year. It is the first American nautical almanac and is considered to reflect great credit on the astronomers of that country. It is under the superintendence of Lieut. C. H. Davis, assisted in the physical department by professor Pierce.

No one has contributed more to the knowledge of Terrestial Magnetism, during the last few years, than my distinguished predecessor in this chair. Formerly we owed theories on this subject much more to the boldness of ignorance than to the just confidence of knowledge, but from the commencement of the systematic observations which Col. Sabine has been so active in promoting, this vague and useless theorizing ceased,—to be succeeded, probably ere long, by the sound speculative theories of those who may be capable of grappling with the real difficulties of the subject, when the true laws of the phenomena shall have been determined. Those laws are springing forth with beautiful precision from the reductions which Colonel Sabine is now making of the numerous observations taken at the different magnetic stations. In his address of last year, he stated to us that the secular change of the magnetic forces were confirmed by these recent observations,—and also that periodical variations depending on the solar day, and on the time of the year had been distinctly made out, indicating the sun as the cause of these variations. During the present year the results of the reduction of the observations made at Toronto, have brought out, with equal perspicuity, a variation in the direction of the magnetic needle going through all its changes exactly in each lunar day. These results with reference to the sun prove, as Colonel Sabine has remarked, the immediate and direct exercise of a magnetic influence emanating from that luminary; and the additional results now obtained establish the same conclusion with regard to the influence of the moon. It would seem, therefore, that some of the curious phenomena of magnetism which have hitherto been regarded as strictly terrestrial are really due to solar and lunar, as much as to terrestrial magnetism. It is beautiful to trace with such precision these delicate influences of bodies so distant, producing phenomena scarcely less striking either to the imagination or to the philosophic mind than more obvious phenomena which originate in the great luminary of our system.

New views which have recently sprung up respecting the nature of heat have been mentioned, though not in detail, by my two immediate predecessors in the chair of the Association. They are highly interesting theoretically, and important in their practical application, inasmuch as they modify in a considerable degree the theory of the steam-engine, the air-engine, or any other in which the motive power is derived immediately from heat; and it is correct theory alone which can point out to the practical engineer the degree of perfection at which he may aim in the construction of such machines, and which can enable him to compare accurately their merits when the best construction is arrived at.

A theory which proposes to explain the thermal agency by which motive power is produced, and to determine the numerical relations between the *quantity* of heat and the *quantity* of mechanical effect produced by it, may be termed a *dynamical theory of heat.* Carnot was the first to give to such a theory a mathematical form. His theory rested on two propositions which were regarded as axiomatic. The first embodied the abstract conception of a perfect thermo-dynamic engine, and has been equally adopted by the advocate of the new theory of heat.—Again, suppose a given quantity of heat to enter a body by any process, and thereby to change its temperature and general physical state, and then, by a second process, suppose the body to be restored exactly to its primitive temperature and condition,—Carnot's second fundamental proposition asserts that the quantity of heat which passes out of the body into surrounding space, or into other bodies, *in the form of heat*, during the second operation, is precisely the same as that which passed into the body during the first operation. This view does not recognize the possibility of heat being lost by conversion into something else,—and in this particular it is at variance with the new theory, which asserts that heat may be lost by conversion into *mechanical effect.* To elucidate this distinction, suppose a quantity of water to be poured into an empty vessel. It might then be asserted that, in emptying the vessel again, we must pour out just as much water as we had previously poured in. This would equivalent to Carnot's proposition with respect to heat. But suppose a part of the water while in the vessel to be converted into *vapour;* then it would not be true that in emptying the vessel the same quantity of water in the form of water, must pass out of the vessel as had before passed into it, since a portion would have passed out in the form of vapour. This is analagous to the assertion of the new theory with regard to heat,—which may be lost according to that theory, by conversion into mechanical effect, in a manner analagous to that in which water may be said to be lost by conversion into vapour. But the new theory not only asserts generally the convertibility of heat into mechanical effect, and the converse,—but also more definitely, that, whatever be the mode of converting the one into the other—and whether the heat be employed to produce mechanical effect, or mechanical force be employed to produce heat,—the same quantity of the one is always the equivalent of the same quantity of the other. The proposition can only be established by experiment, Rumford, who was one of the first to adopt the fundamental notion of this theory as regards the nature of heat, made a rough attempt to determine the relation between the force producing friction and the heat generated by it; but it was reserved for Mr. Joule to lay the true foundation of this theory by a series of experiments which, in the philosophical discernment with which they were conceived and the ingenuity with which they were executed, have not often, perhaps been surpassed. In whatever way he employed mechanical force to produce heat, he found, approximately, the same quantity of heat produced by the same amount of force; the force being estimated in *foot-pounds* according to the usual mode in practical mechanics,—*i, e,* by the motive power employed in raising a weight of 1 lb, through the space of 1 foot. The conclusion adopted by Mr. Joule is, that 1° Fahr. is equivalent to 772 *foot-pounds.*

These results are unquestionably among the most curious and interesting of those which experimental research has recently brought before us. When first announced some ten or twelve years ago, they did not attract the attention which they deserved; but more recently their importance has been fully recognized by all those who cultivate the department of science to which they belong. Of this Mr. Joule received last year one of the most gratifying proofs, in the award made to him by the Council of the Royal Society of one of the medals placed annually at their disposal. It may be known to many of you that we have in Mr. Joule a pupil, a friend, and fellow-townsman of Dalton.

This theory is in perfect harmony with the opinions now very generally entertained respecting *radiant heat.* Formerly light and heat were regarded as consisting of material particles continually radiating from luminous and heated bodies respectively; but it may now be considered as established beyond controversy that light is propagated through space by the vibrations of an exceedingly refined ethereal medium, in a manner exactly analogous to that in which sound is propagated by the vibrations of the air,—and it is now supposed that radiant heat is propagated in a similar manner. This theory of radiant heat, in accordance with the dynamical theory of which I have been speaking involves the hypothesis that the particles of a heated body, or a