

Fired Gunpowder" (published in London, 1802, and recently reprinted, with his other essays, in America).

Our Government official experiments give a pressure per square inch varying from 15.4 to 28.1 tons per square inch, the latter obtained in the 81-ton gun. Rumford's maximum was 277 tons, as shown by overcoming the tested tenacity of metal that the powder tore asunder; or 73 tons, as indicated by the lifting of a weight by the explosive energy.

As I explained in the paper above named, the tearing test is fallacious as a theoretical measure of the force exerted, because the tenacity of the metal was tested by Rumford, as it still is by others, in most cases, by a gradually-applied strain, which should not be compared with a vibratory shock. As a measure of the practical bursting possibilities of gunpowder upon metal of given thickness and tenacity, as usually measured, Rumford's figures are directly applicable, though allowance must be made for the relief afforded by the movement of the shot in a gun.

My appeal was for a repetition of Rumford's experiments by those who are responsible to the nation for these very serious matters, and for a reconsideration of the reliability of the method of testing by the "Rodman" and "Crusher" gauges, which have supplied such very different results from those of Rumford. My reasons for believing Rumford's experiments to be more reliable than those of the Committee were stated as follows, and I still maintain their cogency:—

"(1) The resistance to be overcome, and by which the force was measured, viz. the gravitation of a known weight, was by far more definite and measurable than the degree of indentation or compression of a cylinder of copper, which serves as the measure of force in the Rodman and Crusher gauges.

"(2) In Rumford's arrangement the force of the explosion was more directly applied to the resistance by which it was measured than in the official experiments, where the shock of the explosion was first communicated to a solid piston 1 inch in length, and by this transferred to the copper cylinder of the Crusher gauge or the knife of the Rodman gauge. By this arrangement much of the force is expended upon internal work in the intervening piston, producing mechanical vibration of its substance, and a returning wave of elastic compression, which would have no measurable effect on the gauge. Besides this, another portion of the force compressing the piston must be converted from mechanical motion into heat motion.

"If any reader supposes that I am hypercritical in making this objection, let him try the following experiment. Take a block of iron—a common 1 lb. weight, for example—place it on the hand, and the hand upon a table; then strike the weight smartly with a carpenter's hammer. It will be found that blows which would fearfully mutilate the hand if directly applied to it, may be struck upon the weight thus resting entirely upon the hand, and will scarcely be felt, provided the blows are dealt suddenly and smartly. The mountebank's exploit of breaking a great stone upon a man's bare breast, the common method of reducing the dimensions of geological specimens by holding them in the hand and cracking with a hammer, and the experiment of shooting a bullet through a swinging door without moving it on its hinges, are familiar illustrations of this principle, which appears to have been overlooked in these official researches.

"The complete absence of windage in Rumford's arrangement, by exploding in a perfectly closed chamber, is a third advantage. I therefore regard Rumford's experiments as the best that have yet been made on this interesting subject, although, as he himself admits, they are by no means free from error."

W. MATTIEU WILLIAMS

Photographs of Stellar Spectra

THE article upon this subject in NATURE, vol. xxxiv. p. 439, requires a correction which has been pointed out by Dr. Copeland. The spectrum of the star DM. + 37° 3821 was observed by him on September 22, 1884, and found to contain bright lines; the observation was published in the *Monthly Notices* for December 1884, but was overlooked at the time when the article above mentioned was prepared.

A similar correction, pointed out by Dr. Huggins, is required in the "Investigation in Stellar Photography" by the present writer, published in vol. xi. of the "Memoirs of the American Academy of Arts and Sciences." On p. 208 the method of observing stellar spectra by means of a prism placed before the object-glass of a telescope is ascribed to Secchi. In fact, it had previously been employed by Fraunhofer.

EDWARD C. PICKERING

The Late American Earthquake and its Limits

IN your very flattering *critique* of my "Alphabetical Catalogue of European Earthquakes" the reviewer says:—"The tendency to alignment in volcanoes has often been noticed; Prof. O'Reilly indicates a similar peculiarity in earthquakes, adding that the lines along which they range approximate to great circles. This inference or suspicion can be verified only by detailed charting." Judging from the facts published up to the present relative to recent earthquakes of America and Europe, I think some such verification has been furnished by them. At the Exhibition of Scientific Apparatus held at South Kensington in 1877, I exhibited a globe mounted so as to allow of great circles being easily traced through points on the surface. Several coast-line great circles were shown thereon, amongst them that of the southern boundary of the Tertiary formation in the United States. It was also marked on the sketch earthquake-map of Europe exhibited before the Section of Geology of the British Association at their Swansea meeting of 1882, and on other maps, such as the earthquake map of the British Islands; and yet no leading fact went to prove that any particular significance should be attached to this great circle. The earthquakes of August 27 and 28 in the United States have furnished, in my opinion, some proofs of this significance. The following are the places through which this great circle passes:—Victoria Fort, on coast of Gulf of Mexico; Cairo (Ill.); axis of Lake Erie; Lake Ontario; River St. Lawrence (parallel to); New Brunswick coast of River St. Lawrence; Labrador, south coast; York Point and Straits of Belle Isle; Ireland, Shannon mouth; Wales, south coast of; St. Bride's Bay; Mendip Hills; Southampton; Dieppe, north of; Chalons; Bâle, north-east coast of Zurich Lake; Coire; Trent; Venice; Dalmatian coast; south-west coast of Isola Longa; Mount Olympus; Skyro Island; Syrian coast, head of Akaba Gulf; Arabia, Mount Seiban, Wady Maifa; Cape Guardafui; Pacific Ocean, Paumotu Group; coast of Mexico, near Cape Corrientes; Zacatecas territory.

According to Major Powell's telegram, the origin of the earthquake was along a line of post-Quaternary dislocations on the eastern flank of the Appalachian Chain, especially where it crosses North Carolina. The great circle just described passes more inland than that mentioned by Major Powell, and was taken, as regards position, from the geological map of the United States, by C. H. Hitchcock and W. P. Blake, 1873, but it is parallel to the line limiting the Tertiary formation which crosses North Carolina, and which is probably also the seat of the post-Quaternary disturbance referred to. The great circle in question traverses the area of disturbance between Kennett (Ark.) and Buffalo (on Lake Erie). On the European side the following places lie near its direction. The Bristol coal-fields, where an explosion of fire-damp took place lately, about the time of the earthquake; the English Channel, lat. N. 50° 10' and long. W. 1° 43', where an earthquake shock is reported to have occurred by H. Mohn in your issue of September 23 (p. 496); the point lying about fifty-five miles to the south of the great circle, where it passes at Southampton. Switzerland: M. Forel reports in your journal of the 16th ult. (p. 469) a series of shocks in the western part of Switzerland having occurred in the first days of September, and which he considers as the *suite* of the earthquake of August 27. In Eastern Europe an earthquake occurred on this same date, which travelled eastward from Malta to the South of Italy and reached Smyrna, which lies somewhat to the north of the great circle. In Mexico an earthquake is reported as having occurred at Tequisquitlan on the 3rd ult. I can find no such place, but if it be the same as Tepantitlan, about fifty miles east-north-east of Guadalajara, it would be somewhat south of the great circle in question. As all these places are not far removed from the direction of the great circle, and as there must be several parallel lines of fissuring in the Appalachian Chain, thus forming a zone, there is in this way, I think, evidence furnished that a zone of seismic action exists, having the general direction of the great circle represented by the continuation of the boundary-line of the Tertiary formation in the United States to the west of the Mississippi Valley, as marked on the geological map of Messrs. Hitchcock and Blake.

In the map forwarded herewith I have defined the surface of disturbance by lines joining the extreme points mentioned as having suffered shocks; but further information may, and probably will, modify this outline. The polygonal form thus obtained is, I think, more satisfactory than the curved forms