BALLISTIC EXPERIMENTS FROM 1864 TO 1880

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FROM

1864 TO 1880

BY

FRANCIS BASHFORTH, B.D.,

HONORARY FELLOW OF ST JOHN'S COLLEGE, CAMBRIDGE;
LATE PROFESSOR OF APPLIED MATHEMATICS TO THE ADVANCED CLASS OF R.A. OFFICERS, WOOLWICH;
AND FORMERLY FELLOW OF ST JOHN'S COLLEGE, CAMBRIDGE

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INSTITUTION OF THE ADVANCED CLASS FOR ROYAL ARTILLERY OFFICERS.

WHEN the Council of Military Education were preparing to establish the Advanced Class for Royal Artillery Officers, in 1863, they kindly invited me to become a candidate for the office of Professor of Applied Mathematics. But, as I was otherwise engaged, I felt obliged to decline the invitation. However, when they pressed me a second time, I had considered the matter, and found that it would be possible to determine the resistance of the air to the motion of projectiles by the use of a chronograph specially devised for that purpose. With proper assistance, it seemed to me that this work might be accomplished in about two years. In the Government application for temporary leave of non-residence for me it was stated that:

"No other candidates could be found (although the Council "pushed their enquiries in every direction) possessing to the "same extent the requisite combination of attainments. Should "Mr Bashforth's services, in consequence of the obstacle before "mentioned, be not available, the Council are of opinion that the "loss to the public service will be very great...."

When I arrived at Woolwich, April 1864, I found the President and Vice-President of the Ordnance Select Committee were very decidedly opposed to any new chronograph. They had made numerous experiments, and could furnish me with any quantity of results from their stores! Chronographs with rotating cylinders had been tried and had failed! &c. It was clear that the O.S.C. knew nothing whatever about the application of mathematics to ballistics.

I soon came to the conclusion that if my proposed chronograph was to be used I must provide my own instrument. But still,

I felt that it would be only prudent to ascertain whether, if I provided my own chronograph, facilities would be afforded me for *trying* it, and for *experimenting* with it. A favourable reply was promptly received from the Director of Ordnance, who concluded by stating:

"I am to add that Earl de Grey and Ripon recognises with "much pleasure the zealous and practical manner in which you "have entered upon your duties." May 17th, 1864. (84-B-1100.)

The construction of the chronograph was commenced in my own workshop during our August Vacation, 1864, and it was reported ready for trial with ten equidistant screens in June 1865. But it was not till the following November when the Select Committee thought proper to afford me an opportunity to try my new invention in Plumstead Marshes.

I. First day, Nov. 23, rounds 1, 2, and 5 were very good, but 3 and 4 were defective. Second day, Nov. 29, round 7 was the only good one, 6 and 9 were fired by mistake, and 8 was defective. For the third and last day, Dec. 12, new screens had been provided, when rounds 10, 11, 13, 15, 16, 17, and 18 were good, and only 12 and 14 defective. The trial was considered quite satisfactory, and the results were reported to the Council of Military Education, Dec. 18, 1865, who had them printed for private circulation.

A full account of the chronograph was communicated to the Royal Artillery Institution, Woolwich, which was printed in their *Proceedings* for Aug. 1866, pp. 161–192. This account was also published separately.

In Feb. 1866 it was arranged that an experiment should be made with the new chronograph to determine the resistance of the air to five different forms of heads of elongated projectiles. The forms selected were: (1) Spherical; (2) Spheroidal; (3) Ogival, struck with a radius of *one* diameter; (4) Ogival, struck with a radius of *two* diameters; and (5) an approximation to the form of least resistance.

II. Rounds (1–13) were fired at Shoeburyness on Sep. 25, 1866; rounds (14–31) on Sep. 26; and rounds (32–43) on Sep. 27.

The firing of the gun was often interrupted by the passage of barges, and on Sep. 28 not a single round could be safely fired on account of these barges. At last the experiment was closed by firing the 44th round into the sea, so that only 43 rounds of shot were fired on three days out of the 70 rounds prepared for the experiment. It was never satisfactorily explained how it happened that these *barges* interfered on *every day* appointed for my experiment. Full particulars of each round were given in my Report, dated Oct. 23, 1866.

The remarks made on this Report by the Select Committee showed plainly that they did not know what they were about. They objected that the velocities in one group varied as much as 73·4 f.s., and thereupon expressed *their opinion*, that Navez's instrument would give the "*best absolute velocities*"! Now, if the Select Committee had taken the trouble to *read my Report* before criticising it, they would have found a simple solution of their difficulty. For, when round 32 was first mentioned, it was plainly stated *gun loaded the day before.* The muzzle velocity in the next round, the 33rd, was also sensibly reduced, apparently from the same cause. The Select Committee had to withdraw their objection. The Report of this my first experiment with the new chronograph concluded:

"As an indication of the practicability of working the new "chronograph with rapidity and certainty, I give the following "times of firing several successive rounds when there was *no* "*interruption.*

"Round	23,	Sep. 26, 1866	2h	30′	30″	giving	9 records
,,	24	,,	2	37	20	,,	10 ,,
,,	25	,,	2	44	8	,,	10 ,,
,,	26	,,	2	49	35	,,	10 ,,
,,	27	,,	2	55	0	,,	10 ,,
,,	28	,,	3	0	20	,,	10 ,,
,,	29	,,	3	5	10	,,	10 ,,
,,	30	,,	3	11	8	,,	10 ,,
,,	31	,,	3	15	20	,,	10 ,,
Giving 9 rounds in			0	44	50	and	89 records."

A paper founded on the results of these experiments was communicated to the Royal Society, which was printed in the *Philosophical Transactions*, 1868, pp. 417–441.

Before proceeding further, it will be well to consider what progress the Ordnance Select Committee had made towards the determination of the resistance of the air to the motion of elongated projectiles. The Reports of their ballistic officers were as follows:

"The experiments referred to in this Report have regard "chiefly to initial velocity alone, and for the small distance con- "cerned the law of resistance adopted may be thought of small "practical importance, especially as before the experiments now "being carried on are concluded, the Committee will doubtless be "in a position to say whether this law is better expressed by a "function of the form $v^2 + \alpha v^3$, as proposed by General Piobert, or "by one of the form $v^2 + \beta v^4$, as proposed by the Count de St "Robert and Colonel Mayevski."

Captain Andrew Noble, *Report*, p. 3, 1862.

And again:

"It is regretted that this subject cannot be fully treated in "the present Report, but the difficulties in the way of a clear "solution are so many, and so great, that it would be difficult, "with our present experience, to assign any new law representing, "*with accuracy*, the resistance of the air to the motion of spherical "and elongated projectiles."

Lieut. W. H. Noble, R.A., *Report*, p. 19, April 2, 1865.

From this it is clear that, down to April 2, 1865, the Ordnance Select Committee and their ballistic officers had done nothing, by experiment, towards determining the resistance of the air to the motion of projectiles.

My determination of the resistance of the air for velocities 1,100 to 1,500 f.s., to four forms of the heads of elongated shot, was referred from the War Office to their Select Committee for their observations about Jan. 1867. And in the following May and June the Select Committee instituted experiments of the same kind, for one form of head. Their results were communicated to *The Engineer*, Nov. 15, 1867, claiming to have anticipated my results. Of course I complained to the Select Committee, but in vain. However, a higher authority very properly ordered them to insert in their *Proceedings* the following acknowledgement: