the protractor's edge representing the observed bearing. Move the protractor, and draw a straight line from the point A through the new mark. The base will be along this line, so write along it BASE.

The bearing of each of the stations to be fixed is next taken with the prismatic compass, and similarly drawn (or '*plotted*') on the sketch.

(N.B.—Some difficulty may be experienced at first in holding the drawing-board in one hand and plotting with the protractor with the other hand; the best way is to support the board on the left forearm and palm of the hand, grasping the edge of the board with the fingers bent over on to the paper. Until the sketcher is accustomed to this, he is recommended either to sit down, with the board on his knees, or to lay the board on the ground, and draw kneeling. Under no circumstances should the board be attached to the body by strap or string.)

Before leaving A, 'set' your sketch to the ground, the north end of the parallel lines (magnetic meridians) pointing approximately to Magnetic North; see that each of the bearings that you have plotted run in the proper direction—*i.e.* towards each of the several objects; and see that the name of the object is written along each bearing. Make it a habit to 'set' your sketch roughly after plotting a new bearing, so as to prevent the possibility of your plotting the bearing in the wrong direction (by laying the protractor to the wrong side—a common error with beginners).

Pace the base. Measure the distance by placing the scale on the edge of the protractor against the base-line; mark the spot, putting a small circle round it, and calling it B.

With the prismatic compass, take the bearing of A (as a check); if the bearing from B to A is the reverse of the bearing from A to B, the base has been correctly plotted, and there is nothing wrong with your compass. Thus supposing the bearing from A to B had been found to be 270°, then the bearing from B to A should be 90° (*i.e.* 270 − 180); or, supposing the bearing from A to B was 85°, then that from B to A should be 265° (*i.e.* 85 + 180).

Fix all the stations, by taking their bearings from B, and plotting each one until it intersects the bearing to the same object from A. Put a small circle round the point of intersection, and name the station. Compare your sketch carefully with the ground.

If necessary, extend the triangulation, so as to get in more stations, as explained in Chapter III. For this extension you can proceed to any of the stations already fixed that appear suitable for the purpose, and use the prismatic compass and protractor in the usual way to fix the positions of the new stations. Clean up your sketch.

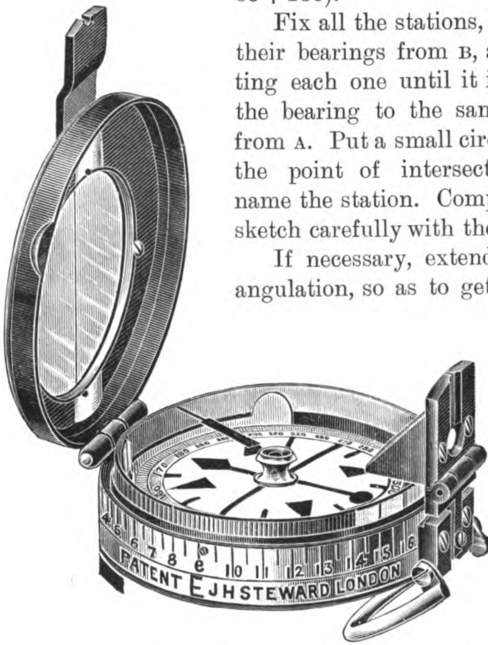


FIG. 18.—LUMINOUS PRISMATIC COMPASS

Thus the groundwork of your sketch is complete, and you have now to get in such detail as is necessary by Traversing, &c.

Traversing with the Prismatic Compass.—Proceed to some spot on the ground that you can identify on your sketch, preferably a fixed (or intersected) station on some road. From this spot take the bearing (*i.e.* the *forward bearing*) of the traverse line along which you propose going, as far as it is straight. Plot this bearing on your sketch ; pace the distance to the point where the direction changes ; mark off the distance to scale, and rub out any superfluous length of line that you have drawn. This new spot is called a *traverse station.* Take a new forward bearing and plot it, and continue as before until the traverse is finished.

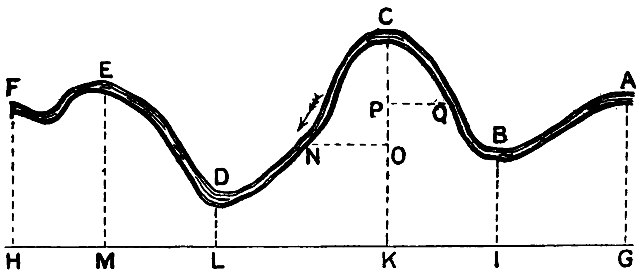


Fig. 19.—Traverse of a River

In large-scale and accurate sketches all roads, streams, banks, &c., are traversed in this way, and, while doing so, minor details of the sketch are drawn-in by eye ; or, if at a distance from the traverse line, by taking their bearing from some known point, and estimating their distance ; or by fixing them in the usual way by bearings from two known points.

The 'Offset' method is also most useful as an aid to traversing with a prismatic compass, especially in open country, and where roads, fences, &c., have frequent changes of direction. Figs. 9 and 19 illustrate this method ; A B C D E F (fig. 19) is the traverse required ; G H is the straight line whose bearing is taken ; G A, I B, K C, L D, M E, H F are 'offsets' at right-angles to G H, whose distances are paced or estimated ;

'secondary offsets,' as O N, P Q, are sometimes employed for additional accuracy. (See page 44.)

Resection with the Prismatic Compass.—This process is valuable both for checking the accuracy of your traversing as you go along, and also for enabling you to find your position on your sketch wherever you may happen to be on the ground. With regard to the latter, it is often a great saving of time to go straight to some object that you want to get on to your sketch, and fix its position there and then without any pacing. This can be effected by resection, if you can identify on the ground two stations or fixed points that are shown on your sketch, and if the intersection made by bearings plotted from these two points to the spot where you are standing is likely to be a good one. (See page 22.) To discover whether the stations are suitable the following is suggested, though after a little experience the eye will judge the approximate angle at a glance: Place your two wrists and palms together, fingers straight and pointing away from you; open your hands until one points to one station and the other to the other station; estimate the angle between your wrists, and you will see at once if it is a good one—*i.e.* neither too acute nor too obtuse.

To Resect your Position.—Take the bearings with the prismatic compass to each of the two selected stations from the spot that you wish to find. Now all that you have to do is to plot the opposite bearing *from* each of the stations, and their intersection will be your position. In order to lay off the opposite bearing you can adopt either of two methods.

(1) If the bearing that you take is under 180° add to it 180°, if over 180° deduct from it 180°; then lay your protractor in its proper position, with its central arrow-head mark up against the station on the sketch to which you have taken the bearing, and plot the bearing that you have obtained by adding or deducting 180°.

EXAMPLE.—Standing at an unknown spot, you find the bearing of Station M (fig. 20) to be 5°, and the bearing of Station P to be 75°; resect your position.

Lay the protractor with its central arrow-head mark to the left and up against the point M, plot the bearing 185°. Repeat the operation at P, plotting the bearing 255° (*i.e.* 75° + 180°). Produce in the opposite direction the two lines thus plotted, until they meet. The point of intersection of the two bearings fixes your position.

(2) Whatever you find the bearing to be, lay your protractor up against the station in the *reverse* way, and plot the bearing that you took with the prismatic compass.

EXAMPLE.—The same as before.

Lay your protractor with its central arrow-head mark to the *right* and up against the point M, plot the bearing 5°. Similarly at P plot the bearing 75°. Your position is the intersection of the two bearings thus plotted (fig. 20).

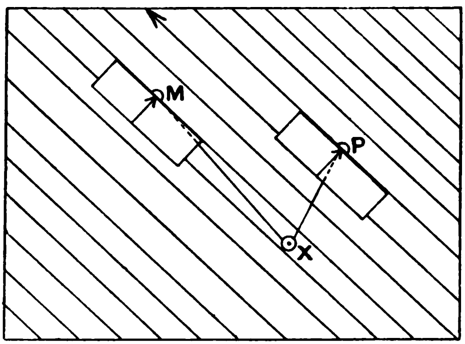


FIG. 20.—RESECTION WITH THE PRISMATIC COMPASS

It is just as well always to take the bearing of a third object, as an additional check to the accuracy of the work.

Summary of Sketching with the Prismatic Compass and Protractor.

(1) Put ruled paper on your board, and an arrow-head at one end of one of the ruled lines.

(2) Select base, and stations (for intersection).

(3) From one end of the base take the bearing of the base, and observe the bearings of stations with the prismatic compass.

(4) Plot all these bearings with the protractor.

(5) Pace the base ; mark it off to scale.

(6) From the new end of the base observe the bearings of the other end of the base, and of stations.

(7) Plot these bearings; put a small circle round the points of intersection; and name the stations.

(8) Extend the triangulation.

(9) Traverse all roads, &c., and sketch-in detail.

(10) Make use of resection.

(11) Compare the sketch with the ground; clean up.

(12) Finish up, either in the field in pencil, or in quarters in ink.

TRAVERSING WITH A PRISMATIC COMPASS AND FIELD-BOOK.—Instead of actually executing the sketch on the ground, the traverse work is sometimes carried out by means of entries recorded in a note-book, the plotting of bearings and distances being afterwards performed indoors. This method is useful in densely wooded country, in wet weather, when there is no time to plot in the field, or when secrecy is necessary; but, as will be seen, it has the great disadvantage that the sketcher is not able to compare his sketch with the ground, and has, therefore, no opportunity of correcting errors.

All that is required is a prismatic compass, with a note-book (*Field-book*) and pencil.

The Field-book is an ordinary note-book—the longer the better, and lengthways up the centre of each page are ruled two parallel lines, about half an inch apart. This column (technically termed the *Chain Column*) is intended to represent the single line of the traverse, and the *two* lines are ruled simply in order that entries may be made clearly between them, instead of being written on the top of the single line. In this chain column are entered three things—viz. the number of the traverse station, the forward bearing, and the distances measured. In the space (called the *Offset Column*) on either side of the chain column are written-in and drawn by eye all the detail on either side of the traverse line. The entries commence at the bottom of the last page of the book and work upwards, the book being held so that the top of the chain column in the book always points in the direction that you are going along the traverse line. Nothing is drawn to scale, and all distances, measurements, &c., are written in.

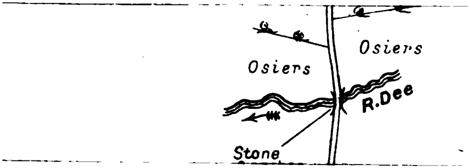
To make a Field-book Traverse of a Route.—Go to the spot where you propose making a start, enter in the chain column a small circle with a dot in the centre (Traverse Station), and write I. by its side (also within the chain column). Take the forward bearing with the prismatic compass up to the first change of direction, write the number of degrees, with the symbol for degrees, in the chain column above the station mark.

Before leaving the station look round the country on each side of the road, take bearings to all conspicuous objects within about 1,000 yards ; draw a line in the offset column of the Field-book in the approximate direction of each object from the edge of the chain column, and write-in along the line the bearing of the object and its name (for identification).

Pace forward along the traverse line until you see something off the route that you think should be noted ; halt ; write, in the chain column, above the last entry, the number of yards (or fractions of a mile) that you have paced (or otherwise measured). If the object to be noted be distant, take its bearing, and write it in the offset column ; or, if near, estimate its distance *at right angles* to the traverse line, and write it down. In this way you will eventually have sufficient data to fix the positions of different objects.

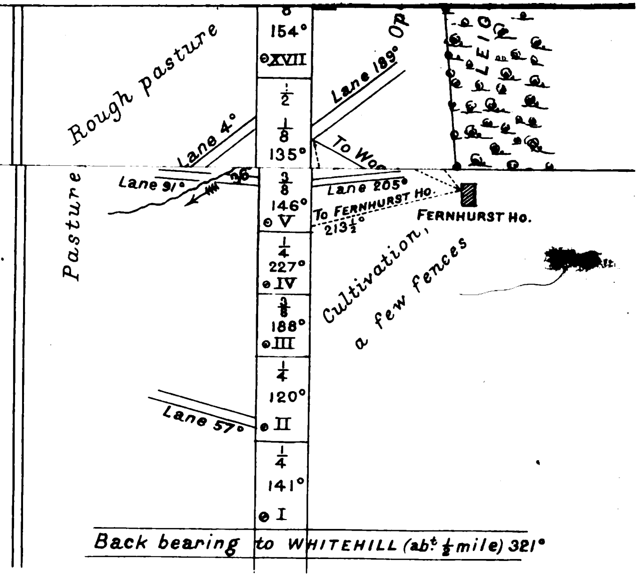
In the case of a stream or a hedgerow that crosses the road or comes up to both sides of it at an angle with it, it is important to bear in mind that the chain column of the Field-book is in reality a single line, as it were, pulled apart or opened out ; and that, therefore, the direction of the stream or hedgerow must be drawn-in in both offset columns exactly opposite the figure in the chain column representing your position on the traverse line.

When you arrive at a change of direction necessitating a new forward bearing being taken, draw a line straight across the chain column. The last figure entered is the *total* distance



Scale_ $\frac{1}{63360}$, or 1 inch to 1 mile.

Note_*The pencil meridian lines used for plotting have been erased.*



Measurements in miles and fractions of a mile. Road throughout metalled, 20', fairly level, good repair, thorn hedges.
[Executed with Prismatic Compass and Field-Book. Distances by Cyclometer.]

measured from the last station, for the figures that you enter in the chain column must all be counted from the last station, and not from the last stopping-place.

Now, above the line you have drawn, put a new station circle and figure it, say, II.; take a new forward bearing, and continue as before.

The method of keeping a Field-book will be understood by studying Plate VI., which shows, on the right, a portion of a Field-book traverse; and on the left is shown the same afterwards plotted to scale.

The plotting is carried out indoors afterwards, of course the sooner the better, so that the ground may still be fresh in your memory. But if the Field-book has been properly kept, the plotting can be done by anyone and at any time.

A suitable scale is decided on, and then the entries in the Field-book are plotted with the protractor on ruled paper, in the same manner as plotting is carried out in an ordinary prismatic-compass sketch executed in the field.

Although a Field-book is seldom used except for traversing, it is quite possible to execute the groundwork of a sketch of an area on similar principles, but its accuracy will depend on the care with which entries are made in the note-book. The examples of plotting given in Appendix III. show the entries that would be necessary in such a case.

FIG. 21.—THE USE OF THE PRISMATIC COMPASS (OLD PATTERN)

CHAPTER VIII

THE THEORY OF CONTOURING

Definitions—Drawing a Contoured Plan—Vertical Interval—The V. I. Rule—Triangle of Reference—Horizontal Equivalent—The Contouring Formula—Scale of Slopes—Slopes and Gradients.

No military sketch is complete, or can be of real value, unless it includes a representation of the topographical features of the country—*i.e.* the relative levels and undulations of the ground. So far nothing has been said in this book with reference to hill-sketching (or contouring), and there are certain matters connected with it that must be understood before setting to work in the field.

A CONTOUR is a line of level drawn on a map or sketch representing an imaginary horizontal line on the ground, so that every point on the line is the same vertical height above the sea, or any other convenient level.

When we speak, for instance, of the 400′ contour on an Ordnance map, we mean that the line marked on the Ordnance map as 400 represents on the ground an imaginary line which is everywhere 400′ above the sea (Mean Tide at Liverpool). So that if, with the map in your hand, you identified an object exactly on the 400′ line and another one also on the 400′ line, you could (unless one or both of the lines ran completely round a detached hill), by following the ramifications of the 400′ line on the map and on the ground, walk from one object to the other without ever going up hill or down—you would be on the same level (400′) the whole way.

Now it is these lines of level which have to be drawn in plan on your sketch, in order to show the shape of the ground and the relative heights of various parts of the ground, and they are drawn *vertically* equidistant. Take, for example, the 6″ Ordnance map of a hilly piece of country, and you will find drawn on it a series of chain-dotted lines figured 100, 200, 300, 400, and so on, which tells you that those lines represent the levels of the country above the sea of 100′, 200′, 300′, 400′, and so on. The map in this case is said to be contoured at Vertical Intervals of 100 feet.

A further explanation may be given. Draw a full-sized plan of a loaf of bread, contouring it at vertical intervals of one inch. Place the loaf on a sheet of paper, and upright by its side stand an ordinary foot-rule. We will say that the height of the loaf is eight inches (eight inches measured vertically from the table to the top of the loaf). Run your pencil round the outline of the base of the loaf: the mark left on the paper when the loaf is removed will be the shape of the lowest part of the loaf. Take a knife and, looking at the foot-rule, cut off from the bottom of the loaf a slice one inch thick; throw it away, and put the loaf down again in the same position as before; pencil round its bottom edge; the line on the paper gives you the shape of the loaf at one inch from its original bottom. Cut off a second slice one inch thick, and do as before; the line now drawn gives the shape of the loaf at two inches from its original bottom. Continue this operation for every inch of the loaf until the top is reached, and the result will be a full-sized plan of the loaf contoured at vertical intervals of one inch.

The above is the general principle of all contouring; but as you cannot perform the simple loaf-slicing process when dealing with actual hills, a general system of calculation has to be devised by which you may know where to draw the outline representing in plan the slice of the hill which you imagine you are cutting off.

Into the calculation there enter three things—viz. the VERTICAL INTERVAL in feet at which the sketch is to be contoured, the SLOPE in degrees of each portion of the hill, and the HORIZONTAL DISTANCE in plan between one contour and another (measured in yards). Each of these matters must be thoroughly explained.

1. THE VERTICAL INTERVAL (generally written V. I.) can be any number of feet that you choose, so long as you write the number on the sketch for the information of the person who has to use it. But the larger the scale of the map the smaller should be the vertical interval, and *vice versâ*, for the reason that it is essential to give as good a representation of the shape of the ground as possible, while at the same time it is obviously inconvenient to crowd out the detail of a small-scale sketch with a superfluity of contour-lines. For military sketches it has been found convenient to adopt a universal system of contouring, and the rule is now laid down that, to discover the V. I. at which to contour a sketch, the *number* 50 *is divided by the number of inches to the mile of the sketch.* The sole reason for this is convenience—*i.e.* its adaptability to the military sketches ordinarily made. So, remembering that the larger the scale the smaller the vertical interval, and *vice versâ*, it will be seen at once that a sketch on a scale of 1 inch to 1 mile would be contoured at 50 feet V. I.; a sketch on a scale of 2 inches to 1 mile at 25 feet V. I.; and other sketches similarly in proportion. When, however, the division results in the fraction of a foot, you can work to the nearest round number, or, in fact, at any V. I. that you consider suitable, for the rule is to be 'applied with common sense.'

2. THE SLOPE of a hill is found by means of some instrument designed for the purpose—*e.g.* the Watkin Mirror Clinometer, the Abney Level (see Chapter IV.), &c. The slope of the hill is merely the number of degrees contained by the angle made by the intersection of the line representing a portion of the hillside and a horizontal line; in other words, it is the number of degrees that the hillside is out of the horizontal.

If no special instrument is available, a makeshift clinometer can easily be improvised out of a protractor. A plumb-line is suspended from the centre of the inner edge of the protractor; when this line hangs vertically downwards (*i.e.* covering the central line, or 90°) the long edges of the protractor must be horizontal. By looking along the upper long edge (*i.e.* the inner edge) of the protractor and making it coincide with the inclination of the hillside, and by observing where the plumb-line falls, the number of degrees out of the horizontal can be read off on the protractor's edge. It would, of course, be better to have a longer straight-edge than an ordinary protractor, and to transfer the protractor graduations to it. In any case, the results cannot be absolutely accurate.

3. THE HORIZONTAL DISTANCE in plan between one contour and another, and how it is arrived at, is the beginner's stumbling-block. The actual and true horizontal distance cannot be measured by pacing or such-like means, because, to be plain, one cannot walk into the side of a hill. We can, however, measure down the outside, or slope, of the hill, and, as military sketches are drawn on comparatively small scales, and as the portable instruments used are not absolutely accurate, the distance measured along the hillside from one contour to another is assumed to be for all practical purposes equal to the horizontal distance—*i.e.* the hypotenuse of a right-angled triangle (such as in fig. 22) is taken as equal to its base.

We decide, therefore, at what VERTICAL INTERVAL the contours have to be drawn on the sketch; we measure the SLOPE with the clinometer; and then we have to *calculate* the distance in yards that it will be necessary to measure up or down the hillside to arrive at the next contour, so as to be able to put down on the sketch (to scale) its exact position, taking into consideration the vertical interval between it and the next contour, and the slope from it to the next contour.

The calculation depends wholly on what is sometimes called the *triangle of reference*—a right-angled triangle—of which the perpendicular is 1 foot, and the angle opposite 1°. By solving this triangle it is found that the base is 57·3 feet—*i.e.* 19·1 yards (fig. 22).

The perpendicular 1 foot is the vertical interval between the lowest and highest points of the triangle; the angle of 1° is the same thing as a SLOPE in the hypotenuse of 1°; and the length of the base (19·1 yards) is the HORIZONTAL DISTANCE between the lowest and highest points of the triangle. This horizontal distance, thus arrived at by calculation, is the HORIZONTAL EQUIVALENT expressed in yards for a slope of 1° at a vertical interval of 1 foot; and by remembering this we can work out the HORIZONTAL EQUIVALENT (written H. E.) for any slope at any V. I.

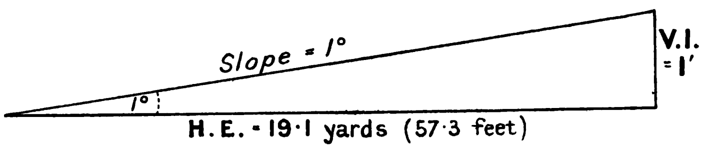


FIG. 22.—THE TRIANGLE OF REFERENCE

From this comes the *formula* to be carried in every sketcher's head (though it is usually engraved for reference on modern sketching protractors):

$$\text{H. E.} = \frac{\text{V. I.} \times 19{\cdot}1}{\text{D. (degree of slope)}}$$

which by transposition becomes:

$$\text{V. I.} = \frac{\text{H. E.} \times \text{D.}}{19{\cdot}1}, \text{ and } \text{D.} = \frac{19{\cdot}1 \times \text{V. I.}}{\text{H. E.}}.$$

The practical use of this formula will be dealt with in the next chapter, when discussing contouring in the field. It will be sufficient now for the student to remember how it was created: that it is a *formula*; that the H. E. is expressed in yards, the 19·1 are yards, the V. I. is expressed in feet, and the slope is expressed in degrees. Lastly, that the answer comes out in yards, feet, or degrees according as H. E., V. I., or D.

respectively is placed in the left-hand portion of the equation. Given two things, you can always find the third.

It is by the application of this formula that the table of horizontal equivalents shown on the sketching protractor is compiled for the convenience of anyone contouring at the more usual vertical intervals. The protractor hitherto in use, and which will be found in the Service for many years to come, gives the H. E. for each degree of slope (shown in the column D.) from 1° to 20° for V. I.'s of 15 feet and of 20 feet. (See Plate V.) Take, for instance, 2° : the H. E. at 15 feet V. I. is 143 yards ; for

$$\text{H. E.} = \frac{15 \times 19{\cdot}1}{2}.$$

Again, at 20 feet V. I., the H. E. is 191 yards ; for

$$\text{H. E.} = \frac{20 \times 19{\cdot}1}{2}.$$

If contouring a sketch at 30 feet V. I., then the H. E. for any degree of slope would be double that shown in the 15 feet V. I. table opposite that degree of slope—*e.g.* the H. E. for 2° at 30 feet V. I. is $143 \times 2 = 286$ yards. So if contouring at 10 feet V. I., the 20 feet V. I. table would be used, and the H. E. given in the table would be halved; if contouring at 40 feet V. I., the H. E. would be doubled ; and so on.

But suppose the sketcher was for some reason obliged to contour his sketch at a V. I. which was not worked out for him on the protractor—say 25 feet V. I.—he would then have to construct his own table of H. E.'s, with the aid of the formula,

$$\text{H. E.} = \frac{\text{V. I.} \times 19{\cdot}1}{\text{D.}}.$$

Thus for 1°, H. E. $= \frac{25 \times 19{\cdot}1}{1}$, 477 yards (omitting fractions); for 2°, H. E. $= \frac{25 \times 19{\cdot}1}{2}$, 239 yards, or simply $\frac{477}{2}$; for 3°, $\frac{477}{3}$; for 4°, $\frac{477}{4}$; and similarly for any degree of slope required.

We now come to the construction of the *Scale of Slopes*, which should be drawn on all contoured sketches, in order that a person using the sketch may be able to measure on it the actual slope of any particular hill represented. The H. E. for each degree is calculated by the formula, and the number of yards thus found is then measured off on the scale of yards; for instance, we find by calculation that the H. E. for 1° at 25 feet V. I. is 477 yards, and we know that, in accordance with the rule laid down, the scale of a map contoured at 25 feet V. I. must be 2 inches to 1 mile. The distance, 477 yards, is therefore measured off on the scale of 2 inches to 1 mile, and the measurement is the H. E. for 1°. This applies equally if we take the 50 feet V. I.; for the H. E. for 1° at 50 feet V. I. is found by the formula to be 955 yards, and the scale of a map contoured at 50 feet V. I. must be 1 inch to 1 mile. A line 955 yards long measured on the scale of 1 inch to 1 mile will be found to be the same length as one 477 yards long measured on the scale of 2 inches to 1 mile. The H. E.'s for 2° and other degrees are, in like manner, calculated, and then measured off the scale of yards.

In the case of sketches contoured in strict accordance with the rule (50 *divided by inches to mile*), a scale of slopes once made, say, on the edge of a card or protractor, will serve for all such sketches. But if the rule is for any reason to be departed from, it will be necessary to construct and draw a special scale of slopes for the sketch on the same principle as described above—viz. apply the formula to discover the H. E.; and then measure the distance so found off the scale of yards of the sketch.

Example.—Let us suppose that the sketch was made on a scale of 6 inches to 1 mile, and that you propose contouring it at 15 feet V. I. To construct the scale of slopes for this sketch: You find, by the formula, that the H. E. for 1° at 15 feet V. I. is 286 yards; so you measure this distance off the scale of 6 inches to 1 mile, and mark it on your scale of slopes as 1° (*i.e.* the H. E. for 1°); again, measure the distance

143 yards off the scale of 6 inches to 1 mile, and mark it 2° ; and H. E.'s for other degrees are calculated, measured, and marked along the scale of slopes under construction in the same way (fig. 23).

Before concluding this chapter and taking the sketcher on to contouring in the field, something must be said about the other term used for expressing a slope—viz. the GRADIENT. *Gradient* is more commonly employed than *Slope* when speaking of roads, railways, rivers, &c., and it is expressed by a fraction of which the numerator is 1 and the denominator such a multiple of 1 (expressed in the same terms) as to show the relationship between the horizontal distance and the vertical distance. Thus a gradient of $\frac{1}{16}$, or 1 in 16, or 1 : 16, implies that for every 1 foot vertically ascended or descended 16 feet will be measured horizontally; or for every 1 yard, 16 yards;

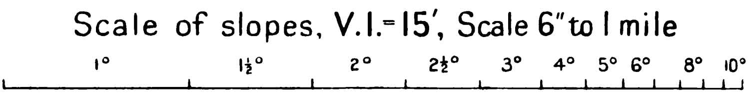


FIG. 23

or for every 1 metre, 16 metres, &c. It may also be defined as the proportion between the perpendicular and the base of a right-angled triangle, and from this, when necessary, we can easily convert gradients into slopes, and slopes into gradients. In the right-angled triangle, referred to a few pages back, it will be remembered that 1 foot V. I. (*i.e.* the perpendicular) gave a base or horizontal distance of 57·3 feet for 1° of slope; thus it is apparent that 1° expressed as a gradient is $\frac{1}{57 \cdot 3}$, but for all practical military purposes it is sufficient to take $\frac{1}{57 \cdot 3}$ as equivalent to $\frac{1}{60}$. Thus a slope of 1° expressed as a gradient is $\frac{1}{60}$, a slope of 2° is $\frac{1}{30}$, of 3°, $\frac{1}{20}$; the gradient being obtained by dividing 60 by the degree of slope. So to convert gradients into degrees of slope the process is reversed, 60 being divided by the denominator of the fraction representing the gradient.

CHAPTER IX

CONTOURING IN THE FIELD

Systematic Contouring—Traversing the Crest-line—Shaping the Contours — Form-lines—Under-features — Rapid Contouring — Summary — Drawing—Approximate Contours—Hill-shading.

DEFINITIONS (see Plate VII.).—A MOUNTAIN is an elevation whose *summit* is 3,000 feet or more above the surrounding country. Its lowest part is called its *base*.

A HILL is an elevation whose *top* is less than 3,000 feet above the surrounding country—*i.e.* above its *foot*.

A BROW is the actual edge of a hill or slope.

A CREST-LINE is a line of level taken, as the highest contour of a sketch, *near* the top of a hill.

A SPUR is a prominent feature projecting from high ground.

A KNOLL is a small eminence, or hillock.

UNDER-FEATURES are minor features springing from main features.

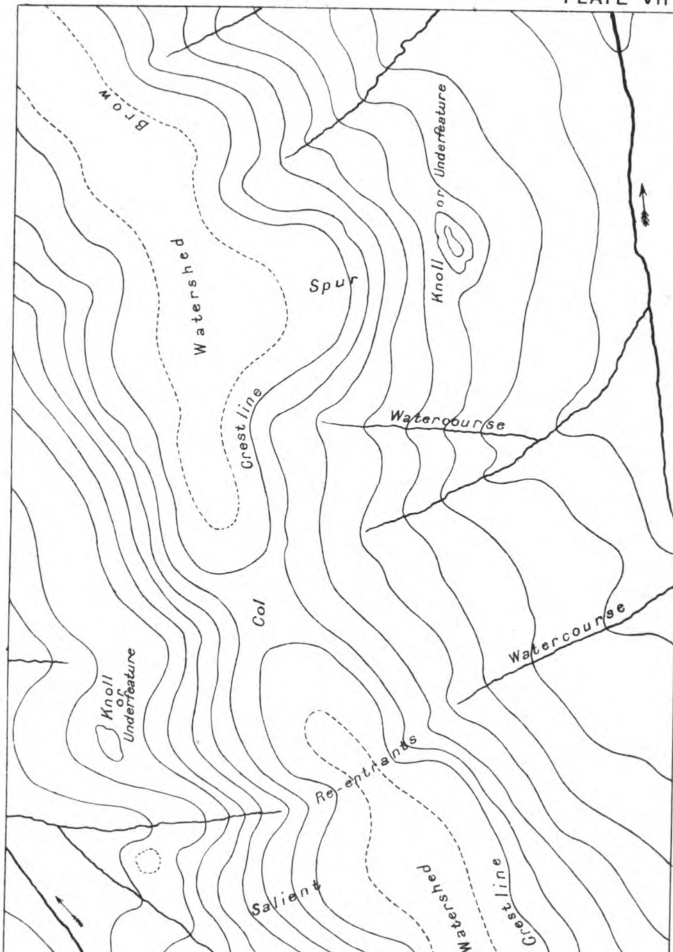
A WATERCOURSE is the lowest part of a valley. The watercourses show the system of surface-drainage of the country.

A WATERSHED, the highest line of a feature—*i.e.* the water-parting; *e.g.* the ridge of the roof of a house.

A COL is a *neck* or *saddle* connecting adjacent heights. From a col the ground slopes up on two sides, and down on the other two sides.

TO CONTOUR A PIECE OF GROUND SYSTEMATICALLY (fig. 24).—A beginner should commence on ground the shape of which is well defined, with bold spurs and noticeable watercourses.

Having completed the plan without the hills, select, somewhere near the highest part of the ground, a line of level to be assumed as a crest-line, so situated that when drawn-in it will show the shape of all the principal salients and re-entrants.


Brow
Watershed
Crest line
Spur
Knoll or Underfeature
Watercourse
Col
Watercourse
Knoll or Underfeature
Re-entrants
Salient
Watershed
Crest line
Brow

Now proceed to traverse this crest-line carefully all round the ground.

When two men are sketching the same piece of ground, the simplest way is for one to move ahead to the centre of a salient or re-entrant, being levelled by his companion with the clinometer reading 0°.[1] If the country is open and fixed stations are visible, the man in rear moves forward to the

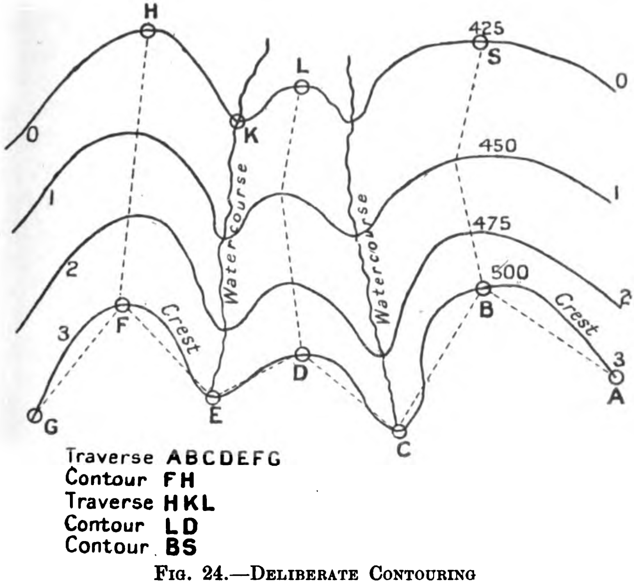


FIG. 24.—DELIBERATE CONTOURING

position taken up by the man ahead, and both set their boards and resect their position.[2]

If the country is such that fixed stations are not visible, then the man in rear must set his board, draw a forward ray

[1] For the method of using the clinometer, see page 28.

[2] Contouring with the plane-table is here described. When sketching with a prismatic compass, the same system is followed, *bearings* being taken and plotted, instead of the board being set and *rays* drawn.

to his companion, and pace the distance to him; while the man ahead would pace the distance as he advanced, set his board at his new position, and draw a ray from the last position. The process is of course exactly similar to traversing a road in open or close country.

When a man is sketching alone, he will have to use his intelligence as to the selection of an object (on his own level) on which to advance, though it is usually simpler to tie a piece of paper or something of the kind to a bush or tussock on the crest-line, and level oneself at the new position by looking back at the paper, &c.

In either case it is merely a matter of practice. The line of advance from one point to another will be straight, but the actual crest-line will generally bend to one side or the other of the straight; the curve is drawn-in by eye, the sketcher remembering that whenever in his advance he finds himself descending he is passing a re-entrant, and that, therefore, the crest-line will curve inwards towards the top of the hill, and *vice versâ* if he finds himself ascending.

Wherever the crest-line touches the head of a watercourse the direction of the watercourse should be sketched-in as far as it can be seen. This will be an immense aid to shaping subsequent contours.

Having completely traversed the crest-line as above described, the sketcher proceeds to fix the positions of contours down the centre, or ridge, of as many spurs as possible. The spurs should be selected for this operation, in preference to the watercourses, as giving a better field of view.

This process is, of course, laborious, but for a beginner it is the surest way of accurately getting in the contours.

Start from the crest-line on a spur; resect your position; draw a forward ray down the centre of the spur as far as it continues straight, noting some distant point in prolongation of this ray (for easy and rapid setting of the board); with the clinometer take the slope of the spur, until the slope changes; by referring to your table of Horizontal Equivalents, discover how many yards have to be measured down the spur to arrive at the next contour. Pace this distance; set the board on the forward or back angle (or with the compass); mark off on the ray that you have drawn the number of yards paced. Face the higher ground, and, looking at the level of your feet, draw in the contour by eye for a few yards to the right and left. Repeat this operation until the bottom of the spur is reached, and all the contours that cut the ray have been drawn-in. Work alternately down and up as many spurs as possible all over the ground. A spur need not necessarily run straight throughout its course; when it changes direction, a fresh ray in the new direction will represent the line on which you are to lay down the contours.

Two seeming difficulties may arise while contouring a slope:

(1) The slope is found to change before the whole distance required to complete a contour at that slope has been arrived at. In this case halt where the slope changes, note how many yards have been paced, take the new slope with the clinometer, make a small mark on your sketch representing your position, and then make a calculation to discover what fraction of a contour has been reached, and what fraction remains to complete the contour.

E.g., slope at starting, 4°; the H. E. for this, when sketching at 15′ V. I., is 72 yards; after going 50 yards the slope is found to have changed to 6°. You have come $\frac{50}{72}$ of a contour; therefore, to complete the contour, you have to go another $\frac{22}{72}$ of a contour *at the new slope*. Now the H. E. for 6° is 48 yards; so you pace on $\frac{22}{72}$ of 48 yards (*i.e.* about $14\frac{1}{2}$ yards), and then draw-in the contour.

(2) The other difficulty is the representation of an underfeature — and to a novice this is very frequently a real difficulty; he can contour down a slope, but when he finds a knoll suddenly confronting him, he does not know how to tackle it.

Here is an example (see fig. 25): You are descending the slope A, B, C, D, and, on reaching the contour C, you find the under-feature X in front of you. With the clinometer at zero note a spot C′ on the same level as C; continue contouring down to D, repeat the operation to find D′; pace the distance D—D′, mark the spot on your sketch, and draw a ray to C′; pace to C′ and mark-in its position, drawing-in the contours at D′ and at C′ right and left, as usual. Now traverse round the topmost contour of the under-feature, and select a spot on it

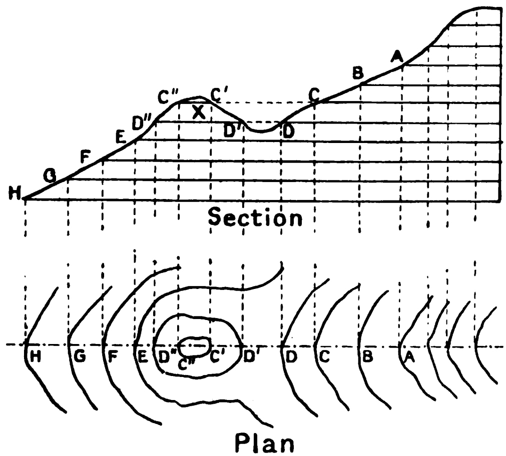


FIG. 25

(as C″) from which to start a new line to go on—C″, D″, E, F, G, &c.; it will probably be possible to draw-in by eye the contour from D′ to D″. Thence continue down the slope in the usual manner.

The above example shows a noticeable under-feature, with two contours, but very frequently an under-feature of even less height than a whole contour will be found. (See fig. 26.) In this case its shape would be represented in plan by a *form-line* (dotted) between two adjacent contours.

Proceed down the slope, drawing-in the contours A and B. After leaving B, note the number of yards paced on reaching *b* just below the level of the top of the under-feature *c*. We will assume that *b* is one-third of a contour below B; pace the distance to *c* (or go to *c* and resect your position). On the way mark with a form-line the position of *a*, say half a contour below B; round the point *c* on the plan draw a small dotted

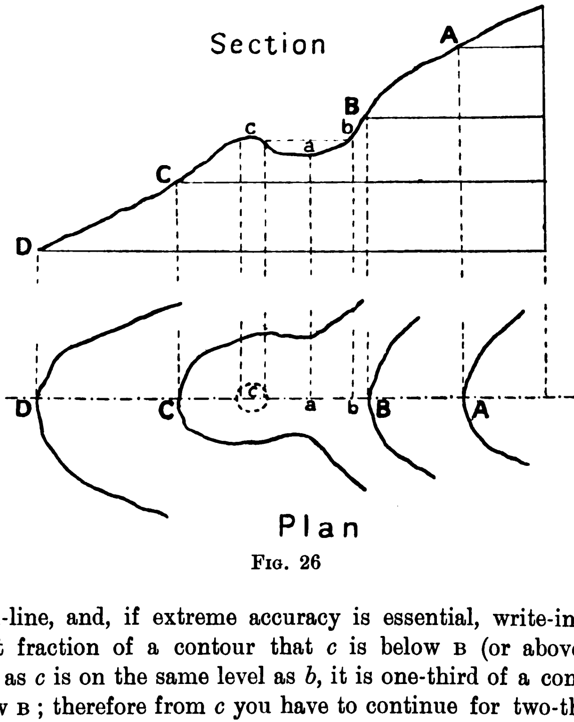


FIG. 26

form-line, and, if extreme accuracy is essential, write-in the exact fraction of a contour that *c* is below B (or above C). Now as *c* is on the same level as *b*, it is one-third of a contour below B; therefore from *c* you have to continue for two-thirds the distance required at the new slope to complete and draw-in the contour C.

(It may be remarked that an apparently insignificant under-feature may be of considerable tactical importance, as causing a portion of the ground at the foot of a slope to be unseen from the top of the slope.)

To Contour Ground Rapidly.—The lengthy method of contouring just described, if thoroughly followed out, will have taught the sketcher to read ground with facility; and he should now, whenever his time for making a sketch is limited, be able to depict fairly the levels of the land with very little labour. The process depends principally on accurately applying the formula $\text{H. E.} = \dfrac{\text{V. I.} \times 19{\cdot}1}{\text{degree of slope}}$, the theory of which has been already discussed.

If time admits, it is always advisable to traverse a crest-line, or at any rate one line of level extending throughout the sketch, and mark-in the watercourses; then, while doing this, find the heights with reference to the height of the crest-line (or line of level) of all objects on the ground that can be identified on the map. Assume the height of the line of level, say 500 feet. With the clinometer take the slope from the line of level to an object; measure off in yards on the sketch the distance of the object from your position on the line of level. Apply the formula. Now, suppose that the slope is found to be 5° down, and the distance of the object (*i.e.* the H. E.) is found to measure 600 yards, you can now work out how many feet the object is below you, or the vertical interval between you and the object, thus:

$$\text{H. E.} = \frac{\text{V. I.} \times 19{\cdot}1}{\text{D.}}$$

$$600 = \frac{\text{V. I.} \times 19{\cdot}1}{5}$$

$$\text{V. I.} = 157 \text{ feet.}$$

Therefore the object is 157 feet below the line of level, which was here assumed to be 500 feet. Figure the line of level 500′ and the object in question 343′. Repeat this as often as possible until the sketch is well covered with heights in feet.

But since when working with a clinometer absolute accuracy of slopes cannot be expected, it is near enough for all practical purposes to take the 19·1 in the formula as 20, which simplifies the calculation very considerably.

With the crest-line (or other line of level) drawn-in and the direction of the watercourses shown, it should be an easy matter to shape-in the contours in conformity with the heights figured on the sketch.

In using this formula two mistakes are often made by beginners.

(1) They forget that it is a *formula*; that the H. E., though in yards, must be left in yards, and the V. I., though in feet, must be left in feet; and that the answer comes out in feet.

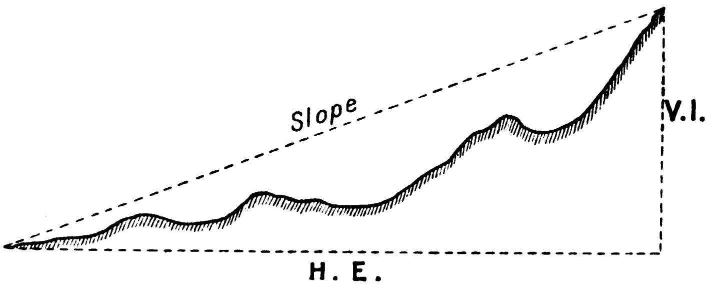


FIG. 27.—RAPID CONTOURING

(2) They are apt to imagine that the vertical interval at which they are contouring the sketch enters into the calculation. Of course it has nothing to do with it; the formula applies whatever the vertical interval between contours may be. The slope that is taken with the clinometer is that of an imaginary straight line drawn from the sketcher to the distant object, and is not influenced in any way by intervening slopes or undulations of the ground. The H. E. that is measured off the sketch is the distance in plan (*i.e.* the horizontal distance) from the sketcher to the object. This will be apparent from the accompanying diagram (fig. 27).

Another Method of Rapid Contouring.—As in the previous method, take the slope to an object with the clinometer; measure its horizontal distance off the sketch. Then calculate *how many contours* there will be between you and the distant object, by means of your table of Horizontal Equivalents. Into this method the vertical interval at which the sketch is being contoured *does* enter. *Example.*—The V. I. of the sketch is 15 feet; the slope to the object is found to be 4°; and the distance of the object is measured as 780 yards. Looking at the H. E. table, you find that the H. E. for 4°, at 15′ V. I., is 72 yards; divide 780 by 72, and the result shows that there are 10 whole contours between you and the object, and $\frac{60}{72}$ of another contour, which is near enough to be taken as a whole contour; so you know that you must fit-in 11 spaces or, including the crest-line, 12 actual lines. You now proceed carefully to examine the ground where these contours are to be placed, and bearing in mind that where the slopes are steep the contours must be close together and *vice versâ*, you draw-in the contours by eye, of course shaping them into the watercourses. This, though not by any means an accurate method, has the advantage of great rapidity, provided that the sketcher has a table of horizontal equivalents to refer to in order to save time in calculating.

Summary of contouring in the field (after deciding on the V. I. to be used):

I. *Deliberate contouring* (fig. 24):

(1) Traverse a crest-line, or other line of level.

(2) Get in the contours down a principal spur.

(3) Traverse the lowest contour reached until the bottom of the next spur is arrived at.

(4) Resect your position, and get in the contours up the spur.

(5) Proceed along the crest-line to the next spur; resect your position, and get in the contours down the spur.

(6) Continue contouring up and down the spurs until the sketch is well covered with portions of contour lines, all of which are numbered from a *datum* (either the lowest part of the ground, the crest-line, or some other line of level).

(7) Complete the contours by joining up those of the same number.

II. *Rapid contouring :*

(1) Remember the formula $H. E. = \frac{V. I. \times 19 \cdot 1}{D.}$.

(2) If possible, traverse the crest-line.

(3) Find, by the formula, the heights of all noticeable objects with reference to the crest-line, assuming a height for the crest-line, and marking-in, in feet, on the sketch, the relative heights of other objects.

(4) Draw-in the contours by eye, shaping them into the watercourses, and arranging them in accordance with the heights marked on the sketch.

III. *Rapid contouring (second method) :*

(1) Proceed as in II., but, instead of figuring relative levels in feet, do so in contour intervals.

(2) Having discovered the number of contour intervals that an object is above or below your position, draw-in the contours by eye, placing them close together where the ground is steep, and *vice versâ.*

IV. *Rapid contouring (third method) :*

(1) Enter, in feet, on the sketch the aneroid[1] readings (or the calculated heights from a visible *datum*) of points visited.

(2) Complete the contouring as in II. (4).

[N.B.—Rapid contouring should not be attempted until the sketcher is thoroughly acquainted with the more deliberate methods.]

When finishing up the sketch, draw the contours in brown (or red) continuous lines of uniform thickness, and figure them clearly, the lowest number to the lowest contour. They can be figured either according to the number of contours, or in feet, from an assumed *datum*, the latter being preferable. The contours should be clear and distinct, standing out well, but without being too thick. When finishing up the sketch in black pencil or in coloured chalks, draw the contours in chain-dotted lines.

Remember that you do not pretend to be anything more than a 'military sketcher'—in other words, an *approximate*

[1] *Vide* Appendix II.

surveyor—and that, therefore, like all military sketching with portable instruments, this system of contouring can at the best only produce *approximate* results—*i.e.* your contours are what would be technically termed *approximate contours.*

After a man has thoroughly mastered contouring, and acquired that 'eye for ground' so necessary for sketching, he will be able to depict the features of the country with very fair accuracy in other and more rapid ways. The principal of these is the employment of *form-lines* (*i.e.* shape-lines) in place of contours, the whole of the hill features being sketched-in, from some commanding positions, by eye. *Form-lines* are not necessarily drawn at regular vertical intervals, and their object is merely to give a general impression of the shape, slopes, &c., of the features of the country.

An inspection of various maps will show other methods of representing the different levels and undulations of the land, by hill-shading, such as brushwork, mezzotint, hachuring, and gradations of colour, but all these things are too elaborate to be worth the attention of the ordinary military sketcher.

CHAPTER X

SKETCHING WITHOUT INSTRUMENTS

Eye-sketch—Improvised Equipment—General Principles—Setting the Board—The Scale of the Sketch—Contouring without a Clinometer—Recapitulation—Zero-line.

It may occur that an officer on service may find himself called upon to make a sketch when unprovided with instruments. It would seldom happen that an officer was without a compass, but his compass might be broken, or he might be in a country where, owing to *local magnetic attraction*, &c., a compass would be useless. A fairly reliable sketch can, however, be made without any instruments, and without even a compass—and this is sometimes termed an Eye-sketch.

Under these circumstances, the first thing to be done is to see in what way you can supply the deficiency in the matter of instruments. You want to make a sketch on plane-table principles, but you have no tripod or plane-table top.

The Board.—You, of course, have paper and pencils, and you must improvise a board of some kind. Anything of convenient size and with a flat surface will do—the lid of a biscuit-tin, the top of a wooden box, or a book. Fasten the paper securely, by wrapping it round and binding it with string.

The Ruler.—All that is necessary is a straight edge; and if you cannot get a piece of wood with a straight edge, cut a strip off the cover of a book or a piece of cardboard about an inch or so wide and eight or ten inches long. In default of anything better, one of your pencils laid flat on the paper would serve as a ruler.

With board and ruler of this description it will be found quite simple to make a sketch of a piece of ground in the following way:

Consider that your board is the top of a plane-table; but, as you have no tripod, you must lay the board flat on the ground whenever you want to draw a ray. Make your sketch exactly in the same way as you would a plane-table sketch (base, intersection of stations, traversing, &c.), but, being without a compass, you must set the board by one or other of the methods which will be found on pages 138 and 139—*i.e.* by the back angle, getting between two fixed points, in prolongation of two fixed points, &c.

The ruler (if of wood) can be converted into a sight ruler by simply sticking a pin in upright at either end, on a line drawn down the centre of the ruler parallel to one of its edges. In this case you would have to lie down flat on the ground to take a sight, which is obviously most inconvenient. A far better plan is to lay the ruler on the board, step back two or three paces, hold up a pencil towards the object, and bring it down sharply two or three times towards the edge of the ruler: it will soon be seen if the ruler-edge is pointing straight at the object, and it can be adjusted until it points in the right direction. This requires a little practice at first, but is readily acquired. Or, instead of the pencil, tie a stone on to a piece of string, and hold it up like a plumb-line, getting the ruler-edge and the object in one straight line and covered by the string.

Use a pin to pivot the ruler against, if your table-top is made of wood; otherwise you must be careful to see that the ruler is up against the point on the paper representing the spot from which you wish to draw the ray.

To find your position: First set the board carefully; then, if you are on a straight road, bank, &c., marked on your sketch (or in the prolongation of two known points or between two known points), a ray drawn from a fixed point, or station, will give you your position; if you are *not* on any such well-defined straight line, you must employ one of the methods described on pages 140 and 188—*e.g. by adjustment* (tracing paper).

Before starting your sketch you must decide to what scale you will make it, and as you have no ready-made scale you must make one for yourself. Settle in your mind what length of line you will call, say, 100 yards or 50 yards, then cut a little bit of paper, and with it mark off these measurements all along your scale, and number them in the usual way. Afterwards, if you come across a foot-rule or anything with inches marked on it, you can measure how many yards on your scale go to the inch, and you can then give a title to your scale, as well as the R. F.

If, however, you happen to have a foot-rule, &c., by all means make use of it to decide your scale, and apportion a certain number of yards to the inch. You know *about* what scale you should use for the particular kind of sketch you are making, so you can arrive at the number of yards to the inch to fix on. A scale of 220 yards to the inch is 8 inches to the mile, which will give an idea of the best scale to work on.

Let us take an example of rather a large scale—viz. 300 yards to an inch. To draw the scale: Mark off inches along the line; divide the left-hand division into three (by folding a piece of paper an inch long into three); then figure the scale as shown in fig. 1, Plate IX.

To give a title to this scale, you might describe it simply as 'Scale of 300 yards to 1 inch,' or 'Scale of 5·87 inches to 1 mile'; and the R. F. would be $\frac{1}{10800}$.

Now, having made the plan of the ground and, as usual, having drawn-in the direction of as many watercourses as possible, proceed to contour the sketch. Contouring without instruments cannot, of course, be very accurate, but with care it can be done accurately enough to be of considerable value for military purposes.

Men who have had much practice in contouring with a clinometer often become experts at estimating slopes (and every officer should try and get into the habit of judging the slope before taking it with a clinometer), which will be found of immense assistance when working without a clinometer.

If you consider that you are a fairly good judge of slopes, contour your sketch as if you were working with a plane-table, estimating the slopes instead of taking them with a clinometer,[1] though it is not easy to traverse a crest-line without some sort of levelling instrument, and it is perhaps better to contour up the slopes instead of down, and to start at some well-defined or fixed point at the foot of each spur.

Decide on a suitable V. I. for your sketch, and then make a table of horizontal equivalents, and a scale of slopes in the usual manner.

There is, however, a far simpler method of contouring without instruments, in which also it is unnecessary to be able to judge slopes. Adopt a V. I. which will give you a multiple of the approximate height of your eye above the ground when you are standing up. For instance, suppose the height of your eye above the ground was 5½ feet, you might use a V. I. of 11 feet, or 16½ feet, or 22 feet. In this rough contouring, however, an inch or two is immaterial; so you need not be very particular about the *exact* height of your eye. Let us assume that the height of your eye is 5½ feet above the ground, and that you propose contouring your sketch at 11 feet V. I. (approximately):

Begin at the bottom of a slope (at some spot easily identified on your sketch); note an object (stone, tuft of grass, &c.) up the slope, on a level with your eye, pace to it, mark off to scale the distance paced, and your new position is above your old position the height of your eye—*i.e.* 5½ feet—and you have paced the H. E. for half a contour. Repeat this operation once, and you will have ascended a complete contour. Draw it in as usual, and number it 1. Continue in the same way to the top of the slope.

[1] See page 90.

When you have thus contoured all the principal spurs, join up the portions of the contour-lines, and the shape of the ground, with relative levels, should be fairly accurate.

In this process of contouring, if there are no noticeable objects on the hillside, a companion is of great assistance: *e.g.* A stands at the bottom of a slope, B ascends until his (B's) feet are on a level with A's eye. A then halts B, and paces the distance to him. One of them then ascends again, and proceeds as before. This will be at once understood from the diagram (fig. 28).

The only difficulty in this method is getting the correct level of the eye. Three ways are suggested, and the sketcher

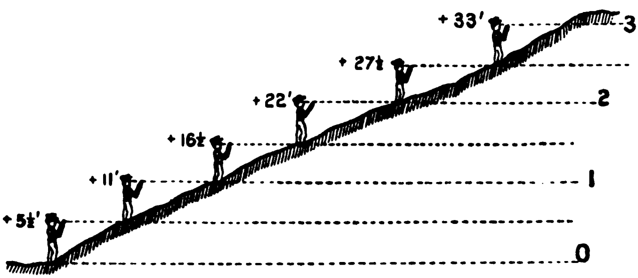


Fig. 28.—Contouring without Instruments

can adopt which he thinks best: (1) Hold your straight-edge horizontally, at full extent of arm, and, with one eye shut, look over the edge, and see where it cuts the slope; (2) hold your board up sideways and look along its upper edge; (3) tie a string to a stone (plumb-line), draw a line across your board at right-angles to one edge, and thus, by fastening the string to the top of the board, make a rough mason's level; when the string, hanging free, is over the line, and so vertical, it is at right-angles to the upper edge of the board, which is then horizontal; look along it. This last is the most accurate way of levelling.

By using a level of this description it is quite possible to traverse a crest-line (or other line of level), which is always a valuable aid to drawing-in the shape of the ground.

When working by levelling up the height of the eye, the actual slopes of the hillside are of no immediate consequence, but you should always draw on the sketch a scale of slopes (approximate), in the manner previously explained (page 86).

As a rule, even on service, it will generally be found possible to collect *some* instruments with which to make a sketch. Get what you can, but do not be put off even if you get none. If, for instance, you find yourself on outpost duty without any instruments, you should be able to turn out a very fair sketch on a page of your pocket-book. Remember the following :

(1) Decide on a scale of yards, and draw it.[1]

(2) Think over plane-table work.

(3) Adjust your paper so that all the ground to be sketched will come on it.

(4) Base.

(5) Triangulation.

(6) Traverse roads, &c., and draw-in detail.

(7) Contour, and draw a scale of slopes (approximate).

To complete the sketch you should, if possible, add the direction of True North, by drawing a Meridian-line (with star at the end), and writing along it *Approximate.* The simplest way to get this line is by drawing the shadow of the sun at noon on your board, after you have carefully set it.

(N.B.—*The Zero-line* of a 'Sketch without Instruments' is the first line drawn or plotted, the direction of all other lines being drawn with reference to this. *Cf.* definition of Zero-line when working with a compass, pages 40 and 70.)

[1] A ready-made scale is provided by cutting a transverse slip from the page of a *ruled* note-book, and by giving a distance to the space between the lines—say, 200 yards.

CHAPTER XI

THE CAVALRY BOARD

Use of the Board—The Route Sketch—Getting the 'Set'—With the Aid of a Map—Without a Map—How the Board is held—Making the Sketch—Area Sketch—Contouring—Scales for Sketching by Time and by Horses' Paces—Bicycle Revolutions.

THE Cavalry Board (fig. 29) was described in an earlier chapter, and, as its name implies, it was originally designed for use on horseback. Its extreme portability and compactness make it an invaluable instrument not only for mounted work, but also for all sketching, when, for one reason or another, a plane-table is not available. It is the instrument *par excellence* for reconnaissance. A man who has learnt the use of a plane-table soon gets into the way of sketching with the cavalry board, which is nothing more than a plane-table without a tripod.

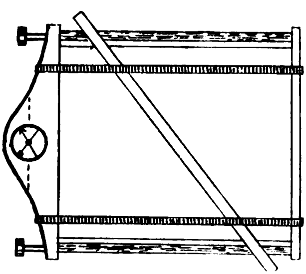


FIG. 29.—CAVALRY BOARD

As a matter of fact, it is nowadays quite as much used on foot as on horseback, and even the cavalry officer is recommended thoroughly to master the instrument dismounted before he attempts to work with it mounted.

Its principal value is for the production of route sketches limited in width, but unlimited in length; but it can also be satisfactorily used for area sketches drawn to suitable scales—

i.e. so that the whole of the ground to be sketched will come within the limits of the board without moving the paper.

The difficulties with which the beginner has to cope are these: He has practically only his right hand to work with, and with this he has to align his ruler and to draw the ray along its edge without shifting its position; there being no pin against which to pivot the ruler, it is necessary to be careful that the ruler is against the point representing the sketcher's position; the board must be held level, otherwise the needle will not swing in its shallow box; the ruler has to be aligned by a method hereafter described. While aligning the ruler, the sketcher has at the same time to see that his board is set by the compass; and also, when aligning the ruler, the sketcher must face the object to which the ray is to be drawn.

Considering how great these difficulties must appear to anyone who has hitherto only worked with a plane-table and tripod, it is astonishing with what little practice the cavalry board can be manipulated, and how accurate will be the results.

To put the Paper on the Board.—The paper can be of any required length, and its width should be slightly less than the length of the rollers. The latter are of two patterns—viz. either a metal cylinder with a slit for the insertion of the end of the paper, or a wooden roller in two pieces. Remove the indiarubber bands.

With the metal roller all that is necessary is to insert one end of the paper in the slit of one roller, and the other end in that of the other roller.

The wooden rollers are held in position by springs; press back the springs and remove the rollers. Then crease down about a quarter of an inch of the end of the paper, place it in the groove of the roller, and secure it in position by putting the detached piece back into the groove on the top of the paper. Cut off any small surplus of paper that projects beyond the roller. Return the roller with its paper into the spring catch. Repeat this with the other roller.

Now wind the paper tightly on to each roller, two or three

PLATE VIII.

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turns on the lower roller, and the bulk of the paper on the upper roller (*i.e.* the roller in the direction towards which you are going to sketch, the compass being on the left). In winding the paper, turn each roller inwards towards the centre of the board, so that the paper will be nipped between the roller and the edge of the board, and thus kept taut. Also be careful that the long edge of the paper is truly parallel with the edge of the board.

When the paper has been stretched quite taut over the surface of the board, the indiarubber bands can be replaced, one at either end, over the paper and parallel with the rollers.

(These bands, though not absolutely necessary, assist in keeping the paper flat, as well as in steadying the ruler. When sketching on foot the ruler should be placed on the top of the bands; when sketching on horseback, under the bands. This refers to boards without attached rulers.)

To make a Route Sketch.—A suitable scale for a beginner is 3 inches to 1 mile, as on this scale a certain amount of detail can be shown, and there is plenty of room on the paper for writing descriptive notes. Later he will work on smaller scales, such as 1 or 2 miles to the inch.

Every endeavour should be made to prevent the sketch running off the paper to one side; but in order to do this it is necessary to know the general direction of the route or road to be sketched. The instructions issued for making such a sketch will usually contain the names of the starting-point and finishing-point taken from a map; or a description of the starting-point and the compass-bearing of the general direction of the route (*i.e.* of the line of advance).

In any case the line of advance is represented on the paper by a pencil-line drawn throughout its length, both the starting-point and the finishing-point being situated on this line.

The first thing to be done is to set the compass for the sketch, and to draw a meridian-line on the paper (the Zero-line of the sketch), or *vice versâ*.

I. If you have a map showing the starting-point and finishing-point, join these two points by a straight line (the line of advance); now look at the North Point on the map, and rule a line parallel to the magnetic meridian, so that it cuts the line of advance; with the protractor discover the bearing of the line of advance.

Knowing the bearing of the line of advance, all that you have to do is to rule on your paper a magnetic meridian so situated that the line of advance ruled up your paper will make with it an angle equivalent to the bearing that you discovered from the map. The simplest way to do this is to mark a spot on your line of advance; up against this spot pivot the centre (arrow-head) mark of your protractor-edge, and turn the protractor round until the required bearing on the edge is over the line of direction; then rule a line along the long edge of the protractor, and this is the meridian-line of the sketch. Place an arrow-head at the North end.

Now, with finger and thumb against the milled rim of the compass, turn the glass round until the black line on the glass (called the *index-line* or *glass meridian*) is parallel to the meridian-line drawn on the paper, the indicator mark at the end of the glass meridian being in the same direction as the arrow-head on the paper.

Your compass is now set for the sketch; and in order to make certain that the glass of the compass has not shifted, the glass meridian should be occasionally compared with the meridian-line on the paper.

But, as a rule, it is not necessary to be so accurate in the matter of the bearing of the line of advance. The approximate bearing is usually quite sufficient; and the following is a rapid method of obtaining it from a map: Lay the map down flat, and draw a line from the starting-point to the finishing-point; place the sketching-board on the map, so that the line of direction on the paper is as nearly as possible parallel to the line of direction on the map, the full roller in the direction of the finishing-point; look at the North Point on the map, and adjust the glass meridian by eye until it is parallel to the magnetic meridian on the map. With the aid of a ruler whose edge is placed against the glass meridian, draw the meridian-line on the paper, indicating the North end, as usual, by an arrow-head.

The situation of the line of direction (or line of advance) on the paper is of importance. If the road or route is fairly straight throughout its course, the line of direction should run up the centre of the paper; if, however, the road takes wide bends to either side, some difficulty may be experienced in keeping the sketch on the paper. With the assistance of a map showing the general course of the road there can be no difficulty, as the greatest distance which the road bends to one side or other of the line of direction can be measured and allowed for. Thus, suppose, on referring to the map, you find that the road diverges at one point as much as a mile from the line of direction, and that this divergence is to the right of the line of direction; if working on a scale of 3 inches to a mile, you must place your line of direction, say, an inch or two to the left of the centre of the paper, in order to be able to sketch-in sufficient detail to the right of the road at the above-mentioned point of greatest divergence. The placing of the line of direction, therefore, when you have a map to consult, is merely a matter of judgment.

II. We will now imagine that your instructions contain no reference to a map, and that you have no map to consult. You are ordered to start your sketch at a certain spot which is shown to you on the ground, you are given the general bearing of your line of advance, and you are told to follow, say, a certain metalled road with telegraph-posts along it.

In this case you first set your glass meridian so that the line of direction straight up the paper runs in the direction of the given bearing. To simplify this, modern cavalry boards have, marked on a circle outside the compass, a series of rays 10 degrees apart, and a long central line (line of direction) parallel to the edge of the board, and consequently parallel to the long edge of the paper. With this arrangement you can at once place the glass meridian in such a position that the line of direction will make with it an angle equal to the given bearing. The only thing to remember is that the line of direction is a fixture, and that you have to get its bearing by moving the glass meridian ; that is to say, the line of direction runs straight up your paper, and the North and South line has to be accommodated to it. This is a little confusing at first, and necessitates careful thinking out, though the principle merely amounts to this : If A is to the left of B, B must be to the right of A ; so, if the line of direction is to the west of the meridian-line, the meridian-line must be to the east of the line of direction.

Example.—Sketch to be made on a general bearing of 50°—*i.e.* the bearing of the line of direction is 50°.

Take up your board, and, holding it with the full roller away from you, look at the engraved circle round the compass. 50°, as you know, is a little more than half-way between North and East; so the line of direction is to run 50° to the East of North. Therefore you must place your North 50° to the West of the line of direction. Turn the glass meridian round until the indicator at its end is opposite the fifth ray to the West or left-hand of the long line (line of direction). Place the edge of the ruler up against the glass meridian, and draw your North and South line on the paper.

(Similarly you can set the glass meridian to suit any given bearing of the line of direction. Remember to hold the board with the full roller away from you, then move the indicator of the glass meridian round in the reverse way to the movement of the hands of a watch. Thus, when the indicator is opposite the 1st ray to the *left* of the line of direction, the bearing of the latter is 10° ; when opposite the 3rd ray, 30° ; when opposite the 20th ray, 200° ; when opposite the 33rd ray, 330° ; and so on.

If there is no engraved circle round your compass, rule on your paper, and parallel to its longer edges, a line of direction ; then, with the aid of a protractor, rule a meridian line to cut the line of direction in such a manner that the latter has the required bearing. Set the glass meridian parallel to the meridian on the paper.)

No further explanation of this is perhaps necessary; though it may be mentioned that the bearing of the line of direction is more often than not given with reference to *points* of the compass—*e.g.* 30° E. of S.; N.N.W., &c.

To continue: As you have no map to guide you as to the course that the road will take, or to what extent it will diverge from the line of direction, you should endeavour to get a bird's-eye view of the road from some high ground, when you may perhaps be able to estimate the amount that the road curves, and so allow for this when drawing the line of direction up your paper. But in nine cases out of ten, for many reasons, this will not be possible, and you had better take your line of direction up the middle of the paper, and risk the road running off to one side. Even if it does run off, no great harm is done; it only spoils the *appearance* of the sketch, and does not affect its value.

When you find that the route is running towards the edge, and is likely to run off the paper altogether, all that you have to do is to draw a line across the paper, and begin afresh a little higher up and farther on the paper, taking care to put a reference figure or letter at the spot where you leave off and a corresponding one at the spot where you recommence. Also be sure that you draw a new meridian-line on the new portion of the paper, so that you may eventually be able to piece the sketch together accurately. This new meridian-line may either be parallel to the original one; or, if the change of direction of the road be considerable, it may be advisable to re-set the glass meridian. When putting the sketch together afterwards, the paper is cut a little above the point where you left off, a pin is put through the point and then through the corresponding point where you recommenced; the two portions of the sketch are moved about until the meridian-line on the one is parallel to that on the other, when they can be gummed together in that position, or, held firmly, cut through at the pin-mark, and joined by a piece of gummed paper at the back. If time is no object, and neatness is desired, the whole sketch can be copied on to one sheet of paper.

III. You may receive no instructions as to the bearing of the line of direction ; for instance, you may be ordered to follow in rear of a column and sketch its route. In such a case, place the line of direction up the centre of the paper ; hold the board (full roller away from you) with the line of direction pointing to the farthest visible spot on the route to be sketched ; wait until the needle comes to rest, and then bring the glass meridian exactly over the needle, with the indicator pointing to North. Draw the corresponding meridian-line on the paper. Should the route run off the paper, begin again, as described above.

IV. The simplest case of all is the sketch of a cross-country, or point-to-point, route on a given bearing, where you are not restricted to roads. Here the given bearing, or line of direction, is placed up the centre of the paper, and there is no possibility of running off. The glass meridian is set as explained in I. and II. above.

Assuming that you are now at the starting-point, with paper on your board, and with the glass meridian set for the sketch, proceed as follows :

If working on horseback, buckle the strap round the left forearm ; *if sketching on foot*, hold the board with its edge between the fingers and thumb of the left hand, thumb on the top of the board. The two ends of the strap may be gathered into the fingers, and so help to steady the board, which should always be kept at the level of the waist, and never brought up to the eye. (See Plate VIII.)

Whenever possible, the compass should be towards the left, so as to be clear of the drawing hand. Put on the paper a pencil-mark (about a couple of inches from the bottom) representing your position—*i.e.* the starting-point. Face the object to which you wish to draw a ray. Turn the board slowly round on your arm, or in your left hand if on foot, until the compass-needle comes to rest exactly under the glass meridian, and with its north end in the same direction as the indicator. The board is now set, and the next operation must be performed without moving it. Lay the ruler on the board, with its edge up against the mark representing your position and pointing roughly in the direction of the object. Correct the alignment of the ruler by holding up your pencil opposite your right eye (left eye being closed), so that it covers the distant object and your position on the paper; bring it down sharply once or twice over the edge of the ruler, any error in whose alignment will thus be at once seen, and can be corrected. (This, of course, requires practice; and in moving the ruler be careful to see that you keep its edge pivoted against the mark on the paper.) The ruler having been aligned, make a mark on the sketch along the edge of the ruler, so that a line drawn from one point to the other is a ray from your position to the object. If sketching on horseback (when you have only the right hand to work with) some care will be required to draw the ray without altering the position of the ruler. When sketching on foot, however, you can utilise the left hand, and hold the ruler with the thumb while drawing the ray.

To know how to manipulate the board, and how to draw rays when the board is set, are the only things to be learned by the sketcher who has already mastered the plane-table. Everything else is simply a matter of applying plane-table principles.

Summary of Steps in Using the Cavalry Board for a Route Sketch.

(1) Determine the situation on the paper of the line of direction.

(2) Lay down the magnetic meridian, and arrange the glass meridian.

(3) Mark the starting-point on the paper.

(4) Set the board; stand facing the object to which a ray is to be drawn.

(5) Align the ruler on the forward traverse station by means of the pencil, always keeping an eye on the compass.

(6) Draw the ray (always away from you).

(7) Fix points (near the route) useful for resection, &c.

(8) Continue the traverse, and draw-in detail, as when using a plane-table.

The beginner, when working on foot, is recommended to make every use of any artificial supports (such as wooden rails or posts) that may be available for carefully setting his board. The board may even be placed on the ground.

When sketching on horseback it is essential to have a horse that will stand still, otherwise it is impossible to keep the board set while aligning the ruler.

An expert sketcher will be able to dispense with the ruler altogether; the pencil is held upright with its point at the sketcher's position on the paper, and the ray is drawn, by eye, by moving the pencil-point along the paper in the direction of the object. But this is not easy to acquire, and the results are not, as a rule, very satisfactory.

To make an Area Sketch with the Cavalry Board.—Remember what was said in Chapter III. ('Foundations of a Sketch') and Chapter V. ('Plane-tabling').

Consider the cavalry board to be the plane-table top, your hand, or the ground, taking the place of the tripod. Proceed with the sketch as follows:

(1) Decide on a scale suitable for the sketch, so that all the ground will come on to the exposed portion of the paper.

(2) Hold the board, or lay it on the ground, to suit the sketch to be made.

(3) When the needle comes to rest, place the glass meridian over it, and draw a magnetic meridian on the paper.

(4) Base and triangulation as usual.

(5) Traversing, and drawing detail.

The board is held, and set, and rays are drawn as described above (route sketch).

Contouring with the Cavalry Board.—If there is plenty of time, when making an area sketch contouring may be carried out by any of the methods explained in Chapter IX. Generally, however, route reconnaissances are made against time, and the contouring must be done rapidly, and each portion of the sketch completed at once. The sketcher will seldom be able to leave the route; therefore he must work out the relative heights of the route and of the surrounding country within view by using the clinometer and applying the formula $H. E. = \frac{V. I. \times 19{\cdot}1}{D.}$. (See page 84.)

Assume a height for your starting-point. Call it 500′, No. 10 contour, or anything you like. Now find the relative heights of noticeable objects on either side of the route. If the objects have not been fixed on the sketch, the distance to them must be estimated; this distance is the H. E. The H. E. having been discovered, the slope from your position to any particular object is found by the clinometer. By the formula calculate the height of the object with regard to your position, and write it on the sketch. When you have laid down several heights in this manner, it is a simple matter to employ them (together with the formula) to find your height anywhere along the route—to resect, as it were, your height. Continue thus throughout the route, always endeavouring to have two or three fixed heights visible from the route, to enable you to find the relative height of your position when required.

From a knowledge of the heights of surrounding objects, and by having the watercourses well marked on the sketch, you will be able to draw-in the contours by eye with quite sufficient accuracy, at whatever V. I. you decide on using.

In very rapid reconnaissances it may be quite impossible to devote any time to the systematic calculation of heights, when all that can be done is to *estimate* the surrounding heights, and shape-in the ground approximately by eye—*i.e.* by the *form-line* method. In such a case an aneroid barometer will be found useful for determining relative heights of various points actually *on* the route, but its readings can only be relied on in settled weather.

Scales for Sketching on Horseback.—As the cavalry board is nominally the instrument used on horseback, the measurement of distances by the mounted sketcher may here be discussed. The military sketcher on foot has to rely for all measurement on his ability to pace yards with accuracy. The horseman relies on his horse to do the measuring, and before commencing sketching on horseback it is necessary to know (*a*) the speed at which one's horse walks, trots, and canters; or (*b*) the exact length of one's horse's paces at a walk, trot, canter, &c. In either case, the horse should be tried several times over a measured distance—say over a couple of miles on a fairly level road—when the rider will discover (*a*) how many minutes his horse takes to cover the two miles at a walk, trot, &c.; and (*b*) how many paces his horse takes to the mile at a walk, trot, or canter; and the results should be carefully written down. It is advisable also to try the horse over uneven ground, so as to be certain of the average rate of his movements and the average length of his paces under all circumstances. For rapid reconnaissance work the trot is the most reliable pace, and when counting paces the 'rises' in the saddle should be counted. Canter measurement is not very accurate, though it may be necessary to have recourse to it when in a hurry; each time the leading foot strikes the ground is counted. At a walk, of course, the length of the horse's pace is the distance between the prints of his two fore-feet.

With a knowledge of the above things, you can now work either *by time*, or by *horse's paces*, and it will obviously be a great saving of labour if you can lay down your measurements on the paper in the same terms as you discover them, and without having to convert each measurement into yards or fractions of a mile. In order to do this, it is necessary to prepare beforehand (*a*) a *scale of time*, or (*b*) a *scale of 'walks,' 'trots,'* &c., and mark them on the edge of a ruler or card.

(*a*) *Scales for Sketching by Time.*—Measuring by the time taken to get from one point to another is the most primitive manner of speaking of distance, and still in vogue amongst all savages. Ask a native how far it is to the next village. His answer will be, so many *hours*—the only measurement with which he is acquainted. We ourselves still employ it in such expressions as 'ten minutes' walk,' 'two hours' march,' 'a day's journey,' and so on. The whole thing is so obvious that it is hardly worth explaining. It is, of course, necessary to know the exact uniform rate at which you are moving; and from that you calculate your scale of time (*i.e.* hours and minutes) like any other scale.

Now to apply this to horseback sketching. A wrist watch is indispensable, and should be worn on the right wrist; you time your horse over a given distance, and we will assume that his rate of travel is a usual one—viz.: that he walks at four miles, trots at eight miles, and canters at twelve miles per hour. We will assume, also, that your sketch is to be drawn on a scale of 1 inch to 1 mile.

To make the scale of time, you calculate as follows: The horse walks four miles in the hour (*i.e.* in 60 minutes); and four miles is represented by four inches (scale $1'' = 1$ mile). Now four inches is quite long enough for your purpose, so you draw a line of that length on the edge of your ruler or piece of card. If you divide this line into sixty equal parts, each part will represent the distance that your horse covers in one minute. You do not, however, want such small divisions, and it will be quite sufficient if you divide your line into six equal parts, of ten minutes each. This shows a total of fifty minutes in the primary divisions, with secondary divisions of one minute (fig. 2, Plate IX.).

The scale thus drawn is available (on the assumed rate above) when sketching at a trot or at a canter, by measuring double the distance off it in the former case, and treble the distance in the latter case; because the horse trots twice as fast as he walks, and canters three times as fast as he walks.

It may be mentioned here that all *time scales* are constructed in this manner; and that *sketching by time* is sometimes the only method that can be adopted—*e.g.* when travelling in a river steamer, train, or balloon, the rate of which is known. It may be usefully employed, also, for rapidly correcting existing maps, in which case the map would be prepared with parallel lines (across the route) a certain fraction of an inch—*i.e.* representing so many minutes—apart.

(*b*) *Scales of Horses' Paces.—Example*: Suppose that you find that your horse takes 1,700 'walk' paces to one mile, and 650 'canter' strides; that your 'trot' *rises* are 530 to the mile; and that your sketch is to be on a scale of 3 inches to 1 mile. You would prepare scales as follows: The R. F. of the scale is $\frac{1}{21120}$.

(1) *The scale of 'Walk' paces.*—Since 1,700 'walk' paces are equivalent to one mile, and 3″ represent one mile, a convenient length for the scale can be arrived at by remembering that the full length of the scale should be under six inches.

Now six inches would represent 3,400 'walk' paces.

You decide to show altogether 3,000 'walk' paces—2,000 in the main portion and 1,000 subdivided into hundreds in the left-hand division.

$$6 : 3{,}400 :: x : 3{,}000$$
$$x = 5{\cdot}29 \text{ inches.}$$

So you measure off a length of 5·29 inches on the edge of your ruler, and divide it up in the usual way (fig. 3, Plate IX.).

(2) *The scale of 'Trot' rises.*—In a similar manner you construct your second scale.

Here six inches will represent 1,060 'trot' rises; and it will be convenient to show 800 rises in the main portion of the scale, and 100 in the left-hand division.

$$6 : 1{,}060 :: x : 900$$
$$x = 5{\cdot}09 \text{ inches.}$$

Put the scale on your ruler as shown in fig. 4, Plate IX.

(3) *The scale of 'Canter' strides.*—For this you decide to show 1,100 'canter' strides—1,000 in the main portion and 100 in the left-hand division.

$$6 : 1{,}300 :: x : 1{,}100$$
$$x = 5{\cdot}08.$$

Fig. 5, Plate IX. shows this scale.

On the sketch itself you draw a scale of yards (3 inches to 1 mile) in the usual way. Measurements in yards are understood by everyone, whereas 'trots' &c. would convey little as to distances. It is immaterial how the sketch was made, though a note may be added to it—such as 'executed on horseback, principally at the trot.'

SCALES FOR SKETCHING WITH A BICYCLE.—A bicycle is often most useful for rapid route reconnaissances, though the actual sketching must not be attempted near the bicycle, as the compass will not work. For the purpose a non-free-wheel machine is the best, as, in measuring the distance along the route from one place to another, the revolutions of the pedal can be counted. Revolutions are counted by observing when one knee comes to its highest position, or when one foot is at its lowest position.

First, find out how many yards are covered by one wheel of your bicycle for each complete revolution of the pedal. Put a mark on the ground vertically under one pedal when it is at its lowest point; run the bicycle forward until the same pedal is in the same position again. Make a mark on the ground, and measure the distance between one ground mark and the other. Suppose you find this to be 6 yards. To construct a scale to work with, all you have to do is to take the revolution (*i.e.* 6 yards) as the unit of your scale, and calculate from this what length of line will represent a convenient number of revolutions at the scale to which you are required to draw the sketch.

Example.—A sketch is to be made on a scale of 3 inches to 1 mile. Required, a scale of bicycle revolutions for the sketch; a bicycle revolution being 6 yards.

You know that on the scale of 3 inches to 1 mile, 3,520 yards are represented by six inches; and that, since one revolution is equal to 6 yards, 500 revolutions are equal to 3,000 yards. You want to show a round number of revolutions on a line about six inches long. Therefore you decide on 400 revolutions

PLATE IX.

. 300 Yards to 1 Inch R.F. $\frac{1}{10800}$.

600 900 1200 Yds.

LES.

1 Inch to 1 Mile.

30 40 50 Minutes

nches to 1 Mile.

1000 2000 Paces.

es to 1 Mile.

500 600 700 800 Trots.

ches to 1 Mile.

1000 Canters.

3 Inches to 1 Mile.

00 300 400 Rev.

in the main portion of the scale, and 100 revolutions in the left-hand portion—*i.e.* a total of 500 revolutions (3,000 yards).

$$6 : 3{,}520 :: x : 3{,}000$$
$$x = 5{\cdot}11 \text{ inches.}$$

Mark off a distance of 5·11 inches along the edge of a ruler or card, and divide it up as shown in fig. 6, Plate IX.

If a free-wheel bicycle is used, the pedals are of no use for counting, and the only way that the bicycle can be utilised for measuring is to tie something on to one of the spokes of the fore-wheel, and count each time it comes round. This gives the revolution of the wheel, the circumference of which must be measured. Suppose the circumference were found to be $2\frac{1}{4}$ yards, then it would be an easy matter to construct a working scale of wheel revolutions, as in the above examples.

Cyclometers, as at present made, do not show sufficiently small measurements to be of much practical value for sketching, except on small scales, though a cyclometer registering tenths of miles is quite good enough for a rapid route reconnaissance on a scale as small as 1″ to 1 mile.

As in the case of horseback scales, it is unnecessary to draw the scale of bicycle revolutions on the sketch. The ordinary scale of yards (or miles) is all that is required.

(N.B.—The class of scale dealt with in this chapter is sometimes called a *comparative scale*, because it is constructed, in comparison with a scale of inches to the mile or miles to the inch, from a common R. F.)

CHAPTER XII

SKETCHES ON OUTPOST DUTY

Tactics in relation to Military Sketching—Importance of an Outpost Sketch—General Principles—Dimensions—Example—Running Base—Amount of Detail to be Drawn.

It is now assumed that the foregoing pages have been more or less studied, and that the sketcher has gained a practical knowledge of the use of his instruments. In this and the following chapters he will be instructed how to apply his knowledge, so that his skill as a draughtsman may be of value to others, as well as to himself, more especially from a tactical point of view. It is important to bear in mind that (as pointed out at the beginning of this book) what are termed 'tactics' and 'field sketching' are inseparable studies, that all military sketching is of necessity tactical, and that the application of all tactical principles depends on the topographical acquirements of the student.

An officer on outpost duty should always make a sketch of the country in the vicinity of his post, not only for the reason that as an accompaniment to his report it will make matters clear to his superiors, but also because such a sketch may prove of the utmost value to the officer who relieves him or reinforces him at a critical moment. Such a sketch should contain a rough small-scale key-sketch of the whole section of the outpost line, and the sketch of the actual ground in the neighbourhood of the piquet or post should be on a scale sufficiently large to show all necessary detail—*i.e.* tactical features.

Above all things, the sketch must be accurate and clear; nothing should be left to the imagination; and it should be, as far as possible, complete in itself, so as to be of use even without a report.

The sketch can of course be executed with any instruments that happen to be available, or without instruments (see Chapter X.), and it would be made in the usual manner, as described in previous chapters. It may not, however, be always possible to adhere closely to the fixed rules of a *base and intersected stations*, but at any rate one or two points can usually be fixed to assist in checking the work as it proceeds.

With other things to attend to, you cannot devote much time to your sketch, and it will be necessary to resort to every artifice to get the work done rapidly and at the same time accurately. Combine as many operations as possible, for you will not be able to go over ground twice. Get in the ground-work, traverse, and contour at the same time.

Set your paper to the ground to be sketched, which should include everything actually occupied by your own command, at least half the distance to neighbouring posts on your right and left, 200 or 300 yards to the rear of your post, and a sufficient distance to the front to give an idea of the country watched by your sentries. In the case of a piquet under ordinary circumstances, therefore, your sketch would extend (from the piquet) roughly 800 yards to the front, 200 yards to the rear, and about 400 yards to each flank.

If you find that you have plenty of time, contour the whole sketch accurately; if you are pressed for time, contour first *with care* such parts of the ground as you imagine to be of greatest *tactical* importance, having regard to the possibility of an attack by the enemy, and then sketch-in by eye the general shape of the remainder of the ground (of course stating which parts are reliable and which are not). Remember that what is wanted is not an elaborate and highly finished drawing, so much as a clear and true sketch of the state of affairs in the vicinity of your post. The O. C. section of outposts, even before he has had the opportunity of visiting your post, must be able, with your sketch in his hands, to see at a glance what dispositions he will have to make in the event of the enemy launching an attack in your direction. An exaggeration or misrepresentation of a feature in your sketch *might* imperil the safety of an army corps.

Let us suppose that you are in command of No. 2 Piquet (see Plate X.), that you have posted your sentries, and have got everything in order. You have been round the ground with your sentries, and have thus got the general 'lie' of it into your head. You now start your sketch.

First, draw-in the position of the piquet (approximately to scale); then, while the paper (or board) is set, draw rays to all noticeable objects (as usual), to the sentries, to neighbouring posts, supports, &c. If any of the latter are situated outside the limits of your sketch, put a half-arrowhead at the end of the ray and write along the ray the name of the object to which it is drawn and the approximate distance.

If the ground is favourable for the purpose, by all means get in a base and fix as many stations as possible, but in the generality of cases you will probably have to work with what is sometimes called a *bent base, running base,* or *running traverse;* which means that you commence traversing at once, and as you pace along you stop whenever a convenient opportunity occurs to enable you to fix a point or station. It is often a good plan to traverse, from the piquet, straight away to one flank, then return to the piquet and traverse to the other flank, then along the sentry line. But it is impossible to lay down any hard-and-fast rule; and anyone who has practised sketching to any extent on the lines recommended in the earlier pages of this book will find no difficulty in setting to work systematically, and applying his knowledge of the subject.

The top of the sketch should be towards the enemy, whose probable direction of attack should be shown by an arrow (say, in blue chalk, two inches long).

The line of resistance—*i.e.* the line to be occupied in case of attack—should be marked clearly, and the nature of the defences provided written in.

If a retirement is to be made, the line of retreat should be shown (red dotted line) ; and similarly if the piquets on being attacked are to be reinforced by the supports, the line of advance of the latter should be shown.

Ranges and directions of all prominent points likely to be occupied by the enemy, whether distant or near, should be noted.

Lastly, the sketch must have on its face a North Point, scale of yards, scale of slopes, descriptive heading, and signature and date.

A study of Plate X. will give an idea of what amount of detail an outpost sketch should contain.

CHAPTER XIII

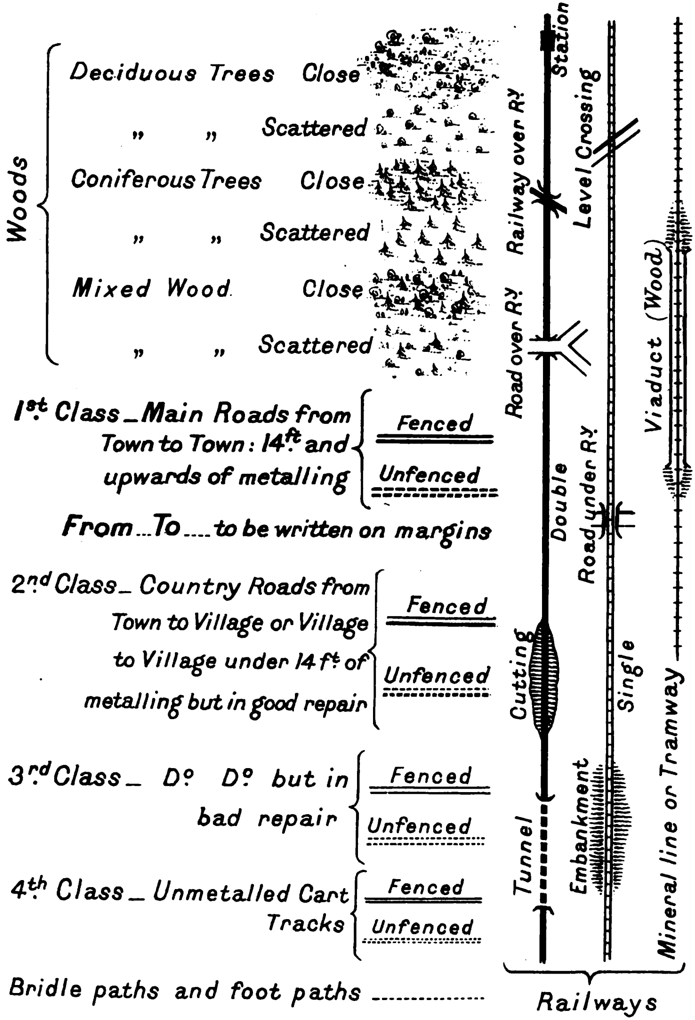
MAP-READING INDOORS

Importance of Map-reading—Study of the 6-inch Map—Scale—North Point—Heights—Bench Marks—Interpolation of Contours—Visibility of Points – Placing Troops on the Map—Describing Country—Reading Small Scale Maps—Drawing Sections.

It is a matter of opinion whether map-reading should be systematically studied before or after map-making. Certainly a man who has no knowledge of military sketching can learn to use a map, but at the same time a man who has learnt to sketch can handle a map and understand it with very little difficulty. Every officer is required to be sufficiently proficient in map-reading to be able, when given a plan of a piece of country and a tactical scheme, to work out the scheme and place his troops on the map, as if he were on the actual ground. It is therefore necessary to become so practised in the art of map-reading as to be able, on taking up a map, to grasp at once the whole lie of the land, and to imagine that, when looking at the map, you are actually looking at the ground that it represents. By a map in this case is, of course, meant a contoured plan of the ground on a scale sufficiently large to show all detail of tactical importance.

Perhaps the best map for a beginner to commence with is the Ordnance map of Great Britain on a scale of 6 inches to 1 mile, which is sold in sheets and can be obtained anywhere. Obtain a sheet of some inland hilly district, and proceed to study it. First, thoroughly grasp the scale; an

SYMBOLS USED ON THE ORDNANCE SURVEY MAPS.
(FOR INFORMATION ONLY.)



inch represents one-sixth of a mile—*i.e.* nearly 300 yards, which will be useful to remember. Practise yourself in estimating the distance from one spot on the map to another, checking your estimation by using the scale of 6 inches to 1 mile on your protractor. In this way you will soon be able to tell at a glance the range from one point to another, which will be of value when you come to place troops on the map.

Next, pay attention to the points of the compass, in order to be able to describe at once the bearing of one object from another. The side margins of all the Ordnance maps are *true* north and south, so that it is only necessary to know the local variation of your compass, when the magnetic bearing of any object can be found at once. It is as well, if you wish to discuss magnetic bearings, to rule across the map a Magnetic Meridian as a guide to your eye, though for approximate bearings it is quite sufficient to deal with *true* bearings—*e.g.* 'a ridge lying to the N.N.W. of our position.' If, however, you are describing the accurate direction of an object for such a purpose as laying a gun, it is advisable to give the bearing in *degrees* (of course, magnetic) and to state the variation of the compass used.

[N.B.—Suppose you find yourself in possession of only a portion of an Ordnance map (without any margin), you can find the true Meridian by remembering that the printing all runs east and west, and therefore at right-angles to True North and South.]

Having mastered the above simple matters, you now proceed to the real business of map-reading—the relative heights, undulations, and inequalities of the country. On the 6-inch map you will find contours carefully drawn at vertical intervals of 100′ above the sea (Mean Tide at Liverpool); these are all numbered 100′, 200′, 300′, and so on. Take a brown or a red pencil, and mark-in these lines distinctly; and with a blue pencil colour all rivers and streams. This, you will find, will be an immense aid in rapidly getting an idea of the general topography of the country depicted. But for exact military calculations this will not be enough, for between two contours at 100′ V. I. it does not necessarily follow that the slope will be continuous; there may be under-features, cols, &c., of considerable tactical importance, and these must be discovered by carefully studying the further information conveyed by the map. All over the map will be found a series of figures representing heights; some of these have a broad-arrow, and B. M., by their sides (*e.g.* B. M. 370), implying that they are *Bench Marks*, actually registered on the ground (by having a broad-arrow below a horizontal line cut on the corner of a house, a bridge, &c.); while others have simply a little dot by their side to show the exact spot to which the height refers.

To make the map more intelligible, apply the coloured pencil again, and *interpolate contours* (between those already marked) at, say, V. I.'s of 20 feet, using as a guide the various heights shown on the map. When this has been completed, you should be able to take in the whole shape of the ground at once.

Now test your ability to read the map accurately. Mark on the map a spot where you imagine yourself to be standing, and find out how much of the surrounding country, within a radius of a mile or so, you would be able to see. To do this, first look at the country generally, for you may be standing on the top of a hill which commands the ground all around. If you see that this is not the case, take each part of the ground separately, and consider it systematically. Draw a line from the point of observation (*i.e.* where you are supposed to be standing) in the direction that you are about to consider. Now, by observing the various contours that cut this line, and their respective heights, you will be able to form an opinion as to the *general section of the ground* along the line. Remember the following:

(1) The general section of the ground (unless a dead level) must be either concave or convex.

(2) If it is concave, then a point at one end of the line is visible from a point at the other end of the line (fig. 30).

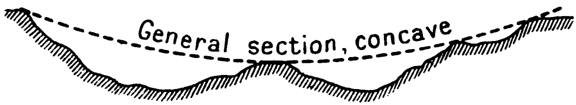


FIG. 30

(3) If it is convex, then the one point is not visible from the other (fig. 31).

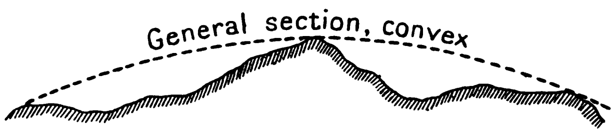


FIG. 31

It therefore becomes a question whether the general section of the ground on a line drawn from the point of observation to any other point whose visibility you wish to discover is concave or convex; and this you find out by noticing where the contours cut the section-line. If they are so situated on the line as to make the upper portion of the general slope of the ground steeper than the lower portion (*i.e.* if the contours are closer together at the top than at the bottom of the slope), then the higher point is visible from the lower; if, on the other hand, the lower portion of the slope is the steeper, then the two points will be invisible from each other.

All this requires very careful consideration; for, although sometimes the concavity or convexity of the general section of the ground is apparent, very frequently the matter resolves itself into a calculation of some nicety.

The calculation shall be dealt with in all cases that are likely to occur:

(1) The heights of the two points the same, and no higher object between them; one point is visible from the other.

(2) The ground falling or rising continuously from one point to the other; one point is visible from the other.

(3) The two points situated on the opposite sides of an open valley; one point is visible from the other. (*Concave.*)

(4) One point situated above the other, with an intervening object of equal height to the higher point; one point is invisible from the other. (*Convex.*)

(5) Between the two points an intervening object whose height may, or may not, be sufficient to obstruct the view from one point to the other. This is the only doubtful case, and you have to determine whether the height and situation of the intervening object make the general section of the ground between the two points concave or convex.

To work out doubtful cases there are several simple methods, of which we will give two:

1*st Method* (fig. 32).—By observing the contours, find the number of contours that the higher point is above the intervening object; also the number of contours that the intervening object is above the lower point (or, if you wish to be more accurate, find the number of feet that the one point is above the intervening object, and the other point below the same). Put the numbers thus found as numerators of two fractions. Now measure the distance in plan (on any scale you like) between the higher point and the intervening object, and between the latter and the lower point. Put the respective distances as denominators to their corresponding fractions. Compare the fractions (*i.e.* the gradients of the slope) to discover whether the upper part of the slope is steeper than the lower. If the fractions tell you that the slope from the higher point to the intervening object is steeper than that from the intervening object to the lower point, then the general section of the ground is concave, and one point is visible from the other. If the lower portion of the ground is the steeper, then the general section is convex, and one point is not visible from the other.

Example.—A is the higher point, B is the intervening object, and C is the lower point; A is 40 feet above B; and B is 50 feet above C; the distance from A to B is 600 yards, and from B to C 400 yards. From this you get the fraction for A to B $\frac{40}{600}$, and for B to C $\frac{50}{400}$. These, on being reduced, are $\frac{1}{15}$ and $\frac{1}{8}$. Therefore the lower portion of the slope is steeper than the upper, and consequently the general section is convex, and A is not visible from C.

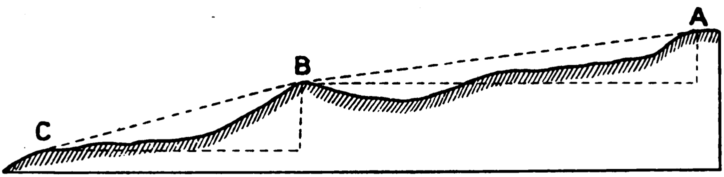


Fig. 32

Taking the same example, and supposing that the plan is on a scale of 6 inches to 1 mile and contours at 20 feet V. I., then you could say that A is two contours above B, and B is two and a half contours above C; place 2 as the numerator of one fraction, and $2\frac{1}{2}$ as the numerator of the other. You need not trouble about the scale, for it is quite sufficient to measure the distance in plan with any sort of unit, say the length of your piece of indiarubber. You find the distance from A to B to be three indiarubber lengths; and that from B to C two indiarubber lengths, so the fractions you wish to compare are $\frac{2}{3}$ and $\frac{2\frac{1}{2}}{2}$, and the gradient from B to C is of course steeper than that from A to B, the general section of the ground convex, and A not visible from C.

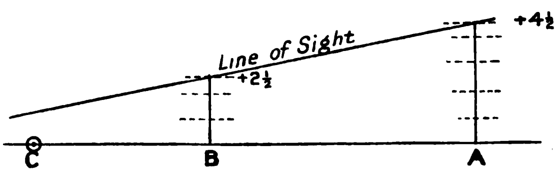


Fig. 33

2nd Method (fig. 33).—This is perhaps a simpler method than the first. Take the same example. Along the edge of a piece of paper (applied to the plan) measure and mark-off the distances from A to B and from B to C. Now transfer these measurements to a straight line drawn on a piece of paper, and from the points A and B raise perpendiculars, making the length of the perpendicular from B $2\frac{1}{2}$ units (of any sort) above the ground-line on which C is situated, and the length of the perpendicular from A $4\frac{1}{2}$ units above the ground-line (*i.e.* two units higher than the height of the B perpendicular). Draw a straight line through the tops of these perpendiculars, and its prolongation will show at once where it passes with regard to C. If it passes above C, then C is invisible from A; if it passes through or below C, then C is visible from A.

By applying one or other of the above methods there should be no difficulty in discovering the visibility of doubtful objects; but it must always be remembered that all this plan-reading (without inspecting the country) is as a rule purely theoretical—for trees, hedges, &c., the heights of which are not given on the plan, would very frequently intercept the view, and upset all indoor calculations. *Bear in mind, therefore, that with the best map in the world it is absolutely impossible for the most skilled map-reader to make reliable dispositions of troops without seeing the ground with his own eyes.* Still, it is necessary, for the application of tactical exercises, to be able to read a map of unknown ground, and place troops on it.

PLACING TROOPS ON A MAP.—Get into the habit of drawing your bodies of troops neatly, and, except on small-scale maps, as nearly as possible to the scale of the map. Do not let a company occupy the space that would be occupied by a brigade. Let everything be distinct and clear, and write-in against each body of troops what it represents—*e.g.* 'No. 1 Piquet,' 'No. 3 Battalion,' 'Standing Patrol,' and so forth.

DESCRIBING COUNTRY FROM A MAP.—With the map before you, you should be able to describe with a certain amount of accuracy the ground seen from any particular point, or the country passed through while going along a road. Practise yourself in writing out clear reports on the country. A good plan is to follow a road from one spot to another on the map—

say from one village to another—by the shortest and best route for wheeled traffic. First, join the starting-point and finishing-point by a straight line; then select the road that diverges least from the straight and that has the least steep gradients. On the 6-inch map you can discover the gradients between adjacent points on the road by noticing the heights marked and measuring the distance to scale. Thus, suppose the height of X is shown as 410 feet and the height of Y as 520 feet, and the distance from X to Y is 660 yards, then the rise from X to Y is 110 feet, and the gradient would be $\frac{110}{660 \times 3}$, or $\frac{1}{18}$. Having selected the route that you propose following, mark it with a coloured pencil, to keep it in your eye. Now begin at the starting-point, put a small red circle on the map, and inside it the reference figure 1; write down in your report a description of the spot sufficient to identify it, the nature of the surrounding country, noticeable objects in view, bearing of the route to be followed, &c. &c. Go on to the next point which you think should be described; give it a reference figure; state how far it is from the last point (or station), and what the gradient of the road is between the two points, the nature of the country passed, and so on. We will give an example:

1 Cross-roads with signboard, 420 yards S.S.W. of OLNEY; surrounding country flat, heather, open. Height, B. M. 310 feet. Roads, N.N.E. to OLNEY; S.W. to BEARSTEAD, 6 miles; N.E. to WATFORD, 2½ miles; S.E. to GRINDAL, 5 miles (route taken).

2 Bridge over GRIN RIVER. River flowing N.E. to S.W. Distance from 1 430 yards. Road from 1 to 2 level for 140 yards, then descends at $\frac{1}{50}$ for 200 yards, then descends at $\frac{1}{30}$ to the bridge (B. M. 286 feet). The road is everywhere commanded by GRINDAL RIDGE (515 feet to 570 feet), distant about 3¼ miles S.E. by E. of bridge. Small fields (fenced) on east bank of river within 350 yards, 'liable to floods.'

The above is perhaps sufficient to show how the map should be studied, the chief points to remember being that you should try and imagine that you are actually going along the road, and making a reconnaissance report on it. (*Vide* Chapters XV. and XVI.)

Having thoroughly mastered the 6-inch map, you should obtain smaller-scale maps of the same ground (1 inch or 2 inches to the mile), and compare them with the larger-scale map. Study them in the same manner; work out schemes on them; and get so accustomed to grasping rapidly the configuration of the country that, no matter what the scale of the map before you, you will be able to read it at once, and give a faithful description of the country to another person.

(It is perhaps a mistake to devote too much time to the study of large-scale maps, as for work in the field one would seldom use a map on a larger scale than 1 inch to one mile; and by becoming accustomed to, say, the 6-inch map the eye is apt to lose its sense of proportion. Though, it may be remarked, with sufficient training, a man's eye and brain should be incapable of being influenced in this manner.)

Drawing Sections.—Before going on to the practical use of maps in the field, we will describe the method of drawing a section of a piece of country. A section, of course, means a cutting; and when you are told to draw a section on a line from one given point to another, you have to imagine that you cut vertically down through the line, and then draw, to scale, the edge (or outline) of the cutting. To make a section, the plan must be fully contoured; and the first thing that you have to do is to take a piece of paper and lay its edge from one given point on the plan to the other, marking on the edge where each contour cuts it, and the height of the contour. Rule a line on another piece of paper, and transfer the information thus obtained to it. This line is the Datum Level. Now raise a perpendicular, from each point representing a contour, of the height of the particular contour on the scale at which the plan is drawn. Join the tops of the perpendiculars all along, and you have a true-scale section of the ground.

It is seldom, however, possible to construct a true-scale section, as, in ordinary country, the heights thus shown would be inappreciable. Take, for instance, a portion of country on a 6-inch map, where the contours were marked at 20 feet V. I., and suppose you were required to draw a section on a line between any two points. If you made a true-scale section, one contour would have to be shown at an interval of $\frac{1}{44}$ of an inch above or below the next one. It is, therefore, customary to exaggerate the heights in a section while retaining the true scale for the distances, and a note as to the exaggeration should always be

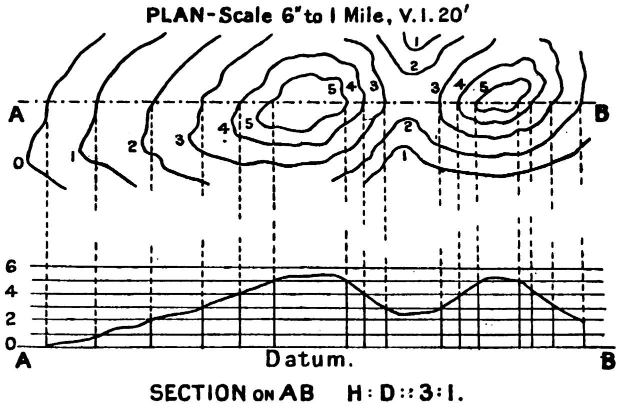


FIG. 34

added to the drawing; thus: 'Heights to Distances as 4 to 1,' or 'H : D :: 4 : 1' (where the true heights have been multiplied by 4 before being marked off to scale).

Example.—Scale of plan, 6 inches to 1 mile. Required, a section on the line A—B. H : D :: 3 : 1 (fig. 34).

Here you first mark-off the position of the contours cutting the ground-line (*datum level*), as described above. Then parallel to the ground-line rule equidistant lines, at intervals of 20 feet exaggerated three times—*i.e.* 60 feet (or 20 yards on the 6-inch scale). Raise perpendiculars from the datum level to the parallel representing the height of each particular contour. Join the tops of the perpendiculars, and the outline gives the required section.[1]

[PLATE XII. This is intended for practice in map-reading, and the student can assume for the sketch any scale and V. I. that he thinks suitable. He should then set himself various questions, in order to examine himself in reading a plan. The following are some suggestions:

(1) From C, what are the approximate bearings in degrees of A, F, and M, respectively?

(2) Draw a section on a straight line from L to D.

(3) What is the steepest gradient of the Exham-Ivybridge road?

(4) Standing on the bridge A, how much of the Poole road can you see?

(5) Is the bridge A visible from Black Hill, from D, from L, from H, or from E?

(6) A scout, advancing S. from Edgmoor, arrives at the K cross-roads; how much of the country to the S.E. and W. can he see?]

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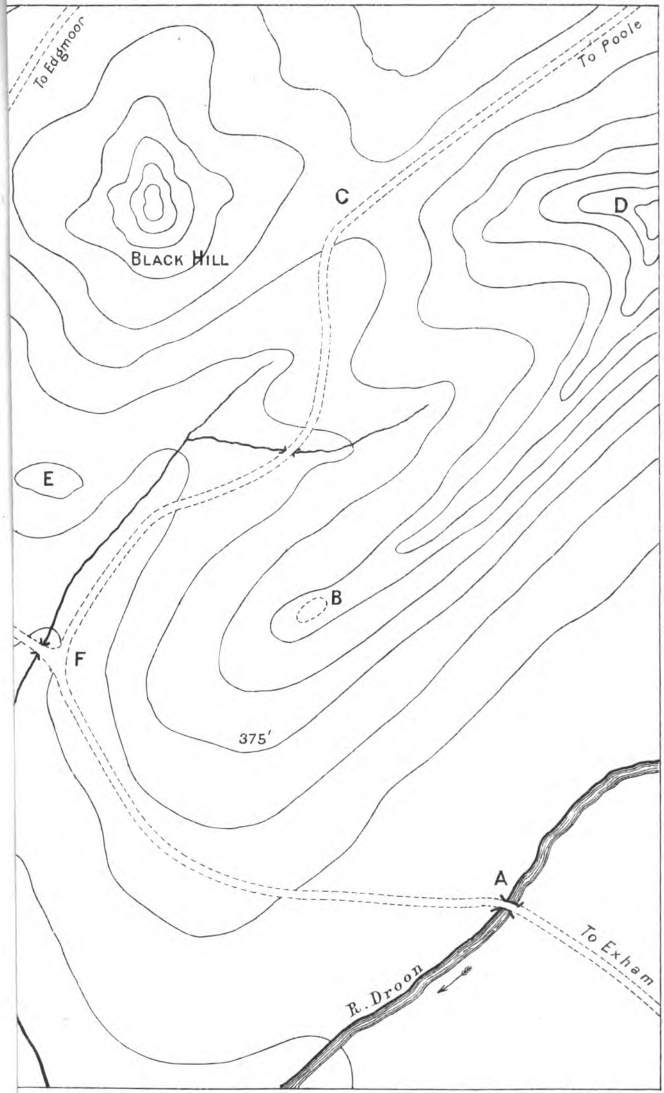
[1] In examinations a vertical scale, as well as the scale of the plan (or horizontal scale), is sometimes given, instead of the proportion between heights and distances—*e.g.* Scale of plan, R. F. $\frac{1}{7920}$; vertical scale, R. F. $\frac{1}{2112}$.



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CHAPTER XIV

MAP-READING IN THE FIELD

Importance of the Subject—Hints—Setting the Map in various Ways—Finding the Observer's Position—The Method of Adjustment—Noting the Situation of the Sun—Finding the Way—Correcting Maps—Application of Knowledge—Systematic Map-study.

PASSING now to the practical part of map-reading—*i.e.* the use of maps on the ground—there is much to be said; and, of course, the subject is of very great importance, for an officer on all occasions must be provided with a map of the country in which he is operating—whether on active service or at peace manœuvres, and he must be able to handle his map readily.

As a rule, you cannot expect to have anything but what may be termed a small-scale map, certainly never of a larger scale than two inches to the mile, and more often one on a scale of miles to the inch. Such maps, therefore, you should get into the habit of using.

(1) Always carry your map so that it comes out of your pocket ready for use—*i.e.* with the printed matter outside, and with the part of the country on which you are working before your eyes as soon as you take out the map. A transparent waterproof envelope, or cover, for the map is a good thing to have, and it should be prepared with squares (ruled faintly), the sides of which represent a certain number of yards on the scale of the map.

(2) Make certain that you have the scale of the map in your head, and have some rapid method of measuring distances on the map. (See page 10, footnote.)

(3) If the map is not one with true meridian margins (*e.g.* Ordnance Survey), be sure that you know how it is drawn with reference to the points of the compass. (*Look for the North Point.*)

To use a map, it is necessary to be able to set the map to the ground rapidly and accurately, and also to be able to find your position on the map at once.

SETTING THE MAP TO THE GROUND: I. *With a Compass.*—If you have a Magnetic North and South line drawn on the map, all that is necessary is to lay the map on the ground and adjust the compass to it; turn the map round until the needle of the compass comes to rest exactly over the magnetic meridian, and the map is set.

If you are using a map on which the magnetic meridian is not shown, but which has either a true meridian drawn on it, or the margins of which you know to be true North and South, then, being acquainted with the variation of your compass, you can lay off, with the protractor, a magnetic meridian to which to adjust your compass. But it might happen that you have no protractor, in which case adjust your compass to the true meridian line, turn the map until the needle points the number of degrees (to the east or west of the true North) equivalent to the variation of your compass, and the map will be set.

The above is the simplest and usually the most accurate way of setting a map; but, for reasons already explained, you may not be able to use a compass, or you may not have one at hand.

II. *Without a Compass.*—There are several methods of setting a map without a compass.

(*a*) *By the sun at noon.*—Remember that at noon in the Northern Hemisphere the sun is true South, in the Southern Hemisphere true North. Therefore, at noon, lay the map on the ground, set roughly by the sun, then stick a pin upright into the true meridian line, and revolve the map until the shadow of the pin falls exactly on the true meridian line.[1]

[1] A rough method of finding True South *at any time of the day*, with a watch set to local time, is as follows: Hold the watch horizontal and face upwards; in the Northern Hemisphere align the hour-hand on the sun, in the Southern Hemisphere align XII on the sun; a line bisecting the angle formed by the hour-hand and a line drawn to XII will point approximately to True South.

(*b*) *By a straight road, bank, &c.*—If you can identify on the map and on the ground a straight road, bank, hedge, or any long line, proceed to it, and lay your map on the ground, oriented (or set) as far as possible by observing the position of the sun and noting the time of day. Place the edge of a ruler against the bank, &c., on the map; then turn the map round until the ruler points in the direction of the bank, &c., on the ground.

To align the ruler, you must either lie on the ground and look along its edge, or proceed as in 'Sketching without Instruments'—*i.e.* step back, hold up a pencil in a line with the object, and move the map about until the edge of the ruler is aligned on the object.

(*c*) *By placing yourself between two objects.*—If you can identify two objects on the map and on the ground, place yourself between them; place the ruler-edge up against the two objects on the map; then, by observing first at one end of the ruler and then at the other, turn the map round until each end of the ruler points to the corresponding object on the ground.

(*d*) *By placing yourself in prolongation of two objects.*—Identify two objects on the map and on the ground; place yourself in prolongation of them. Now if you join the two points on the map by a straight line, and if you place your ruler-edge against this straight line, the method of setting the map is similar to that described in (*b*).

(*e*) *Rough setting.*—When it is necessary to set your map in a hurry, identify your position and some distant object; gather up the map in your hands, so that you can place the thumb of one hand on the one spot identified, and the thumb of the other hand on the other spot; turn round until the imaginary line joining your two thumbs coincides with an imaginary line joining the two points on the ground.

There should now be no difficulty in setting the map under ordinary conditions. The next matter is that of IDENTIFYING YOUR POSITION on the map. This, if you have a reliable map, is generally quite simple, as you will be able to pick up such noticeable objects as cross-roads, buildings, corners of fields, &c., and estimate your distance from them. But in a vast open country it may not be so easy to discover off-hand your whereabouts, when one of the following methods will have to be resorted to :

I. *Resection.*—If you can set your map to the ground as described above, employ the plane-tabling processes for finding your position. Identify two objects on the map and on the ground, and draw rays from the two objects towards you, when the point of intersection of the two rays gives you your position.

Should you have set your map by placing yourself on a straight road, bank, &c., a ray drawn to cut such straight road, &c., from *one* object will perhaps be sufficient to fix your position.

II. *Adjustment.*[1]—This is useful when you cannot first set your map to the ground, and it is sometimes called the Method of Adjustment, or the *tracing-paper* method. Take a piece of tracing-paper; fix it to your drawing-board in some way. Select and identify three objects on the ground that are shown on the map. Stick a pin into the tracing-paper to represent your imaginary position; pivot the ruler against the pin, and draw rays on the tracing-paper to each of the three selected objects, being careful to write along each ray the name of the object. Now unfix the tracing-paper, and apply it to the map, moving the former about over the latter until each of the rays that you have drawn passes through its corresponding object on the map. When this has been done, pin the tracing-paper down on the map, prick through the point of intersection of the three rays on the tracing-paper, and your actual position on the map will be marked.

[Accuracy is only ensured by selecting three objects the

[1] This method, and that known as the A B C, or Three-point, Problem, are not included in the *Manual of Field Sketching* (1903). *Vide* TRIANGLE OF ERROR, Appendix IV.

centre one of which is nearer to you than the other two; and your position and the three points must never all lie on the circumference of a circle.]

You should now be able to set your map and find your position on it under any ordinary circumstances. Get into the habit of bearing in mind the points of the compass, so that as soon as you take out your map you can set it roughly. The position of the sun can generally be approximated even on a cloudy day, and your watch will give you an idea as to the time of day, and thus the whereabouts of North and South. Recollect that at noon the sun is true South in the Northern Hemisphere, and true North in the Southern Hemisphere; that (as the earth completes a revolution round the sun in twenty-four hours, and as there are 360° in the complete revolution) the position of the sun alters 15° per hour; and that, consequently, the sun before noon is nearer to east by 15° each hour, and after noon nearer to west by the same amount.

In all that we have been discussing it has been assumed that you are working in a country sufficiently open to enable you readily to identify objects by which you can set your map and find your position. But there are many tracts of country in which, even with a knowledge of the various methods of using a map already described, it would be quite possible to lose one's way, and most difficult to find one's way. Take, for example, the comparatively small area known as the New Forest (Hampshire): A novice, visiting the forest for the first time, though carrying a compass and the 1-inch map, will find it anything but easy to follow the tracks marked on the map, much less to lead a body of troops from one point to another without a check. In heavily wooded country of this nature, where points cannot be picked up readily, and where cross-tracks are constantly met with, you must set to work systematically. As you walk along, hold your map in your hand, always approximately set; mark with a coloured pencil the route you have followed as you advance; keep your eye on the sun, or the compass, to prevent your accidentally taking a wrong turning;

check distances (either by pacing, or by time) ; and above all, if you are not alone, and if you are the guide of the party refuse to listen to anyone's advice when the route appears doubtful. Rely solely on your own ability to find the way out of the difficulty.

Maps are not always up to date; you should, therefore, be on the look-out for alterations. New roads may have been made, new houses erected, or old houses pulled down. Make it a practice to enter such alterations on your map whenever you come across them. To go about the country concerned with this alone will ensure your becoming an adept at map-reading.

Having satisfied yourself that you can handle a map, proceed to put your knowledge into practice. Take your map to some commanding position, from which you can obtain a good view all round; set the map, and mark your exact position on it. Now compare the map with the ground, making use of field-glasses, if you have them with you.

First, look at the whole lie of the country; settle which are the main watercourses, and where the minor ones flow into, or join, them. If you are high up, you will see all this at once, and by studying the country you will observe exactly how the greater part of the rain of a heavy summer storm will flow down from the watersheds by means of the watercourses into the streams and rivers of the valleys, and how these streams and rivers again flow down into the larger rivers, which in their turn flow down to the sea. Once obtain a thorough grasp as to how the water falls from the higher ground to the lower, and a knowledge of the general topography of the country is a simple matter.

After studying the actual country in this way, turn to your map and see how everything is represented, more particularly with reference to the contours and heights marked on the map. Now go into matters of detail. Look for noticeable objects on the ground, estimate their distances from your position, and the lateral distance from one object to another; then pick them up on the map, note their names, measure the distances by scale, and see how far out you were in your estimation. This is invaluable as a practice in judging distance for range of guns, &c., or for judging the time that troops would take to pass between two points. Estimate also the bearing of each object, checking your estimation by means of the protractor and map, or by means of the compass. Various exercises, such as these, will occur to anyone anxious to train himself to get the fullest information out of a map. Do not grudge time for this sort of study; sit down for a couple of hours or so on a hill-top, and work out the ground thoroughly in all directions. Divide your map up with a pencil into small squares, and try to identify on the ground everything shown on the map in each square. Some objects represented on the map may not be visible from your position; endeavour to locate them, by drawing rays on the map, and identifying the relative positions of other objects which *are* visible, or by measuring the distance on the map and estimating it on the ground.

As a preliminary to reconnaissance, steady practice in the comparison of maps with the ground is essential; for, until the eye has acquired the habit of rapidly and readily observing all that is presented to it—until, that is to say, the officer has learnt to OBSERVE—no good reconnaissance work is possible.

CHAPTER XV

RECONNAISSANCE

Definition and Object—The Habit of Observing—Its Acquirement—Different Forms of Reconnaissance — Route — River — Defensive Position—For the Attack of a Position—Information to be Reliable—Training the Memory.

THE importance of careful reconnaissance work has increased with the improvement in weapons; for whereas a century or less ago troops might march along with impunity up to within 200 or 300 yards of the enemy's position and await the opening of fire to disclose his dispositions, nowadays it would be absolute madness for bodies of infantry to advance, over unknown ground and without having located the enemy, to within even 1,000 yards or more of him.

By the term 'reconnaissance,' as here used, is implied the collection of information for some particular purpose, and reporting the same. An expert sketcher will have acquired an eye for country which will be of the greatest assistance to him in reconnaissance work; his training in the appreciation of slopes, distances, &c., will naturally make him a ready observer, and quick to take in a situation; he will, moreover, with a few strokes of his pencil be able to record what he has observed, and thus, as it were, illustrate his report. In reality, the chief object of the study of the preliminary parts of the subject of this book is to inculcate in the officer habits which will tend to make him a reconnoitrer. He must be able to sketch with rapidity and accuracy; and he must be able to write a clear and intelligible report leaving out nothing that is important, and inserting nothing that is unimportant. This entails a thorough knowledge of all branches of military science; for unless a man has studied tactics, military engineering, and other matters, he cannot hope to do much good in reconnaissance work. But before all things he must, as was said in the last chapter, be an observer—he must *train* himself to observe—for the majority of men are not of themselves sufficiently observant to carry out useful reconnaissance work without training.

This habit of observing is an acquirement that is immensely developed by military sketching, and also by studying maps on the ground (as described in the last chapter), and the student who has worked steadily through this book and put everything into practice up to this point may rest assured that he has (perhaps unwittingly) laid the foundations for fitting himself to undertake the serious duties of a reconnaissance on the results of which may depend his general's dispositions.

The points to remember are that, on service, it may fall to the lot of *any* officer (even the most junior) to make a reconnaissance; that, though he may not at the time think that the part of the country allotted to him to reconnoitre is of any vital importance, yet the most trivial detail (*e.g.* the slope of the ground at some particular point) may turn the whole course of events; and that, consequently, if he does not know his business as a reconnoitrer, he may upset every calculation and convert a certain victory into a defeat.

Now, the matter of training yourself in observation is neither difficult nor uninteresting. Whenever you go into the country (whether on foot, horseback, or bicycle) take a map with you, and set yourself some definite task. Make a mental note of the names of the public-houses that you pass; when you get home write them down in order, and check them some other day. Observe branch-roads, look them up on the map, and see where they lead to. Count the houses between any two points on the road. Look out for bench-marks cut on houses, bridges, &c. (See page 128.) Make a practice of noting, whenever you meet a cart, the number of horses drawing it, their colour, and the name on the cart. In a hundred and one other and similar ways, train yourself to keep your eyes open, until you instinctively become observant.

Again, on a railway journey, when looking out of the window, try and get a general idea of the configuration of the country through which you are passing. Notice the streams; see what portion of the land is drained by them, and which way they are flowing. Look at the hedgerows; observe what natural cover is provided by banks and ditches to troops skirmishing parallel to the railway line.

These are only a few suggestions; dozens of other things will occur to anyone who is really keen on improving his powers of observation. But it is not enough merely to gaze into space and think of these matters casually. If you wish to fit yourself for reconnaissance work, you should endeavour to write down at the end of your journey exactly what you have observed between certain points on the line (say between two stations), and the next time you make the same journey check your notes and amplify them.

Such is the groundwork of reconnaissance. Examine yourself thoroughly and make certain that you are not superficial in your observation. Here is a test: Ride along a couple of miles of a country road; then stop, and try to write down in your note-book what you have seen. Give a general description of the road and the country on each side; describe the carts passed, and individuals on foot, and where you passed them. Test your ability in making a rough sketch (from memory) of the road traversed.

While using your eyes in this manner, apply, at the same time, your reasoning powers. Begin with small matters. For instance, you see outside a cottage a baker's cart, on which is painted 'John Brown, Baker, Horton'; referring to your map, you see that Horton is a village three miles from where you are. You instinctively ask yourself why the Horton baker comes so far afield, and you come to the conclusion that

Horton is the nearest village to the cottage. But, on looking at the map, you find that the village of Southam is only two miles from the cottage; then why, you wonder, don't these people get their bread from Southam? The affair becomes pure inquisitiveness, and you promptly ask the baker's boy why he supplies the cottage, when Southam is so much nearer than Horton. He tells you that there is no baker at Southam, and that his master is the only baker within a radius of five miles of Horton.

Trivial everyday things of this nature assist in the development of the habit of observation; and there is no part of the country where it is not perfectly easy to find something to observe. Even the water-supply of your own station will provide you with plenty of food for reflection. Begin at the end (*i.e.* the water coming out of the tap) and follow it to the beginning (*i.e.* the source of supply); and if you are energetic enough to work out actually on the ground the whole system of the water-supply to the station, you will probably find that in so doing you will gain a vast knowledge of the topography of the country adjacent to the station.

All that has been said so far is preliminary to reconnaissance work—*i.e.* the acquirement of the habit of gathering information of a general nature. You have been working, as it were, with civilian eyes, and you should now go about your business with military eyes. Carry in your head everything that is contained in '*Combined Training*.' Be on the look-out for things of a tactical nature; imagine yourself to be leading a column along a road in an enemy's country. Keep your eyes ahead. Note exactly where you think the enemy would be likely to oppose the advance of the column that is supposed to be with you; where his artillery would find positions; where your column could halt or bivouac in safety; where your advanced-guard could hold its ground if suddenly attacked; how your flanking parties would have to move, &c. &c. Saturate yourself with these military ideas, until you instinctively feel that, wherever you are moving, an enemy is trying to outwit you, and that it is your duty to outwit him. This state of mind is not arrived at in a day; but when it has been attained, when you involuntarily move in the presence of an imaginary enemy, then—and not till then—are you fitted to undertake a reconnaissance on active service.

The kind of work that you may find yourself called upon to perform is manifold, though the various reconnaissances can be brought under certain headings:

I. *Reconnaissance of a Route.*—This will be entered into fully in the next chapter, and may be regarded as a type of all reconnaissance work.

II. *Reconnaissance of a River.*—Make a sketch of the course of the river, and of the valley on each side (say, for 1,000 yards from the banks). Enter as many notes as possible on the face of the sketch,[1] but if you have more to describe, write a separate report. Note particularly the following points:

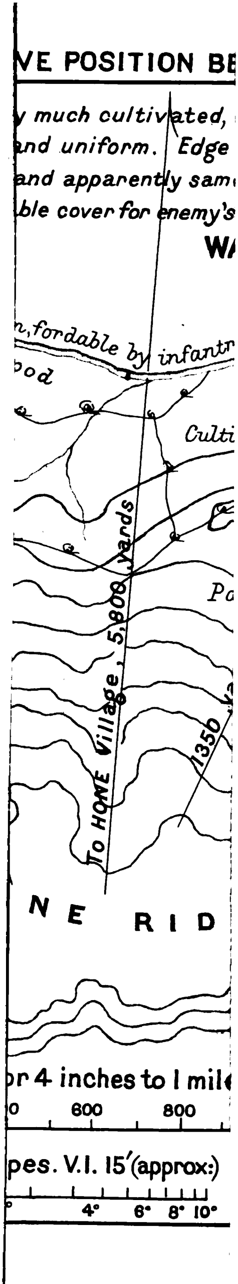
(*a*) Breadth, depth, and current throughout.
(*b*) Bridges, ferries, fords, &c.
(*c*) Nature of bottom (if hard or soft).
(*d*) Nature of the banks.

Add any information that you obtain from the inhabitants as to the change in the river between winter and summer.

Remember your special instructions for the reconnaissance, which will probably have for its object the collection of information as to available crossings for a force of a certain strength, or the preparation of a scheme for holding the river-line between two given points. (For fuller details see 'Reconnaissance Notes and Memoranda,' Appendix I.)

III. *Reconnaissance of a Defensive Position* (Plate XIII.)—In this case you would be given detailed instructions to guide you in your work; you might be called on to sketch and report on a certain position with a view to its being held by a force of a certain strength, or you might be ordered to find the best position suitable for occupation for a given purpose between two

[1] This is the rule for all reconnaissance work, though sometimes a separate report is essential. *Vide* 'Reports,' Appendix I.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named points. You would seldom be called on to do more than sketch the ground and furnish a report on it; the disposition of the troops would be made by your C. O., though it would, of course, be your duty (as a reconnoitrer) to provide your C. O. with such information as would assist him in the disposition of his troops. You must, therefore, be intimately acquainted with the tactical principles governing the defence of positions; [1] and though, as a junior officer, it would be presumption on your part to suggest the manner for occupying the position (unless ordered to do so), your sketch and report should be so complete that no doubt can possibly arise as to the strength or weakness of any particular point.

Sketch the ground on any suitable scale—the larger the better—getting in as much detail as time will permit. Contour the ground (or shape-in *form-lines*) to the best of your ability. Leave nothing to the imagination. If your sketch leaves a loophole for doubt at any point, make it quite clear by adding a note in the margin (*e.g.* the height of the trees in a wood might cause ground to be concealed from the view of the defenders, though this might not be apparent from your sketch. Add a note to this effect).

While sketching the ground, you should make such a study of it as to be able, if required, to guide a party to a particular post in the dark. You must carefully note landmarks, and consider their probable appearance under altered conditions of light Regard the position also from the enemy's point of view, so that when the position has been eventually taken up, you will have no hesitation in deciding against which part the enemy will launch his main attack.

Whenever possible, supplement your plan and report with freehand drawings of the position as seen from various points, and of the country round as seen from the position. Figured hand-sketches and sections of parts of the ground likely to require artificial defences (trenches, breastworks, &c.) are also valuable.

[1] *Vide* '*Combined Training*,' 1902.

IV. *Reconnaissance for the Attack of a Position.*—This would, on service, probably have to be undertaken in the presence of the enemy, and the work must, therefore, necessarily be done rapidly.

Make a large-scale sketch of the ground over which the attack will be made, and, as far as possible, of the enemy's position; or, if you have a fairly reliable map of the country, make an enlargement from it, then check it and fill in detail on the ground. In all probability you will not be able to do more than this in the way of sketching, though you will be able occasionally to get under cover and make notes of all you see, getting-in some *form-lines*, and adding any landscape sketches that you can draw. (*Vide* Plate XIV.)

Keep always uppermost in your mind the object of the reconnaissance. At whatever point you happen to be, imagine yourself to be leading a body of troops in the attack; observe the folds in the ground which would give cover to your men; observe at which points they would come under the hottest fire.

Try to discover the enemy's dispositions, and of course his strength; where his guns are posted; how his flanks are secured; what is the weakest, and what the strongest, part of the position.

Look for various positions for your artillery (stating exactly how many guns can be brought into action at each position).

Be careful to note any dead ground in front of the position, but remember that it is most difficult to be certain on this point.

Bearings, or compass directions, of various objects in the position are of vital importance. State clearly whence the bearings were taken, and the variation of the compass used.

Do not attempt to gain *kudos* for yourself by jumping at conclusions. Do not give unreliable information. To state the fact that the flanks of the position were weakly held when you had not been within a thousand yards of them would be misleading; it would be preferable to report that, *as far as you* *could see* when at a distance of a thousand yards from the flanks, they *appeared to be* capable of being turned.

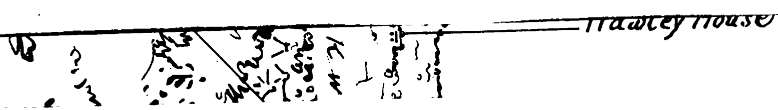
When making a reconnaissance of this kind you would probably be mounted, and would endeavour to get as near as possible to the position. The chances are that the enemy's outposts would not fire on you, but would allow you to get through the lines, and then capture you. It is therefore important to keep your eyes open, and to be quite sure that you know your way back, if you have to make a bolt.

To reconnoitre an enemy's position in daylight without being observed is almost an impossibility, unless the ground is exceptionally favourable, and you yourself an expert scout. Still, with the aid of range-finders, useful measurements may be made from points at fairly safe distances from the enemy. At night-time a bold reconnoitrer may steal up to the sentries without being seen, and thus collect most valuable information. It is, however, a hazardous undertaking, and requires nerve; moreover, you must trust entirely to your memory for your eventual report.

This matter of memory, as we have already said, is an important factor in all reconnaissance work, and every officer should exercise his memory with regard to country that he has been over. Make it a habit, after executing a sketch, to try to draw the ground from memory and write out a description of it; on returning from a route march, plot from memory the route followed; or after a field-day, attempt to put down the successive movements of your company throughout the day. Constant practice is the main thing, and even the record of a day's hunting or of a day's shooting faithfully set down on paper will be of assistance in keeping the machinery of *observation, memory, and reporting* in working order.

Almost any form of reconnaissance will be similar to one or other of the above four instances, though, of course, the circumstances under which the reconnaissance is made will always vary. You may be called upon to make a reconnaissance of a railway, coast, woods, village, defile, or almost anything;

but, whatever it happens to be, be quite certain, before starting, that you know what you have to do, and refresh your memory by referring to any available memoranda on the particular subject. If you have a really good map of the country, it would be a waste of time to draw another, though you must make certain that your map is up to date, correcting it if necessary. Not having actually to make a sketch of the ground will enable you to devote all the more time to observation, so your descriptive notes will be more complete, and your work of greater value. But there are many parts of the world (in which the British army may be called upon to operate) still unmapped, and it is therefore essential that you should be able to execute a sketch of the country if called upon to do so.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CHAPTER XVI

RECONNAISSANCE OF A ROUTE

How to make the Sketch—Value of the Cavalry Sketching-board—Rapidity essential—Tactical Reconnaissance—Schemes—Reporting—Register of Miles—Hill Sketching—Landscape Drawings—Rate of Work—The Report—Accommodation and Supplies.

THE amount of sketching to be performed on a route-reconnaissance must depend entirely on the time available. On service, the rapidity with which the reconnaissance is carried out will probably be all-important; and then, as has been pointed out, if you had a good map you would make a tracing or an enlargement of the route, filling in detail and checking the map as you proceeded along the route. In peace-time, and for practice, you should make your own sketch of the route with whatever instruments are available. The different methods of executing the sketch have been already fully described in previous chapters. Thus, if you are using a plane-table or a prismatic compass, your route-sketch is merely a traverse with those instruments; or with the prismatic compass it may take the form of a field-book traverse (page 77); without instruments, the sketch would be a traverse as described in Chapter X.; while a route-sketch with the cavalry-board was explained in Chapter XI.

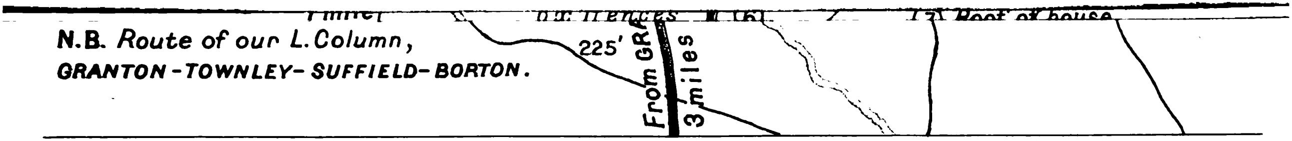
Whatever instrument you use, the result should be the same: the sketch should show half a mile to one mile of country on each side of the route, with the general direction of the route running approximately up the centre of the paper (starting-point at the bottom). A reference to Chapter XI. will explain how this is arrived at with the cavalry board ; but, when sketching otherwise, unless you take elaborate precautions beforehand, you may have to cut your paper after plotting the route, so as to have the margins of the paper more or less parallel to the general direction of the route. This is, of course, a clumsy means to an end, as slips of paper will have to be gummed together, and the written matter cannot be completed until you have decided on the cutting of the paper margins. Moreover, an ordinary drawing-board will not take a sheet of paper long enough to include more than a few miles of a route on a scale of, say, three inches to the mile. It is evident, therefore, that for sketching a route rapidly and for any considerable distance, a cavalry board is by far the best instrument to use; and if you cannot procure one you can, at any rate, improvise some sort of a board with which you can work on cavalry-board principles. All that is necessary is a board (even a large note-book) with a compass attached to it. You can then complete your sketch, with written notes on its face, &c., as you go along, and it will be ready to hand-in at any moment. This is a very important feature of a route-reconnaissance; there should, if possible, be no finishing-up afterwards, for you should be able to ride straight in to head-quarters and hand in your sketch and report at once. Consequently a route-sketch should usually be finished in pencil (unless you happen to have a stylograph pen), and each mile or so of the route should be completed and done with before you go on to the next mile.

As a rule, a route-reconnaissance is made with the object of collecting information for one of two purposes :

(*a*) Tactical—*i.e.* where an enemy has to be thought of.

(*b*) Non-tactical—*i.e.* where the sole idea is accommodation, supplies, and transport, and the information required of a purely statistical nature.

The regimental officer (of cavalry or infantry) would more usually be concerned with (*a*); while (*b*) would be carried out



ROAD........ General direction N.W.; 1st class; good repair; fairly level; passable by all arms. Fenced by thorn hedges, on E. side growing on bank 2' high. Telegraph poles on E. side of road, 6 wires. Post and Telegraph at **THORNHAM** and **HALFIELD**. Nothing to impede usual rate of marching.

COUNTRY.... Between **THORNHAM** and (6) ground to E. rises gently; for the most part grass fields averaging 2 acres, with thick hedges. From (6) to **HALFIELD** steep slope up to **WEAVER'S DOWN**, about 500' above **HALFIELD**, surface hard and stony. Route of left column visible occasionally across the river. Enemy's guns on **WEAVER'S DOWN** would command almost whole road from (1) to (11).

POSITIONS ETC... Should the enemy advance and hold the line (10)—**HALFIELD—WEAVER'S DOWN**, it will be necessary to make a wide turning movement to N.E. before advancing from **THORNHAM**.

Executed on foot, with Cavalry Board, Aneroid, and Abney Level. Heights relative to Aneroid reading at **THORNHAM BRIDGE**, viz. 220'

W. Smith Capt.
Blankshire Regt.
18.4.03.

by a specially trained Staff, or Army Service Corps officer (though *every* officer should train himself for this special class of work).

I. First as to the *tactical* reconnaissance.

The instructions issued to you will confine you to definite objects on which to report. In peace-time you would be given some sort of a scheme, of a simple nature. You would be told the exact situation of your own force, where the enemy was supposed to be, whether your reconnaissance was with a view to a retirement or an advance of your force, whether friendly columns would be marching by routes parallel to that which you were to reconnoitre, the strength and composition of the column for whose advance or retirement you were prospecting, and other information of a similar kind.

Generally speaking, what would be required of you would be a sketch and report on a certain length of route, so accurately compiled that when handed to the Chief Staff Officer of the column, he would know—

(1) How to guide the column, by day or night, without any chance of mistake.

(2) Approximately the best places to halt, bivouac, or camp.

(3) Where the usual rate of marching is likely to be checked.

(4) The general condition of the route and of the adjacent country on either side.

(5) Positions favourable for an advanced or rear guard to hold.

(6) Positions for line of outposts.

(7) Positions likely to be taken up by the enemy's artillery and other arms, to oppose the advance of the column.

(8) Any possible place where the enemy could form an ambuscade.

(9) Lateral communications with friendly columns.

Now it must be remembered that a Chief Staff Officer is a busy man; if, therefore, you are to be of any assistance to him, your work must be so carefully and accurately put on paper that, in looking at it, he will see everything at a glance. There should be no necessity for wading through a mass of notes to discover any particular item of information: what you have to say should be short and to the point. Read over what you have written, and ask yourself whether a total stranger to the country would understand it.

In many instances, if you make your sketch on paper of sufficient width, you may be able to enter all the necessary notes on the face of the sketch, but in this case you must take care not to crowd-out the sketch with your notes. Keep everything clear and distinct; when you have any remarks to make about a particular spot, put against the spot on the sketch a reference-number (red, enclosed in a circle), and a corresponding reference-number in front of your note in the margin. It is advisable to start numbering the reference-figures at the bottom of the sketch—*i.e.* at your starting-point—and the corresponding marginal notes should be, as far as possible, on a level with the spot on the sketch that you are describing.

At each mile of the road from the starting-point draw a line straight across the sketch, and write at the end, '1 mile,' '2 miles,' &c. This is of great assistance to anyone looking at the sketch, and wanting to get a rapid idea of distances.

Write along the road, here and there, the width of the metalled portion, the gradient and the *nature* of the fences on either side; but do not waste time by drawing-in all the hedges, &c., of an enclosed tract of country: it is quite sufficient to write on the sketch 'Intersected by hedges; fields averaging two acres,' or something of that kind. Similarly, when passing through a village, it is unnecessary to draw-in each house; endeavour to get the outline of the village, then lump in the cottages anyhow, locating the church or any large building that you consider might be of importance. In your notes you can give the approximate number of houses in the village.

Contouring a route-sketch was fully dealt with in Chapter XI., so we need not say more than that it is impossible in a rapid route-reconnaissance to do anything except generalise the shape of the ground. Lay down, as carefully as you can, the direction of all the watercourses; endeavour to fix the relative heights of the more noticeable features; and then shape-in contours, or *form-lines*, which need not necessarily be drawn at regular vertical intervals, so long as it is evident what they represent. The sketch must show clearly what parts of the ground command other parts, and you must include everything within view, even though it may be off your paper. For instance, guns posted on a ridge three or four miles from your route might command the route throughout: draw rays from different points on the route towards the ridge, and write along them information such as: 'To ridge, about 5,000 yards, commanding route from (10) to (15).'

Marginal freehand landscape sketches are most valuable, if drawn with the sole object of explanation, and not for the purpose of beautifying the sketch and 'puffing' your artistic abilities. A bold outline drawing will very frequently tell a stranger more about a particular object than will a written explanation of a dozen lines. Always name the exact spot from which your drawing was made, and the compass direction of it—*e.g.* 'View of Blackdown Hill looking N.N.E. from (12).' [1]

[Photographs would, of course, be even better, were it not for the time and trouble of developing and printing, and the possibility of mistakes as to locality, &c.]

Under ordinary circumstances you should be able, with practice, to make a reconnaissance-sketch and report at the rate of about three miles per hour when on horseback, and two miles per hour on foot; while with a bicycle, on a fairly good road, there should be no difficulty in doing four or five miles per hour.

Sometimes it may not be possible to give sufficient information in marginal notes without crowding up everything. Under such circumstances, if you are working on a long piece of cavalry-board paper, leave six or eight inches at the bottom, on which to write your report; or you can make use of a separate sheet of paper. Reference-numbers in circles should be written

[1] *Vide* Plate XIV., and page 159.

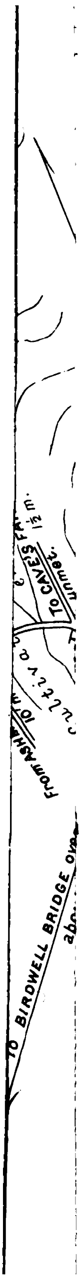
on the sketch, and corresponding numbers made use of in the report. The information should be tabulated under certain headings ; thus, under heading *The Road*, the whole of the road from start to finish should be described ; under the heading *Bridges*, all the bridges along the entire route should be dealt with, and so on. This method of working up the information is considered more satisfactory than compiling a guide-book (or road-book) description of things as they are encountered, for the principal reason that the officer for whom the report is made may want to discover quickly all the information about one particular thing—*e.g.* rate of marching—and it would be a waste of time to wade through the whole of your report in order to pick out what you have to say, here and there, about the gradient of the road, &c.

Entries should be brief and to the point ; there must be no ambiguity in the wording ; the use of abbreviations[1] is dangerous, as they are liable to be misunderstood ; proper names should always be printed in BLOCK. Be careful to sign and date your report, and to give it the same heading as your sketch, to which it should be secured in such a manner that the two can be studied simultaneously.

II. With regard to a *non-tactical* reconnaissance, the information to be collected would usually relate to accommodation and supplies for the troops that were to march by the route, and the transport that could be requisitioned in the vicinity of the route ; the object, of course, being to discover to what extent the troops would be able to subsist on the country. In a friendly country the inhabitants themselves would probably furnish the information ; but the resources of a hostile country, vacated for the time being by the enemy's troops, would have to be reconnoitred by competent officers.

A sketch of the route (with reference-numbers as usual) should accompany the report, and the latter should be in tabulated form, for easy reference.

[1] The following symbols are authorised: × = yards, ′ = feet, ′ inches ; but when used, they should be written very distinctly.



To CAVE'S
1½ m.
10 m.
TO BIRDWELL BRIDGE

It is important, in reporting on a town or village, to give the names and addresses of the more influential of the inhabitants, so that they may be made responsible that the requisitions are complied with.

The information in the report[1] should be given under the following headings: (1) Name of place, or reference-number on sketch; (2) Accommodation for men and horses for a night; (3) Supplies; (4) Transport, and where to be found; (5) Water-supply.

LANDSCAPE SKETCHES.—Concerning the matter of free-hand sketches of positions, &c., to which occasional reference has been made, it is often imagined that only an *artist* is capable of undertaking such work. With practice, however, it has been found that almost any officer can produce most successful outline drawings, which, with the addition of some written notes, will be of real value. What is required is not an artistic picture, but a true representation of the various main outlines that catch the eye at once.

A novice is recommended to rule, say, one-inch squares on a sheet of glass, and similar squares on a sheet of drawing-paper of the same size as the glass. Hold the glass upright, at the full extent of the left arm, and make a copy of the outlines of the landscape seen through the glass, as if copying a plan-drawing by the method of squares. It is useless to attempt to draw all the detail; what is wanted is the outline of the principal features of the panorama, drawn more or less in perspective. Put-in the foreground with thick dark (B.B.) strokes, the middle distance with somewhat finer (H.B.) strokes, and the background (or far distance) with quite light (H.H.) strokes. Training of the eye to take in the landscape presented to it, and training of the hand to depict faithfully what the eye sees, are the main points. Everything else comes with practice.[2]

[1] For estimation of supplies, &c., see Appendix I.

[2] A valuable treatise on *Military Freehand Drawing*, by Lieut-Colonel Heard, will be found in the 'Journal of the R.U.S. Institution,' February, 1903.

CHAPTER XVII

MARCHING ON COMPASS-BEARINGS

Day, and Night—Description of Magnetic Luminous Compass—Marching by Day—The 'Set' of the Compass—Recording Distances—Marching through Thick Woods—The Direction of the Line of Advance—Night Marching—Darkest Nights the Best—Preliminary Training—Stars and their Uses—Luminous Watches—Foggy Nights—Two Methods of Marching—Previous Training—Importance of Self-reliance.

To be able to use a compass successfully for finding the way from one point to another across country requires practice, though to march on a compass-bearing in the *day time* is by no means as difficult as it at first appears. At *night* the difficulty is certainly much greater.

For day marching any form of circular compass can be used, but at night it is essential to have one prepared with luminous paint. At all times it is convenient to work with a compass which can be set to the bearing on which the march is to be made; and there are several patterns in the market. The pattern known as the *Magnetic Luminous Compass* (N.C.O.'s) is in general use in the army, and the following is the inventor's [1] description of it (fig. 35):

'The magnetic luminous compass (N.C.O.'s pattern) consists of a metal case, with lid which opens and folds back flat. The compass-card has its outer margin graduated to 2° (from 0° to 360°), and shows also the 32 cardinal points of the compass. The centre portion of the compass-card is prepared with luminous paint for night operations, the North Point being clearly indicated by a large black arrow-head.

[1] Lieut.-Colonel W. Verner.

'The compass-card rests on a single pivot, and is provided with a check-stop and a lock-stop. The upper part of the case carries a milled ring, in which is an index-line; and the ring can be turned round so as to bring the index to any required position. The ring is made to work with a convenient amount of friction, not too tightly nor too easily, by means of a couple of small screws on opposite sides of the compass-box.

'The outside of the compass-box is graduated to 5° (from 0° to 360°) *reversely—i.e.* from N. to W. and round by S. and E. These gradations are numbered 2, 4, 6, &c., in place of 20, 30, 40, the noughts being dropped to make the reading clearer.

'The bow-ring and the opposite end of the lid are notched so as to facilitate the process of laying the compass on a N. and S. line on a map, and also for roughly taking bearings of objects.

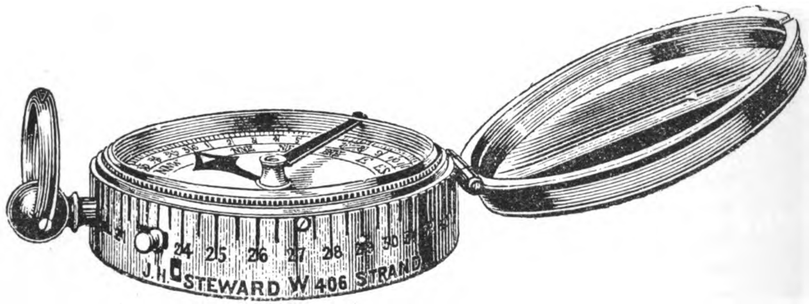


FIG. 35.—MAGNETIC LUMINOUS COMPASS (N.C.O.'S PATTERN)

'Inside the compass-box, and exactly opposite to the bow-ring, is a fine white line, or 'lubber's line,' to enable bearings to be read off the compass-card. This is done by aligning the notch in the bow-ring and that in the lid on an object, and then, by raising the eye, reading the bearing which coincides with the 'lubber's line' directly from the card.

'Inside the lid is a broad line of luminous paint for night operations.

'The bottom of the compass-box is fitted with an indiarubber friction-ring to prevent it from slipping off a sketching-board, &c., when tilted accidentally.'

A glance at the compass while reading the above description will make matters quite clear.

TO USE THE COMPASS FOR MARCHING BY DAY.—We will suppose that you are ordered to find your way from the spot where you are standing to a point, the magnetic bearing of which by your compass is 270°, and distant 3½ miles. You have to take a bee-line, over hill and dale, through woods, &c. Proceed as follows: Open your compass, and adjust the index-bar by revolving the milled rim until the metal indicator (at the end of the index-bar) is exactly over the figure 27 (*i.e.* 270 with the nought cut off) on the outside edge of the box.[1] Now lay the compass flat in the palm of the left hand, held at the level of your waist, the compass being so placed that the lid is away from your body. Turn yourself slowly round until the arrow-head marked on the card comes to rest exactly under the index-bar. *Your line of advance is in prolongation of the white line in the lid of the compass.* The reason for this will be understood by remembering what was said about the line of direction in getting the set for a cavalry board. The white line in the lid of the compass corresponds to the line of direction ruled lengthways up the paper of the cavalry board; and the index-bar corresponds to the glass meridian of the cavalry board. In this case your line of direction is 270°—*i.e.* due W.—and, owing to the fact that the outside of the compass-box is graduated in the *reverse way*, when you adjusted the index-bar to 270° you adjusted it (with reference to the 'lubber's line') to the *reverse* bearing—viz. 90°—*i.e.* due E. Again, when you turned yourself round and brought the north end of the needle under the index-bar, you so placed the compass that 90° on the outside of the box was in the direction of Magnetic North, and therefore the white line in the lid (which is a continuation of a line drawn from the pivot-point to the 'lubber's line') is 90° west of north—*i.e.* 270°, which is the bearing on which you are to march. In a word, as your line of direction is 90° W. of north, north must be placed 90° E. of your line of direction.

[1] Should it occur that the figure representing the bearing on which you have to march lies under the hinge of the compass lid (*i.e.* a bearing within a few degrees of N.), you must set the *tail* of the index-bar to the *opposite* bearing—*e.g.* bearing, 360°, set the tail to 180° on the rim.

Having set the compass, the only difficulty is to march accurately in prolongation of the white line in the lid. To effect this, the simplest plan is to prolong the white line by holding over the compass, with the right hand, a cane (or walking-stick) at an angle of about 45 degrees, and then, noting some tree or other object in the distance covered by the stick, march on it. Select objects as far away as possible, but be sure that, in your advance, you never make a mistake as to their identity.

Proceed in this way from object to object, carefully pacing the distances and writing them down. At each halting-place, and before looking for a fresh object on the given bearing, see that your index-bar has not shifted, and that the lock-stop has been unclamped.

Keep your distances totalled up, so that you may know when you are nearing your destination.

The accuracy of a march depends, of course, on the absence of initial error in the compass, and on the care with which the objects to march on are selected. With an average compass, anyone, after two or three practices, should be able to find his way to a point within about 100 yards to the right or left of an objective in a march of a couple of miles over ordinary country.

In wooded districts dense undergrowth will impede the view very considerably, and you may frequently find yourself confronted by a thicket. In such a case it will often be a good plan to pace at right-angles to the line of advance, until clear of the thicket; then advance on a line parallel to the original line of advance; and when the thicket is passed pace back to the original line of advance.

To obtain for yourself the bearing of the line of advance you must either (1) have a map showing both the point of departure and the objective, or (2) you must, when standing at the point of departure, be able to see the objective, although the intervening ground may be of such a nature as to render the objective altogether invisible after you leave the starting-point.

In the former case (1) draw a straight line on the map from the starting-point to the finishing-point; then across this line rule a magnetic meridian line; by means of the protractor measure the angle made by these two lines, and you will get the bearing of the line of advance, to which to adjust, or set, your compass; or simply set your map to the ground at the starting-point, adjust your compass to the line joining the starting-point and finishing-point (the lid of the compass towards the latter), and when the needle settles bring the index-bar over it. In the latter case (2) stand at the starting-point and face the finishing-point; place your compass open on the ground, or flat in the palm of your hand, and revolve it until the white line in the lid points straight towards the finishing-point. As soon as the needle has come to rest, clamp it; then bring the index-bar over the needle (indicator mark opposite the north end of the needle). Read off the outside rim of the box the figure opposite to the indicator mark, and write it down in your note-book for reference, in order to be certain of the bearing even if the index-bar shifts after you set it.

With regard to the last-mentioned case (where at starting you can see the objective), it is obvious that if the objective were likely to remain in view throughout you would not require to use a compass. But we are supposing that your starting-point is on a commanding position, and that to reach the objective you will have to descend into the valleys, through woods, &c. Or, again, here is another instance: Just before dusk you reach a hill-top from which you can see your camp, ten miles away. You adjust your compass as above described, so that the white line in the lid of the box points in the direction of the camp. When darkness comes on, and the camp is no longer visible, you employ your compass to guide you as when making a night march, to which we are now coming.

Night Marching.—Without entering into a discussion on the subject of night marches and night attacks, we may say that, whether dangerous undertakings or not, they are at times inevitable in modern warfare, wherein surprise is of vital importance. (See *Combined Training*, 1902.) For night marches by roads local guides would usually be employed; in country with well-defined features maps made on tracing-paper, with the principal features drawn in solid black lines, and then fastened on a card prepared with luminous paint will be found of great assistance; but for carrying out marches or attacks across open country the compass may frequently have to be relied on. To lead a column by night by means of a compass, even under the most favourable circumstances, necessitates not only skill but also a considerable amount of self-reliance, neither of which can be attained without immense practice.

The darkest nights are best, as the luminous paint[1] shows up clearer. But at the same time the presence of stars is important.

Before commencing the march, the bearing must, of course, be discovered by the map, or by visiting the ground (if possible) in the daytime. The compass is then set to the bearing as usual, and if a change of direction is to be made during the advance, a second compass (set to the second bearing) should be carried. But it must be remembered that a change of direction necessitates the most careful measurement of the first advance, and should never be resorted to if it can be avoided.

As a beginning, you are recommended to see for yourself what night work with a compass is like by going out alone, and trying to find your way across a short distance of ordinary country. This will give you a better idea of the difficulties of leading a column at night than anything else.

You must be provided with a luminous compass (such as

[1] It is important to remember that luminous paint loses its luminosity when un-exposed to light. Compasses with lids should be exposed to daylight for at least half an hour immediately before they are intended to be used at night.

shown in figs. 35, 36, and 37) and a stick painted with luminous paint (or at any rate white enough to be seen in the dark). Now, having set the compass, and holding it as for day marching, you endeavour to pick up an object in prolongation of the luminous line in the lid of the box, after the black arrow-head on the luminous card has come to rest under the black index-bar, both of which show up in the dark against the luminous

MAGNETIC LUMINOUS COMPASS (OFFICERS' PATTERN)

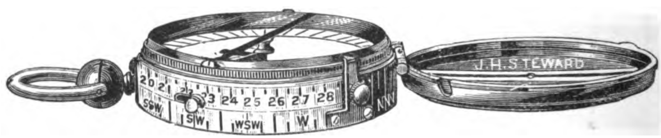


FIG. 36.—AS A NIGHT-MARCHING COMPASS

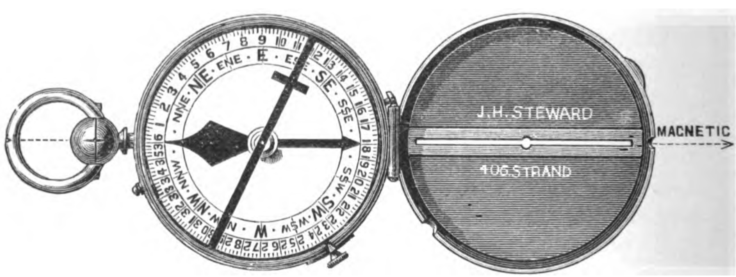


FIG. 37.—AS A PLANE-TABLE COMPASS. (About two-thirds size.)

background. As a rule, you will find the greatest difficulty in seeing an object on the earth, and you will therefore have to march on a star. With the heavens covered with stars, it is no easy matter to remember on which particular one you are marching, and here comes in the value of some knowledge of the principal constellations. Supposing that you are able to overcome this difficulty, and are quite sure of your star, you have still to bear in mind that, if you are out for any length of time, the position of the star will have altered slightly (15 degrees per hour), and you will be off your line. It is advisable, therefore, for anything like accurate work, to select a fresh star to march on every quarter of an hour or so.

An assistant will be found useful (and, indeed, usually necessary) as an intermediate point between yourself and the star. He should carry on his back a large piece of card painted with luminous paint; then, as he advances, you keep him 'dressed' on the star; and you follow him.

As in night work any sort of light is out of the question, and as time is often an important factor, you should prepare the face of your watch with luminous paint, either by painting the hands and figures, or better still by painting the whole face and leaving the hands and figures in black. On starry nights, however, and when you are well accquainted with the principal stars, you should be able to tell the time with fair accuracy without a watch.

On dull, cloudy, or foggy nights, when the stars are obscured, you must adopt another method for using the compass which, though slow, is quite as accurate. For this you must have two or three assistants (certainly always two, and half a dozen if possible), each with a luminous card, or slab, about one foot square fastened to his rifle. Standing with your compass in your hand, and your stick prolonging the luminous line in the lid, you direct one man to place himself a convenient distance in front of you, and another man a short distance ahead of the first. The second man should hold his luminous card high up, so that you can see both luminous cards; which you ought to be able to do if within 100 yards of you. You now move the two men, right or left, until they are both in the required alignment; after which you proceed to the second man, take his place, and repeat the operation.

With several men to work with, the advance can be carried out rather more rapidly, especially if the men have been trained. The first two men are aligned as before; as soon as they are in position, No 3 goes to the front and is brought into the alignment; then No. 4 places himself in front of No. 3, and is aligned; then No. 5, and so on. When all the men are 'dressed' in this way, the rearmost man runs to the front and gets into the alignment; then the next man from the rear places himself in front of him, the remainder of the men doing the same thing one by one. The officer with the compass follows in rear, to see that the proper direction is being kept. The operation is simplified by the luminous cards being

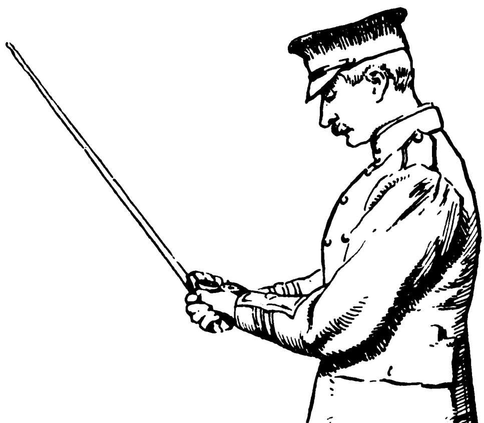


FIG. 38.—MARCHING ON A COMPASS-BEARING

painted with luminous paint on both sides, as the men going to the front can pick up their own 'dressing' at once by looking to the rear.

In training men for this work, it is advisable to select them for their intelligence; drill them carefully first in the daytime, and then at night with *lanterns*, before attempting the use of luminous cards.

If a record of distances has to be kept, special men must be employed for the purpose, with no other duties to perform.

What has been said above about marching on compass bearings is perhaps sufficient for the beginner. To become proficient in the use of the compass by night, he must be constantly at it. Charts of the stars [1] should be well studied, and the eyesight should be specially trained for night work; for, with training, a man's powers of seeing objects in the dark develop enormously. Lastly, the man who undertakes to lead a compass march at night must have absolute confidence in his own ability; once having started, to listen to the advice of others (even though he may imagine that he is going wrong) is fatal. The man with the compass is 'the man at the wheel,' and should never be spoken to.

[1] The *Planisphere* (George Philip & Sons, 32 Fleet Street) is recommended.

APPENDIX I.

RECONNAISSANCE NOTES AND MEMORANDA

ACCOMMODATION.—To estimate temporary accommodation for *men* in buildings, frontage in yards × number of storeys × number of rooms from front to back = number of men. Stabling for *horses* in sheds, allow 2 yards of frontage for each horse; for more than one row of horses the shed must be at least 8 yards deep.

BIVOUACS.—Allow for a battalion, or a battery, 75 yards × 150 yards; for a regiment of cavalry, 165 yards × 150 yards. (See *Combined Training*, Part VII., and Appendix B.)

BOG.—*See* MARSH.

BRIDGES.—Material; length and breadth, nature and number of arches, and their dimensions; if capable of bearing heavy guns, traction engines, &c.; height of roadway above the water. *See also* DEFILES.

CAMPS.—For spaces, &c., consult *Combined Training*, Part VII.

COUNTRY.—In general descriptions use the following terms: Hilly, undulating, flat, open, close, fenced, cultivated, pasture, marshy, rocky, hard surface, wooded, covered with scrub, gorse, or heather, practicable for all arms—or as the case may be.

CURRENT.—To find the approximate velocity of a river or stream, throw a piece of stick into the centre of the stream, pace along the bank, and note the number of feet that it travels per minute. Under 1 mile per hour is called sluggish, above 3 miles per hour rapid, 5 miles very rapid, 6 miles a torrent. A *fall* of 6 inches per mile (in a deep and wide river) will produce a 'rapid' current.

DEFILES.—Anything the passage of which necessitates a reduction of front may be considered a defile. Mountain-passes, narrow valleys, bridges, fords, drifts, causeways, roads across swamps, streets, &c., are all defiles. Note length and breadth of defile, possibility of enemy forming ambuscade, nature of flanks, how passage can be secured. If reconnoitring for a retirement, consider best positions for rear-guard, or for picketing neighbouring heights; observe what obstacles are at hand for blocking the defile.

FORAGE.—*See* SUPPLIES.

FORDS.—Infantry on an emergency can ford a river up to their armpits, say, 4 feet; artillery should be able to keep their limber-boxes out of water (about 2½ feet); cavalry can cross in 4½ feet of water without their horses attempting to swim. These are the maximum depths for fording rivers in anything like order. Observe state of river—if full or otherwise. Report on length and breadth of ford (as a guide to time required for crossing), current, nature of bottom, and of banks approaching the ford. If reconnoitring a difficult ford for an immediate crossing, mark the route to be followed by a line of stakes driven into the river bed.

FORESTS.—*See* WOODS.

FUEL.—Do not describe fuel as 'abundant' except in a well-wooded country. The ordinary allowance of fuel (sticks) for cooking per man is 3 lb.; if drinking-water has to be boiled the allowance would be much greater. When operating near a railway line, coal or mineral oil may be obtainable. In a barren country, failing everything else, animals' dung has frequently been the only fuel available.

GRADIENTS.—*See* SLOPES, and page 87.

HILLS.—*See* DEFILES; MOUNTAINS.

MARCHING, RATE OF.—Infantry, 2½ miles per hour in large bodies, including halts. Cavalry and artillery, trot 8 miles, walk 4 miles, walk and trot 5 miles per hour.

MARSH.—Note its extent, depth, nature of bottom, whether likely to impede movements of infantry, whether horsemen could ride through it. State time of year observed. Are there any made roads through it?

MOUNTAINS.—Heights, if obtainable. Roads and tracks by which they can be crossed, especially tracks for flanking parties near main passes. Approximate slopes of sides of mountain. Nature of sides, if rocky or otherwise. View obtainable from different spots on the summit; signalling-stations, &c. *See also* DEFILES.

RAILWAYS.—Every country through which a railway runs is almost sure to be properly mapped; the country must have been accurately surveyed for the railway, and it will therefore seldom be necessary to make a sketch of the railway route. Officers travelling on foreign railways should always keep their eyes open, as their observations may at some future time prove of great value. Note the following:

(1) Country on each side; fences, &c.
(2) Gauge; nature of rails; how laid; line single or double.
(3) Dimensions of tunnels, cuttings, embankments, and bridges. How these could be blocked, or destroyed; if destroyed by enemy, how they could be temporarily repaired.
(4) Stations, and especially size of platforms (for rapidly entraining troops).
(5) Branch-lines, sidings, junctions, &c.
(6) Rolling-stock; dimensions, numbers.
(7) Water and fuel for locomotives to be found along the line.
(8) Telegraph-lines; number of wires (useful for entanglements).

To disable a railway-line.—Remove a few rails from sleepers, or cut the rails with gun-cotton (1 lb. of gun-cotton per rail).

To destroy a railway-line.—Tear up rails, burn sleepers; or blow up the bridges and tunnels. Railway demolitions must always be carried out with a mind to the future. It may be only necessary to render the line unworkable by the enemy for a short period, and you may have to repair the line afterwards for the use of your own troops.

REPORTS.—In all reports remember the following:

(1) Write clearly and concisely.
(2) *Print* all proper names.
(3) Never give information as reliable if it is merely hearsay or supposition.
(4) When referring to reference-figures on your sketch be sure that they are marked on the sketch.
(5) Do not use vague terms, such as '*large* pond,' '*wide* road,' '*small* village'; but give approximate dimensions.
(6) Describe situations of objects, &c., in points of the compass, and never in such general terms as *right*, *left*, *front*, or *rear*.
(7) Add *place*, *date*, *signature* (with rank and regiment).

[*See also* Reconnaissance Sketch and Report, Plate XV.]

RIVERS.—*See* CURRENTS and FORDS.

ROADS.—Metalled or not; width of metal; condition of repair; if any material for repair at hand; whether hilly or otherwise; steepest gradients; fences on either side; if heavy rain will affect road. [Remember that a gradient steeper than 1 in 20 at any part of a road will retard the movement of waggons enormously.]

SLOPES OF GROUND.—

5° and under = *gentle*; all arms can move in formation.

5° to 15° = *ordinary*; difficult for all arms in formation.

15° to 25° = *steep*; difficult for infantry in formation; cavalry and artillery cannot move in order.

Over 25° = *very steep*; infantry can only move or crawl in extended order; difficult for horsemen to move at a walk even singly.

SOUND.—Sound travels (in a calm) at the rate of about 380 yards per second. To discover distance of guns, note the time between seeing the flash and hearing the report. Each second multiplied by 380 will give the approximate distance in yards. [You should practise the estimation of seconds. One to four counted deliberately gives a second; and the best way to remember the number of seconds counted is to count thus: One—two—three—four; two—two—three—four; three—two—three—four; and so on; the first number of each count being a register.]

STREAMS.—*See* CURRENTS.

SUPPLIES.—The approximate contents of ricks may be estimated as follows:

$$\frac{\text{Cubic yards of rick}}{12} = \text{tons of hay.}$$

$$\frac{\text{Cubic yards of rick}}{17} = \text{tons of straw.}$$

Cubic contents in yards can be found roughly as follows

Rectangular ricks: Length × breadth × height to eaves + ½ height from eaves to ridge.

Circular ricks: Full height × ⅓ radius squared.

[The above rules are good enough for *estimating* available supplies, but cannot be relied on for *purchasing* hay or straw.]

SWAMP.—*See* MARSH.

TREES.—Observe kind of trees; deciduous or coniferous; if suitable for bridging, for abatis, &c. *See also* WOODS.

VISIBILITY OF OBJECTS.—On a clear day in Europe the following may be taken as a rough guide to distances of objects, when seen with the naked eye, without a background—*i.e.* on the sky-line:

Church spires	10 miles.
Chimneys of houses	3 miles.
Large tree-trunks	$1\frac{1}{2}$ mile.
Single panes of windows	$\frac{1}{4}$ mile.
Man standing up	3 miles.
Horseman	4 miles.
Man's features	100 yards.

A background of any kind reduces the above distances. The position of the sun affects the visibility of objects very considerably. No rules can be laid down for the Tropics, where the conditions of visibility are influenced by such things as mirages.

WATER.—One cubic foot of fresh water = $6\frac{1}{4}$ gallons = $62\frac{1}{2}$ lb. in weight. A stable bucket holds about $2\frac{1}{2}$ gallons.

Requirements for men and horses.—Allow for each man, for all purposes, 4 gallons per diem; and for each horse, for all purposes, 12 gallons per diem.

To calculate the water-supply of a stream, measure in feet the average breadth, average depth, and velocity per minute (*see* CURRENT); these multiplied together, and then multiplied by $6\frac{1}{4}$, will give the number of gallons that the stream will supply per minute. For small streams a simpler method is to dam the stream so that the water all flows over the dam at one point; then by catching the flow at this point in a vessel whose contents you know, and by counting the number of times that the vessel fills in a minute, you obtain the supply of water.

Quite a small stream will yield sufficient water for a division of all arms, if troughs and other watering arrangements are put up. A stream 4 feet wide and 6 inches deep, flowing at the rate of a mile an hour, will give about 1,100 gallons per minute, or 66,000 gallons per hour, which would be almost a day's allowance for a division.

The amount of water obtainable from a well is difficult to gauge; the best plan is to pump the well dry rapidly and then discover at what rate the water again flows into it (how many gallons per minute).

No water should be described as 'good for drinking' until it has been subjected to three separate tests—viz. (1) nitrate of silver, to discover chemical impurities; (2) permanganate of potash, to discover animal pollution; (3) Nessler's Solution, to discover vegetable impurities. Unless your particular duty is to test water, it is unlikely that you will be provided with the materials for doing so; therefore always add the note 'water not tested,' if you have been unable to make the above tests.

WEATHER.—The weather to be expected may affect the success of operations very considerably, but it is impossible to lay down any rules for forecasting the weather that will apply to all parts of the world. Every officer should make it his business, wherever he may happen to be, to find out from the inhabitants something about the prevalent winds, local indications of coming storms, fogs, &c. An aneroid is useful. (*Vide* Appendix II.)

WOODS.—Note particularly the following: Size, situation, nature of trees, undergrowth, roads through, clearings, soil. *See also* TREES.

[N.B.—A convenient note-book for field messages, reports, and reconnaissance work in general is that known as *Army Book* 153, the pages of which are ruled with squares, of sides representing 100 yards on a scale of four inches to one mile.]

APPENDIX II

USEFUL INSTRUMENTS AND SKETCHING ACCESSORIES

THE following is a description of a few simple instruments, &c., the use of which, if he can obtain them, will often be of great assistance to a sketcher or reconnoitrer:

ANEROID.—An aneroid barometer should be in the possession of every officer, even if it be carried only for his amusement. It is a delicate instrument, and must not therefore be subjected to rough treatment, such as a sudden jar. The general appearance of the aneroid is too well known to require description, and it need only be said that on the dial is marked a scale of inches, with usually the corresponding altitudes above the level of the sea, which is taken as 29·5 inches. A hand or pointer indicates the altitude, &c., and good aneroids have an attached magnifying glass for reading off the small subdivisions, as well as a revolving rim with pointer to register the last reading. Within the instrument there is a flat cylindrical box of very thin metal and almost exhausted of air, the casing of the box being so sensitive as to rise or fall with the changes of atmospheric pressure. This rise or fall of the surface of the box is communicated to the pointer on the dial by means of an ingenious mechanism which it is unnecessary to describe in detail here.

As a weather-glass, the aneroid barometer is of great value to an officer in attempting to forecast the weather for coming operations, &c.[1]

As a sketching instrument it can be used for contouring and taking levels and heights, and is especially useful when

[1] Some useful hints on forecasting the weather are given in *Whitaker's Almanack*.

rapidity is of more importance than absolute accuracy, though with a really good surveying aneroid the results *in settled weather* should be quite accurate. An ordinary aneroid barometer costs from £1 to £1 10*s.*; a Vernier surveying aneroid (reading to every 5 feet of altitude up to 10,000 feet) costs from £7 to £8; and between these two there are numerous patterns at varying prices.

CAMERA.—A small pocket camera would often be valuable, especially for rapid reconnaissance work, provided that very careful records were kept of each photograph taken, and that means existed for immediate development and printing. Photographs are inclined to exaggerate perspective.

CHAINS AND TAPES, though used for accurate measuring by trained surveyors, are too cumbersome and slow for the ordinary military sketcher.

CYCLOMETERS assist considerably when making a small-scale road sketch with a bicycle. They are not manufactured to register single yards; in fact, the smallest unit registered by any cyclometer in the market is 17½ yards.

FIELD-GLASSES.—A reconnoitrer should be provided with the best field-glasses procurable.

MAP-MEASURERS are sold in various patterns, and are of some little saving of time in measuring distances on a map when dealing with indoor tactical schemes, &c.

MARQUOIS SCALES.—Useful principally for ruling parallel lines at given distances apart. The set consists of scaled rulers and a right-angled triangle (of wood or of celluloid), the shortest side bearing a certain proportion to the longest side.

PEDOMETER.—A simple watch-shaped instrument for recording distances walked, by means of a pendulum which swings with the motion of the body. Each step taken is registered, and the dial shows from quarters of miles to 50 miles. It has to be kept in a vertical position when in use, and must be regulated by trial to the particular pace of the walker. The pedometer is hardly reliable enough for measuring short distances, but for checking long distances (*e.g.* for the sketch of a route when marching with a column) it is worth carrying. Tied round the neck of a native in Africa or India, it may be of considerable aid to a sketcher in making a rough traverse of a day's march. The cost is about 12*s.* 6*d.*

PERAMBULATOR (or ODOMETER).—A large wheel arranged to be pushed ahead of a person walking, and registering on a dial, in fractions of a mile, the distance covered by its revolutions. Useful on long marches, if a native can be secured to push it.

RANGE-FINDERS.—These are of many patterns, each one requiring special study. As aids to rapid sketching they are invaluable. Distances on the ground can be measured by them, and then marked off at once, to scale, on the sketch, thereby saving both time and labour. The most portable and cheapest range-finder is the *Weldon*, costing about two guineas. (*Vide Handbooks* for different range-finders.)

WATCH.—A good watch should be worn by every officer; a repeater is valuable for night work. A wrist watch is indispensable for sketching by time on horseback—a *stop watch*, if possible.

Watches with luminous dials (fig. 39) can be bought for about £2.

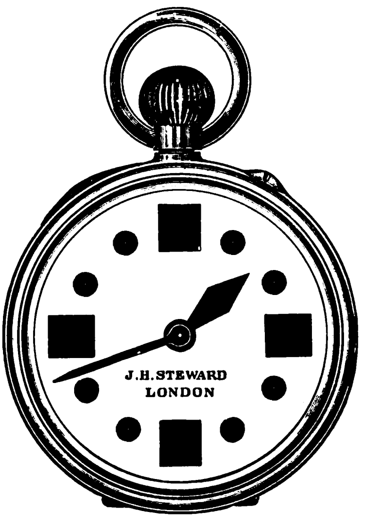


FIG. 39.—LUMINOUS WATCH

APPENDIX III

EXAMINATION QUESTIONS.[1]

DRAWING GROUND. (*a*) *From Memory.*—This is a test of your ability to remember what you have sketched, and is occasionally asked in examinations nowadays. You should therefore, whenever making a sketch, get the whole lie of the country into your head, and try to remember certain distances that will assist you in drawing the groundwork of the sketch from memory. Of course, if this class of question becomes common, the object of the examiner will be defeated, as it will be simple enough to learn up one or two *sketches* without remembering anything of the actual ground.

(*b*) *From imagination.* Example.—Within a square of 8-inch sides draw a piece of country, scale 4 inches to 1 mile, V. I. 20 feet. Show the following: A railway, several roads, a river, bridges, a lake, two villages, and as many other conventional signs as you remember. The highest part of the ground to be 230 feet above the lowest.

In all questions of this kind you must set to work systematically and use common-sense. The examiner wishes to discover whether you are acquainted with the conventional signs, and whether you know how things are usually found in ordinary country. The simplest way to begin is to draw first the 8-inch square, then arrange the system of drainage for the ground that you propose putting in the square. Draw the river, showing by an arrow the direction in which it is flowing; think how it will be

[1] The few questions here dealt with are usually stumbling-blocks to the beginner. For the working-out of every variety of question set in examinations he is recommended to study Bowhill's *Questions and Answers in the Theory and Practice of Military Topography*, though he should note carefully the changes introduced in the official *Manual*, 1903.

fed; draw streams flowing into it, and waterless watercourses at the heads of the streams. Now contour the ground throughout in the following way: Commence with the river. Measure its width, to discover what volume of water it is likely to contain and so decide its fall—this will also give you an idea of the width of the valley through which the river is flowing. At the lowest part of the river, just within your sketch, draw the first contour crossing the river with a wide bend. Number this contour 0. Assuming that you give the river a fall of 20 feet per mile, measure four inches (*i.e.* 1 mile) up the river, and draw your next contour crossing the river. Number the contour 1. Deal with each stream, or tributary of the river, in a similar way, commencing with the stream nearest to the lowest part of the river. Arrange the point where each contour crosses the stream in accordance with your assumed size and fall of the stream. Be careful to number each portion of contour as you draw it, remembering that the lowest contour on a stream entering the river between 0 contour and 1 contour will, of course, be No. 1. Contour. When you have marked in the crossing-points of contours on all streams and watercourses, join up contours of the same number throughout, bearing in mind that the contours bend up the streams or watercourses, and that the latter must be exactly in the centre of the bend. The wider the valley, the wider the bend of the contour. Contours crossing a narrow valley, high up a watercourse, would usually be drawn V-shaped. Between two watercourses or valleys the ground would be shaped as a spur running down towards the low ground, or main valley.

Having drawn-in the system of drainage and the contours, the rest is simply a matter of common-sense. Everything must be accommodated to the ground that you have drawn. Decide where villages would usually be found. Draw the roads communicating between villages, and be sure that their gradients are not too steep. Lay the route for the railway without any great engineering difficulties; show embankments and cuttings and tunnels, if necessary. Select the sites most suitable for bridges. Locate the lake in a natural position—not on the side of a hill, for instance.

REDUCING AND ENLARGING MAPS.—In all these questions you would be given the scale of the original and the scale of the copy required, and you would reproduce the map by the method of squares (page 3). You decide for yourself what length you will make the sides of the squares either on the copy or on the original, and you then work out by simple proportion what length it will be necessary to make the sides of the other squares. The proportion therefore stands thus:

Original scale : Copy scale : : Side of square on original : Side of square on copy.

Example (1).—*Reproduce a portion of a 1-inch Ordnance map on a scale of 3 inches to 1 mile.*—Here the proportion is obvious: the map is to be enlarged to three times the scale. Take the length of the sides of the squares on the copy as 1 inch, then the length of the sides of the squares to be drawn on the original map will be $\frac{1}{3}$ inch.

Example (2).—*The R. F. of a map on which have been ruled 1-inch squares is* $\frac{1}{7920}$. *Required, a reproduction on a scale of 6 inches to 1 mile. What will be the length of the sides of the squares to be ruled on the drawing-paper?*—First get both your scales in the same terms, then state the proportion:

$$8 : 6 : : 1 : x,$$

which tells you that $\frac{6}{8}$ (or $\frac{3}{4}$) inch is the length of the sides of the squares for the copy.

Example (3).—*You are required to reproduce, on a scale of 3 miles to 1 inch, a map which is drawn on a scale of 3 inches to 1 mile. What sized squares would you rule on the original map and on the drawing-paper for the reproduction?*—This does not require any great calculation, for you see at once that you are asked to reduce the map to one-ninth its original scale. So the whole thing is a matter of deciding, for both original and copy, what sized squares you will use, in order that the length of their sides shall be in the proportion of 9 to 1. As a rule, it is best not to have squares too large, as it increases the difficulty of copying accurately; but in a large reduction of this kind you might rule 3-inch squares on the original and $\frac{1}{3}$-inch squares on the copy, which gives the required proportion.

Example (4).—*You have a French sketch-map the scale of which has been torn off, but between two points on the map which measures 3·4 inches is written '4550 metres.' You* *wish to reproduce this map on a scale of* 4 *inches to* 1 *mile. What sized squares will you rule on the original and on the paper for the copy?* [1 *metre* = 1·093 *yards.*]—Here the first thing to be done is to find the scale of the original. 4550 metres is represented by 3·4 inches; therefore 4973·15 yards is represented by 3·4 inches, and 1 inch represents 1462·7 yards (*i.e.* 52657·2 inches).

$$\text{Original R. F.} = \frac{1}{52657{\cdot}2}.$$

$$\text{Copy R. F.} = \frac{1}{15840}.$$

So the proportion is set out as follows:

52657·2 : 15840 : : Side of square on original :
Side of square on copy.

You now compare the R. F.'s, and remember that the smaller the scale the larger the number of the denominator of the fraction, and you observe that you have to enlarge the map in the proportion of 52657·2 to 15840; or, in other words, the reproduction is to be 3·32 times the scale of the original.

All that remains is to consider the sizes of the two sets of squares. If you rule 1-inch squares on the original, you must rule 3·32-inch squares on the paper for the copy. But these are rather too large; it would be better to rule $\frac{1}{3}$-inch squares on the original and 1·11-inch squares for the copy.

To rapidly enlarge or reduce a traverse.—A quick method of reproducing a traverse (*e.g.* a road) on a different scale is as follows (Plate XVII.):

Pin down the original map from which the traverse-line has to be produced; on it rule a straight line from the starting-point to the finishing-point of the traverse, A B. By the side of the map pin down a sheet of drawing-paper, with its longer edge parallel to the line joining the extremities of the traverse, and a few inches from it. *To reduce* (fig. 1, Plate XVII.).—On the drawing-paper take a point C so situated that, when straight lines are drawn from it to the extremities of the traverse on the map, those straight lines will form the two sides of an isosceles triangle of which the line joining the extremities of the traverse will be the base. Having drawn this triangle partly on the map and partly on the paper, the next thing to determine is the position for the extremities of the reduced traverse. Suppose a reduction is required, say, to $\frac{1}{8}$ the scale of the original: Mark off from the apex of the triangle, and along each side, $\frac{1}{8}$ the whole length of the side. You now have on the drawing-paper the extremities of your new traverse *a b*, and it remains only to get-in the windings of the traverse. Mark, on the map, each point where the road changes direction; draw straight lines from those points to the apex C. Begin at one extremity of the traverse on the map, take the first straight portion of the road, and parallel to it rule a line from the corresponding extremity of the new traverse as far as the adjacent ray; parallel to the second straight portion of the road rule another line forming the second straight portion of the new traverse; and so on until the whole of the windings of the new traverse have been drawn parallel to the windings of the original traverse (or road). In this manner the reduction is accurately produced.

An *enlargement* (fig. 2, Plate XVII.) from the map is made on the same principle, the process being reversed. The extremities of the traverse, A B, are joined by a straight line, and on the map itself (*i.e.* on the side of the traverse away from the drawing-paper) is constructed an isosceles triangle, A C B, the sides of which are produced on to the drawing-paper until there is sufficient space between them to admit a line parallel to the base of the triangle and of the length (in inches) that represents, on the new scale, the line joining the extremities of the traverse on the map. This is arrived at as before, by measuring from the apex of the triangle, along each side, a distance that bears to the length of the side of the original triangle the same proportion as the length of the new traverse is to bear to the length of the original traverse. Thus, if it were required to enlarge a portion of a road to 3 times the scale: After laying down the triangle on the map, you prolong its sides until their total length from the apex is 3 times the length of the sides of the original triangle. The two points thus found give you the extremities of the new traverse *a b*. Rays are drawn and produced, and parallel lines are then laid down as in the case of a reduction.

VARIATION OF THE COMPASS.—Problems relating to variation require very careful solution, since the examiner who sets them usually endeavours to fog the examinees as much as possible. In solving these problems, read them over until you thoroughly

ATE XVII.

grasp what you are given and what you have to find. Only three things enter into them—viz. Magnetic bearing of an object, true bearing of an object, and the variation (East or West). You have to find one of the three things; and, to do so, you must be given the other two. These three things, however, a skilful examiner is able to present to you so disguised that, unless you keep your wits about you, the question looks hopeless. Remember the following:

(1) Sun's True bearing at noon in the Northern Hemisphere = 180°.

(2) Sun's True bearing at noon in the Southern Hemisphere = 0° (or 360°).

(3) The bearing of a *shadow* of an object is the opposite bearing of the sun from the object.

(4) The position of the sun changes at the rate of 15 degrees per hour.

(5) The True bearing of the Pole Star when on the Meridian 360° (or 0°).

There are several ways of working out these problems, and with practice they can be solved mentally. But the beginner is recommended to use his protractor and adopt a systematic method.

All possible questions on variation can be reduced to the following types:

(*a*) Given variation, and the True bearing of an object; find the Magnetic bearing of the object.

(*b*) Given Magnetic and True bearing of an object; find the variation, East or West.

(*c*) Given variation, and Magnetic bearing of an object; find the True bearing of the object.

Example I.—Variation 15° *E.; True bearing from B to A,* 320°*; find the Magnetic bearing of A from B.*—Take your protractor, and draw a North Point with variation 15° E. Lay the protractor against the True meridian (arrow-head mark against the point of intersection of the two meridian lines), and plot the given True bearing of 320°. Now lay the protractor against the Magnetic meridian, and read off from the edge of the protractor the Magnetic bearing which is opposite the 320°. It will be found to be 305°.

Example II.—True bearing of A from B is 340°; *Magnetic bearing of A from B is* 355°; *find the variation East or West.*—With your protractor draw a True North and South line. Place the protractor against it, and plot 340° (*i.e.* the True bearing of A from B; B being the point on the True North and South line at which the arrow-head mark on the protractor is placed). Draw the line B A. Now with the arrow-head mark on the protractor at the point B, and with B as the pivot revolve the protractor until 355° is over the line B A. Draw another line along the inner edge of the protractor, so as to intersect the True North and South line at B. This is the magnetic North and South line (or Magnetic meridian). Measure the angle between this line and the True North and South line, and you find the variation to be 15°. As the Magnetic is to the left (or West) of the True meridian, the variation is called West. Answer = 15° W.

Example III.—Variation 17° *W.; Magnetic bearing of A from B is* 350°; *find the True bearing of A from B.*—This is worked out in a similar way to Example I., the North Point being first drawn, the given Magnetic bearing then plotted, and the corresponding True bearing being finally read off by applying the protractor.

The above three examples are typical straightforward ones; we will now show how they can be veiled.

Example IV.—The variation of your compass is 16° *E.; it is noon in the Northern Hemisphere; what is the Magnetic bearing of the sun?*—This is worked out in exactly the same way as Example I., for you are given the variation and the True bearing of an object (*i.e.* of the sun = 180°); and you are asked to find the corresponding Magnetic bearing. Answer = 164°.

Example V.—I take the bearing (with my compass) of the Pole Star when on the Meridian, and find it to be 345½°; *what is the variation of my compass?*—The True bearing of the Pole Star when on the Meridian you know to be 0° (or 360°); the Magnetic bearing of the same object you find to be 345½°. So, to find the variation, proceed as in Example II. Answer = 14½° E.

Example VI.—The variation of your compass is 15° *E.; you are in the Northern Hemisphere, and you find that the Magnetic bearing of the sun is* 160°; *what is the local time?*—Here you are given the variation, and the Magnetic bearing of an object (*i.e.* the sun). Proceed as in Example III., and find the corresponding True bearing—viz. 175°. Remembering that at noon the True bearing of the sun would be 180°, and that at the time of your observation it is 175°, you see at once that it is not yet noon, and that the position of the sun has to change 5° to arrive at noon. You know that the position of the sun changes at the rate of 15° per hour; consequently the local time is one-third of an hour before noon—*i.e.* 20 minutes to 12.

Example VII.—You are in South America, and with your compass you find the bearing of the sun at noon to be 340°; *what is the variation of your compass?*—Compare Example V. and Example II. (recollecting that the sun at noon in the Southern Hemisphere is True North). Answer = 20° E.

PLOTTING COMPASS-BEARINGS

Example 1.—On a scale of 4 inches to 1 mile, plot the following:

Base A, B = 650 yards.

Bearings:

At A, bearing of B, 48°	At B, bearing of E, 108°
" " E, $70\frac{1}{2}$°	" " G, $116\frac{1}{2}$°
" " G, 83°	" " F, 189°
" " D, $106\frac{1}{4}$°	" " D, 156°
" " F, $131\frac{1}{2}$°	" " A, 228°
" " C, $321\frac{1}{2}$°	" " C, 266°
" " H, 10°	" " H, $273\frac{1}{4}$°

What is the bearing of C from G? (280°.)
What is the distance of C from B? (787 yards.)

Example 2.—Scale 6 inches to 1 mile. Base A, B = 910 yards.

Bearings:

At A: B, 90°; C, 10°; D, $45\frac{1}{2}$°; E, $62\frac{1}{2}$°; F, $160\frac{1}{4}$°; G, 190°	At B: A, 270°; C, 312°; D, 343°; E, 9°; F, 210°; G, $245\frac{1}{2}$°

At X {F, 234°; B, 323°} by resection.

What is the distance from B to X? (456 yards.)
What is the distance from B to F? (1,122 yards.)

TRIANGLE OF ERROR (Resection with the Plane-table).—When there is any possible doubt as to the reliability of the compass (from local magnetic attraction, &c.) the only sure way of setting the plane-table and finding one's position on the sketch is as follows:

Set your sketch by the compass, as usual. Select three objects in the country which you can identify on your sketch as reliable fixed points. If possible, select the points so that your position on the ground will be somewhere within a triangle formed by imaginary lines joining the three points in the country.

Now draw a ray from each of the three points towards you. If the three rays meet in one point on the sketch, that point is your position on the sketch, your table is accurately set, and the compass consequently reliable. But if the three rays do not meet in one point on the sketch, they must form a triangle, which is termed the *triangle of error*; and there must be something wrong with your compass (if you are certain that your fixed points are reliable).

It is evident that your position will be somewhere about the triangle of error, and you have to determine exactly where.

(1) If you have been able to select your points so that you are standing inside the triangle of imaginary lines mentioned above, then your position on the sketch will be inside the triangle of error. Estimate it as accurately as you can, on the condition that it must be perpendicularly distant from each ray in proportion to its distance from the point from which that ray is drawn. (Fig. 1, Plate XVIII.)

(2) If you are standing outside the triangle of imaginary lines, your position on the sketch will be outside the triangle of error. (Fig. 2, Plate XVIII.)

(3) In this latter case, your position on the sketch must be either to the right or to the left of *all* the three rays forming the triangle of error, as you stand looking towards the three objects in the country. Whether it will be to the right or to the left is determined by slightly turning the table-top one way or the other, and observing whether, by drawing new rays from the three points, the triangle of error is decreasing or increasing in area. Thus, suppose you revolve the table-top to the *right* and the triangle of error formed by the new rays has *decreased*, then your position on the

sketch is to the *right* of all the original rays; but, if the triangle of error has *increased*, then you are revolving the table-top the wrong way, and your position on the sketch must be to the *left* of all the original rays.

(4) About the triangle of error the three rays make six sectors, but the point representing your position can only lie in one of two sectors, because none of the others will fulfil the condition that the point is to be to the right or to the left of *all* the three rays.

(5) You now know [by means of (3) and (4)] in which sector round the triangle of error the point representing your position must be, and you estimate the exact spot on the sketch, bearing in mind that lines drawn from the spot to cut each of the three rays at right angles must be proportional in length to the distance from the spot to the points from which the rays have been drawn.

(6) After estimating your position on the sketch, whether (1) or (2), lay the ruler against the estimated point and the most distant of the three points. Revolve the table-top until it is set by this ray. If you find that rays from the other two objects still do not meet in the estimated point, but form a triangle, you must repeat the operation until you eliminate the error.

[N.B.—Never select the three fixed points so that they and your position will be on the circumference of a circle.]

APPENDIX IV

GLOSSARY OF TERMS[1]

ALIDADE.—The somewhat pedantic name given to the Sight-vane ruler used with the Plane-table.

ANGULAR TEST.—A check for the accuracy of intersection of stations. With a plane-table, the board is set, and a ray is drawn from one fixed station to another one at a distance. Similarly with a prismatic compass, the bearing is taken. Any error will be seen at once. *See also* CHECK-BEARING, LINEAR TEST.

BACK ANGLE.—The straight line drawn from the sketcher's position to the last place that he came from. The *Back Ray* or *Back Bearing*, and consequently the opposite to FORWARD ANGLE (*q.v.*).

BASE.—The line measured and laid down to scale on a sketch on which are afterwards built up the series of triangles of a *triangulation*. (Base of a Mountain, *see* MOUNTAIN.)

BEARING.—The angle made by a line drawn from the centre of the compass-card to an object and a line drawn towards Magnetic North. The *True bearing* of an object has reference to True North.

BROOK.—A small stream.

BROW.—The actual edge of a hill or slope.

CARDINAL POINTS.—The four principal *points of the Compass*—viz. N., S., E., and W.

[1] This list has been inserted as an *Aide mémoire.* Terms not defined here will be found in any dictionary. The *Manual of Field Sketching and Reconnaissance*, 1903, differentiates between (1) Topographical Forms, and (2) Technical Terms, but the distinction is perhaps sufficiently apparent.

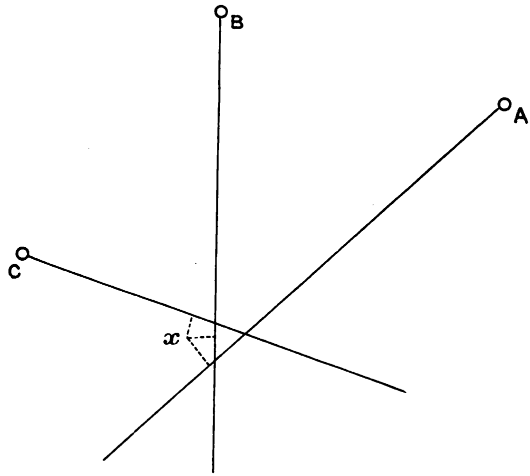


Fig. 2. Outside the Triangle.

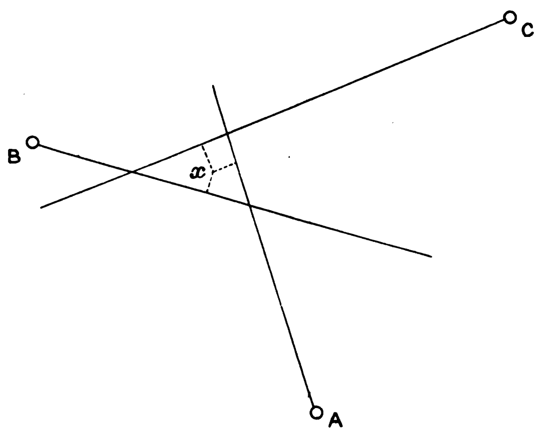


Fig. 1. Inside the Triangle.

TRIANGLE OF ERROR.

CHAIN COLUMN.—In a *Field-book*, the column up the centre of the page in which are entered *Traverse Stations*, forward bearings, and distances along the *Traverse lines*.

CHECK-BEARING.—A bearing taken, when working with a prismatic compass, to some fixed point to ascertain the accuracy of a traverse. *See also* ANGULAR TEST.

CLOSING ANGLE.—The ray drawn, or the bearing taken, from the last station of a traverse to a fixed point as a test of the accuracy of the whole work.

COL.—A *Neck* or *Saddle* connecting adjacent heights. From a col the ground slopes up on two sides, and down on the other two sides.

CONTOUR.—A line of level drawn on a plan to represent an imaginary horizontal line on the ground, so that every point on the line is the same vertical height above a *datum*, or given level.

CONVENTIONAL SIGNS.—The symbols fixed on to be used in military sketching to represent various details.

CREST-LINE.—A line of level taken, as the highest contour of a sketch, *near* the top of a hill. *See also* BROW.

DATUM.—A *given* or assumed level to which all other levels are referred. Usually, though not necessarily, the lowest point on the ground.

DECLINATION.—*See* VARIATION.

DEGREE.—The 360th part of the circumference of a circle. The divisions of the compass-card, angles, bearings, slopes, &c., are all named in degrees, minutes, and seconds (60 seconds = 1 minute; 60 minutes = 1 degree).

DIP.—The tendency of one end of a compass-needle to *incline* downwards. (*Vide* explanation, page 54.)

EQUAL ALTITUDES.—The term applied by elementary books on Military Sketching to the method of finding the Variation of the compass by the sun at noon.

FORM-LINES.—The term used, as synonymous with Shape-lines, to express a method of drawing (in plan) the topographical features of a portion of country hastily and without reference to regular vertical intervals. The lines are drawn like contours (*i.e.* continuously or chain-dotted), except when they are introduced into a fully contoured sketch in order to show the shape of an under-feature of less height than a whole contour. In this case they are drawn dotted.

FORWARD ANGLE.—The straight line drawn (either a *ray* or a *bearing*) from the sketcher's position to the next proposed position ahead. *Forward Ray* or *Forward Bearing* would better express the meaning of the term. *See also* BACK ANGLE.

GEOGRAPHICAL MERIDIAN.—*See* MERIDIAN.

GRADIENT.—The rise or fall, usually stated as a fraction from one point to another—*e.g.* $\frac{1}{25}$, which signifies that there is a rise, or fall, of 1 foot for every 25 feet measured horizontally. This would be spoken of as a gradient of 1 *in* 25.

HACHURING.—The method of shading hills on maps, in order to show their relative slopes, by short lines drawn either *horizontal* to, or *vertical* to, contours or imaginary contours.

HILL.—An elevation whose *top* is less than 3,000 feet above the surrounding country—*i.e.* above its *foot.*

HORIZONTAL EQUIVALENT.—In contouring, the horizontal distance (always expressed in yards) in which a given difference of level will occur, at a given degree of slope. *See also* TRIANGLE OF REFERENCE.

INCLINATION.—*See* DIP.

INTERPOLATION.—The old term for RESECTION, *q.v.*

INTERSECTION OF STATIONS.—The process of fixing the Stations of a *Triangulation,* usually from the two ends of a *Base.*

KNOLL.—A small eminence, or hillock.

LINEAR TEST.—The measurement of a line on the ground and the comparison of its length with the corresponding line on a sketch plotted from a Field-book, as a test of the accuracy of the work. *See also* ANGULAR TEST, CHECK-BEARING, CLOSING ANGLE.

LUBBER'S LINE.—The vertical line engraved on the inside of the rim of the compass-box (Service Compass), to assist in rapidly reading from the compass-card the bearing of an object. When the compass is 'set,' the lubber's line should point to Magnetic North.

MAGNETIC BEARING.—*See* BEARING.

MAGNETIC DECLINATION.—*See* VARIATION.

MAGNETIC MERIDIAN.—A Magnetic North and South line. The Magnetic Meridian at any place is the line coinciding with the axis of the needle of the compass set up at that place. *See also* MERIDIAN.

MAGNETIC VARIATION.—*See* VARIATION.

MAP.—The representation on a plane of the surface of the earth or of a portion of it, compiled from the work of surveyors in the field.

MERIDIAN. (True Meridian or Geographical Meridian).—A True North and South line—*i.e.* a line which, drawn at any place on the surface of the earth, passes through that place and through the poles of the earth. *See also* MAGNETIC MERIDIAN.

MILITARY SKETCH.—A military survey made with portable, or pocket instruments, by any officer or non-commissioned officer.

MILITARY SURVEY.—A topographical survey, usually of limited extent, made for military purposes.

MOUNTAIN.—An elevation whose *summit* is 3,000 feet or more above the surrounding country. Its lowest part is called its *Base.*

NORTH POINT.—A diagram drawn on every military sketch to show the True and Magnetic Meridians of the sketch.

NORMAL SYSTEM OF CONTOURING, OR NORMAL SCALE OF SLOPES.[1]—An arrangement the basis of which was that sketches drawn to a scale of 6 inches to 1 mile should be contoured at Vertical Intervals of 20 feet, and that sketches drawn to other scales should be contoured at Vertical Intervals in inverse proportion—*e.g.* 3 inches to 1 mile, V. I. = 40 feet; 8 inches to 1 mile, V. I. = 15 feet. To find the V. I., it was necessary to divide 120 by the inches to the mile of the sketch. THIS HAS NOW BEEN ABOLISHED, AND FOR IT HAS BEEN SUBSTITUTED THE RULE THAT THE V. I. OF MILITARY SKETCHES

$$= \frac{50}{\text{Inches to the mile of the sketch}}.$$

OFFSET.—A line to an object *set off* at right-angles to a traverse-line, and measured. A *secondary offset* is a line at right-angles to a main offset.

ORDNANCE MAPS.—Maps of Great Britain on various scales issued from the Ordnance Survey Office. The side margins are in all cases True North and South.

ORIENTATION.—*See* SET.

PLAN.—The delineation of a portion of country, or of any object, as seen from a position vertically over them—*e.g.* from a balloon.

[1] Obsolete, though to be found on sketches prior to 1903.

PLOTTING.—Laying down on the paper, with the aid of a protractor, the measurements, bearings, &c., that have been taken in the field (frequently from entries recorded in a *Field-book* or other note-book).

POINTS OF THE COMPASS.—The 32 divisions of the compass-card; called by names derived from the four terms for the *Cardinal Points*—viz.: N., S., E., and W. Each *point* is equivalent to $11\frac{1}{4}$ *degrees*.

RAY.—A straight line, drawn by means of a Sight (or other) ruler, representing an imaginary line on the ground from the sketcher's position to an object.

REPRESENTATIVE FRACTION.—The fraction representing the linear proportion between the map and the ground. Usually written R.F.

RESECTION.—The method of finding on a map the point representing the spot on the ground at which one is standing, by making use of other points the positions of which can be identified both on the map and on the ground.

RIVER.—A flowing body of water, running at all seasons.

RIVULET.—A small stream.

SADDLE.—*See* COL.

SCALE.—The proportion which a map or sketch lineally bears to the actual size of the ground represented.

SCALE OF SLOPES.—A scale drawn on every contoured military map or sketch, to show the *Horizontal Equivalent* for each degree of slope in accordance with the *Vertical Interval* used. Also called *Scale of Horizontal Equivalents*.

SECONDARY OFFSET.—*See* OFFSET.

SET.—A map is said to be *Set*, or *Oriented*, when all lines on the map are parallel to, or coincide with, the lines that they represent on the ground. Each object represented on the map would then be in its relative position, and the N. end of the needle of a compass adjusted to the Magnetic Meridian on the map would point to Magnetic North.

SLOPE.—The angle (measured in degrees) formed by a straight line representing the profile of a hill and a horizontal line. *See also* TRIANGLE OF REFERENCE.

SPUR.—A prominent feature projecting from high ground.

STATIONS.—Objects selected on the ground, each one of which forms the apex of a triangle in laying down the *Triangulation* on the sketch, or the change of direction in a Traverse (*q.v.*).

STREAM.—A small river.

SURVEYING.—The art of measuring and representing in plan, at a reduced scale, the shape and size of a portion of the surface of the earth. *See also* TOPOGRAPHICAL SURVEY and MILITARY SURVEY.

THALWEG.—*See* WATERCOURSE.

TOPOGRAPHICAL SURVEY.—A survey to which is added a delineation of the heights of the various features—*e.g.* the contoured Ordnance Maps.

TORRENT.—A body of water rushing violently at certain seasons, and dry at other seasons.

TRAVERSE.—A series of straight lines the directions and lengths of which are measured, and then, together with the detail to a certain distance on either side, drawn to scale on the paper. Each of the straight lines of a traverse is called a *Traverse-line.*

TRIANGLE OF ERROR.—(*See* Appendix III. p. 188.)

TRIANGLE OF REFERENCE.—A right-angled triangle of which the perpendicular is 1 foot, the angle contained by the base and hypotenuse 1°, and the base 57·3 feet, or 19·1 yards. This is referred to in all calculations of H. E., V. I., and Slopes. In practical contouring the base is taken as equal to the hypotenuse.

TRIANGULATION.—The method of forming the foundation of a sketch, by a system of triangles built up on one or more measured bases. *See also* INTERSECTION OF STATIONS.

TRUE BEARING.—*See* BEARING.

TRUE MERIDIAN.—*See* MERIDIAN.

UNDER-FEATURE.—A minor feature springing from a main feature.

VARIATION.—The angle (measured in degrees) between a line drawn towards the Magnetic North Pole and a line drawn towards the True North Pole at the particular spot where the observation is made. Also called *Magnetic Declination. Annual Variation* is the difference in the angle between one year and the next. *Positional Variation* is the difference in the angle between one place and another at the same time. *Diurnal Variation* is the temporary fluctuation in the angle that occurs during the day (only a small fraction of a degree).

VERNIER SCALE.—A scale so constructed that, by sliding its edge along the edge of a plain scale for which it has been prepared the measurements can be read with greater accuracy.

VERTICAL INTERVAL.—The interval in feet measured vertically between one contour and the next on a contoured plan. *See* TRIANGLE OF REFERENCE.

WATERCOURSE.—The lowest part of a valley. The watercourses show the system of surface-drainage of the country. The central line of a watercourse is sometimes described as the *Thalweg.*

WATERSHED.—The highest line of a feature—*i.e.* the water-parting (*e.g.* the ridge of the roof of a house.)

WELL-CONDITIONED TRIANGLE.—A triangle (in a *triangulation*) whose angles are neither too acute nor too obtuse to give good intersections.

ZERO-LINE.—The initial line of a sketch, or the line with reference to which all other lines are drawn. The zero-line of a sketch executed with a compass is the Magnetic Meridian; of a sketch without a compass, the first line drawn.

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