fact, when reduced to a vacuum, 300,400 kilometres per second, while we may now regard it as well established that the true velocity is less than 300,000.

The next determination of the velocity of light was that of Michelson,[1] whose result was 299,910 kilometres per second. His investigation being a part of the first volume of the present series need not be here discussed, but it is worth while to remark that his method seems far superior in reliability to any before applied.

An attempt has been made by Messrs. James Young and George Forbes to improve Fizeau's method, by diminishing the uncertainty arising from the gradual extinction of the visible image.[2] By the method of these experimenters the result depends, not upon the moment when the image disappears, but when two images, side by side, are equal in brightness. This is effected by employing two reflectors, at unequal distances, but nearly in the same line from the telescope, to return the ray. Each reflector then forms its own image in the field of view of the sending telescope. With a regularly increasing velocity of the toothed wheel, each image goes independently through the same periodic series of changes as when only one mirror is used; but owing to the unequal distance the period is not the same. If the speed of the mirror be carried to such a point that the difference of phase in the two images is half a period, then one image will be increasing while the other is diminishing, and the stage at which the two images are equal would appear to admit of fairly accurate determination.

The distant reflectors were separated from the observing telescope by the Firth of Clyde. The distances were respectively 16,835 feet, and 18,212 feet. A study of the printed descriptions of their experiments gives the impression that the performance of the subsidiary parts of the apparatus was not such as to do justice to the method. The resulting velocity of light was 301,382 kilometres per second, and the difference between the extreme results of twelve separate determinations was 4000 kilometres.

The most important result of the work of these gentlemen, could it be accepted, would be the establishment of a difference between the velocities of differently-coloured rays. We may regard it as quite certain, from the absence of any change in the colour of the variable star, β Persei, while it is increasing and diminishing, that the difference between the times required by red and by blue rays to reach us from that star cannot exceed a moderate fraction of one hour. It is quite improbable that its parallax is more than 0″·1, and therefore probable that its distance is 2,000,000 or more astronomical units. The possible difference between the velocities in question can, therefore, only be a small fraction of the hundred-thousandth part of either of them. No apparatus yet devised would suffice for the measurement of a difference so minute, and we are justified in concluding that the phenomena observed by Messrs. Young and Forbes arose from some other cause than a difference between the velocities of red and blue rays.

The present determination had its origin as far back as 1867. In his "Investigation of the Distance of the Sun," published in that year, the author introduced some remarks upon Foucault's method, and pointed out the importance to the determination of the solar parallax of repeating the determination of Foucault on a much larger scale, with a fixed reflector placed at a distance of three or four kilometres.[3]

From that time forward the subject excited the attention of American physicists, several of whom formed plans, more or less definite, for executing the experiments. As, up to the year 1878, no important steps in this direction had been taken, the author, in April of that year, brought the subject before the National Academy of Sciences, with the view of eliciting from that body an expression of opinion upon the propriety of asking the Government to bear the expenses of the work. The subject was referred to a Select Committee, who, in January, 1879, made a favourable report on the subject, which was communicated to the Secretary of the Navy. On the recommendation of the Secretary, Hon. R. W. Thompson, Congress, in March following, made an appropriation of $5000 for the purpose, and the author was charged by the Department with the duty of carrying out the experiments.

In the meantime it became known that Mr. Michelson had made preparations for repeating Foucault's determination at his own expense, with the desirable improvement of placing the fixed reflector at a considerable distance. But before the reliability of Mr. Michelson's work had been established, the preparations for the present determination had been so far advanced that it was not deemed advisable to make any change in them on account of what Mr. Michelson had done. The ability shown by the latter was, however, such that, at the request of the writer, he was detailed to assist him in carrying out his own experiments, and acted in this capacity until September 1880, when he accepted the Professorship of Physics in the Case Institute, Cleveland, Ohio. After the departure of Mr. Michelson his place was taken by Ensign J. H. L. Holcombe, U.S.N., who assisted in every part of the work to the entire satisfaction of the projector until its close.

[1] "Astronomical Papers of the American Ephemeris," vol. i. part iii. Owing to an error in applying one of the corrections the result was given as 299,942 kilometres.

[2] *Philosophical Transactions* for 1882, p. 231.

[3] Washington Observations, 1865. Appendix ii.

PANCLASTITE

DR. SPRENGEL has sent us a reprint of a note sent by him to the *Chemical News* on this subject. After showing that these new explosives, so named by Mr. Turpin, are not original, he continues:—

"The 'beau idéal' of a detonating explosive is a mixture of 8 parts (88·9 per cent.) of liquid oxygen and 1 part (11·1 per cent.) of liquid hydrogen.

"In my paper of 1873 I say, p. 799:—'On referring to the foregoing table the reader will be reminded that peroxide of hydrogen is the highest oxygen compound known, while nitric anhydride is the compound which contains the largest amount of oxygen available for combustion (74 per cent.). But as this compound, as well as the next two, nitric peroxide (69·5 per cent. oxygen) and tetranitromethane (65·3 per cent. oxygen) are: at present: on account of their nature and their difficult preparation, mere chemical curiosities, my attention naturally turned to the fourth, to *nitric acid* (63·5 per cent. oxygen), which is a cheap and common article of commerce.'

"Now, when Mr. Turpin's attention turned to the second oxidiser on my list—to nitric peroxide—he found that this substance does *not corrode* metals, such as iron, copper, and tin under 356° F. (180° C.); and further, that combustible liquids, such as petroleum, carbon bisulphide, and nitro-benzene are readily soluble in nitric peroxide *without* rise of temperature. These are valuable properties, *first noticed by Mr. Turpin.*

"What was formerly a chemical curiosity is now an article of commerce. Nitric peroxide may be bought to-day at eighteenpence the pound, and I see ways and means of producing it a great deal more cheaply. Nitric peroxide is a yellowish liquid, heavier than water (sp. gr. = 1·451), and boils at 71° F. (22° C.), but may be kept like ether or similar volatile liquids. In France it is sent about in tinned-iron cans.

"Taking as a typical example a benzene-mixture—

$$\left.\begin{array}{l} C_6H_6 = 18{\cdot}4 = \begin{array}{l}17{\cdot}0\ C\\ 1{\cdot}4\ H\end{array} \\ 7\tfrac{1}{2}(NO_2) = \underline{81{\cdot}6} = \begin{array}{l}56{\cdot}8\ O\\ 24{\cdot}8\ N\end{array} \\ \qquad\qquad 100{\cdot}0 \end{array}\right\} = \begin{array}{l}62{\cdot}6\ CO_2\\ 12{\cdot}6\ H_2O\end{array}$$

we see, that the 18·4 parts of benzene require 56·8 parts of oxygen for the oxidation of their carbon and hydrogen to carbonic acid and water. This oxidation or combustion takes place at the moment of explosion at the expense of the 56·8 parts of oxygen, contained in the rest of the mixture—the 81·6 parts of nitric peroxide. No other explosive now in use (including blasting gelatin) contains weight for weight a greater amount of combustible matter, and as an explosion of *these* bodies is simply a sudden combustion, I again beg to draw attention to the fact that the oxygen available for combustion in gun-cotton is most probably not more than 32·3 per cent. and in nitroglycerin 42·3 per cent.,[1] while in this case we have without a doubt 56·8 per cent. Hence no other explosive now in use can rival this and similar mixtures in power, as I published in 1873. They still remain *the most powerful* explosives known.

"It hardly need be said that an explosive of this nature consists of two parts—an oxidising and a combustible agent—and that Mr. Turpin with the same *naïveté* lays claim not only to the first, but also to the latter half of the subject.

"None of my *safety*-explosives are licensed in England, though many of them, when mixed, are much less sensitive to concussion than common gunpowder.

"In April 1884 the French military authorities were busy near Rochefort with shells of the 'système Turpin.' These shells, so my informant said, were made of such a size, and possessed such a prodigious power, that a ship struck by one of them would inevitably be sent to the bottom of the sea, even were she the strongest ironclad afloat. It is devoutly to be hoped that those whose office it is to provide for the defence of the British Navy *will be ready* in the hour of need to serve out shells, filled with an explosive of equal force or better still with something superior, approaching more closely the 'beau idéal.'"

[1] Of these, by the bye, only 38·8 per cent. can be utilised for want of fuel, as pointed out by me in my patent of 1871, and verified four years later by the force of Nobel's blasting gelatin, in which the excess of 3·52 per cent. oxygen is utilised by the dissolved gun-cotton, an explosive too rich in carbon. See Abbot's table, p. 17, in "The Hell-Gate Explosion near New York and so-called 'Rackarock,' with a few words on so-called 'Panclastite,'" by H. Sprengel. London: E. and F. N. Spon, 1886.

MR. VERBEEK ON THE KRAKATÃO DUST-GLOWS

As it appears from the letter of Mr. Douglas Archibald in NATURE of April 29 (p. 604) that some doubt exists as to the quantity of volcanic dust ejected during the Krakatão eruption in 1883, it may not be inopportune to give an abstract of what Mr. Verbeek—the best authority on the subject—says in the second part of his book. The mistake in the number of cubic kilometres—which Dr. Riggenbach or his critic magnified from 18 into 150—may possibly have arisen from the comparison Mr. Verbeek draws between the quantity of volcanic substances ejected by the Tambora in 1815 and that ejected by Krakatão.

Junghuhn estimated the quantity of ashes ejected by the Tambora in Sumbawa at 318 cubic kilometres, but Mr. Verbeek reduces it by calculation to about 150, though he adds that the data are insufficient to form a really correct estimate. It is certain, however, that the quantity was considerably larger than that ejected by Krakatão. To calculate this quantity Mr. Verbeek made observations everywhere on the islands and along the coasts of the Straits of Sunda; while the thickness of the ashes which fell into the sea was computed according to the difference in the depths of the sea before and after the eruption, a difference which greatly varies, and amounts in some places to 40 metres, if not more. Wherever some doubt exists for want of previous accurate deep-sea soundings, Mr. Verbeek gives the lowest figures. These observations are all illustrated by maps. Mr. Verbeek estimates the quantity of ejected material which fell round the volcano at 18 cubic kilometres at least. The possible outside margin would, however, not exceed 3 cubic kilometres. Of this quantity, two-thirds, or 12 cubic kilometres, lies within a circle with a radius of 15 kilometres drawn round Krakatão, one-third, or 6 kilometres, outside it. Of the finer ashes a large quantity were already, during the first three days, blown into the sea, as appeared from observations made on ships; and Mr. Verbeek assumes that considerably less than 1 cubic kilometre remained floating in the upper regions of the atmosphere. This quantity would correspond to a layer of 0·002 millimetre thickness divided over the whole surface of the earth, or of 0·004 millimetre over the temperate zones only.

Such an infinitesimally thin layer could hardly have been the principal cause of the atmospheric phenomena. They must be accounted for in a great measure by the large volume of aqueous vapour ejected by Krakatão, the amount of which lies, unfortunately, beyond all calculation. We have to deal with two distinct phenomena, as Prof. Michie Smith also has shown by the two different spectra, and these phenomena had different causes: thus, the blue and green tints of sun and moon, which were specially observed during the first month after the eruption, and only in places close to the equator, must be principally ascribed to the *solid* particles in the volcanic ash-cloud, as various observations have shown that these are the main cause of the special absorption of the rays of light by which the sun appeared blue and green; the aqueous vapour may have increased the phenomenon, for it is known that the sun can look bluish through mist. It cannot be said to be a proof to the contrary that Mr. Lockyer saw the sun green through the steam which escaped from the funnel of a steamer, for probably a quantity of ash and soot-particles escaped from the funnel at the same time, and it is possible that the sun appeared green from that very fact. The steam was thus in the identical condition of our volcanic cloud. It was only in the beginning after the eruption, before the ashes had spread very far, and when, therefore, their density was greater, that they were able within a limited space to give green tints to the sun. This phenomenon ceased when the ashes were dispersed further round the globe—in the northern hemisphere by the south-west, in the southern hemisphere by the north-west winds—and when probably also a portion of them fell gradually on the earth.

The crimson after-glows which soon followed the eruption were observed *at the same time* over a much larger area than that within which the blue and green sun was seen at successive periods, and they are believed by Mr. Verbeek to have been caused mainly by the masses of aqueous vapour thrown out by Krakatão, and which formed the greater part of the volcanic cloud. This vapour, after condensing and freezing in the higher and colder regions of the atmosphere, produced the remarkably beautiful sunsets, while the ashes may have intensified the phenomenon, besides serving as a centre of condensation for the vapour. The real cause of the crimson glows was therefore probably the same as that of the evening red, their intensity being a consequence of the extraordinary quantity of vapour in the upper regions emitted by Krakatão.

THE PARIETAL EYE OF HATTERIA

Some little time ago, whilst engaged in work upon *Hatteria punctata*, I found a curious sense-organ embedded in the substance occupying the parietal foramen, but was unable at the time to examine the specimen further; Prof. Moseley has kindly directed my attention to a short paper published in the *Zoologischer Anzeiger*