duct and of the vasa deferentia. Harvey, who was opposed to the notion of Fabricius, expresses the opinion that an intercourse once or twice repeated might suffice to impregnate a whole bunch of yelks, he having found that an egg laid on the 20th day of seclusion of a hen produced a chick*. This fact is an interesting one, however explained. It might be adduced in favour of the opinion of Fabricius; but inasmuch as the passage of the fully-formed egg in the act of expulsion does not necessarily secure the expulsion of any spermatozoa previously received into the oviduct, it is of little value in the argument: and here I may mention that I have detected spermatozoa in the oviduct, even in that portion in which the egg was receiving its calcareous incrustation.

III. "Researches on Gun-cotton.—Memoir I. Manufacture and Composition of Gun-cotton." By F. A. Abel, F.R.S., V.P.C.S. Received April 10, 1866.

(Abstract.)

A review of the researches on the production, properties, and composition of gun-cotton hitherto published, and a brief examination into the probable causes of the discrepancies exhibited between the results and conclusions of different experimenters, are followed in this paper by a criticism of the several steps in the system of manufacture of gun-cotton, as prescribed by Baron v. Lenk.

The conclusions arrived at on this subject are founded upon carefully conducted laboratory-experiments, and upon extensive manufacturing operations carried on during the last three years at the Royal Gunpowder Works, Waltham Abbey. In some of these operations v. Lenk's system of manufacture, as originally communicated to the English Government by that of Austria, was strictly followed; in others, various modifications were introduced in different stages of the manufacture—such as in the composition of the acids used, in the proportion borne by the cotton to the acids in which it remained immersed, in the duration of the treatment of cotton with the acids, and in the methods of purification to which the gun-cotton was submitted.

Exception is taken to one or two points in the general system of manufacture, and directions are indicated in which they may be advantageously modified; but the general conclusion arrived at is that, although Baron v. Lenk cannot be said to have initiated any new principle as applied to the production of gun-cotton, he has succeeded in so greatly perfecting the process of converting cotton into the most explosive form of pyroxyline or gun-cotton, and also the methods of purification, as to render a simple attention to his clear and definite regulations alone necessary to ensure the

* Opera Omnia, a Col. Med. Lond. ed. 1766, p. 206.

manufacture of very uniform products, which are unquestionably much more perfect in their nature than those obtained in the earlier days of the history of gun-cotton. Great stress is laid upon the fact that deviations from the prescribed process, which at first sight may appear trivial (such as a slight modification in the strength of the acids used, the neglect of proper cooling-arrangements), are certain to lead to variations in the products of manufacture, affecting their explosive characters, or their permanence, or both. A considerable deviation from the normal composition, due evidently to some accidental irregularities in the course of manufacture pursued, has been exhibited occasionally by gun-cotton obtained from the manufactories at Hirtenberg and Stowmarket.

The composition of gun-cotton has been made the subject of a very extensive series of experiments, both analytical and synthetical. The material employed in the analytical researches consisted of ordinary products of manufacture, prepared at Waltham Abbey, and obtained from Hirtenberg and Stowmarket. The general analytical results are as follows:—

Air-dry gun-cotton contains very uniformly about two per cent. of water, which proportion it reabsorbs rapidly from the atmosphere after desiccation. If exposed to a moist confined atmosphere, it will gradually absorb as much as six per cent. of water; but it rarely retains more than two per cent. upon re-exposure to open air.

The mineral constituents of gun-cotton vary according to the quality of the water employed in its purification. The average proportion of ash furnished by gun-cotton prepared at Waltham Abbey, where the water used is hard, amounts to one per cent. It should be observed that the process of "silicating" the gun-cotton, which is prescribed by Von Lenk, but the value of which is not admitted, has been applied at Waltham Abbey only in special experimental operations. Its use naturally adds to the mineral constituents contained in the finished products.

The proportions of matters soluble in alcohol alone, and in mixtures of alcohol and ether, were found to be remarkably uniform in products of manufacture obtained by strictly following Von Lenk's directions. In the ordinary products from Waltham Abbey, the matter extractable by alcohol amounted to between 0·75 and 1 per cent., and consisted of a yellowish nitrogenized substance possessed of acid characters, and evidently produced from matters foreign to cellulose (which are retained by cotton fibre after its purification), and the products of oxidation which escape complete removal when the gun-cotton is submitted to purification in an alkaline bath. The average proportion of matter extractable by ether and alcohol after the alcoholic treatment is from 1 to 1·5 per cent. This consists of one or more of the lower products obtained by the action of nitric acid upon cotton-wool, the existence of which was established by Hadow. The causes of the invariable production of small proportions of these substances in the ordinary manufacturing operations, and of their existence in larger quantities in exceptional instances, have been carefully examined into.

Their absolute removal from specimens of gun-cotton, purified for analytical purposes, was found to be almost impossible.

The methods employed for determining the proportions of carbon, hydrogen, and nitrogen in gun-cotton, and the relative proportions of carbonic acid and nitrogen furnished by its combustion, have been very carefully tested. Four different methods of determining the carbon were employed, and forty-nine successful estimations of that element have been accomplished in a variety of products of manufacture. A number of very concordant hydrogen-determinations, and eighteen direct estimations of the volumes of nitrogen furnished by the complete oxidation of gun-cotton, have been made. The individual as well as the mean results obtained in these analytical experiments correspond much more closely to the requirements of the formula $C_6 H_7 N_3 O_{11} = C_6 \left\{ \begin{matrix} H_7 \\ 3\,NO_2 \end{matrix} \right\} O_5$, *trinitro-cellulose*, or $C_{12} H_{14} O_7, 3N_2 O_5$, *trinitric cellulose*) than to the formula recently assigned for gun-cotton by Pelouze and Maury, $C_{24} H_{36} O_{18}, 5\,N_2 O_5$. The determinations of the comparative volumes of carbonic acid and nitrogen have furnished results closely in accordance with those of the direct determination of nitrogen.

Since the specimens of gun-cotton analyzed always retained small quantities of the products soluble in ether and alcohol, it was to be expected that the proportion of nitrogen found would be slightly below, and consequently that the carbon-results would be somewhat above, those which the chemically pure substance should furnish. The variations exhibited by the analytical results do not exceed such as are ascribable to the above cause.

A number of experiments were instituted with Hadow's method of determining the composition of gun-cotton, which consists in reducing the latter to cotton by means of potassic sulphydride. The results show that, although the method is useful for controlling the results obtained, by determining the increase of weight which cotton sustains by treatment with nitric acid, it does not afford sufficiently definite and trustworthy data to render it applicable as a method of ascertaining the degree of perfection of manufacturing products, *i. e.* the extent of freedom of a specimen of the most explosive gun-cotton from admixture with the soluble varieties.

The treatment of cotton with nitric and sulphuric acids has been varied in many ways in laboratory experiments, with the view to examine fully into the increase in weight sustained by the former, upon its conversion into the most explosive gun-cotton, and to determine what circumstances may exert an influence upon the amount of increase,—an acid mixture of uniform strength being employed throughout the experiments (3 parts by weight of sulphuric acid of spec. grav. 1·84, and 1 part of nitric acid of spec. grav. 1·52). The results arrived at may be briefly summed up as follows :—

Finely carded and carefully purified cotton-wool will sustain an increase

of weight varying between 81·8 and 82·5 upon 100 parts of cotton, if submitted for 24–48 hours to treatment with a very considerable excess (about 50 parts to 1 of cotton) of the acid mixture. Similar results may also be obtained by repeatedly treating the same sample of cotton for comparatively brief periods with fresh quantities of acid, provided this treatment be not too greatly prolonged. Lower results (somewhat above or below 78 upon 100 parts of cotton) are obtained if the cotton be submitted to treatment with a large excess of acid for only brief or for very protracted periods, or if it be left for about 24 hours in contact with a comparatively limited proportion of acid (10 or 15 to 1 of cotton). The increase of weight which 100 *parts of pure cellulose* should sustain by *complete* conversion into a substance of the formula $C_6 H_7 N_3 O_{11}$, is 83·3; if converted completely into a substance of the composition $C_{24} H_{36} O_{18}$, $5 N_2 O_5$, it should sustain an increase in weight of 77·78.

There is strong evidence that the differences between the highest results furnished by carefully purified cotton-wool, and the number 83·3, are to be principally ascribed to the small proportions of foreign matter still existing in the fibre at the time of its conversion.

The maximum increase of weight sustained by cotton of ordinary quality, such as is used in gun-cotton-manufacture, is, as might have been anticipated, below the result obtained, under similar conditions, with cotton of finer quality and more thoroughly purified. The highest numbers obtained by treatment of such cotton, in small quantities, with a considerable excess of acid, were somewhat below 181, from 100 of cotton. The increase of weight which this quality of cotton sustains is, however, more generally about 78 per cent.

Experiments are quoted which show that the attainment of lower results with cotton of ordinary quality is ascribable to the existence of higher proportions of foreign matters in the cotton under treatment.

Some quantitative manufacturing experiments yielded results considerably below those obtained with some of the same cotton in laboratory operations (171 and 176 of gun-cotton having been produced from 100 of cotton). The causes of these differences are investigated and explained.

The identity in their characters, and close resemblance in composition, of the most perfect results of laboratory experiments, and of the purified products of manufacture, the close approximation frequently exhibited by the weight of the former to the theoretical demands of the formula $C_6 H_7 N_3 O_{11}$ (which may be expressed as

$$C_6 \left\{ \begin{matrix} H_7 \\ 3\,NO_2 \end{matrix} \right\} O_5, \text{ or } C_{12} H_{14} O_7, 3 N_2 O_5),$$

and the satisfactory manner in which the unavoidable production of somewhat lower results in the manufacturing operations admits of practical demonstration, appear to afford conclusive evidence of the correctness of

either of the above formulæ, as representing the composition of the most explosive gun-cotton, and demonstrate satisfactorily that the material, prepared strictly according to the system of manufacture perfected by Von Lenk, consists uniformly of the substance now generally known as trinitro-cellulose, in a nearly pure condition.

IV. "On the Mysteries of Numbers alluded to by Fermat." By the Rt. Hon. Sir Frederick Pollock, Lord Chief Baron, F.R.S., &c. Received March 19, 1866. [See page 115.]

April 26, 1866.

J. P. GASSIOT, Vice-President, in the Chair.

The following communications were read:—

I. "On the Dentition of *Rhinoceros leptorhinus* (Owen)." By W. Boyd Dawkins, M.A., Oxon., F.G.S. Communicated by Prof. J. Phillips, F.R.S. Received March 28, 1866.

(Abstract.)

The fossil remains of the genus *Rhinoceros* found in Pleistocene deposits in Great Britain indicate four well-defined species. Of these the *R. tichorhinus*, or the common fossil species, ranged throughout France, Germany, and Northern Russia, and, like its congener the Mammoth, was defended from the intense winter cold by a thick clothing of hair and wool. Its southern limit in the Europæo-Asiatic continent was a line passing through the Pyrenees, the Alps, the northern shore of the Caspian, and the Altai Mountains. It has not yet been proved to have existed in Europe anterior to the deposit of the Boulder Clay. The second species, the *R. megarhinus* of M. de Christol, characterized by its slender limbs and the absence of the "cloison," has been determined by the author among remains from the brick-earths occupying the lower part of the Thames valley, and from the Preglacial forest-bed of Cromer. The species ranged from the Norfolk shore southwards through Central France into Italy. In France and Italy it characterizes the Pliocene deposits, being found in the former country in association with *Mastodon brevirostris* and *Halitherium Serresii*, in the latter with *M. Arvernensis*. From its southern range we may infer that the megarhine species was fitted to inhabit the warm and temperate zones of Europe, just as the tichorhine was peculiarly fitted for the endurance of an Arctic winter.

The third species is the *R. etruscus* of Dr. Falconer, confined to the forest-bed of the Norfolk shore, and, like the *R. megarhinus*, found in the Pliocenes of France and Italy; it ranged across the Pyrenees as far as Malaga, and is the only species known to occur in Spain.

The fourth, the *R. leptorhinus* of Professor Owen, is the equivalent of