

rocket. The fire from the tube ignites the lower rocket, and the leader instantaneously conveys it to the upper, thus insuring their going off together, and attaining the greatest range that can be got out of them; the figure A shows the leader entered and ready for immediate use. I enclose a copy of an extract of a letter from Captain de Courcy to the Commodore Controller-General on the subject, in which he says, "I have to report I witnessed a trial of them on the "3rd, when the line was thrown over the 'Stag' cutter. The leaders "supplied with the rockets often fail in conducting the fire, and are "liable to break at the joint. Lieut. Harris's leaders are easily made, "and much easier adjusted to the rockets than those supplied." This letter was dated March 7th, 1864. On March 14th the matter was forwarded to the Board of Trade, in whose hands it now is.

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## CALCULATION OF RANGE FOR THE SERVICE OF ARTILLERY.

A Paper contributed by Captain J. R. CAMPBELL, Hants Artillery Militia.

THAT the course of a projectile is not a straight line, but a curve technically called its *trajectory*, is a fact known to every gunner and rifleman of the present day; and he learns from this that, in order to hit an object, he must give his gun a certain elevation depending on the distance he is from it, the nature of the gun and projectile, charge of powder, &c. Give him the distance or range, and he can, by the aid of certain rules or by reference to tables, ascertain the elevation required. In target practice, where the ground is measured out, this naturally ceases to be a matter of question; but in war, when firing at an actual enemy, or at his works, or ships, the range is seldom or never known. For short distances, and within certain limits of error, it may be *judged* by the eye, but for the higher artillery ranges, especially across water, this is impossible. Artillerymen generally depend upon their first shot or two—*trial shots* as they are termed—correcting each succeeding one by the result of the last, until they strike the object. But there are disadvantages attending this system, which is, besides, clumsy and unscientific. I will mention what I believe to be two.

1stly. In many cases, owing to the nature of the ground where the shots pitch, or other causes, it may be extremely difficult to observe the graze of the trial shots. We read of actions where at least the majority of the shots fired by one contending party have either all dropped short of, or all passed over, the heads of their adversary, and I ascribe this principally to the want of some better method of determining the range. The late engagement between the "Kersage"

and "Alabama" affords no bad illustration of the defects of the present system. Few of the "Alabama's" shots seem to have struck her adversary.

2ndly. During the time you are testing the elevation by trial shots, your enemy, supposing him to have found the range, may be destroying you with shot and shell.

I might, perhaps, also mention the expense of ammunition thus fired in vain, which, in the case of the colossal ordnance now fabricated, can be no trifle. It is said that one projectile from Sir W. Armstrong's 600-pounder would render a ship *hors de combat*; but to do this it must *hit* her, and, I presume, ought to strike close to her water-line; and although I grant that at very close quarters any calculation of the range would be unnecessary, yet cases might occur where our enemy, drawing less water, or steaming faster than ourselves, might be able to avoid this condition.

Now by means of trigonometry we have in most cases the power of measuring the range with sufficient accuracy for practical purposes. There are several ways of doing this; and the object of the present paper is to describe that which appears to me the simplest and most expeditious.

Suppose the distance  $AX$  (in the accompanying fig.) to be the range required. A base line  $AB = 100$  units is measured from  $A$  at right angles to it. This (on land) may be done by pacing, or better by means of a chain or cord, the direction being taken by a pocket sextant set at  $90^\circ$ . A man or flag is placed at each of the points  $A$ ,  $B$ , and the angle  $ABX$  measured by the instrument. Then we have

$$AX = 100 \tan. ABX$$

$$\text{or } \log. AX = 2 + \log. \tan. ABX,$$

from which equation the distance  $AX$  may be calculated.

The following table is constructed for the purpose of showing at once the range subtended by an angle read off on the sextant, thereby avoiding such loss of time and trouble as would be required in working out the equation.

The 2nd column gives the ranges or values of  $AX$  expressed in units, corresponding to the values of the angle  $ABX$  placed opposite to them in the 1st column. The shorter ranges are computed for each successive  $10'$  in a degree, and the longer ones are taken at every  $3'$ . The 3rd column contains the *mean* value of a minute for angles whose magnitude may lie between that opposite which it stands and the one below it on the table. I have adopted this arrangement in order to render the table concise and handy. It would be easy to construct one with the range expressed for every minute in a degree. I believe, however, the time required in finding the range of the intermediate angles will never exceed a few seconds.



TABLE.

Angle.	Range.	1' =	Angle.	Range.	1' =	Angle.	Range.	1' =	Angle.	Range.	1' =
78° 41'	500	·7	83° 15'	845	2·2	85° 40'	1,320	5·0	87° 15'	2,082	13·0
50'	506	·8	20'	856		45'	1,345	5·6	18'	2,121	
79° 0'	515		25'	866	2·4	50'	1,373		21'	2,160	13·3
10'	523		30'	878		55'	1,401	5·8	24'	2,202	14·0
20'	531	·9	35'	889		86° 0'	1,430	6·0	27'	2,246	
30'	540		40'	901		3'	1,448	6·3	30'	2,290	15·6
40'	549		45'	913		6'	1,467		33'	2,337	16·3
50'	558		50'	925	2·6	9'	1,486		36'	2,386	17·0
80° 0'	567	1·0	55'	938		12'	1,505	7·0	39'	2,437	17·6
10'	577		81° 0'	951	2·8	15'	1,526		42'	2,490	18·3
20'	587		5'	965		18'	1,547		45'	2,545	19·3
30'	598		10'	979	3·0	21'	1,568		48'	2,603	20·3
40'	609		15'	993		24'	1,589	7·6	51'	2,661	21·0
50'	620	1·2	20'	1,008		27'	1,612		54'	2,727	22·3
81° 0'	632		25'	1,023	3·2	30'	1,635	8·0	57'	2,794	23·3
10'	643	1·3	30'	1,039		33'	1,659		88° 0'	2,861	24·3
20'	656		35'	1,055		36'	1,683	8·3	3'	2,937	26·0
30'	669	1·4	40'	1,071	3·4	39'	1,708	8·6	6'	3,015	27·0
40'	683		45'	1,088	3·6	42'	1,734	9·0	9'	3,096	28·6
50'	697	1·5	50'	1,106		45'	1,761	9·3	12'	3,182	30·3
82° 0'	712		55'	1,124	3·8	48'	1,789		15'	3,273	32·0
10'	727	1·6	85° 0'	1,143	4·0	51'	1,817	9·6	18'	3,369	34·3
20'	743	1·7	5'	1,163		54'	1,846	10·3	21'	3,472	36·0
30'	760		10'	1,182	4·4	57'	1,877		24'	3,580	38·6
40'	777	1·8	15'	1,204		87° 0'	1,908	10·6	27'	3,696	41·0
50'	795	1·9	20'	1,225	4·6	3'	1,940	11·3	30'	3,819	43·6
83° 0'	814	2·0	25'	1,248		6'	1,974	11·6	33'	3,950	47·3
5'	825		30'	1,271	4·8	9'	2,009	12·0	36'	4,092	
10'	835		35'	1,295	5·0	12'	2,045	12·3			

*Note.*—The decimals in the values of 1' for the higher ranges need seldom be taken into account, although I have thought it best to shew them.

The following examples will show the working of the table:—

1. Suppose the base to be 100 yards, and the angle 85° 36', what is the range? For 85° 35' the table gives 1295 yards, a yard being here the value of a unit, and we see that between the latter range and 1345, the minute corresponds to 5 yards. Hence,  $1295 + 5 = 1300$  is the range required.

2. Let the base be 50 yards, and the angle observed, 88° 23'.  $3472 \div 2 \times 36 = 3544$  would be the distance were the base 100 yards, i. e., if, as in the last example, the unit were 1 yard. In the present case, the unit being half a yard, we must divide the above number by 2, and we get 1772 yards as the range required.

3. Let 200 yards be measured for a base, and suppose the angle = 88° 7'. The value for this angle given in the table is  $3015 + 27$

= 3042, but as the unit in the present case = 2 yards, we must multiply by 2.  $2 \times 3042 = 6084$  yards is the distance sought.

The value of  $1'$  is a measure of the *error* in the observation arising from the fact of the sextant only reading to  $1'$ . In the 1st example this error is *not greater* than 5 yards; in the 2nd it is at most equal to 18 yards, and in the 3rd does not exceed 54 yards. This error rapidly increases as the angle approaches  $90^\circ$ .

The above examples show how the same table may be made to serve for a base of any length. But for localities where only a shorter distance than 100 yards is available, it would be advisable to compute a table, on the same principle as that on the last page, to a base equal to the number of yards at command.

It can be readily shown, that if in measuring the base an error is made =  $d$  units, the error thereby resulting in  $R$ , the range, will be

$$\frac{R}{100 - d} \times d \text{ when the base} = 100 + d,$$

$$\text{and } \frac{R}{100 + d} \times d \text{ when the base} = 100 - d.$$

When  $d$  is small (say 1 or 2 yards), we may neglect it in the deno-  
mination in calculating this error, and consider it  $= \frac{R}{100} \times d$  nearly.

Thus, suppose 98 yards measured for 100 in the base, and the real range to be 3000 yards, the observation would give about 60 yards too much, viz. 3060. Should the base be more than the proper length corresponding to the table, say 102 yards, then, the result of the observation would be 60 yards too little, viz. 2940. It appears to me that this method of measuring range might be employed on board ship, although, owing to my want of experience in naval gunnery, my opinion on this point is of little value. Suppose, however, an imaginary base line of 50 yards or more, according to the size of the vessel, to traverse the deck from stem to stern parallel to the keel. A telescope, centered in a vertical plane perpendicular to this base line, is mounted over the end nearest the stern. When the range is to be taken, the ship is brought round, either by her screws or rudder, until the object to be fired at can be seen through the telescope. At this moment the base line will be at right-angles to the range, and a signal from the officer at the telescope to one at the other extremity of this line gives the time for the latter taking the angle (by quadrant or sextant\*), which being read off, and referred to a table calculated to the base line of the ship, the range is obtained with more or less accuracy according to circumstances.

Tables of this kind might be rendered more complete by the addi-

\* Or this may be done by means of a telescope, mounted in a similar manner to that at the stern (both being furnished with cross wires), the former having, however, in addition to its motion in a vertical plane, one also round an upright axis, like a theodolite; its position with regard to the base line being indicated by the degrees and minutes on an arc in a plane parallel to the deck.

tion of extra columns showing the elevations for the guns, and length of time fuze due to each range.

Doubtless there are cases on land where the range could not be found in the manner I have described, owing to the impossibility of obtaining a sufficient length of base for all directions of fire. In some such cases other means are practicable. The range from a fort on a hill overlooking the sea, for instance, is easily estimated by the *dip* or angle of depression of a theodolite. This angle read off on the vertical circle of the instrument, and the known height of the telescope above the water, furnish data for the construction of range tables, in using which, however, a correction for the height of tide must be applied, similar in *principle* to that shown (page 434) for an error in measuring the base.

Again, where a fort covers a small island or has its front washed by the sea, a base of 100 yards may generally be obtained, weather, &c., permitting, by sending out a boat attached to a rope of this length,—the observation being taken on shore where the other end of the rope is fixed.

Measuring the vertical angle subtended by a distant object and from it deducing the range is a common plan, but it has several drawbacks, the height of the object is usually only *supposed*, and in the case of a ship she may have a *heel* which will falsify your result, even supposing you to know the exact height of her truck above water. The variation, in the angle too, is so slight compared to that in the range, that no sort of accuracy can be expected in long ranges.

In conclusion I would suggest the applicability of the table (page 433) for other purposes than those of gunnery, such as measuring the breadth of rivers, and in taking rough military surveys.

#### PROPOSAL FOR THE ESTABLISHMENT OF SANITARY OFFICERS IN POPULOUS DISTRICTS, WITH THE VIEW OF IMPROVING THE STANDARD OF PUBLIC HEALTH, AND AMELIORATING THE CONDITION OF THE ARMY MEDICAL DEPARTMENT.

Contributed by R. DOMENICHETTI, Esq., M.D., Surgeon, 75th Regt.

In the present day no fact has been so generally recognised as the improvement of the public health by attention to the principles of sanitary reform, whether we regard the condition of the Army and Navy, or the civil population of this country. It is not my intention to consider how this has been brought about, but merely to advert to it as an accomplished fact, the details of which may be seen in the elaborate statistical reports of the Registrar-General.

With the view of enforcing these principles, and applying them