common agreement among observers that the violence of storms is exerted over only limited areas, and is progressive in its character. There is also the other fact, that for structures of great span, the danger from repeated or "rhythmic" gusts (spoken of by Mr. Cooper) is exceedingly small. An examination of the storm record, given in the Central Park report, will show that the gusts are hardly such as to cause this danger to structures whose period of vibration is very slow.

The experiments and observations needed to secure a scientific treatment of the whole subject, and uniformity of practice among engineers, must be more exhaustive than any heretofore made; but we shall never reach the desired end by assuming that it is unreachable. In the hope that this review may assist in promoting a movement in the right direction, this paper is respectfully submitted.

P. S.—The writer would submit the following copy of a letter just received from Prof. Cleveland Abbe, of Washington, hoping that its suggestions may be favorably received by the Society.

ARMY SIGNAL OFFICE,
WASHINGTON, D. C., Feb. 8, 1881.

Mr. Collingwood, Assistant Engineer, etc.:

SIR: In reply to yours of the 5th inst., I will say that the relation between wind pressure and velocity has not as yet formed the subject of any special investigation by the officers of this office, as it is of minor importance in the study of weather and climate. But the practical importance of this subject, to engineers and others, is such, that this office has, on several occasions, considered the propriety of establishing at favorable stations, such as Cape Hatteras, and Mount Washington, apparatus for observing simultaneously both force and velocity during gales and hurricanes.

There has always existed, however, considerable diversity of opinion as to the apparatus most appropriate to this investigation, and I should be glad to receive from the Society of Engineers, or other experts, any suggestions upon this subject.

Not having access to the bulletins of your society, I can scarcely judge how far you have gone in the consideration of this very difficult subject, but I will append a list of titles of memoirs that you may find convenient to refer to.

I should be glad to obtain copies or titles of any memoirs relating to this subject which have been published in America.

Very respectfully yours, CLEVELAND ABBE.

T. R. ROBINSON.—Description of an improved Anemometer, etc. Trans. Royal Irish Academy. Vol. XXII. Dublin, 1850.

G. H. L. HAGEN.—Ueber den Widerstand der Luft gegen Planscheiben, etc. Abhandlungen d. Akad. d. Winnenschaften. Berlin, 1874. An abstract also to be found in Pogg. Annalen, Vol. 152, p. 95.

S. CAVALLERA.—Di un apparecchio per la determinazione, Sperimentale delle costanti, degli anemometri. Torino, Atti Accad. Sci., VIII. 1872–3, pp. 663–683.

F. STOW.—On large and small anemometers. Read January 17, 1872. Quarterly Journal of the Meteorological Society. April, 1872. Vol. I, pp. 41–49.

F. DOHRANDT.—Bestimmung der Anemometer Constanten. St. Petersburg, 1874, p. 60. Art. 5, Vol. IV., Wild's Repertorium.

H. THIESEN.—Zur Theorie der Wind Stärke-Tafel. St. Petersburg. 1875. Art. 9, Vol. IV. of Wild's Repertorium für Meteorologie.

H. THIESEN.—Same. Art. 11, Vol. V., of Wild's Repertorium für Meteorologie.

T. R. ROBINSON.—Proceedings Royal Irish Acad. 2d Ser., Vol. II., January, 1876, and abstract in Zeitschrift Oesterreichischen Gesellschaft für Meteorologie.

H. WILD.—Ueber den gegenwartigen Zustand der Anemometer verification. Bulletin de l'Acad. de St. Petersburg. Vol. XXIII., p. 176, December, 1876.

F. DOHRANDT.—Bestimmung der Anemometer Constanten (Fort Setzung), p. 28. St. Petersburg, 1878. Art. VI., Wild's Repertorium für Meteorologie.

WILLIAM E. WORTHEN.—I would ask Mr. Collingwood if he knows of any instrument by which to determine wind pressure. Some years since I had occasion for such a one, and went to Mr. James Green, the mathematical instrument maker. He showed me some, but said that they were not reliable, and that there were none manufactured that he would indorse, nor do I find since then any new form. Wind pressure is, I believe, generally estimated from velocity measures, but in pursuing my inquiry on these I consulted Charles B. Richards, one of our members, who had made experiments with two of Casella's anemometers, in his arrangements for the ventilation of the Connecticut State House; the results are published in the Journal of the Franklin Institute, May, 1875. Each instrument was tested by the maker, and a table of corrections furnished with each, and yet Mr. Richards reports that the indications of the two meters differed so widely that little confidence could be put in them. I have never been able to arrive satisfactorily at either the plus or windward pressure on a structure, or the minus or leeward. In the matter of ventilation of houses—I take it into consideration for the furnace air-ducts in the construction of chimneys—I follow examples that have stood. There is one at Hastings-on-the-Hudson, a part of the wreck of a sugar house, that ought, I think, to have blown down long ago. In "Silliman's Journal," some forty odd years since, I read of fowls being taken up in a whirlwind, and their feathers being blown out by the explosion of the air in their quills, showing that there was a considerable vacuum in the storm center. Mr. Chesbrough suggests whether there might not be a wind pressure instrument made on the principle of a pendulum, in which the force might be estimated by the amount the pendulum is swung out of plumb by it. It would seem that the list of a ship under canvas by the wind might offer some data of calculation, but they are unsatisfactory. M. Perrodil, in the "Annales des Ponts et Chaussées of 1877," gives a description of a steam gauge in which the velocity of the current is determined by the torsion of a wire. I have full drawings from him, and price.

A NOVELTY IN RAILWAY CONSTRUCTION.

The Darjeeling Tramway or Himalayan Railway is a novelty in railway construction, and will be justly regarded as one of the engineering sights of India. In his speech at the opening Sir Ashley Eden claimed for the enterprise the merit of having "solved problems never before solved in the history of railway undertakings. We know," he said, "of no other line which ascends 7,400 ft. in 50 miles, mounts gradients of 1 in 21, and comes round curves of 70 ft. radius." The line is described as presenting to the eye the appearance of a "snake winding up into the clouds." The tramway, which is 50 miles long, enables the journey from Calcutta—361 miles—to be performed in about 24 hours. Its terminus at Darjeeling is 7,690 ft. above the level of the sea. The capital of the Darjeeling Tramway Company is stated to have been raised entirely in India. The line was originally to have been completed within eighteen months, but this period has been exceeded.

The first rail was laid in May, 1879, and the contractors, Messrs. Mitchell Ramsay, succeeded in laying down the last between Jore Bungalow (7,800 ft. of elevation) and Darjeeling (about 7,400 ft.) in June last. The gauge is 2 ft. The rails are manufactured of toughened steel, and about 24,000 have been used in the construction of the entire line. Sleepers are laid at intervals of 2 ft. 8 in., extra sleepers being laid below the rail-joints; altogether above 100,000 sleepers have been used up. Bearing plates have been placed under the outer rails of all curves of 120 ft. radius and under, so as to preserve the rigidity of the outer rails. Taking the entire ascent, which commences at about the ninth mile from Silliguri beyond Lukua, at the edge of the Terai, the ruling gradient is 1 ft. in 25, but in isolated steep places the gradient is 1 in 20. From the ninth mile the line curves and recrosses the road frequently, as a rule, however, keeping to the in or hill-side of the roadway. The first distinct deviation from the ascending road occurs at a place locally known as either the Horse Shoe, the Trestle Bridge, or as Agony Point, where the line simply beetles over the edge of the *khud*, and where the trains for safety's sake slacken speed. Above Tendoria, at the nineteenth mile, the train passes through a narrow bridge and slowly describes a loop of some 640 ft. in length and then recrosses the same bridge. From the loop onward the line gradually ascends, bearing away to the right, with the *khud* below to the right of the train; while on the left rises a crumbling steep hill-side, looking very threatening, with enormous bowlders of disintegrated rock, some of which have already given much trouble to the line watchers and authorities of the company. The line doubles to the leftward near Mahanuddy and its tea-garden, and then runs parallel, but in the reverse direction, above the road which the train has just traversed. The ascent continues gradually to Kurseong, some 5,200 ft. above the sea, and thence onward past some very troublesome and equally unsafe hill-sides toward Sonada. Thence on to Jore Bungalow. From Jore Bungalow the line descends from the saddle, circling round wide deviations toward Darjeeling proper, which is reached in about seven hours, run through from Silliguri, provided no landslips or other obstacles bar the way. The engines at present used are tiny tank ones, the carriages like open tramcars of the rudest and most uncomfortable description. As regards the engines, they are just like ordinary level-line locomotives, trusting in the descent to very powerful brakes.

RICHMOND, VA., PUMPING ENGINES.

The most expensive hydraulic exhibit at the Centennial was the pumping engine furnished by Mr. Henry R. Worthington of this city, which supplied the entire exhibition grounds with water from its location on the west bank of the Schuylkill, just outside of the inclosure. The engine was of the duplex pattern, and had a capacity of 6,000,000 gallons daily. The plungers of the two horizontal, double-acting pumps were 22¼ in. in diameter; the cylinders 29 and 50¼ in. in diameter, and the stroke 4 ft. There were two single-acting air pumps, each 29¾ in. in diameter and 24-in. stroke, operated from the ends of a horizontal beam, with vertical lever attached, which received motion from one of the cross-heads. The pump was obliged to raise the water 208 ft.

At the close of the exhibition the engine was taken to the works of Mr. Worthington, in Brooklyn, where it remained until about six weeks ago, when the company received an order for it from the city of Richmond, Va., and on last Monday it was ready for steam.

The permanent pumping works of Richmond are being built on the canal near the Three-Mile Locks, which ar about three miles from the heart of the city, and will be run by water power. To keep the city supplied with water meanwhile—the old pumps being insufficient either in very high or very low water—this new steam pump was ordered. It is located on the north bank of the canal, about 150 yards below the locks.

It will require 180 horse-power to pump 6,000,000 gallons of water each 24 hours. The Erie City Iron Works furnish the four boilers. The boiler tubes are each 5 ft. in diameter and 14 ft. long, and were made within 10 days after the reception of the order. The pipes, which are to connect the steam pump with the main line (from the pump house to the new reservoir), are 24 in. in diameter and 677 ft. long, and were made and have all been delivered by R. D. Wood & Co., of Philadelphia. The water this steam pump will supply to the people of Richmond will be real river water, for it is taken up from the canal at a point only about 150 yards below where it enters into the canal from the river at Grant's dam. Right beneath the suction-pipes a brick and cement-lined well has been constructed. The bottom of the well is lower than the bottom of the canal, and a connection between the well and canal will soon be made.

The water from the pump will be forced up the hill in a diagonal line, 677 ft. to a junction with the new pump-house mains; from this point to the new reservoir the line is nearly straight. The connection pipes are 2 ft. in diameter; the main pipes 30 in. The vertical lift is about 185 ft. For the entire work the City Council appropriated $80,000.

THE STORAGE OF ELECTRICITY.*

BY SIR WILLIAM THOMSON.

The first and most obvious use of Faure's accumulator was stated by the author to be the production of electric energy at the most convenint time, and to keep it in store until it could be most conveniently used; but its largest use in electric lighting would be to allow steam or other motive power and the dynamo to work economically all day, or throughout the twenty-four hours where the circumstances were such as to render that economical, and then storing up the energy so that it might be drawn upon when the light was required. There was also a very valuable use of the accumulator in its application as an adjunct to the dynamo, in order to fulfill the first condition of giving greater regularity to the light-giving current and storing up an irregular surplus in such a manner that the stoppage of the engine would not stop the light, but only reduce it slightly, and so also that there would always be a good residue of two or three hours' supply of full lighting power after the driving machine was stopped, or a supply of light for eight or ten hours for a diminished

* Abstract of paper read in Section A, British Association meeting, York.