

receivers are practically the same as those already described.

The steering telegraph was given a year's test in sea service on board the United States ship New York, and the test having been passed successfully, the apparatus has since been installed in the United States battleships Indiana and Massachusetts. It is now being installed in the Texas and is to be installed in the Brooklyn. The above particulars and cut appear in a recent issue of London Engineering.

THE TEMPERATURE OF INCANDESCENT LAMP FILAMENTS.

REFERENCE in a recent number of the Electrical World was made to a method of measuring the temperature of incandescent lamp filaments as employed by M. Janet. In a communication to the Académie des Sciences and published in Comptes Rendus, M. Janet gives more explicit details of the method employed. The method is based upon the experimental results of M. Violle, who has determined the mean specific heat of carbon between zero degrees and 1,000 degrees C. If E be the applied potential difference at the lamp terminals, by varying E both the resistance and temperature will vary. A curve may be plotted by using the resistance R as abscissa and E^2/R as ordinates where E^2/R is the loss in radiation at any temperature θ . By employing a lamp under normal conditions and interrupting the current at a specified time, the variation of the resistance of the filament may be observed as the filament cools. A second curve having the time as abscissa and the resistance as ordinates may be plotted. A third curve may be derived from the first by using the time as abscissa and the loss due to radiation at each instant as ordinates, the area of which curve will give the total loss due to radiation through the range of temperature employed, and by dividing by the mechanical equivalent of heat, the corresponding quantity of heat may be obtained. Assuming the filament to be of pure carbon, it is weighed and M. Violle's formula applied. M. Violle found that (a) above 1,000 degrees C. the mean specific heat of graphite may be expressed thus: $C_0^t = 0.355 + 0.00006 \times t$, where t is the time. (b) The heat given off by one gramme of graphite, between the temperature of volatilization and zero degrees Centigrade, is 2,050 calories. Therefore the boiling point of carbon is 3,600 degrees C.

ELECTRIC LIGHTING OF AVENUE DE L'OPERA, PARIS.

SINCE the 23d of November, Avenue de l'Opera, one of the finest thoroughfares of Paris, has been lighted by electricity, and the results obtained are certainly, from every point of view, most satisfactory. In the few lines that follow we shall give various data as to the principal arrangements adopted.

In order to supply the arc lamps of Avenue de l'Opera, a branch circuit was taken from the line already established in Rue Petits-Champs and in the avenue. It comes from the municipal works of the Halles. The primary line of 2,400 volts supplied by Ferranti accumulators enters a kiosk installed to the left, at the corner of Avenue de l'Opera and Rue Petits-Champs. The wires of the branch first traverse high tension bipolar interrupters, NN, and fusible circuit breakers, AA, insulated in petroleum and placed in porcelain receptacles. These apparatus are placed upon a slab of white marble that may be seen in the center in Fig. 2, which shows the installation of the transformers and the distributing apparatus in the kiosk. Each of these two circuits is connected with a 15 kilowatt Labour transformer constructed by the Société d'Eclairage Electrique, and designed to supply 25 arc lamps of a model that we shall describe further along. The transformers are placed at the upper part of the kiosk. The primary circuits have an e. m. f. of 2,400 volts, and the secondary ones of 220 volts. At their exit from the transformers the secondary circuits supply the lamp circuits, which all end in the kiosk, each at a separate board. The cables, which are concentric, of 0.006 square inch section, and covered with lead, are placed directly in the ground at a depth of 24 inches, with a metallic grating to indicate their presence. The concentric cable permits of preventing the effects of induction upon the

iron armature and upon the different neighboring cables.

The arc lamps are mounted by fives in tension. Special branches have been formed through the aid of junction boxes at the foot of each lamp post. It is in these boxes that the junctions of the annular cable are made. At the exit the concentric core of the cable is connected with a bipolar commutator of two directions that permits of making the current pass into the lamp or into an equivalent resistance.

The lamps, which are 50 in number, are distributed in 10 circuits, 5 of which are permanent and 5 variable. The two transformers mentioned above are each designed to do duty for 5 circuits. It is possible, at will, to couple either the permanent or the variable circuits upon the same transformer through the maneuver of special commutators.

The distributing boards designed for each circuit of 5 lamps are likewise placed in the kiosk to the right

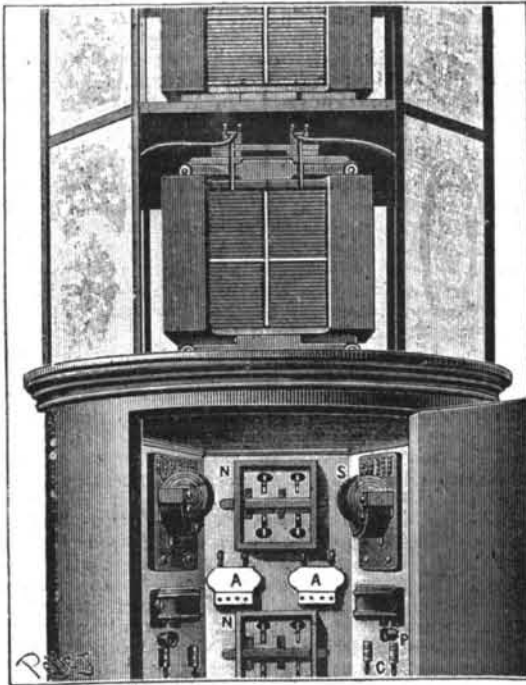


FIG. 2.—INTERNAL VIEW OF THE KIOSK CONTAINING THE TRANSFORMERS.

and left of the board at which ends the line coming from the works. Each board includes two circuit breakers, C, a plug, P, for interposing an amperemeter, a self-induction coil, S, and a grounding apparatus of the Cardew type.

The lamps used are the Kremenezky differential ones, with fixed luminous point, of 14 amperes, operating by fives in tension upon 220 volts. These lamps were selected after a competition at the Halles works between the various models of lamps for alternating currents.

The effective electromotive force at the terminals of each lamp is 36 volts. A loss of 20 volts is reckoned in the self-induction coil for assuring a certain elasticity of regulation.

The lamps are placed upon posts 16 feet in height and 43 in number at the right and left of the avenue, and 7 in number in the center of the thoroughfare. An internal reflector is fixed in the globe so as to send all the light to the ground. The distance between the posts is about 58 feet. Fig. 1 gives a general view of the installation of the posts and shows the arrangement adopted. The view was taken from Theatre Français Place.

The installation here described, which gives life to the avenue and modifies its aspect at night, was made by the municipal service of electricity of the Halles under the direction of M. H. Marechaie, engineer of the first section. The lighting is brilliant and shows three sharply defined lines of fire.—La Nature.



FIG. 1.—GENERAL VIEW OF AVENUE DE L'OPERA (PARIS) LIGHTED BY ELECTRICITY.

SCENERY OF THE MOON.

By Sir ROBERT BALL, Lowndes Professor of Astronomy, University of Cambridge, in the N. Y. Sun.

NOTWITHSTANDING that the moon is 240,000 miles distant from the earth, it would in some respects be hardly an exaggeration to assert that we are better acquainted with the topography of our satellite than we are with that of the globe which forms our home. No doubt it may at once be admitted that with respect to a large portion of the moon, dwellers on the earth are necessarily in total ignorance. It is a peculiarity of our satellite that it manages its movements in such a manner as to withhold nearly half of its surface from ever being inspected. It follows that we have no means of learning what is on the other side of the moon. I do not suppose, however, that in these days any one believes that if we could see it we would find any characteristic difference between the scenery on the remote side of the moon and on the side which is turned toward the earth. So far, however, as the neighboring globe is displayed for our observation, we can certainly assert that there is hardly a spot possessing the size of an ordinary parish which has not been studied and photographed, sketched by competent draughtsmen, duly laid down on elaborate charts of the lunar surface, and in many cases received the dignity of a special name.

The circumstances of the moon's situation render it much easier for us to survey its scenery than it is to survey the scenery of any other celestial body. For in the first place, the moon may be regarded as quite close to the earth, in comparison with the distances by which we are separated from the other heavenly objects. The sun is nearly four hundred times as far away as the moon; and that planetary globe whose surface we have studied to the greatest advantage—I mean, of course, Mars—is, even under the most favorable conditions, still at a distance from the earth which is not less than one hundred and forty times as great as that of the moon. But besides its comparative proximity, there is another circumstance which renders it comparatively easy for us to study the features on our satellite. If a globe like the earth in size, as well as in other particulars, had been situated at the same distance from us as that at which the moon now revolves, it seems quite possible that we should never have been able to obtain any clear notion as to the geography of such a globe. For our earth is, of course, surrounded by a thick coat of atmosphere: this atmosphere is at all times, and in all parts, more or less opaque from the presence of large quantities of floating material, while there are always some regions where there is temporarily complete obstruction from the presence of clouds. The atmosphere would thus oppose great difficulties to the study of the geography of our earth by an outside observer. It may, indeed, be well doubted whether even the outlines of the continents could be completely discerned, notwithstanding that the area of the earth at the distance of the moon would be thirteen times larger than that of the moon as presented to us.

For the purpose of the terrestrial astronomer, it fortunately happens that the moon is almost entirely destitute of atmosphere. The features of its surface are consequently never obscured by any of those causes which would tend to hide the features of the earth from outside scrutiny. Whenever the clouds on our globe are out of the way, it is then possible to observe the moon with but little obstruction. If we also remember that many of the features of our satellite are within reach of a telescope of comparatively moderate power, it will not be surprising that the lunar scenery has attracted so much attention and that thousands of minute features on its surface have been carefully identified. In some cases, accomplished observers have devoted themselves with praiseworthy assiduity to the detailed examination of special parts on the surface.

It would be impossible to enumerate all the astronomers of recent times whose labors have been directed to the study of the lunar scenery. I may, however, here mention a few names, adding the remark that there are doubtless many others whose valuable labors could not be overlooked if it had been possible to give a more complete account of the subject than would be practicable within the limit of the present article.

First, I must mention Mr. Nasmyth, who was at once a famous mechanical engineer, a skillful artist, and a devoted student of the stars. He employed his well-earned leisure in the study of celestial objects, and he devoted especial attention to the moon. The work which he produced in conjunction with Mr. Carpenter is a standard authority on the lunar scenery, and is perhaps one of the most beautifully illustrated books that has ever been devoted to the subject of the heavens. I must also refer to Prof. Holden and other distinguished astronomers at the Lick Observatory, on the top of Mount Hamilton, in California. They have applied their resources to the photography of the moon with remarkable success, and some of their pictures of our satellite have formed the basis upon which Dr. Weinek has produced exquisite drawings of the lunar features.

As, perhaps, the latest book on the topography of the moon, I may mention the elaborate work by Thomas Gwyn Elger, who is himself one of the most assiduous of lunar observers. He has collected together the most interesting facts relative to the topography of our satellite. I am much indebted to the various authorities I have named for information which I am utilizing in the present paper.

When we look up at the full moon, even without calling the telescope to our aid, we at once notice the presence of a number of large dark patches. It is certainly true that there are no sheets of water nor anything like water at present visible on the moon, even with the highest power of our telescope. In fact, there are sound physical reasons why it does not seem the least likely that there could be any water in the fluid form present in our satellite. At the same time the appearance of these dark spots, in days before telescopes were employed, suggested that those objects were basins of water, and accordingly they were anciently called "seas." In modern days, astronomers have somewhat awkwardly retained this name, or its Latin equivalent, to designate these peculiar dark tracts, notwithstanding the absence of water. Many of these are of enormous extent, so-called seas, to be reckoned in thousands of square miles. In fact, nearly half the visible surface of the moon is so occupied. It

is still an open question as to whether these regions have ever been covered with water. No doubt it seems the simplest supposition, so far as certain phenomena are concerned, to believe that they are the basins in which great seas did once roll, but that as the moon has gradually cooled down from a primeval state in which it was largely composed of molten matter, the water from the seas penetrated into the interior, and there entered into chemical union with the materials which were crystallizing. It certainly does seem that whole oceans full of water could have been thus disposed of. There are, however, many who believe that these dark regions are due to the pouring forth from the interior of vast volumes of molten lava which spreads over deep hollows, burying more or less completely the objects which had previously occupied them. In some places indications are found that these regions were once occupied by other structures of which only vestiges are any longer to be discerned.

There can be no doubt that these so-called seas lie lower than the general surface of the moon. If water was to be poured on our satellite, it would certainly tend to fill the basins once again. Close examination of these remarkable tracts shows that the grayish, slaty tint that they usually present is by no means uniform. As Mr. Elger remarks: "I have frequently seen the surfaces in many places covered with minute glittering points of light, shining with a silvery luster, intermingled with darker spots and a network of streaks, far too delicate and ethereal to represent in a drawing." In certain places in the lunar "seas" regions of a yellowish or greenish tint have been occasionally noticed when the illumination was under suitable conditions. Such tints have sometimes been attributed to the possible presence of some form of vegetation, though this would hardly be compatible with the absence of a lunar atmosphere.

The grandest illustration of this class of objects is the great Oceanus Procellarum, which covers an area not very different from that occupied by European Russia. If, however, we desire to look at one of the objects of this class which seems most emphatically to suggest its origin to have been an ancient sea basin, I would specially call attention to the Mare Crisium. It needs but little effort of the imagination to fill this remarkable gulf with water, and then to see how its margin forms the cliffs against which the waves have hurled themselves for centuries. Close examination reveals that the floors of these "seas" are marked over with various irregularities, so that when such features are spoken of as smooth, it must be understood that this is merely by way of contrast to the extreme ruggedness which prevails over the greater part of the lunar surface.

The most characteristic features of the scenery of our satellite are, however, the remarkable objects which are the results of volcanic phenomena. There are many classes into which these objects can be divided, but for our present purpose it will, perhaps, be sufficient if we attempt to give some brief account of what may be called the walled plains, and of the volcanic craters properly so termed. According to Mr. Elger, the most perfect example of a walled plain on the moon is the great object known as Ptolemaeus. The remarkable district so designated covers an area on our satellite considerably larger than Wales. It is situated nearly centrally on that face of the moon directed toward us, so that it generally lies very conveniently placed for examination. It will be recognized as the last of a chain of four magnificent objects of the same character, which lie along the coast of that darkest of lunar seas, known as the Mare Nubium. Ptolemaeus may be described as almost circular in outline, though sometimes it might be regarded as a rudely six-sided figure. Its appearance may be compared to that of an eyeglass, whereof the little handle is formed by a beautifully shaped crater bearing the name of Herschel. The floor of Ptolemaeus is a plain, not much depressed below the general level of the lunar surface. It is so vast that an observer placed in its midst would see a boundless horizon stretching away from him on all sides. He would not realize the fact that Ptolemaeus was surrounded more or less completely by a noble circle of lofty mountains, for these mountains would be below his horizon. Some of the peaks ascend one mile, and, in certain cases, even two miles above the interior of the plain. At certain points the mountain chains will be found interrupted by mighty passes. Especially is this the case on the margin between Ptolemaeus and the next adjoining walled plain, which is called Alphonsus.

To my mind, however, the most interesting of these objects, as well as perhaps the most perfect representative of its class, is the beautiful walled plain named Plato. This is so well placed, and has such a striking appearance, that it is probably one of the first objects which a student of lunar topography succeeds in identifying. No other object of the same character happens to lie in its neighborhood, and, consequently, there is but little difficulty in distinguishing the walled plain referred to; for it may be remarked that the aspect of the moon changes so frequently that the identification of some features is at times a little troublesome. This partly arises from the never ending varieties of light and shade as the moon changes from day to day.

There is also another circumstance which is sometimes apt to puzzle the beginner, for, owing to what is called the moon's libration, the face which is directed toward us is not always exactly the same. Hence it follows that at different times the distances of objects from the circular edge of the moon to which they are lying nearest will be found to vary. The difficulties will, however, not prevent the student from readily identifying the superb object known as Plato. It lies in the northern region of the moon, and as our telescopes exhibit the object inverted, this means that Plato must be sought at the lower part of the field.

This walled plain is situated on the coast line of a magnificent lunar sea, namely, the Mare Imbrium, which may, perhaps, be described as a stupendous gulf branching off from the Oceanus Procellarum. This is, indeed, the region of the moon toward which we would specially direct the attention of the student. There he will find magnificent examples of the most striking types of lunar scenery. The floor of Plato measures about sixty miles across. It may be said to be flat, with the exception of certain small irregularities; but the fact which chiefly strikes the attention of

the observer, and which is specially noticeable in the photographs, is the unusual darkness of that floor as compared with other parts of the moon. The rampart of mountains which surrounds Plato is comparatively perfect, and no more pleasing lunar picture can be beheld than when the shadows of these mountain peaks lie stretched along the dark central floor, as they do when the sun is in such a position that it would just appear to be rising to a lunar inhabitant who was stationed in the neighborhood.

I may mention that the shadows of lunar mountain peaks not only greatly enhance the beauty of our lunar picture from a spectacular point of view, but they have another importance. They present to the astronomer the only means which he possesses for measuring the altitudes of the lunar mountains. For, as a lunar mountain is more or less pointed toward the observer, its elevation above the surface cannot be attained by direct measurements.

We may illustrate the process employed in the determination of the altitude of a lunar mountain by the operation of calculating the height of a flagstaff from knowing the length of the shadow which it casts at noon. If the length of that shadow be measured on certain days, which will, of course, vary with the latitude of the observer, then the length of the noontide shadow of the flagstaff would not be different from the height of the flagstaff itself. If the observations be made on any other days save those which have just been mentioned, then the length of the noontide shadow would be greater or less than the altitude of the flagstaff. However, by a little calculation, which any one who has learned mathematics can easily understand, it is possible from knowing the length of the shadow and the true altitude of the sun at noon on the day in question, to determine the height of the flagstaff by which that shadow has been cast.

We can measure the lengths of the shadows which are cast by the mountain peaks on the surface of the moon. Suppose, for instance, the shadows were observed to extend half way across the floor of Plato; in such a case we know that the length of the shadow would be about thirty miles. From our knowledge of the relative positions of the earth and the moon we can determine the height of the sun as it would have appeared to a lunar observer. These facts suffice to enable us to ascertain the altitude of the corresponding peaks.

The isthmus on which Plato is situated contains many other interesting objects. In fact, the student could have no better study than to familiarize himself with the characteristics of the several objects, around the Mare Imbrium. Beginning at the northern point, we first come to the very remarkable bay known as the Sinus Iridum. Then comes Plato, and then the gulf sweeps round by a noble range of mountains called the Caucasus, between which and the range of the Apennines there is a passage which leads into the Mare Serenitatis.

At this point the observer will not fail to notice three splendid rings lying out in the Mare Imbrium. The smallest of these is the Autolyceus. Directly below that is the larger ring known as Aristillus, which is thirty-four miles in diameter. Its rampart rises upward of two miles above the surrounding plain, while the interior of it is depressed some 3,000 feet below the level of the general lunar surface. Aristillus may be regarded as a typical lunar crater, inasmuch as it is adorned by a lofty mountain peak ascending from the center. A view of the multitudes of details in this mighty extinct volcano will reward the diligent student who has the use of a good telescope. If he should be an artist, he will find ample scope for practice with his pencil in delineating the many features of this superb piece of lunar scenery. The third of the three craters which form this noteworthy group lies far out in the Mare Imbrium, and is the famous lunar object known as Archimedes. This crater is not quite so large as Plato, but its floor presents multitudes of points of interest to assiduous lunar observers.

Returning, however, to the neighboring coasts from our survey of these objects out in the Mare Imbrium, we perceived the splendid range of the lunar Apennines. The objects so called are by far the most magnificent range of mountains that can be seen on the moon, ascending, as some of its peaks do, to an altitude of about 18,000 feet above the surrounding plain. This superb range extends for a distance of no less than 400 miles along the shore of the Mare Imbrium, and the special summits which have been noticed upon it are to be numbered in hundreds. The Apennines project a mighty promontory into the Mare Imbrium, which terminates in the crater known as Eratosthenes. This object is of interest as being, perhaps, the volcanic vent for the mighty forces which were once concerned in the upheaval of this mountain range connected with it.

The promontory thus magnificently ended points to another lunar feature. This is the great crater Copernicus, which is regarded, and I believe justly regarded, as the most noteworthy object on the moon. It stands isolated in the Oceanus Procellarum, and this peculiar situation gives to Copernicus a distinctness which makes it very easy to recognize. The central regions of the ring are adorned by a mountain, some of whose peaks attain about half a mile in altitude. Among the features which make Copernicus specially interesting as a telescopic object are the remarkable terraces which are to be seen in its interior. They are apparently due to successive floodings of the crater by lava. It seems probable that they were produced in the following manner: Suppose that in connection with some outbreak the crater became filled with lava, then after a period of quiescence the surface of this would become congealed. If the molten lava beneath subsided, it would leave a margin of solidified material, which would form the first or highest terrace. At a subsequent outbreak the basin might have been only partially filled, so that the lava did not ascend to so great an altitude. This would in due course become congealed on the surface, and again the lava would subside, thus forming a second terrace.

I must here specially mention a remarkable characteristic of lunar scenery which is displayed on a grand scale by Copernicus. I allude to the presence of bright radiating streaks which extend from the great crater for many hundreds of miles over the lunar surface. The explanation of these bright streaks offers

one of the most difficult problems in lunar physics. They are sometimes thought to mark lava flows from the central spot at some earlier phase of eruption than the crater as it now stands would indicate. It does not, however, seem apparent why these streaks should in this case possess the peculiar brightness which characterizes them.

Near the southern pole of the moon is the remarkable crater known as Tycho. This is situated in a region where the scenery indicates the wildest and most magnificent confusion. Tycho is specially noticeable for the number of bright streaks which radiate from it. Indeed, at the time of full moon, when these streaks are peculiarly visible, they have frequently been likened to meridians diverging from a pole. Nasmyth supposed that these streaks were due to cracks in the moon, and that through these cracks lava had welled out from beneath. He gives a striking illustration of the mechanical possibility of this doctrine, by showing how a glass globe has been observed to crack in such a way as to produce a system of streaks exactly resembling those seen to diverge from Tycho on the moon.

It is known that great volcanic outbreaks on the earth, such, for example, as the renowned discharge which took place at Krakatoa in 1883, have been attended with the evolution of enormous quantities of volcanic dust, or comminuted pumice, which was of a light grayish color. It may, as Mr. Elger suggests, perhaps have happened that volumes of volcanic dust have issued from the fissures produced in the moon, under the influence of the cracking suggested by Nasmyth. This dust would accumulate along the lines of fissure: for it must be remembered that, as there is no air on the moon, there would be no wind to blow the dust away, as there would be on the earth. There, consequently, the dust would remain, and its characteristic whiteness would present just the same appearance that the streaks now seem to have. This view seems to present the most reasonable explanation at present available as to the origin of these remarkable lunar characteristics.

One more striking feature in the scenery of our satellite should be referred to. I mean the deep but narrow clefts or chasms which extend for hundreds and often for thousands of miles across the lunar surface. These chasms seem in all probability to owe their origin to earthquake shocks, by which the moon was shaken in the days when its volcanoes were still active. Those days seem, however, to have long since passed. The volcanoes on the moon no longer give any manifestation of energy. They are all extinct and silent; for though one or two cases have been recorded in which apparent changes have been thought to have taken place, yet, even if we admit the reality of such changes, they are but insignificant.

The fact is that the moon appears to have lost its volcanic energy. This is doubtless due to the circumstance that our satellite, being a small globe, relatively to the earth, has already cooled down to such a point that there is no longer sufficient internal energy left to produce a volcanic outbreak. The earth is so much larger that it still retains large quantities of internal heat, which manifests itself occasionally in the eruption of volcanoes. The difference between the earth and the moon in this respect may be expressed in this way: That while we have many extinct volcanoes on the earth, and comparatively few active ones, yet on our neighboring globe all the volcanoes seem to have passed into the extinct condition.

METEOROLOGY IN SCHOOLS.

AMONG the many new subjects that are now pressing for admission to the course of instruction in our schools there is none better entitled to such admission than meteorology. There is no subject of greater practical importance. There is none a knowledge of which does more to make our daily life interesting. There are few subjects that lend themselves more readily to teaching. The next few years are destined to witness a very great extension the teaching of meteorology in our schools. At present this teaching, so far as there is any, is vague, indefinite and unsystematic in many cases, because the teachers themselves do not know how to go to work.

The liberal policy of our weather bureau makes it possible for every school in the United States to receive a daily weather map, an opportunity given to the schools of no other country. These maps present the facts of the weather conditions over the United States, and it is from these facts that the scholars should be taught to draw their own conclusions as to the general laws controlling our weather and its changes from season to season and from day to day.

Simple observations, however carefully made, are not enough. A simple inspection of the daily weather map, with its great store of material gathered from all over the country, is not enough. The observations should be summarized and studied, and the results of such study should become familiar to all the scholars. Then a systematic progressive course of instruction in the practical use of the weather map should follow. Beginning with the simple elements alone, such as temperature, winds and weather, and going on to the more complex relations existing between pressure and weather, etc., the children will progress materially and without difficulty, until they have discovered for themselves the principal laws which are working to give us our changes from hot to cold and wet to dry.

Such systematic study of the daily weather maps is easily within the scope of the children in the upper and middle grades of our grammar schools, and it should unquestionably precede any text book work, which may be taken up later, if opportunity offers. In order to advance and systematize the teaching of meteorology in our schools, the New England Meteorological Society two years ago offered a brief course of instruction in the use of the daily weather maps, in accordance with the recommendations of the committee of ten on secondary school studies, to teachers in places in the vicinity of Boston. This course has now been given in Cambridge, Hingham, Natick, Abington, Brockton and Peabody. In all these places instruction in meteorology has been introduced into the schools, in accordance with the scheme proposed, and the results attained have been satisfactory. The experiment has proved everything that was expected of it.

The work thus begun in a small way here in New England, where so much has been and is being done for