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Military Surveying

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LECTURE.

Friday, May 15th, 1863.

COLONEL P. J. YORKE, F.R.S., in the Chair.

MILITARY SURVEYING.

By MAJOR F. R. TAYLOR, Professor of Military Surveying, Royal Military College, Sandhurst.

WITHOUT the knowledge of the topography of a country, military operations in time of war could not be carried on with any chance of success. History affords us many examples of the immense advantages which have ever attended a knowledge of the ground at the seat of war, and the defeats and disasters which ignorance of it has entailed on armies; it is therefore absolutely necessary, previous to the application of strategy in determining military movements, to procure the best plans of the country that are in existence, verifying them on the ground, if possible, by actual observation, and in the absence of such plans, sketches must be made by skilled officers employed for that service; and as this duty has generally to be performed in the presence of an enemy, and sometimes under fire, the more rapidly it can be done consistent with tolerable correctness, the better. This is called field-sketching, and is distinguished from a regular military survey by the latter being usually of much greater extent of country, away from the vicinity of an enemy, the base accurately measured two or three times over, with a chain, rods, or compensation bars, according to the magnitude and importance of the survey; the angles taken with a theodolite, and the sides of the triangles computed by trigonometry.

Military surveying or topography is an art which was little known or cultivated before the time of Frederick the Great of Prussia, though Anaximander, a Milesian philosopher (who died 517 B.C.) is said to have made the first geographical maps; and doubtless even anterior to that period, the generals of antiquity had used rough sketches of the ground they marched through or fought on; for in Layard's *Nineveh*

and Babylon, we read of a number of bas-reliefs being discovered in the ruins, representing the progress of an Assyrian army during a campaign; I have copied one, which may be regarded as a specimen of ancient topography. The subject is King Sennacherib crossing, or apparently marching down a stream in a valley, and it is interesting to observe that some of the conventional signs which I presume were employed at that period (about 713 B.C.) are nearly the same as we use at the present day; for instance the cultivated ground, woods, vineyards, and rivers, &c. The hills are represented in profile with their bases towards the stream; not at all a bad idea, but not to be compared with the present system of plan-drawing, which besides showing the correct distances between objects, is so easy of acquirement, that any one with a little attention would soon be able to make a useful sketch. It is not at all requisite to be an artist, or to draw beautifully; it is of infinitely more importance that correctness of detail and distances should be attended to, with the proper shape and shade of the hills; to put into the plan everything that may be of use for a military purpose, and not to fill the paper with a quantity of useless minutiae, with the view of making the sketch look pretty, perhaps defeating the object for which it is made, and puzzling the officer who has to be guided by it. I may here remark that in my opinion every officer in the army ought to know something of the principles of military drawing, for though he may never be called upon to execute a sketch, he might be placed in circumstances where the ability to read one correctly, may be of importance.

My intention to-day is to address a few words to you on military drawing and surveying, not with the idea of imparting anything novel, or instructing those well versed in the subject, for very little can be said that has not been written over and over again in many works, but to endeavour to show those not so well acquainted with surveying, the quickest and easiest method of gaining proficiency in an art so essential to a soldier.

Military drawing is the art of delineating on a horizontal plane the irregular surface of the earth; and surveying and sketching, adapting this drawing so as to make a miniature representation of a portion of country to a certain scale.

There are three styles of drawing, rough specimens of which I have drawn: the horizontal, the vertical, and brush-work. The vertical is seldom used in the British army, and brush-work is more adapted for indoor work and finished plans, it is therefore with the horizontal drawing I shall have more to do. It is quicker done, more easily acquired, and as the strokes are at right angles to the watercourses, expresses ground more forcibly than the other styles.

It is impossible, according to any known method of hill-drawing (except actual contouring, of which I will say a few words in the course of the lecture) to express accurately the heights of the different features, and the angles their slopes make with the horizon, it is only by continually studying good models constructed with contour lines marked upon them, and copying the best drawings, that any approximation can be made to reality. Even then, no two individuals ever

agree as to the intensity of shade that ought to be used in a sketch, and it is this which must ever constitute the difficulty of reading correctly a plan, portions of which have been executed by different draftsmen, each with his own idea of shading. The advantage of workmen who are to construct one whole between them, studying in the same school is obvious. To be sure, methods have been invented by different men for showing the heights and slopes of a hill in a survey, such as Major Lehmann's conventional scale of shades; he supposed white to represent the horizontal, and black a slope of 45° , and dividing these two extremes into nine parts, he prepares a different shade for every 5° of slope. This method has not only the objection of the extreme attention required by the draftsman, who has nine different shades to refer to, and must be continually measuring the slope of the hills with a clinometer (a little instrument of which I will presently speak), but it has also the disadvantage of not being able to show the difference between a slope of 45° and a precipitous rock, in fact between a surmountable and insurmountable obstacle. There is also Colonel Van Gorkum's system of normals, but this also has the disadvantage of being complicated, and not adapted to rapid sketching; which, after all, is the aim and object of the military surveyor. I will therefore confine myself to the horizontal style of military drawing, as practised at the Royal Staff and Military Colleges, and in a country peculiarly well adapted for out-door instruction.

The horizontal system of military drawing is a modification of contouring; that is, a number of short, straight, or slightly curved lines are drawn parallel to, or in the direction that contour lines would take in following the sinuosities of a hill or range of hills, the shading to commence at the first contour or water-shed line, and to increase or diminish in depth as the descent is steep or gentle, and to continue to the plain or to the watercourse. By practising from good models and drawings, almost any one, by devoting four or five hours a week for about two months, would gain a sufficient proficiency in the proper touch to enable him to go out field-sketching, which I will proceed to, after mentioning the principal instruments used in military surveying. My time being limited, I cannot enter into a minute description, or explain the method of using them,—any of the works on surveying will show this.

The chief instruments are the

Theodolite,
Box or pocket sextant,
Prismatic compass,
Protractor,
Chain.

Of these without doubt the theodolite is the most accurate, and for a military survey up to about 20 square miles, a five inch instrument on a tripod will be large enough. The theodolite takes both vertical and horizontal angles, the latter without reduction.

The pocket sextant is a useful little instrument, and can be made to read as near as $30''$. Though the arc is not generally graduated to more than 120° , a still greater angle may be obtained by using some inter-

mediate object, taking two angles, and adding them together. It must be seen that the instrument is in proper order, the index error (if any) corrected, and that the objects subtending the angle are nearly in the same plane; the sextant will also take a vertical angle by holding it sideways. Although there will be a slight error in the observed angle, on account of the parallax of the instrument if the objects are near; this error decreases as the distance increases, and at half a mile vanishes altogether.

The prismatic compass is the most useful of all instruments for a military sketch, and when mounted on a tripod might be read as near as 15', but this tripod being rather a cumbersome and conspicuous object to carry about, is seldom used now; by holding the compass steadily in the hand with the card vibrating clear of the glass, it can, on a calm day, be read to a degree easily; and even on a windy day, when the card cannot be quite steadied, if the mean is taken between the two extremes of vibration, it will be very nearly correct. The sketcher should know the variation of his particular compass.

The clinometer is a small instrument used for finding approximately the heights of hills, buildings, &c., and with a table of natural sines and tangents attached, this can be done on the ground. To use the instrument, station yourself at the bottom of a hill, or at a convenient distance in front of a building; hold the clinometer to your eye with the upper edge in a line with the top of the hill or building, and read the angle opposite to the piece of string, which is retained in a vertical position by the weight of a small bullet. To find the height of the hill, pace to the top, and multiply into the natural sine of the observed angle, and to find the height of the building, pace to the foot and multiply into the natural tangent, in either case add the height of your eye from the ground.

The different kinds of sketching-cases in use are very numerous, and there is not one that I know of but has some inconvenience; that which I use myself, and have done some hundreds of sketches with, is 14 inches square, and made so that the paper can be fastened either inside or outside the flap. It has also a pocket inside for pencils, knife, protractor, &c. The disadvantage of this case, on account of the smallness of the fastenings, is, that the sketch is apt to be carried away by a tolerably strong wind; but again, on the other hand, if I made the fastenings strong enough to defy the wind, they would interfere greatly with the protractor when the work gets near the edge of the paper. If any one would kindly invent a sketching-case combining the good qualities of all that are in use now, without their inconveniences, he would confer a great boon upon field-sketchers at large.

I will now proceed to field-sketching. Presuming the workman has a tolerable idea of drawing from models, can use the prismatic compass, understands protracting angles, both with reference to the meridian and with any other line, knows the conventional signs or details used in a military plan, as shown in the diagram, he may with this amount of information execute a field-sketch, for which the following instruments will be required:—

Sketching-case and paper, with parallel lines, at unequal distances, ruled across.

Prismatic compass.

Ivory protector with scale.

Pencils, india-rubber, and penknife.

I will endeavour to exemplify the proceedings step by step, by showing the details of an actual sketch of about a square half-mile done by myself, a diagram of which I have brought with me. I select my base A B, for the following reasons, because A and B are both prominent points, and the ground between them is flat; because at A there is a small tree, and at B a post—objects that are likely to be of use as the work progresses—and because from both these points I have a commanding view of the greater portion of the ground comprised in the sketch, a circumstance which greatly facilitates triangulation. Commencing at B, one end of my base, I pace from B to A, and make a note of the distance, viz., 508 paces; being now at A, the other end of the base, with the prismatic compass, I take the bearings of some of the most conspicuous points around me, selecting those that I judge will make good triangles with the base, that is, in which the angles are neither too obtuse or acute (from 60° to 90° are the best); having decided upon the four trees, corner of wood A, brow of hill, fir-tree, corner of wood B, and bush. I take their magnetic bearings carefully with the compass, together with the bearing of the other end of the base; I select a convenient point, Δ on my paper, and protract all these angles, making the length of the lines for the present indefinite; I now pace back from Δ to B, which I find this time to be 512 paces, and contrasting this with the first measurement of 508, which shows a discrepancy of 4, I take the mean 510 as the best approximation to correctness, and lay off that distance from my scale in yards on A B, thereby defining both extremities of the base on paper (while on the subject of pacing I may remark that every one in field-sketching ought to know the length of his average pace, so as to calculate accordingly; my own pace being as nearly a yard as possible, I am saved the delay of reduction). At B also I take all the necessary angles, viz., to all the points observed at A, or as many of them as I can see, and new objects; I find from this place I can see the four trees, corner of wood B, and bush. I therefore protract the bearings of these three, and determine their position by intersection; I also take the direction of the new objects—post, tree X, stump, and flag. As it is a good plan to do as much as possible at a station, to prevent the necessity of returning to it, I commence sketching a little at B, I remark the hill curves round me almost in the shape of a semi-circle, so, judging the breadth at top, I transfer the shape to paper; I next see the re-entering bend at D is almost in the direction of the base; I pace along the base towards A, and measure an off-set of 20 yards at right angles, which gives me the point D on paper, and which I connect by the eye to B, shading off a little way to represent the slope of the hill. Looking now towards the four trees which I have fixed by triangulation, I see that there is a range of features almost on the line joining D and the four trees, so I pace along that line,

FIELD SKETCH.

putting in the different curves on the way by off-sets, taking care if I leave the direct route for the purpose of taking these off-sets, that I leave some mark on the ground, so as to be able to resume it correctly. I am now at the four trees, and can do a good deal here; having fixed this point by intersection from both ends of the base, I may take the sides CB , CA , as new bases to triangulate on. Consequently, by taking angles at the four trees, I can determine the position of stump, flag, and corner of wood A , and the direction of oak brow, which I fix from wood A when I get there, and in this manner I extend my triangulation until I have a sufficient number of points distributed over my sketch. Before I leave this station and lose sight of the ground I have just sketched, I see if my shading is correct, and in proportion to the steepness of the different slopes, and having once adopted a certain degree of shadow, I must make the little bit I have finished act as a kind of guide and standard throughout the drawing. Standing at the four trees I see the road, which passes close to me, is quite straight up to and beyond the corner of wood B , therefore pacing in the direction of wood A for four paces to get a point on the road, I connect this with wood B , by two dotted straight lines to express a road without hedges; I also take the bearing of the cross road, and pace as far as E , where there is a turning; going back to C , I pace along the straight road as far as F , putting in the different salients and re-enterings on the way (that is, the convex and concave turns of the hills). At F I come to another road, nearly at right angles to the one I am on; with my compass I take the bearings in both directions, and pacing to I , the brow of the plateau, I find the road takes a turn, which I put on paper by the aid of the compass. I also take an off-set at right angles towards the brow on my left, which I connect by the eye to the points F and I ; returning to F , I pace along the road towards M , putting in the road GE , GH on the way, by merely joining the points G and E , and taking an angle from G to H ; when I come to the point M , I find there is a steep re-entering, and that the road takes a slight turn, I connect the re-entering to B by the eye, and lay off the direction of the turn with the compass, and pacing off to post, taking care to put in everything on the way, I complete my sketch so far. Standing at post, I see the next curve of the hill is in the prolongation of a line joining stump and post, I take advantage of this, and pace in that prolongation to the fall of the hill, sketching it in without the necessity of using my compass. Walking off to the point O , I interpolate, that is, find my position on paper in the following manner:—I look around me for some of the triangulated points, and fix on two which are near me, and from which, straight lines will form a good angle (in this case, bush and post seem the best). I take the forward angles to these points with my compass and lay off the back angles, or angles diametrically opposite from them on paper, the intersection of these lines will give me my position, which, having found, I connect the shape of the intervening ground to where I last was. In somewhat similar manner I proceed with my sketch until the paper is filled; interpolating at important places, occasionally pacing in the

direction of fixed points, sometimes taking bearings and pacing in their direction, and now and then judging short distances, but always working from triangulated points as much as possible, so as to avoid accumulated errors, which must necessarily accrue in measuring by the pace. I do not think I need detain you any more with this subject; of course practice, as in everything else, will make perfect; correctness of eye, and a good judgment of distances are of much value. A scale, and north point (both magnetic and astronomical) should invariably be added to the sketch. Some little difficulty will occur at first in joining the under features or lower spurs neatly to the upper ridges. Seldom or never do we find isolated hills; some way or other we shall find what we fancied at first, single mounds, to have a connection with the neighbouring elevations.

I will now give a short description of the method of conducting a military survey, which, in principle, is somewhat the same as field sketching, inasmuch as a base is measured and triangulation performed, but much greater accuracy is required, more perfect instruments used, and instead of pacing the base, it is accurately measured with a chain or other instruments. I do not presume to treat of national undertakings, like the Ordnance Surveys of Great Britain and Ireland, which are very seldom required, but will speak of military surveys of much smaller proportions, say from about 4 or 5 square miles up to about 15 or 20. For surveys of these dimensions, a base from about three-quarters of a mile up to 2 miles carefully measured with a chain two or three times would be sufficient, supposing the chain itself to have been compared with standard measure both before and after the measurements, and the links counted. The inequalities of the ground, if any, should be reduced to the horizontal, though especial care ought to be taken to select ground as level as possible.

In a primary series of triangles, all the angles should be observed, and the condition most favourable to the accuracy of computation is that in which each triangle is nearly equilateral. When two angles only are observed, as is frequently the case in a secondary series of triangles, the unobserved angle ought to be nearly a right angle; if much smaller or larger, ill-conditioned triangles are formed, which must always be avoided.

If it should be more convenient to take the angles previous to measuring the base, the sides of the triangles may be calculated from an assumed base, and afterwards corrected in the proportion of the assumed to the subsequent measured base. All observed angles are essentially spherical, but when the sides of the triangles do not exceed more than 4 or 5 miles in length, we may consider the angles as rectilinear, and compute the triangles by plane trigonometry; the three angles together ought to be equal to two right angles, if not—and the error is great—the angles must be observed again; if small, the increment or decrement must be equally divided among the three angles, so as to make the sum equal to 180° .

This diagram is an outline of a survey of about 4 square miles done by myself last year near Sandhurst. Having chosen my base A B for the same reasons that I have previously mentioned in field-sketching,

F I E L D B O O K .
<p>1017</p> <p>$0^{\circ} 35'$</p> <p>⊙</p> <p>3</p>	<p>Wood</p> <p>S.W. For^{wd}</p>
<p>1700</p> <p>1280</p> <p>600</p> <p>$206^{\circ} 10'$</p> <p>⊙</p> <p>2</p>	<p>25</p> <p>S.W. For^{wd}</p> <p>35</p>
	<p>580</p> <p>$268^{\circ} 4'$</p> <p>⊙</p> <p>1</p>	<p>N.E. For^{wd}</p>
<p>Commence at Midrow Hill, 21st October 1862.</p>		

except that as there was not any defined object at B, I put up a small banderol, or small flag, temporarily.

With my theodolite I observed angles at A, B, C, D, E, F, and G, and by the help of plane trigonometry, I calculated the length of the sides of the triangles A B C, A B D, C A F, &c., according to the formula in the annexed diagram; and in the triangle G H F, the one most remote from the base, I measured the side G H to compare with the same computed; this measurement is called a base of verification, and ought to be resorted to occasionally to check the work, especially in extended triangulation. In my case the measured and computed line G H, which is over 1,000 yards, differed by 5 links, which is about as much as a good long step, not a very great deal in a rough survey; but too much if for any important object. Very little trigonometry is required for the computation of rectilinear triangles, with a little tact all the complicated problems can be avoided, and the solution confined to the first and most simple, viz.:—The sides of triangles are to one another as the sines of the opposite angles, and indeed I find more reliance can be placed on this than the others. Having computed my triangles, and tested their accuracy by a base of verification, I can lay them down on paper to any scale. The scale you see before you is 24 inches to a mile, equivalent fraction $\frac{1}{2640}$, that is, the actual country is 2,640 times larger than the map. The next thing is to traverse the roads, for the performance of which the following instruments are required:—

- 1 theodolite,
- 1 chain and 10 arrows,
- 2 banderols,
- 1 rod for measuring offsets,
- Ink-bottle and pens,
- Field-book with blotting-paper,

together with two assistants to chain.

The diagram will show how a field-book is kept, commencing at the bottom and working upwards. The two parallel lines represent the chain from which the offsets are always taken. I may commence traversing at any of the triangulated points I find most convenient; suppose I say at Midrow Hill or station 1, as I will call it in the field-book and plan. Having set up the theodolite exactly over the station, by using a plummet or dropping a stone, I level and arrange it so as to take the first angle with reference to the magnetic north, to the little flag which I place at the point 2, where the nearest road takes a turn; after the angle is taken, which appears to be $268^{\circ}.4'$ N.E., the distance is measured with a chain and entered in the field-book in links, as in the diagram. Leaving one of the flags at station 1, I take the theodolite on, and level it at station 2, pulling up the flag and sending it on to station 3, where the next turning of the road is. After the 1st angle is taken with reference to the north, the services of the needle are dispensed with for the present, the traversing being carried on by the back angle method, which is more accurate than entirely depending on the needle; this latter has many objections, such as insufficient accuracy of adjustment, local attractions, slight variations at different

periods of the day, &c. Proceeding by the back-angle method, at station 2 I look at the vernier on the horizontal arc of the theodolite to see that the last forward angle, viz., $268^{\circ}4'$ has not been altered during the transit of the instrument from station 1 to 2; I then carefully turn the telescope with the vernier clamped at the above angle, to the foot of the flag which I have left at station 1, taking precautions not to touch the clamping or tangent-screw of the vernier. As soon as I have got the cross wires of the telescope coincident with the bottom of the flag, with the aid of the large clamping and tangent-screws, I make the large clamping-screw tight, which keeps the horizontal arc firm, and which is not moved again until all the angles at station 2 are taken.

By this process it must be evident that I have got the theodolite in exactly the same position at No. 2 station as at No. 1, with the horizontal zeros pointing to the north, which I can prove by loosening the needle and unclamping the vernier, turning the zero of the vernier to the zero of the horizontal arc, and observing if the zero in the compass-box agrees with the north end of the needle. In surveying, with a large party I resort to this proof at every station, as I find novices are very apt to turn the wrong screws, unless carefully watched. At No. 2 station I take my angles, reserving the forward one for the last, in order that the instrument may be all ready for taking the back angle from station 3. Before I commence measuring the distance between the 2nd and 3rd station, I take the offsets with my rod, that is, the distance from the chain to the hedges, or the sides of the road, and note them in my field-book as in the diagram. I now chain from 2 to 3 stations, putting down in my field-book any little detail I may come across, such as beginnings and ends of woods, cross-roads, streams, houses, &c., with their approximate position and actual distance from the last station in links, and every time the chainmen have exhausted their ten arrows, 1,000, 2,000, or 3,000, &c. links must be noted down in the book. Particular care must be taken when the arrows are handed from one assistant to the other, to see that the whole ten are given over and received. The theodolite is now brought to No. 3 station and the same process carried on, the flag being taken to No. 4 station. This system however must not go on too far without some check, therefore, when I get to No. 6 station, I will take the forward angle to Bear Hill, which is one of my points of triangulation. I will now cast adrift the back angle, and, taking the theodolite to Bear Hill, I level and arrange it as I did at station 1, and take the bearing of a flag which I placed at station 6, when I took away the theodolite. If I find the bearing agree with the angle I had previously taken from station 6 to Bear Hill, I may conclude my work is so far correct, and continuing thus, commencing my operations always at some triangulated point, and checking them; whenever I come near another, I get the direction and measurements of the roads, which I plot down on paper with either a circular or semicircular brass protractor.

A portion of the outline just done is traced on to drawing-paper and fitted to the sketching-case, at least two of the triangulated

points ought to be in each section, and as the azimuthal deviation of the compass about to be used may not be the same as the theodolite employed for the triangulation, the parallel lines from east to west cannot be drawn until the bearing from one of the triangulated points to another is ascertained with the compass. At some convenient time during the survey, the heights of the principal hills ought to be found, either by trigonometry or levelling from some datum mark, and the result shown on the plan by marking from the highest as No. 1, No. 2, &c., and if there are two or more hills of the same height, they must be marked with the same number; this will show at a glance the relative commands of the various hills.

I have now gone through the different descriptions of military surveying that are applicable to rapid sketching with more or less accuracy. There is yet another method, to which I have previously alluded, of showing hills with mathematical accuracy, but unfortunately exacting an amount of time and labour which can seldom be given; I mean contouring, which is more adapted to engineering purposes than for military surveying. A series of horizontal lines are found with the aid of the spirit level and vane, all over the surface of the ground at equal vertical distances apart, commencing at high-water mark and working upwards. The diagram shows an actual contour sketch of a hill near Sandhurst.

It may sometimes happen that an officer is called upon to make a sketch in a hurry and at a moment when he is unprovided with compass, protractor, or any of the instruments generally required, and difficult as this may appear at first view, it is astonishing how easy it is in practice, and how accurately, comparatively speaking, sketches have been executed by simple pacing and a correct eye; this is called eye-sketching or sketching without instruments. The diagram illustrates a portion of country done by myself in this manner; being furnished with a straight flat rule or lath about a foot long, and having made a scale of paces on a piece of cardboard or thick paper to suit myself, I procured a sheet of plain paper which I fitted to a case (if I had not had a case I would have fastened the paper to a flat piece of wood or old book-cover), and on arriving at the ground, I commence at the point A, where there are cross-roads, and where one runs straight for a considerable distance. I fix upon a convenient point on paper, and draw two parallel lines in any direction I think fit, which I call the road, and the point A my own position; although I draw this at random it will be for the first and last time, for the position of all other roads, points, hills, &c., must have reference to this first road. I now place my paper and case on the ground with the straight ruler coincident with one of the parallel lines, and direct the whole, paper, rule and case, in the direction of the actual road which I can accomplish more effectually by stepping back three or four yards; having got my road on paper in a line with the real road, I take up the ruler (leaving the sketch on the ground) and direct it by the eye towards B, C, & F, in succession, drawing lines of convenient length to represent portions of these other roads. With the ruler I also ascertain the direction of the hill E. I now pace along the road

A, F, to the top of the hill, about 1,300 yards, putting down on my sketch any detail on my way within reasonable distance on both sides of the road, say 100 yards or more, judging the direction and distances by the eye. At the point F, where the ridge of the hill crosses the road, I see that the head of the valley lies between me and the point K, where there is a large conspicuous tree known as the Pollard. I get the direction of the Pollard from the point F, on paper in the following manner: I place my flat rule on the line A, F, and turn the ruler, paper, and all towards the point A, from where I started, this brings my road on paper parallel to the real road, and taking up my ruler, I turn it towards the Pollard, and draw a line. Leaving some mark at F, I pace along the line to the Pollard, putting in the different features on the way, to the right and left of my route within a short distance; arriving at the Pollard, I take the back angle to the mark I left at F, and the forward one to the brow of the hill E, putting down and shading off all the hills and valleys on my way, occasionally taking offsets, if necessary. At E, I can take a back angle at the Pollard, and forward one to O, towards which I pace, sketching in every useful thing on my way, and in this manner I go on until the sketch is finished. In an eye-sketch, one must always know where one is on paper, and a back angle must be taken for the purpose of getting the paper parallel to the country before a forward one can be laid down. The astronomical north can be found approximately by observing the shadow of the sun at twelve o'clock on the sketch, when it has been placed parallel to the ground by some back angle. Of course a scale should be made if there is time.

This kind of sketching will be found of the utmost value in a military reconnaissance, an important duty, usually performed by the Quartermaster-General's department, in which not only must a rough plan of the country be made, but graphic information added in the shape of a report, embracing everything that is likely to be useful to the General, or other officer in command. It is evident that the officer who should be selected for this service, besides being a proficient in Military Surveying, ought to have tact, coolness, and a knowledge of the language or patois of the country he is in. I have not time to enumerate in detail the particulars that should be mentioned in the report accompanying the sketch in a reconnaissance, they should be represented clearly and legibly, the source from which the information is derived must be stated, and nothing entered by guess-work.

It is impossible to epitomise into a single lecture all that can be said on military drawing and surveying, and I fear, much, that I have not clearly explained some of the subjects. In ordinary instruction I find it necessary to elucidate the most simple thing, and never take it for granted that a student must know what appears so easy to myself, but in a lecture this is obviously impossible. If, however, the descriptions I have just given of the various kinds of sketching have afforded the slightest information to any one here present, it will give me great satisfaction.