A Brief History of Powder Testers

by H. G. MULLER

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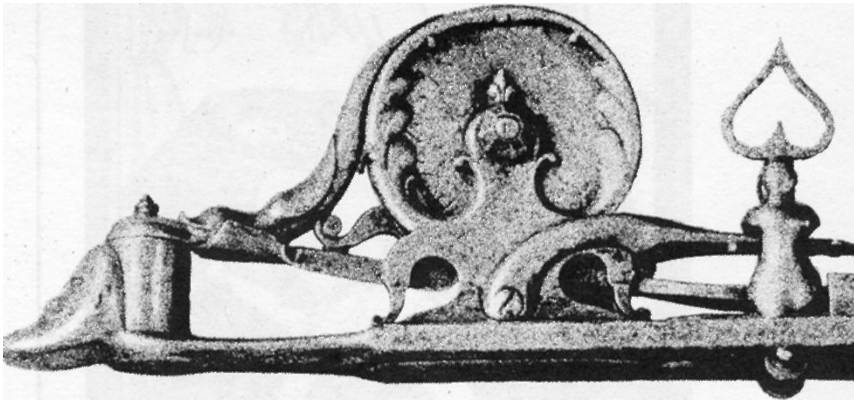
For almost 600 years, from about 1250 to 1850, gunpowder was the only explosive and propellant known. It consists of a mixture of carbon, sulphur and saltpetre. On ignition, more stable products of combustion, largely gaseous, are formed, and a considerable amount of heat is produced. The sudden increase in volume results in a loud noise and the heat produced causes a flame: this is an explosion.

The composition of gunpowder, i.e. the ration of the three ingredients, varied widely through the centuries. J.R. Partington, in his *A History of Greek Fire and Gunpowder* (Heffer, 1960), gives 38 different compositions which were used between 1260 and 1827, and an even greater number for various uses after that date, as for instance in small arms, cannon, sporting and blasting powders. In 1792 the great French chemist Berthollet[1] concluded from theoretical considerations that the best ratio was 75 parts of saltpetre, 12 parts of sulphur and 13 parts of charcoal. In 1888 Nobel and Able[2] established that 1 gram of powder gave 271.3 mililiters of gas at 760 mm pressure and 0°C. Since the heat liberated in the explosion amounted to 700.7 calories, the gasses would be hot and the volume larger still.

Early Powder Tests

Early tests on gunpowder depended on an inspection of the powder, an observation of its burning in the open and finally, on an inspection of the residue.[3,4,5] Fig. 1, taken from a 15th-century Viennese

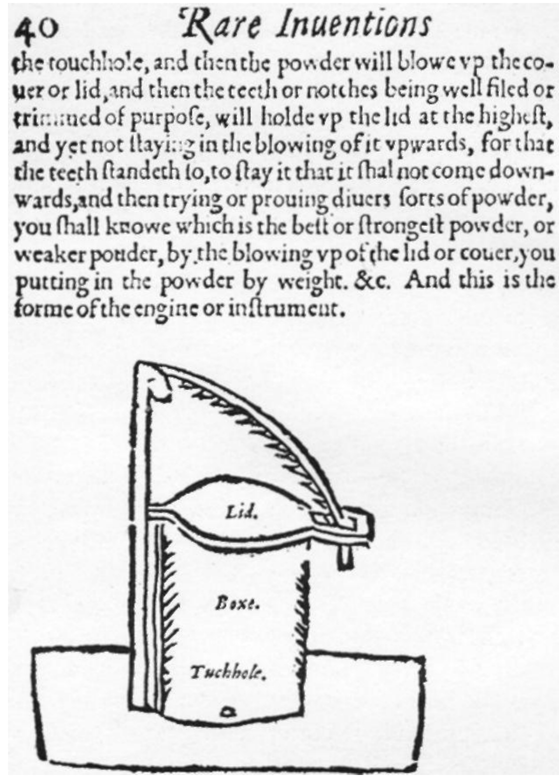


manuscript, shows such a test. Several pictures of this type can be found in old manuscripts, and Guttmann[6] noted that some of the experimenters shown invariably cover their eyes. The reason is not hard to guess—there exists at least one tombstone of a master gunner wearing an eye patch. .

Certainly not the earliest, but perhaps the most concise account of. this type of testing is given in Chapter 14 of the book *The Art of Gunnery* published in London in 1647 by Nathanael Nye, mathematician and master gunner of the city of Worcester:

> How you may by taste, feeling, colour and burning, know good and ill powder, and how amongst many sorts of Gunpowder you may know the best sort.
>
> 1. By how much gunpowder is the harder in feeling, by so much the better it is.
>
> 2. Gunpowder of a fair Azure or French Russet colour, is very good, and it may be judged to have all its receipts well wrought, and sufficient of the Peter well refined.
>
> 3. Lay two or three corns of Gunpowder upon a white piece of paper, the one three fingers distant from the other, and put fire to one of them, if the powder be good and strong, you shall see them all on fire at once, and that there will remain no grossness of 'Brimstone or of Saltpeter, no not any thing but a white smoky colour in the place where they were burned, neither will the paper be touched.
>
> 4. If good Gunpowder be laid upon the palm of your hand, and set on fire, you will not be burned.
>
> 5. Gunpowder that hath a very sharp taste, hath abundance of the Peter not well refined, and will moisten again.
>
> 6. If white knots, or knots of a French russet colour, shall remain after powder is fired, it is a sign that the Saltpeter was not well refined, but left full of salt, and grease, especially when the same knots shall in burning be dankish, and leave moisture in the place where the Gunpowder was burned.
>
> 7. If hard, dry and white knots, or pearls, shall remain after the Gunpowder is set on fire, it is a sign that the Gunpowder is not well wrought, and it becometh every gunner to beware of such powder, because if it doth lie long in a Piece it will wax so fine, that if you unload, not the Piece, it will in his discharge indanger the Piece of breaking.
>
> 8. If small black knots (which will burn downwards in the place where proof is made) remain after firing, they do show that the Gunpowder hath not enough of the Peter, and this it is of little force or strength, and slow in firing.
>
> 9. If a little heap of Gunpowder set a fire, doth make a noise, rise up with great speed, and yield little smoke, it is a sign of very good powder.
>
> 10. If the flame of fired Gunpowder shall rise

Fig. 1—Testing gunpowder by flashing it on a table. From a Viennese manuscript, 1437.



40 *Rare Inuentions*

the touchhole, and then the powder will blowe vp the couer or lid, and then the teeth or notches being well filed or trimmed of purpoſe, will holde vp the lid at the higheſt, and yet not ſtaying in the blowing of it vpwards, for that the teeth ſtandeth ſo, to ſtay it that it ſhal not come downwards, and then trying or prouing diuers ſorts of powder, you ſhall knowe which is the beſt or ſtrongeſt powder, or weaker powder, by the blowing vp of the lid or couer, you putting in the powder by weight. &c. And this is the forme of the engine or inſtrument.

Fig. 2—Bourne's powder tester of 1587.

up slowly, continue long, make little noise, and yield smoke in great abundance, it is a sign that the powder hath much Cole and Brimstone and too little Peter.

11. If Gunpowder burned upon a board shall black the same, it is a sign that there is overmuch Cole in that powder.

12. When Gunpowder is moist, or full of the earth of Saltpeter, it is naught to be shot out of great Ordnance, for it shameth the Gunner which useth it.

13. If Gunpowder be very black, it is either a sign that there is too much Cole, or that it is moist, and when you rub it upon white paper, it will black it more than other good Gunpowder will do.

14. Amongst many sorts of powder to know the best, make a little heap of every sort, and then setting those heaps one from another mark well when you put fire unto them, which of the heaps did soonest take fire, for that powder which will soonest be on fire, smoke least, and leave least sign behind it, is the best sort of Gunpowder.

Early Powder Testers

It seems that the first powder tester was described by William Bourne in 1587 in a book printed in London entitled *Rare Inventions and Strange Devises Very Necessary for all Generalles and Captaines.* The 54th "devise" describes a powder tester but it is not known if Bourne invented the instrument himself or merely recorded it. His book is now exceedingly rare and for this reason the section will be given verbatim (cf. Fig. 2):

> And as touching this, how for to make an Instrument or Engine for to knowe the goodnesse or the badnesse of powder (that is to say) to know the strength or weaknesse therof, they may doo it in this manner: first make in mettall or yron a round boxe of an ynch and a halfe in breadth more or lesse at your discretion and of two ynches deepe more or lesse, at your discretion, and then let that be placed so, that it may stand vpright, and haue a little tuch-hole at the lower part thereof, and then let the vppermost part at the mouth thereof, haue in mettall or yron a lid or couer that may goe with a ioynt vpon the one side thereof, and the couer or lid to be of a reasonable weight, and the other side of the couer or lid right against the ioynt to haue a square hole fitted of pupose, and then vppon that side that the ioynt

> of the couer or lid is of, there must bee raised a thing that must haue of yron or other mettall a part of a circle, and the other ende to goe through the square hole in the lid couer, and the other ende to goe with a pinne or ioynt right ouer the ioynt of the couer or lid, and the sayd crooked thing or part of a circle, to haue teeth or notches like vunto a Sawe, and the teeth to stand vpwards, and then it is finished, and then whensoeuer that you lift to prooue the strength of powder, and you hauing of diuers sortes of powder then wey some small quantitie of the powder and then put that into the Boxe, and then let downe the couer or lidde, and then giue fire vnto it at the touch-hole, and then the powder will blowe vp the couer or lid, and then the teeth or notches being well filed or trimmed of purpose, will holde vp the lid at the highest, and yet not staying in the blowing of it vpwards, for that the teeth standeth to, to stay it that it shall not come downwards, and then trying or prouing diuers sorts of powder, you shall knowe which is the best or strongest powder, or weaker powder, by the blowing vp of the lid of couer, you putting in the powder by weight &c. And this is the forme of the engine or instrument.

It is apparent from the drawing (Fig. 2) that the tester had a very large volume. Either the powder was extremely weak or else we have an explanation of the fact that none of Bourne's "wretched little engines" has survived. A third explanation is that since the lid yielded at the slightest pressure, there was a flash rather than a detonation, and hence little pressure was produced.

Furttenbach's Tester

Johann Furttenbach described his tester in 1627 in his *Halinitro-Pyrobolia,* printed in Ulm, Germany, and states that he invented it himself. After discussing the disadvantages of the visual and auditory tests he states:

> It is almost impossible to know precisely which, and how much, advantage one powder has before the other, from which arises a great error because by guess the worse is taken for the better in consideration; where no certain end point exists, there no infallible decision can be. Which error I have considered for many years, [and] whether a means could not be invented to ascertain closely how one powder compares with the other, and allow recognition of a forceful rise of an inch higher or less high. Finally, and not long ago in particular, I invented an instrument which in my opinion serves the purpose . . .

I do not wish to inflict upon the reader the full description of his instrument — it is shown in Fig. 3. The powder is placed into the barrel E and the weight F is shot upwards guided by two wires. Furttenbach recorded that cannon powder *(Carthaunen Pulver)* lifted the weight 4 inches, Mezan Powder, 5 inches, sporting powder *(Biirch Pulver) 9* inches, and an "extraordinarily fine powder prepared With particular diligenzia", 12 inches. With Furttenbach, powder testing had become a science.

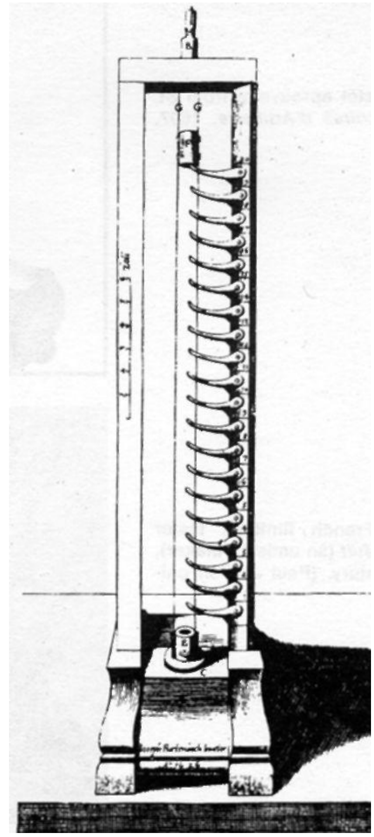


Fig. 3 — Furttenbach's powder tester of 1627.

It is perhaps amusing to record that the copy of Furttenbach's book in the library of the British Museum shows his autograph in his own handwriting, together with the comment "I have signed this, so that my character may be diagnosed."

It should be pointed out that in the Kunsthistorische Museum in Vienna there is, according to Guttmann,[7] a 19th-century replica of the Furttenbach tester. This was recently mistaken for an original.

The Work of Nye

The work of Nye was, as already observed, published in 1647. In it, he describes in detail a vertical tester, virtually identical with that of Furttenbach except that the former had 20 ratchets and the latter only 9. There can be little doubt, if we compare the two drawings, that Nye copied Furttenbach, al-

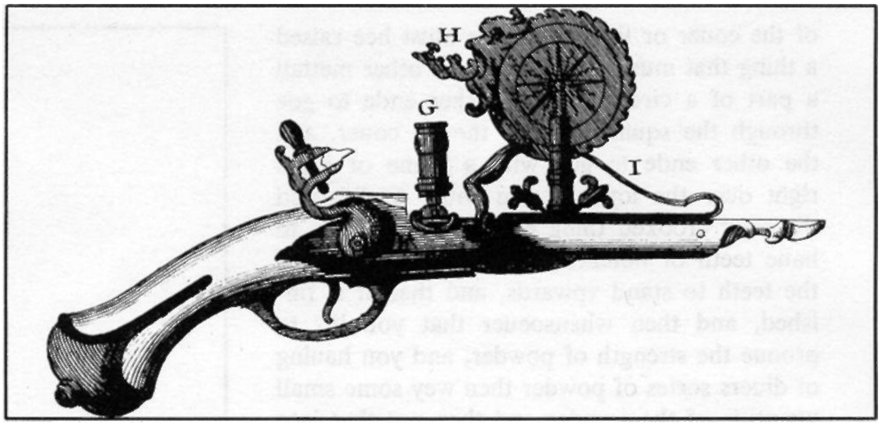


Fig. 4 — A pistol eprouvette from St. Remy's *Memoires d'Artillerie,* 1697.

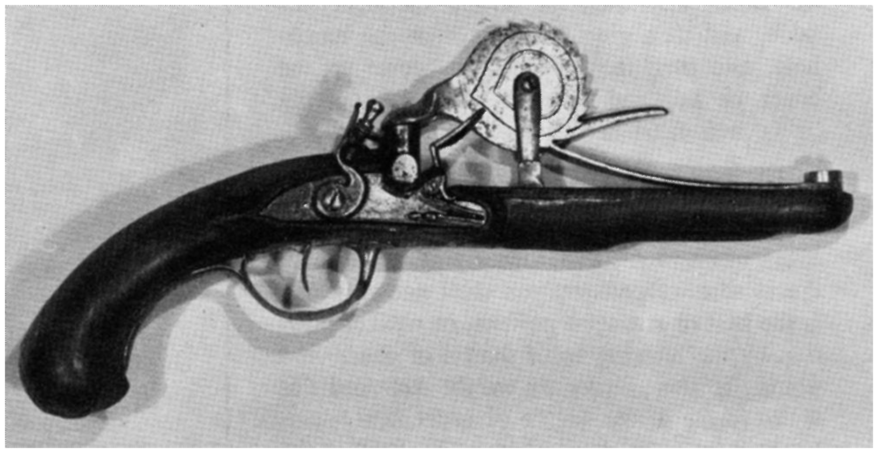


Fig. 5 — A French flintlock tester signed *J.B. Muit* (an unlisted maker), mid-18th century. (Paul J. Wolf collection)

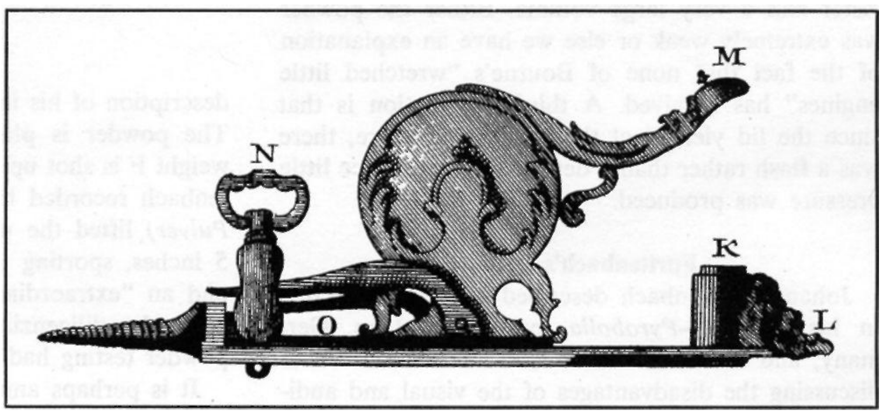


Fig. 6 — A match-type tester from St. Remy (see Fig. 4), 1697.

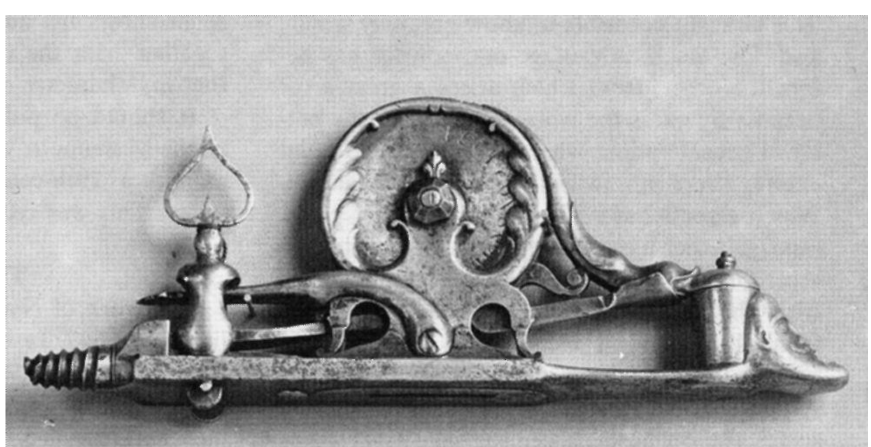


Fig. 7 — An Italian (Brescian) match-type tester, 17th century. (In the Walters Art Gallery, Baltimore, Md.)

though he does not acknowledge him. There is also no mention of Bourne's tester but, like him, Nye calls his own an "engine".

Nye introduced two other quantitative tests: discharging a pistol against a bank of clay, and, more important, testing by *mortar eprouvette.* The latter was adopted by Louis XIV of France (b. 1638, reigned 1643-1715) officially on September 8th, 1686, and was used by most European countries until well into the 19th century.

Figure 1 1 shows an English *mortar eprouvette* which was used as late as 1895 for the testing of gunpowder. Guttmann gives a full description of the gun and its use. (The French word *eprouvette* for powder tester appeared in English about the middle of the 18 th century and disappears from British encyclopedias about 1900.)

Again it is worth while to quote Nye *verbatim:*

> How to try the strength of powder some other ways than is before rehearsed.
>
> If you charge a pistol, and discharge it against a bank of clay, do this with a little powder, always observing to take the like quantity to a grain of one sort of powder, as you do another sort: then by measuring how far the bullet pierced in the clay, you may have some guess at the strength: also if you can make Rockets, such as fly into the air, and are made of powder dust, and charcole dust, by the strength or weakness of these you may know the like of powder.
>
> If you can get a little Morter Piece (what a Morter Piece is you may read anon) cast at the iron furnace where the iron is made, to get one made in such a place is no difficult thing: Let it be made about three inches Diam: at the mouth, and let the Chamber of the said Piece be three quarters of an inch Diam: and two inches and one third part of an inch deep, load the Chamber with about half an ounce of powder, but put no wad in after it, the reason is, because one wad may be bigger than another, which will cause error, then put into your Morter a bullet of lead or iron that will just fit the bore: now if it be of Iron, it will weigh three pound and ten ounces, if of Lead, almost five pounds: This Morter-piece being erected at a certain and unvariable elevation, and then being discarged, shall (by its several ranges) tell the exact difference of powder above any other instrument that can be invented, for by noting how many paces a shot rangeth, you shall find the true difference and be able to set down the true and infallible proportion betwixt all sorts of powder whatsoever.
>
> Because you may fail in procuring one made at the Furnace where iron is made, I will show you in the following Treatise how you may make such a one which may serve your turn.
>
> Thus having in the foregoing Treatise set down by whom, at what time, of what strength and violence Gunpowder was and when invented, also how to make any sort of gunpowder, & lastly to try its strength: I shall hencefollowing set down such Rules, that an ingenious man may learn to be a perfect Gunner, for I have omitted nothing that is necessary in that art.

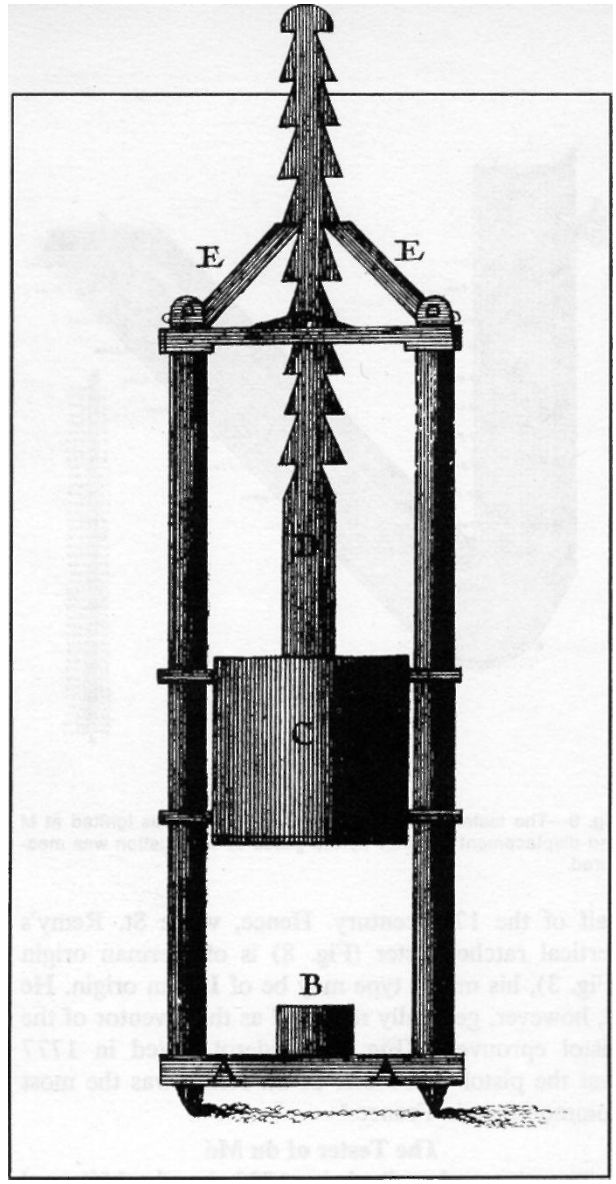


Fig. 8 — A vertical ratchet tester from St. Remy (see Fig. 4), 1697, similar to Fig. 3.

The Work of St. Remy

Surirey de Saint Remy published his book *Memoires d'Artillerie* in Paris in 1697 and in it described three testers. One is the pistol eprouvette shown in Figure 4. A surviving model is at present in the collection of P. J. Wolf and shown in Figure 5. Figure 6 shows a match-type tester and Figure 7 a similar one in a style of chiselled metal most clearly identified with Brescian (Italian) work of the second

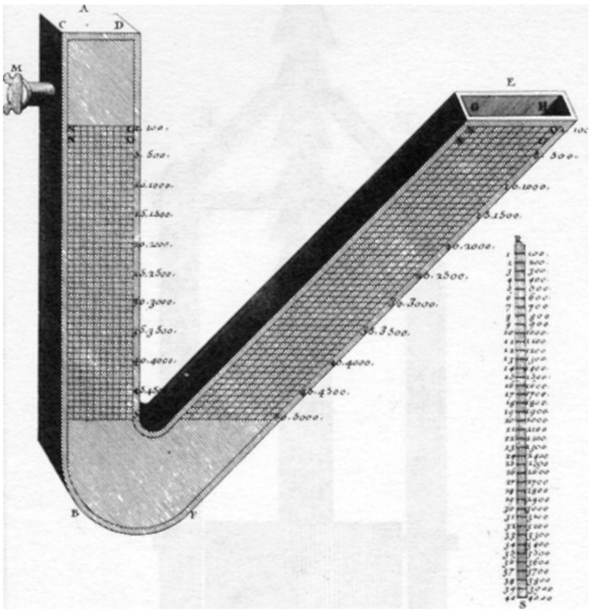


Fig. 9 — The tester of du Me, 1702. The powder was ignited at M and displacement of water by the gases of combustion was measured.

half of the 17th century. Hence, while St. Remy's vertical ratchet tester (Fig. 8) is of German origin (Fig. 3), his match type may be of Italian origin. He is, however, generally regarded as the inventor of the pistol eprouvette (Fig. 4). Diderot stated in 1777 that the pistol eprouvette of St. Remy was the most common type in France.[8]

The Tester of du Me

The tester described in 1702 by du Me[9] and shown in Figure 9 operated on a principle different from any tester previously ^developed, and it proved to be of great significance in elucidating the mechanism of the explosion. The tube was filled to the mark with water, and one cubic inch of powder ignited in sidearm M. The water displaced by the gas produced was determined, and found to be 4000 cubic inches.

The Work of Robins and Hutton

Principles of Gunnery (London, 1742), the authoritative work by Benjamin Robins, the noted mathematician, authority on fortifications and Engineer General to the East India Company, was of great significance and was translated into both German and French. He noted that de la Hire supposed the force of gunpowder to be due to the increased elasticity of the air contained in and between the grains and resulting from the heat of the explosion. Robins, however, using du Me's principle, discovered that gunpowder fired in a vacuum or in air produced 244 times its volume of elastic fluid (today we would call it a gas). Hence he argued that at explosion the elasticity of the "fluid" produced by the powder and contained in its original space was about 1,000 times greater than the elasticity of the air (the atmospheric pressure).

He also introduced what is now known as the ballistic pendulum (Fig. 10). He fired a ball of 0.25" diameter against the plate GKHI and measured the swing from the tape M. In this way he calculated the ball's velocity as 2,400 ft. per second. The method also allowed a fairly accurate evaluation of several different powders and as a result of his work the performance of English powder was greatly improved.

Robins concludes by stating that "the ascertaining of the force of powder and thence the velocity of bullets by its explosion, and the assigning of a method of truly determining their actual velocities from experiments, are points from which every necessary principle in the formation and management of artillery may be easily deduced. Considering, further, the infinite importance of a well-ordered artillery to every state, the author flatters himself that whatever judgment may be formed of his success in these enquiries, he will not be denied the merit of having employed his industry on a subject which,

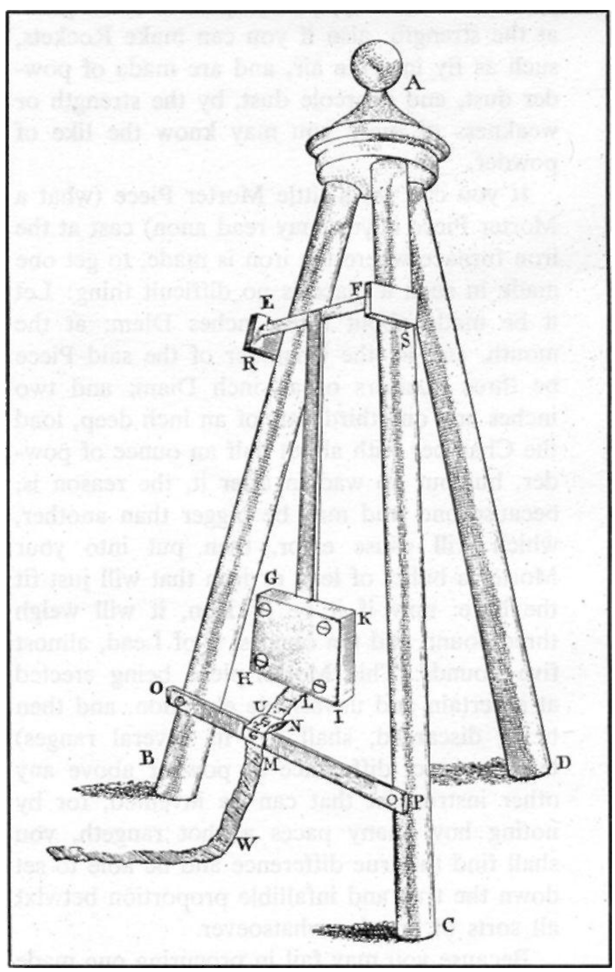


Fig. 10 — The Ballistic Pendulum of 1742 invented by Robins.

though of a most scientific nature, and of the greatest consequence to the public, has been hitherto almost totally neglected".

Charles Hutton,[10] Professor of Mathematics at the Military Academy, Woolwich, continued these studies. He revised and edited Robin's *Principles of Gunnery* in 1805. Hutton experimented with a modified form of the ballistic pendulum and stated that the maximum pressure of gunpowder was about twice that given by Robins (2000 atm. or 13 tons per sq. in.). He also concluded that "it would be a great improvement in artillery to make use of shot of long form, for thus the momentum of a shot, when fired with the same weight of powder, would be increased in the ratio of the square root of the weight of the shot".

Hutton also used a recoil gauge with which the recoil of a gun or cannon barrel could be measured. This type was in general use in England from about 1811[11,12] to after 1857[13]. Several modifications are on record: In 1812 Durs Egg took out a patent covering his invention where the recoil was measured against a spring or weight. As late as 1906 the *Harmsworth Encyclopedia* mentions under the entry

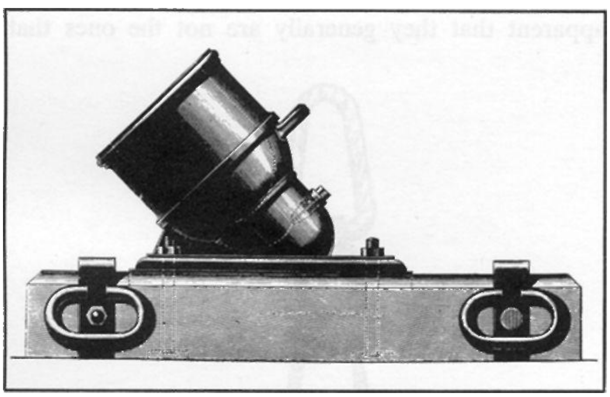


Fig. 11 — An English Mortar eprouvette.

"Eprouvette" a half-pounder gun where a tracer marked the extent of recoil over a waxed drum.

Count Rumford's Experiments

In 1797 the classical experiments of Count Rumford were communicated to the Royal Society.[14] He was previously known as Sir Benjamin Thompson, but on being created a *Graf* (count) in 1792 by the Elector Karl Theodor of Bavaria for his services rendered as a Bavarian General, he took his title from the name of his native town in America. He published several books and, although his experiments were made in Munich in 1792, they were communicated to the Royal Society. In prosecuting his remarkable experiments Rumford had two objects in view: (a) to ascertain the force exerted by explosive powder when it completely filled the space

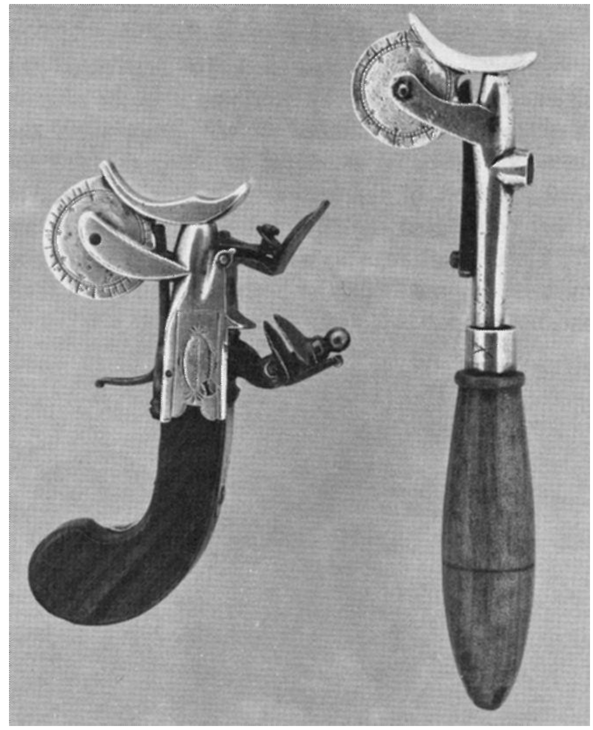


Fig. 12 — Two powder testers: "Commonly sold at the shops" in the early 19th century. (Author's Collection)

in which it was exploded; and (b) to determine the relation between the density of the gases and the tension.

The apparatus used by Rumford consisted of a small wrought iron vessel 0.25 inch (6.3 mm) in diameter, and containing a volume of 0.0897 cubic inch (1.47 cc). It was so arranged that the charge could be fired by the application of a red-hot ball: at the other end it was closed by a hemisphere upon which any required weight could be placed.

For carrying out an experiment, a given charge was placed in the vessel, and a weight considered equivalent to the resulting gaseous pressure was applied to the hemisphere. If, on the charge being fired, the weight was lifted, it was gradually increased until it was just sufficient to confine the product of explosion, and the gaseous pressure was calculated from the weight found necessary. The powder employed was sporting powder of very fine grain and, as it contained only 67 per cent of nitre, it differed considerably from ordinary powder. Its gravi-metric density was 1.08, but in his experiments Rumford appears to have arranged it so that the weight of a given volume of gunpowder was nearly exactly equal to that of the same volume of water. The charges with which Rumford experimented were very small: the largest, with one exception (which destroyed his vessel) was 18 grains (1.17 grams). The total quantity of powder required to fill the vessel was about 28 grains (1.81 grams). Rumford calculated that the tension of exploded gunpowder such as that employed by him, when filling completely the space in which it is confined, is 101,021 atmospheres (663 tons/sq. in.). He accounted for this enormous pressure by ascribing it to the elasticity of the steam contained in the gunpowder, the tension of which he estimated as being doubled for every addition of temperature equal to 30°F. He further considered the combustion of powder in artillery and small arms to be comparatively slow, and hence he assumed that the initial tension is, in their case, not attained.

Fig. 13—A tester of unknown origin. (Paul J. Wolf Collection, Missoula, Montana)

Some Other Eprouvettes

Contemporary with these scientific experiments, the pistol eprouvette of St. Remy was adapted in several European countries to existing pistols. Although all eprouvettes are extremely scarce, it is these which occasionally turn up in the antique trade. Figure 12 shows two such "powder-triers acting by a spring, commonly sold at the shops"[11]. Both are English and, judging by the almost identical wheel engraving, contemporary.

Figure 13 shows an interesting tester from the P.J. Wolf collection. This is possibly the Hoer recoil gauge described by Guttmann[7], who stated that "the unequal friction in the joints, the variation in the length of arms with varying temperatures, and the small charge, all go to make this instrument very untrustworthy."

The Regnier tester (Fig. 14) was used in France in about 1840 for the testing of sporting powder. "Powder for sporting usually marks 12 on this eprouvette and superfine powder 14. Each degree represents the effect of 1 kg. of powder placed so as to bring the two legs nearer together."[15] The tester of Devisme (Fig. 15) was depicted in the *Illustrated London News* of July 5th, 1851. Quite a number of these commercially sold, hand-held eprouvettes are still in existence.

Electrical Testers

The first idea of using electricity in ballistic experiments came from Prussia, where, in 1838, the Testing Commission of the artillery had such an instrument constructed to measure the muzzle velocity of a projectile. Progress in electricity gave rise to several such instruments in various European countries. In England, Sir Charles Wheatstone (the inventor of the Wheatstone bridge) experimented with his "electromagnetic chronoscope", but the error was too large: the velocity under identical conditions varied from 38.5 to 88.9 m/s). The instrument of the Belgian Capt. Navez,[18] built in 1847, was an improvement, and by the 1890's the chronograph of le Boulenge was widely used (Fig 16). Here the missile broke two wire screens (R and R,) a given distance apart, and the time taken for it was measured in terms of the space traversed by a freely falling body in the same time.

Conclusion

The history of gunpowder tests and eprouvettes is too interesting to merit the neglect it has suffered in general arms literature. Quite a number of eprouvettes are still in existence, but if these are studied in the light of their contemporary literature, it becomes apparent that they generally are not the ones that

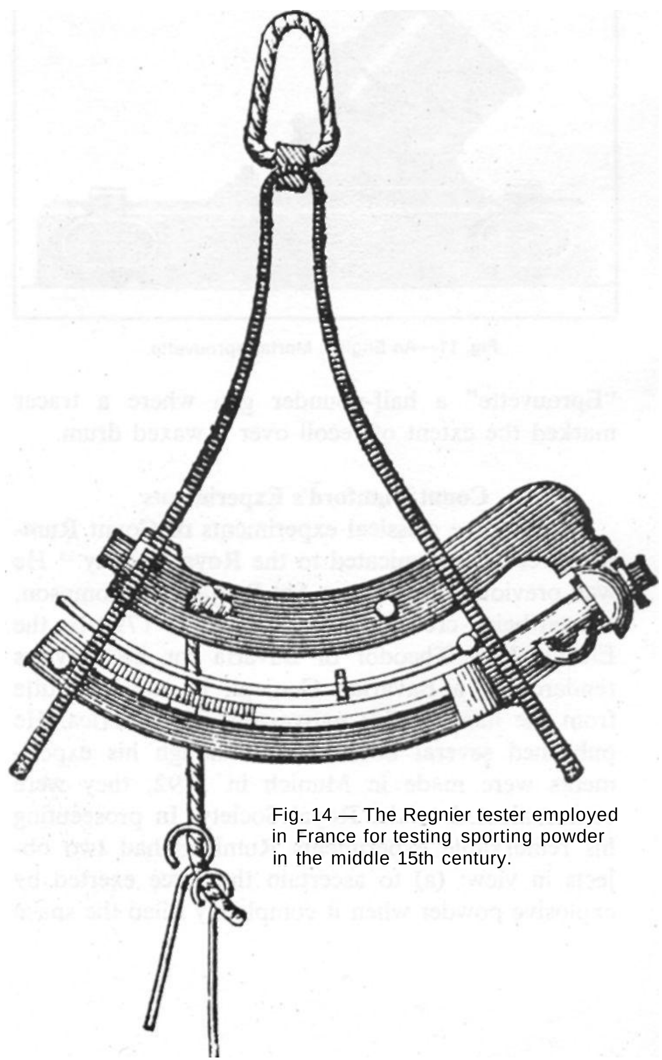
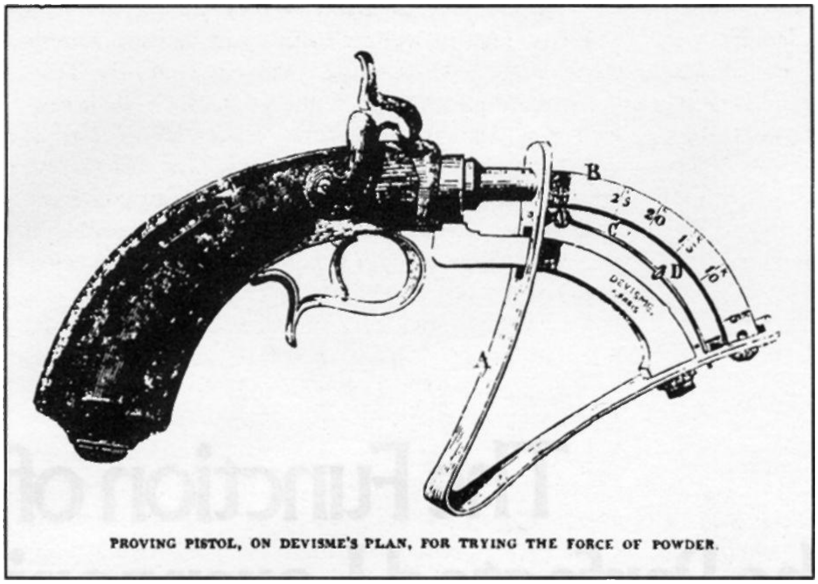


Fig. 14 — The Regnier tester employed in France for testing sporting powder in the middle 15th century.



PROVING PISTOL, ON DEVISME'S PLAN, FOR TRYING THE FORCE OF POWDER.

Fig. 15 — The Devisme tester, middle 19th century.

produced the great advance in scientific knowledge, but rather everyday household and gunshop devices.

Bourne's "wretched little engine," however feeble, was the first attempt at measurement. Furttenbach's invention was the next milestone and was to be used for over 200 years. Robins, Hutton and Rumford will be remembered for their great skill in applying analytical thought to the problem. Navez and le Boulenge pioneered electrical methods; and finally, with Capt. T.J. Rodman of the U.S. Army[17] and his pressure gauge, we have one of the last experiments on gunpowder. By then Schonbein had invented gun cotton and gunpowder had largely run its course. The era of the high explosive, for good or bad, had arrived.

ACKNOWLEDGEMENTS

I wish to thank most sincerely Mr. M. McLaren of the Explosives Research and Development Establishment, Waltham Abbey, for some fascinating early material, and Mr. P.J. Wolf, Missoula, Montana, for Figs. 5 and 13. Fig. 7 is reproduced by permission of the Walters Art Gallery, Baltimore, Md.

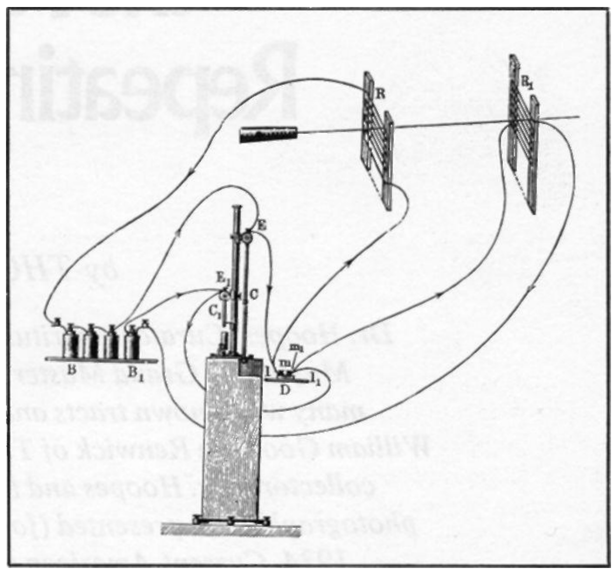


Fig. 16 — The chronograph of leBoulenge, 1890s.

NOTES

1. Berthollet, M.: (Trans. Hake, C.N., and Macnab, W.): *Explosives and Their Power;* Murray, 1892.
2. Nobel, A., and Able, F.: 1880, *Phil. Trans.,* 170, 203.
3. *Codex German.*, 600, Munich Staats-Bibliothek, Paper 22, 11 folio, ca. 1350-1400.
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