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running vaguely about after his men with a sort of idea that he ought to pull each individual man about, and put him into his place, and the major generally galloping about after the captain. The want of subdivisions has always struck me as a misfortune about our "skirmishing drill." I am very much obliged to you for the attention you have paid to me.

The CHAIRMAN: I ask the permission of the meeting to return our best thanks to Colonel Jones for his very interesting paper.

AN OCCASIONAL NOTE ON THE USE OF THE ANEROID-BAROMETER IN SURVEYING.

By Captain R. H. FAWCETT, 33rd Regiment, Garrison Instructor, Curragh Camp.

IN 1868 a notice appeared in the Journal of the Royal United Service Institution to the effect that brief "occasional notes" from Members serving abroad, on subjects of professional interest were admissible, with the approval of the Committee. I propose to avail myself of this permission with special reference to the use of the aneroid barometer in surveying, as I have been so often asked for simple formulæ and the means of applying them to ascertain heights; that I am sure there is much interest taken in the subject by many who have not had opportunities of investigating the powers of the instrument.

The value of the aneroid as a handy and portable instrument for rapidly obtaining relative heights in surveys, has, I think, been underrated. It is of great value, especially in cases of military surveying, where time is frequently priceless.

The points chiefly valuable in an aneroid are its portability, as in the pocket it takes up no more room than a watch, and the observations and calculations can be done so quickly, that a Staff Officer riding from one hill to another, can easily obtain their relative heights.

In a survey, readings may be noted down in a pocket-book, or even on the margin of the sketch, and calculated out on return at leisure.

When there is plenty of time, and the ground is practicable, levelling or contouring would certainly be adopted in preference; but even then the occasional consultation of the aneroid might be an advantageous check to error. But if pressed for time, or contouring be impracticable or extremely difficult, the aneroid gives heights with sufficient accuracy for ordinary military operations, and is far more accurate than the eye; moreover, the reading may be taken in equal or less time than it would require in most cases to make a good judgment of height.

The simple formula given below may be worked out almost directly on the ground, if necessary.

The best example of the value of the aneroid occurs in a survey I lately made of the Nasciar Lines at Malta, and the range, which by a geological fault, divides the island. Here, on account of the rocky and abrupt nature of the formation, and the way in which every available patch of soil has been terraced for cultivation, it would be a most

serious toil at least, to run levels. The aneroid gave me the command of one point over another approximately, with very little trouble. Though it cannot show the height with the accuracy of levelling or contouring, yet its indications may be generally relied on to 10 to 20 feet, according to the care taken, and the number of observations made.

It is of course in abrupt, hilly, and almost mountainous countries, that the aneroid is most useful. For heights of 50 or 60 feet above the plain varying slightly in their relative heights, the reading of the pocket-aneroid might be difficult, and the slightest error important. I have however observations above and below a bridge, the height of which I afterwards measured with a good plumb-line, which show that sufficient accuracy may be obtained with care.

Aneroid observations.		Actual measurement.
1st obs.	2nd obs.	
46 feet.	45 feet.	47 feet.

It almost invariably happens that such small heights can be contoured or levelled quickly, but the case is different with hills of 300 or 400 feet above points in the survey. The contouring of these would take up much time, and the advantage of the aneroid, as far as this reason goes, increases with the height.

The obvious objection to the use of the barometer for ascertaining heights, is the influence of the weather; but this objection seems generally exaggerated. My experience is that, in very stormy, *gusty* weather, the barometer may be influenced so much in the course of a few hours, as to cause uncertainty; yet even in this case, relative heights may be taken, if the points from which the barometric indications are taken, are reached quickly one after the other. A very heavy cloud, that is one on the verge of precipitation into rain, will doubtless have its influence; but, unless a cloud is direct overhead, its influence seems generally gradual, and may be allowed for by returning to some point where the aneroid has been previously consulted, and consulting it again. The mean may be taken, or such allowance made as the duration of time elapsed in passing from one point to the other, warrants. I have done this many and many a time, but found that, as a general rule, the original observations were trustworthy, unless the cloud was dense and directly overhead. It is only in very severe, windy weather, when it is coming on a hurricane, or something like it, that the assistance of the aneroid need be despised; and in this case the prismatic compass itself is almost useless; but, as a rule, very little surveying is done on such days, even in urgent cases; few such days occur in the year at home or abroad.

Most aneroids are compensated for temperature, or should be; the purchaser should particularly make certain of this. Yet, even though it be compensated, it is safer to allow correction for temperature in the case of a survey in hot climates where readings may be taken in the very early morning, and again when the sun has full power.

In reading the indications of the aneroid, the eye is very easily deceived, unless care be taken.

If the aneroid be laid flat on the hand and read, and again held up so that the hand of the instrument shall be parallel to the eyes, there will be found to be a difference.

Again, if it be held *parallel to the eyes* with the higher reading uppermost, the weight of the hand will cause it to read lower than if the position were reversed and the lower reading uppermost. That is, that if the barometer when flat reads 30.10, it may, when held parallel to the eyes and with 28 inches at top, read 30.06, and, when reversed so that 31 inches is uppermost, read 30.04.

The first mode of reading obviously is the most liable to error.

Of the two latter modes it does not matter which is used, provided it is always read the same way. The differences between the readings will be the same. For choice I prefer always to hold it so that the higher number of inches is uppermost. The chief point is to hold it parallel with the eyes; but there is no doubt some fixed rule should obtain with observers.

The mode of using the aneroid for surveying is as follows :—

The reading of the instrument should be taken previous to starting in the place where it is generally kept, or better still from a bench mark (Σ), the exact height of which above the sea, can always be obtained by reference to the Ordnance Survey Department.

On return, the reading should also be carefully noticed at the same place.

If the difference be slight, the mean may be taken as giving the approximate height of the barometer at the time the observations were taken.

For example, if the barometer read—

At starting at 9.30 a.m.	29.50
At top of hill	} about 11 a.m. {
At bottom of hill	
On return at 1 p.m.	29.60

the barometer has risen on account of weather .10 or $\frac{1}{10}$ th of an inch. Hence the height the barometer would have been at the home station at 11 o'clock (when the hill observations were taken) may be estimated as 29.55.

The observations on the hill, if taken soon after one another, will give the relative heights, if this alone be required, without reference to the weather movements of the barometer. If, however, some time has elapsed between the readings, such reference should always be made, and it is obvious that in all cases such proceeding is the more exact and satisfactory.

Some aneroids have a regular scale attached to them, so that the height may be read off. I have never had an opportunity of fairly testing these; they would evidently be exceedingly valuable where the scale could be thoroughly relied on.

In reading a pocket aneroid there is probability of error; in reading the scale there is a second chance of error, and the calculation is so extremely simple that there is no necessity to run the risk of a double error.

A table is given in "Shifts and Expedients of Camp Life," by W. B. Lord, R.A., and T. Baines, F.R.G.S., from which we can see the movements of the instrument at various heights. From this table I make an extract to give a guide to the difference shown per inch of movement at various heights.

Aneroid barometer reading.	Height in feet.	Taken as inches.	Difference in height per inch.
31·00	0	31	—
29·99	900	30	900
29·01	1,800	29	900
28·02	2,750	28	950
27·01	3,750	27	1,000
25·99	4,800	26	1,050
25·01	5,850	25	1,050
23·97	7,000	24	1,150
22·98	8,150	23	1,150
21·99	9,350	22	1,200
20·97	10,650	21	1,300
19·99	11,950	20	1,350

This shows that a fall of an inch in the aneroid has different values at different heights. But it is only for great heights that there is much difference. The barometer at sea level is generally between 27 and 31 inches, unless a West Indian hurricane is afoot; and for military purposes we do not require to ascertain great heights hurriedly. Therefore the following simple formula will generally suffice:—

Admiral Fitzroy appended to his barometer the rule to add 0·1 for every 100 feet of height. In other words, that the barometer would fall 0·1 for every 100 feet. This was probably intended as a general average to suit different positions. Yet it is sufficiently near the mark that Captain James, R.E., has recommended it for surveying, in the Royal Engineer's Papers, giving as an easy rule that a fall of 1 inch represented a height of 1,000 feet very nearly, when the total relief does not exceed that quantity. This rule is extremely simple, and at the very least would enable a near guess to be made at once as to the command of one point over another with a minimum of calculation. But when the barometer generally stands between 30 and 28 inches, the rule given by Negretti and Zambra is—I have always found—very nearly as simple, and more trustworthy. Divide the difference between the aneroid readings at the lower and upper stations by ·0011, the quotient will give the approximate height in feet.

To put this in a form easily remembered, it is that $\frac{d}{\cdot 0011} = \text{height}$ in feet, d being the difference between the two stations.

For example—

At bottom of hill aneroid reads ..	30·38
„ top „ „ ..	30·02

d or difference = ·36

$$\frac{.36}{.0011} = \frac{3600}{11} = 327 \text{ feet.}$$

This is, to the best of my knowledge, the most useful formula extant.

It differs from Admiral Fitzroy's formula by giving 909 feet to an inch instead of 1000, and is therefore more likely to be true when the barometer reads above 28 inches. There is a formula to be found in Belleville's "Manual of the Aneroid and Mercurial Barometers," which works out very nearly the same for such cases.

As the sum of the readings of the barometer is to their difference, so is 55,000 (or twice the assumed height of the atmosphere in feet) to the elevation required.

$$S : d :: 55,000 : x.$$

But for moderate heights this gives little, if any, advantage in accuracy over the one given by Negretti and Zambra. Many other easy formulæ have been given which have not stood the test.

I have by me some 50 cases in which I have worked out the last formula and the one of Negretti and Zambra's, as well as several others. The result I have found to be that the simpler one is sufficiently close for military purposes, and is most rapidly worked. I have tested them against levelling and bench-marks.

Still even for military purposes of surveying, a closer approximation may often be desirable, and Major Robinson, R.E., who made observations in 1849 (see "Aide Memoire Papers," vol. ii, p. 418) found "on investigation that each instrument should have its own register for indicating heights from certain peculiarities in their construction." This may be done by taking the instrument to a known height and ascertaining the movement. This should be generally done where accuracy is necessary, and not once, but five or six times; and the mean taken of all the observations which may be taken, to give the amount *that* barometer will rise or fall for the height.

No instruments of the kind, even chronometers, can be made exactly accurate; but if the instrument have a constant rate of error, and this be known, we can attain accuracy for practical purposes.

The best way, then, is to select a day and time, or days and times, when the barometer is not likely to be much influenced by the weather, and by carrying the barometer to two points, the difference in height of which can afterwards be accurately ascertained, the rate at which it moves for every 100 feet can be easily calculated.

It may be noteworthy for Officers who may, in the course of duty, have to go up great heights, that I took an aneroid to Abyssinia, graduated to 25 inches, and that, being at heights much over 5,000 feet, the hand came round to 31 and 30 inches or so for the second time. I thought the aneroid must be thrown out by this, and discontinued observations. On return home, I left it for some time with the makers, but was assured that it had been working correctly, and moreover was told that the difference between 25 and 31 was purposely exactly an inch. I might therefore have gone on with the observations, merely reading 31 as 24, 30 as 23, and so on.

On the other hand, Captain Tapman, R.M.A., informs me that an aneroid in his possession was thrown out of gear, though not seriously, by being taken up a height beyond what it was graduated for.

It may be as well to ascertain this point from the optician at the time of purchase, as well as what the difference given by the instrument for each 100 feet at 30 inches is; but, above all, see that it is compensated for temperature, as most are now.

A large aneroid is more accurate and more easily read than a small one, but it is not so portable. A pocket aneroid can be easily slipped into the coat pocket, and I think this preferable to carrying it in the waistcoat pocket; for the object is to keep it at about the same temperature. In ordinary work, the waistcoat pocket would be the best place, as it is for a watch; but when a man tramps up a steep and high hill he becomes much hotter than he was at the foot; this might affect the aneroid in his waistcoat pocket, but not that in his coat pocket. The small aneroid might enable one to take useful observations in an enemy's country without suspicion.

For the benefit of Officers serving abroad, where books may be inaccessible, I append the formulæ given in "Practical Meteorology," by Dr. Drew, and extracts from his table sufficient to enable them to be worked out. Any one, however, taking up the subject thoroughly, should have that work for reference.

Speaking of the aneroid, Dr. Drew says, "As no correction need be applied for temperature as regards instrumental variation, a simpler formula may be adopted than for a barometrical barometer; perhaps the best is one by Poisson, from which Professor Patton (in the "Journal of the Geographical Society, vol. xxi) has derived the following rule:"—

Multiply the number in the following table opposite to the mean of the temperatures of the air at the two places (in degrees of Fahrenheit) by the difference of their barometrical heights, and divide by their sum.

$$x = \frac{dT}{S} \text{ where } d = \text{difference of barometer readings.}$$

T = number opposite mean temperature.

S = sum of barometer readings.

x = height in feet.

Condensed Table.

At 32° = 52416.

40° = 53348.

50° = 54512.

60° = 55677.

70° = 56842.

80° = 58007.

90° = 59172.

If the number 116 be added or deducted for every degree of the temperature above or below the nearest temperature for which a number is given, then a close approximation is reached.

For example, let temperature at the top of the hill be 48° , and at the foot 56° , then the mean temperature is 52° .

$$\begin{array}{rcl} \text{T for } 50^{\circ} & = & 54512 \\ \text{Add } 116 \times 2 & = & 232 \end{array}$$

$$\text{T for } 52^{\circ} \quad \underline{54744}$$

Again, if the mean temperature be 57° .

$$\begin{array}{rcl} \text{T for } 60^{\circ} & = & 55677 \\ \text{Deduct } 116 \times 3 & = & 348 \end{array}$$

$$\text{T for } 57^{\circ} \quad \underline{55329}$$

The formula and table may be written on a small piece of paper, and gummed on the back of the aneroid.

Dr. Drew gives also other formulæ, but this is the simplest; and, as before mentioned, it is only in the case of a considerable height and some range of temperature, that it is necessary to take the latter into consideration at all.

In conclusion, the aneroid is so peculiarly handy, portable, and adapted for obtaining useful results in military surveys in war, that I consider it would be a great advantage if, in the ordnance survey, some of these instruments might be thoroughly tested with regular levellings, so as to prove their comparative accuracy. From this we might hope to obtain more exact formulæ than we have at present, especially with regard to heights between 100 and 800 or 900 feet.

I have written this in great part for the inexperienced, for I hope to see the aneroid some day in general use with Officers.

Those who wish to go thoroughly into the subject, may get information from—

Practical Meteorology, by Dr. Drew, p. 219 *et seq.*

Aide Memoire, vol. 2, p. 418.

Royal Engineers' Papers, vol. 7, p. 28 *et seq.*; vol. 8, p. 176 *et seq.*

Symon's Meteorological Magazine, June—August, 1866; October, 1867; November and December, 1870; February, 1871.

Shifts and Expedients of Camp Life, &c., by W. B. Lord, R.A., and T. Baines, F.G.S., p. 742 *et seq.*

APPENDIX.

The following is a specimen of the working of an afternoon ride over a survey, to settle some points doubtful and to take in one or two new ones of small importance.

The ride was about 20 miles, but, on account of the difficulties of ground and detours requisite, the points could not be reached so quickly one after another as would be generally possible.

Time, P.M.	Position.	Barometer reading.	Height in feet above sea level by this observa- tion.	By previous observa- tion.	
3.0	At home	29.72	—	—	—
3.15	Pieta (5 ft. above sea level)	29.88	—	—	—
3.30	Bench mark 229 on road..	29.84	46	—	{ By Ordnance sur- vey afterwards as- [certained, 50.258.
3.50	Dome of Musta.....	29.64	232	230	
4.0	St. Speranza	29.68	195	—	{ By previous obser- vation, a differ- ence of 50 feet in relative height be- tween S. Speranza and Andrea.
4.15	St. Andrea.....	29.625	248	—	
4.40	Top of Gebel Mir Hanno..	29.58	295	—	—
5.0	Valley at St. Caterina ...	29.825	73	70	—
5.15	Via Selina and Melicha ..	29.75	141	137	—
5.45	St. Giovanni	29.80	102	—	—
5.55	Chapel at fork of roads ...	29.75	160	147	—
6.0	Bend of road to P. Camp.	29.79	114	120	—
6.10	{ Madalena Tower, 5 ft. above sea	29.915	—	—	—
7.0	Pieta, 5 ft. above sea	29.92	—	—	—
7.15	At home (on return)	29.75	—	—	—

Barometer at home 3.0 = 29.72.

Ditto ditto 7.0 = 29.75 between 3 and 7 (4 hours), hence
presumable rise through weather = .03.

Barometer at Pieta (5 ft. above sea) at 3.15 p.m. = 29.880.

Ditto Madalena at 6.10 „ = 29.915.

Ditto Pieta at 7.0 „ = 29.92.

Presumable rise through weather in 4 hours = .04.

As from the general working of the barometer through the previous
part of the day and the condition of the day, there appears no reason
to expect any sudden “jump” in the barometer, we may allow for
weather a rise of .01 every hour.

That is, that at 3 p.m. the bar. at 5 ft. above sea would read 29.88

„ 4 p.m. „ „ „ 29.89

„ 5 p.m. „ „ „ 29.90

„ 6 p.m. „ „ „ 29.91

„ 7 p.m. „ „ „ 29.92

Taking these conditions, we proceed to compare them with the
readings at different heights at and about the times:—

Bench mark (229) on road at 3.30 p.m. reading 29.84
5 ft. above sea level 3.30 p.m. 29.885.

<i>1st Formula :</i>		
Lower station	29·885	$\frac{d}{\cdot 0011} = \frac{450}{11} = 40\cdot 9$
Upper „	29·840	Add 5 feet 5
<i>d</i> or difference =	<u>·045</u>	
<i>S</i> or sum	= 59·725	Height above sea level <u>45·9.</u>

2nd Formula:

S	:	d	:	: 55000	:	x
59·725	:	·045	:	: 55000	:	x
<hr/>						
55000 × ·045						
59·725	=	41 feet above Pieta point.				

Add 5 feet = 46 feet above sea level.
 Height taken as 46 feet.
 And so on with each reading.

"THE AUSTRIAN CONFIDENTIAL REPORT AND NEW METHOD OF PROMOTION."

By Lient. CHARLES E. H. VINCENT, 23rd Royal Welsh Fusiliers.

THE subjoined description of the detailed confidential report, which is furnished annually to head-quarters on every Officer in the principal Continental armies, may be found interesting. It is needless for me to remark how invaluable it has proved in the Prussian service. By its agency alone, the right man was always appointed to the right place. The tactical genius found himself brought before the enemy, whilst the more sedentary and inactive talents found ample employment in the difficult task of administering the civil government of conquered provinces, towns, and villages.

In time of peace a post falls vacant. May be, it requires private means, social qualification, a somewhat peculiar knowledge or temperament. Reference is made to the ledger at head-quarters, and the choice becomes limited to two or three from whom it is not difficult to select. In war, Officers commanding divisions, detached posts, &c., are furnished with a summary of the principal qualifications of each Officer under their command. A "parlementaire," somebody to examine deserters, to attend on a prisoner of rank, is wanted. The "summary" instantly facilitates the appointment. I will take the Austrian Report as the specimen, entering as it does into the minutest details.

It is written on a printed form at half margin. The questions or points on which information is to be furnished are printed on the left. The information is to be written explicitly, yet concisely, on the right.

Page 1 shows—Corps, name, rank, employment, date of birth, religion, education, place; mode and extent of ditto before

entering army. Personal relations before entering service (in any other profession or army). Date and method of entering army. Courses afterwards passed through. Private relations (married, single, or a widower, children, independent means). Medals or decorations.

Page 2—Promoted, transferred, passed over, &c. Length of service absolutely with corps.

Page 3—How been employed to be given year by year (if the Officer has been employed in various ways to be shown thus):—1868, January to June, Acting Adjutant; 1863, June to December, Comptroller duty; 1869, January to March, Aide-de-Camp; 1869, March to October, Musketry Instructor.

Page 4—Campaigns, wounds, services in the field.

Page 5—Special services. Special and peculiar abilities, painting, gymnastics, swimming, drawing.

Page 6—Year to which Report refers. Present employment, knowledge of languages (whether slightly or thoroughly). Capabilities in matters connected with military duty (riding, judgment in horseflesh, training of recruits, &c.). Capabilities in matters unconnected with military duty. Zeal, success, ambition, thirst for knowledge. Conduct and character before the enemy, on service in peace, in private life. State of health, fitness for a campaign. Special remarks. Claim for promotion. Remarks by Inspecting General.

As the General's report checks that of the Commanding Officers, it is difficult for the latter to show pique or favoritism. I will but add one word on the new law for promotion in the Austrian Service (March 14, 1871).

Promotion goes by seniority or non-seniority. Those who elect for the more rapid advancement of the latter method, which is open to all, have to pass a very severe practical and theoretical examination. They are then promoted in numerical order on the list of successful candidates. Every sixth step below field rank, and every fourth above it, is given to a non-seniority candidate. Promotion goes right through the Army, arm by arm. In all cases, Captains have to submit to a very severe practical and theoretical test before they are promoted; to prepare for which, it is optional with them to study for eleven months at a special school, and all promotion depends on "thorough fitness." The Staff is organised much on the model of our own, but "mathematics" form no part of the entrance examination to the Staff College, or of the course of instruction there, while civil administration, the exact topography and military power of every European State are the objects of unceasing study.