quarter of an inch upon the paper. One-quarter inch squared paper is used, the vertical lines marking fifteen minute intervals and the horizontal one-inch change in water level. To prevent the water freezing in the shaft during the winter months, oil was used, which had the effect of depressing the water level below the frost line.

In order to increase the value of these records, a similar instrument was set up at the Burlington Canal last September. Before bringing before you some interesting tracings taken from these instruments, permit me to summarize previous investigations in other countries.

This phenomenon had been noted by Duillier as early as 1730, upon the Swiss lakes, where it obtained the name of seiche, owing to the apparent "drying up" or recession of the water upon one side of the lake, when rising at the other. In 1779, De Saussure remarks that he believes local variations in the air pressure may be the cause. Vaucher supposed that the atmospheric pressure diminished over one part of the lake, while over another it remained constant or increased. If this change in pressure occurred suddenly, the water which had thereby been set in motion would not come to rest again until after a number of oscillations. Professor Forel agrees with this theory, which has also been accepted by Studer, Meyer and Favre. From 1854 to 1856 an important series of observations were made by six observers placed at different points upon the shore of Lake Geneva, who, using a system of signals to warn each other of the approach of an oscillation, noted the variations of the barometer and of the lake level. As Professsor Forel, in his article, entirely disregards these barometric observations, they do not appear to have been published

In 1876 Forel set up an automatic instrument to register these movements, and from records extending over four months he deduced the existence of three varieties of seiche, viz., transverse, duration 10 minutes; longitudinal, duration 70 minutes; intermediate, duration 25 minutes. Upon this instrument he also observed movements of what he terms "vibration" caused (1) by steamers. The interval between these is from 9 to 60 times greater than that between ordinary waves, and they preceded the approach of a vessel by about 25 minutes, or when it was 9½ kilometres distant, continuing for two or three hours afterwards. (2) By wind, having no regular time or rhythm, and varying in amplitude from nothing to 10 millimetres, and in duration from 45 seconds to three or four minutes. He remarks that "sometimes there are little or none with a strong wind."

Lord Kelvin gives a theoretic law for the duration of these seiches in any lake, viz.: the semi-period of an oscillation is equal to the time that a body, travelling at the rate which it would acquire in falling from a height equal to half the mean depth of the lake would take to traverse the length of the lake. Thus, the duration of a seiche is proportional to the square root of its mean depth. (Archives des Sciences Naturelles, Geneva, 1876). Applying this to Lake Ontario, and assuming the mean depth to be 300 feet, we obtain a theoretical duration for a longitudinal seiche, of over five hours. As will be shown later, the mean interval between the longest undulations, as taken from the Humber traces, is about 4 hours and 49 minutes. In 1880 Professor Forel, in a letter, states that the smaller and more rapid oscillations may be accounted for by dividing the lake surface into more than one nodal point. (Archives des Sciences Naturelles, Geneva, 1880). Mr. Crosman in his valuable charts of the great lakes refers to the existence of a "seiche" movement similar to that observed upon the Swiss lakes. He also states that when the lakes are undisturbed by the action of the wind, a regular series of small waves can be detected, which have a marked time interval of ten minutes. These pulsations appear on Lake Superior almost without cessation. Lastly, H. C. Russell, of Sydney, New South Wales, has studied these oscillations at the south end of Lake George by means of a self-recording gauge, and has obtained longitudinal seiche movements whose amplitude is about four inches, and time interval two hours and eleven minutes.

As the chief object of this paper is to demonstrate the direct action of the atmospheric waves upon the water, permit me to dwell for a moment upon the movements of the upper strata of our ocean of air, "at the bottom or on the shoals of which we live," as Humboldt so poetically says.

The late Professor Helmholtz, of Berlin, who has made a special study of atmospheric waves from theory and analogy with ocean waves, has clearly demonstrated the existence of huge waves or billows in the atmosphere like the waves in the ocean, which are due to friction between atmospheric strata of different densities, moving in different directions and with varying velocities. He also states these waves may be of all sizes from the minutest ripple to the gigantic billows which affect the barometer at the bottom of this ocean.* This theory is sustained by Professor Langley, of Washington,† and by Mr. Clayton, of the Blue Hill Observatory. The latter has also shown that the larger waves, as marked upon the barograph traces, have a maximum frequency with north-easterly winds, and a minimum frequency when the wind is from the south-west.‡ The chief point of origin of these waves appears to be at the lower boundary surface of the upper or poleward current which travels approximately from the south-west to the north-east in its spiral course around the globe. Its average summer velocity at this latitude is 60 miles per hour, which increases to 112 miles per hour during the winter months. When the lower stratum of air is travelling in an opposite direction to the superincumbent upper current, huge waves or billows are set up between these rapidly moving opposing currents, which are of different densities. Such conditions would exist during the approach of a cyclonic storm from the south-west. The influence of these huge waves extends to the earth's surface, where they have been recorded upon barograph traces. Other forms of wave movement in the lower air stratum (say cumuli level) may be caused by two subsidiary strata travelling at velocities and in directions differing from one another, as may often be observed during the approach of an important storm centre. These waves also extend to the earth's surface, and are recorded upon the barograph traces as short and rapid undulations.

Under certain conditions the existence of these atmospheric waves may also be observed in the cloud formations; for instance, during fine anti-cyclonic weather, one has frequently noticed great parallel bands of cirri clouds appear in the west, and rapidly extend eastward in advance of a severe storm. These represent the crests of the larger or primary billows mentioned by Helmholtz, and are caused by the lower denser stratum of air being forced up into a lighter and cooler level, where condensation takes place.

In order to pursue the study of the still smaller atmospheric undulations, which cannot be discerned upon the ordinary barograph, a simple form of self-recording air barometer was constructed and set up at the Observatory,

* From the Sitzungs-berichte of the Royal Prussian Academy of Sciences at Berlin, July 25th, 1889.

† Internal Work of the Wind, Smithsonian Contributions, 1893.

‡ Blue Hill Meteorological Observations, Vol. XL., Part III, Appendix E, 1853.