A PROJECTION PHONEIDSCOPE.

By GEO. H. STONE, Kent's Hill, Me.

By combining the essential features of the phoneidoscope (described in the SCIENTIFIC AMERICAN SUPPLEMENT No. 122) with President Morton's method of projecting interference tints, the sound vibration figures of soap films can easily be projected and even measured on the screen before an audience. The method has also this advantage, that the movements in the whole film can be observed at once. A bright light is needed, preferably from the sun or electric lamp. A beam of light falls obliquely on the film and the reflected beam is passed through a convex lens. A better effect is secured by holding the film vertically; when it is horizontal, reflection from mirrors is needed, which causes a great loss of light. Films from one and a half to two inches in diameter are so strong that they become monochromatic before bursting, and last longer when in vibration than when still. Under the action of sound pulsations the film becomes violently agitated, rapid vortical motions ensue, polygonal figures bounded by bright lines appear, and often in the center of each is a whirling spot of light, connected with the perimeter of the polygon by faint vortical or nodal lines. A circular film breaks up into variously shaped polygons, while a square film has a decided tendency to break into nearly regular squares, and a hexagonal film into hexagons. The interference colors are very brilliant, and the whole forms an instructive and beautiful experiment, the figures varying with every change in the pitch or quality of the voice or sounding body.

THE COMING TOTAL SOLAR ECLIPSE.

By J. NORMAN LOCKYER.

THERE is no doubt whatever that the eclipse which will sweep over the United States next July will be observed as no eclipse has ever been observed before. The wealth of men, the wealth of instruments, and the wealth of skill in all matters astronomical already accumulated there, make us Old Country people almost gasp when we try to picture to ourselves what the golden age will be like there, when already they are so far ahead of us in so many particulars.

Draper, Hall, Harkness, Holden, Langley, Newcomb, Peters, Peirce, Pickering, Rutherford, Trouvelot, and last, but not least, Young, are the names that at once run easily off the pen to form a skeleton list, capable of considerable expansion with a little thought, when one thinks of the men who will be there. One knows, too, that all the enthusiasm of devoted students and all the appliances of modern science—appliances in the creation of which many of those named have borne so noble a part—will not be lacking. So that we may be sure that not only all old methods but all possible new ones will be tried to make this year one destined to be memorable in the annals of science side by side with 1706, 1851, 1860, and other later years.

Thank heaven, too, there is no necessity that the thankless task of organizing an "Eclipse Expedition" from this country should fall on any unfortunate individual, among other reasons because—and this is a very hopeful sign of increasing general interest taken in scientific work—Messrs. Ismay, Imray & Co., the owners of the White Star Line, have expressed in the warmest manner their desire to aid English observers by a considerable reduction of fares, and the directors of the Pennsylvania Railway Company, as the readers of *Nature* have already been made aware, have done the like in the case of observers coming from Europe in their individual capacity.*

The progress in that branch of knowledge which requires the aid of eclipse observations has been so rapid during the last few years, that the eclipse of 1868, though it happened only ten years ago, seems to be as far removed from the present as the Middle Ages are in regard to many other branches of culture. The work done by the spectroscopy since that year, when in the hands of Janssen, Pogson, Herschel, and others it added so enormously to our knowledge, has gradually covered larger and larger ground, and each successive eclipse in 1869, 1870, 1871, and 1875 has seen some variations in its use, so that its employment has proved the most novel, if not the most powerful, side of the attack.

Young's work of 1869 will no doubt form the keynote of much that will be done this year so far as the coronal atmosphere is concerned. It will be remembered that Young in 1869 observed a continuous spectrum, while Janssen in 1871 observed a non-continuous one, for he recorded the presence of the more prominent Fraunhofer lines, notably D. This positive observation from so distinguished an observer demands attention, not only on its own account, but because of the question which hangs upon it, which is this: Does the corona reflect solar light to us or does it not, and, if it does, where are those particles which thus act as reflectors? On this point the photographs taken in Siam in 1875 are silent, as the method employed was not intended to discriminate between a continuous and a discontinuous spectrum.

But, although this point remains, how greatly has the ground been cleared since 1869. That wonderful line, "1474," is more familiar to us now; and yet there has been almost a chapter of accidents about it. In the first place, with regard to this line above all others, there appears to be a mistake in Angström's map; the solar line at 1474 is not due to iron at all; with the most powerful arc there is no iron line to be seen there. Then Secchi attributed it to hydrogen, though I am not aware on what evidence. But, whatever be its origin, the fact remains that we now know by its means that the solar hydrogen is traversed and enveloped by the substance which gives rise to the line to an enormous height, so that it forms the highest portion of the atmosphere which is hot enough to render its presence manifest to us by spectral lines. Here, so far as I know, only one point of difference remains. In 1871 I most distinctly saw the line trumpet-shaped, that is, with the base broadening as the spectrum of the photosphere was reached, while Janssen saw it stopping short of the spectrum of the photosphere. The importance of this point is that, supposing one of us to be mistaken, and one or other observation to represent a constant condition, then, if the line broadens downward till the sun is reached, we are dealing with a gas lighter than hydrogen, capable of existing at a high temperature, which thins out as the other gases and vapors do, in consequence of its vapor density being below that of hydrogen; or, on the other hand, if the line stops short as a constant condition, it represents a substance which is probably dissociated at the lower levels, and is therefore probably a

compound gas; and then the question arises whether it has not hydrogen as one of its constituents.

Perhaps I may conveniently refer to a paper of mine which was lately read at the Royal Society in this connection, because it may be that the solar regions most worthy of the closest study at the present time are precisely these higher reaches of the sun's atmosphere. There is little doubt, I think, that around the sun's visible atmosphere matter exists at a temperature low enough not to give us its autobiography in the bright line manner, and there is evidence that matter existing under such conditions, absorbing as it must do some of the sun's light, will, if it remains elemental, give us an absorption of the fluted kind, or again will absorb only in the blue or ultra-violet region.

Now the more the chemistry of the reversing lower layer of the sun's atmosphere—that in which the upper level of the photosphere is bathed—is examined, the more metallic is it found to be. For instance, my own work has enabled me to trace with more or less certainty eighteen metallic elements,* in addition to those recorded by previous observers; but of metalloids in this region I have traced none. The persistency with which metal after metal revealed itself to the exclusion of the metalloids led me to throw out the idea some time ago that perhaps the metalloids lay as a whole above the metals, and shortly afterward I obtained evidence which seemed to me of a very satisfactory nature as to the existence of carbon, its presence in the sun's atmosphere being rendered probable by fluted bands, and not by lines. There were two points, however, which remained to be settled before the matter could be considered to be placed beyond all doubt.

The first was to establish that the fluted bands generally present in the spectrum of the electric arc, as photographed, which bands vary very considerably in strength according to the volatility of the metal under experiment, were really bands of carbon—a point denied by Angström and Thalen.

This point I have settled by two photographs, in which the carbon bands remain the same, though one spectrum is that of carbon in air, the other of carbon in dry chlorine.

The next point was to insure accuracy by the most positive evidence that there was absolutely no shift in the carbon bands. Such a shift is produced when the part of the arc photographed is not perfectly in the prolongation of the axis of the collimator of the spectroscopy. Its effect is to throw the lines of iron, for instance, a little to the right or a little to the left of the Fraunhofer lines with which they really correspond.

I have now obtained a photograph which supplies such evidence. There are metallic lines close to the carbon bands which are prolongations of Fraunhofer's lines, while the lines which I have already mapped at W. L., 39.27 and 39.295, in the spectrum of iron, are also absolute prolongations. Therefore there is no shift in the carbon flutings, and the individual members of the fluted spectra in the brightest portion are absolute prolongations of a fine series of Fraunhofer lines in the ultra-violet.

Now how does this connect itself with observations of the upper parts of the solar atmosphere?

Angström has already shown that the true carbon lines which we get when a coil and jar are employed are not reversed in the spectrum of the sun, and I have already shown that the calcium spectrum in the sun is similar to the spectrum obtained when the spark, and not the arc, is employed. Accompanying the change from a high to a higher temperature there is a change in the intensity of the lines—some thicken, others become thinner. We can only match the relative thickness of the solar calcium lines by employing a very powerful coil and jar—so powerful, indeed, that the lines, and not the flutings, of carbon would be visible in the spark given by it. It is fair, then, to say that, if carbon were present with the calcium in the sun's reversing layer, we should get the lines of carbon when we get the calcium lines appearing as they do.

As we do not get this evidence, we are driven to the conclusion that the carbon vapor exists not only in a more complicated molecular condition (as is evinced by the flutings) than the metallic vapors in the sun's atmosphere, but at a lower temperature. It must, therefore, exist above the chromosphere, that is, in a region of lower temperature. Lower pressure, again, is indicated by the feeble reversal, so that everything points to a high level.

The question is, will this region be recognized during the coming eclipse?

Coming down lower we reach a level better known, and of which, perhaps, the interest during the eclipse will now be less, if we except the possibilities opened out to us by photography. One good photograph of the lines visible in the lower chromosphere will be of incalculable value. Attempts may be made on the cusps just before and after totality, and if only one of these succeeds we shall have the ordinary solar spectrum as a scale. If good pictures near H can be secured, enough information now exists for that region to enable us to determine the chemical origin of the bright lines photographed. These remarks apply to attempts made with spectroscopes furnished with slits in the ordinary way; there is little doubt, however, that the method utilized for the Siam eclipse in 1875, the method suggested by Prof. Young and myself for the Indian eclipse of 1871, will also be taken advantage of; here the chromosphere itself becomes the slit. A dispersed series of spectral images of the thing itself, instead of the spectrum of a part of the image of it focused on a slit, is obtained, the position of each image in the spectrum enabling its chemical origin to be ascertained if only a comparison spectrum can be secured at the same time.

In 1875, in the expedition to Siam, the photographs of this nature were obtained by means of a prism, and the results obtained by that expedition led me to think that, possibly, this method of using the coronal atmosphere as a circular slit might be applied under very favorable conditions if the prism, or train of prisms, hitherto employed, were replaced by a reflection grating, with which the generosity of Mr. Rutherford has made many of us familiar for the simple reason that, while a prism only gives us one spectrum, a brilliant grating placed at right angles to an incident beam gives us spectra of different orders, so-called, on each side of the line, perpendicular to its surface. Of these two or three are bright enough to be utilized on each side, so that we can get six in all.

To test this notion I made the following experiment with a grating given to me by Mr. Rutherford. This magnificent instrument contains 17,280 lines to the inch, ruled on glass, and silvered. Its brilliancy is remarkable:

In front of the condenser of an electric lamp adjusted to throw a parallel beam I placed a circular aperture, cut in

cardboard, forming a ring some 2 inches in interior diameter, the breadth of the ring being about $\frac{1}{8}$ inch. This was intended to represent the chromosphere, and formed my artificial eclipse.

At some distance from the lamp I mounted a $3\frac{3}{4}$ inch Cooke telescope. Some distance short of the focus I placed the grating; the spectrum of the circular slit, illuminated by sodium vapor and carbon vapor, was photographed for the first, second, and third orders on one side. The third order spectrum, showing the exquisite rings due to the carbon vapor flutings, was produced in forty-two seconds. The first order spectrum, obtained in the same period of time, was very much over-exposed. It is, therefore, I think, not expecting too much that we should be able to take a photograph of the eclipse, in the third order, in two minutes. Similarly we may hope for a photograph of the second order in two minutes, and it is, I think, highly probable also that a photograph of the first order may be obtained in one minute. To make assurance doubly sure, the whole of the totality may be used during the coming eclipse, but if there be several such attempts made, it will certainly be worth while to try what a shorter exposure will do.

Now by mounting photographic plates on both sides of the axis, one solidly mounted equatorial of short focal length may enable us to obtain several such photographs, with varying lengths of exposure. I insist upon the solidity of the mounting, because, if any one plate is to be exposed during the whole of totality, the instrument must not be violently disturbed or shaken while the eclipse is going on. I think, however, it is quite possible to obtain more than one photograph of the lower order spectra without any such disturbance in this way. The same plate may be made to record three or even four exposures in the case of the first order in an eclipse of four minutes' duration, by merely raising or lowering it after a given time, by means of a rapid screw or other equivalent contrivance, so that a fresh portion of the same plate may be exposed. Similarly the plates on which the spectra of the second order are to be recorded may be made to perform double duty.

If one equatorial thus mounted were to be devoted to each quadrant of the coronal atmosphere, it is certain, I think, that most important results would be obtained.—*Nature*.

ON THE AEROLITIC EPOCH OF NOVEMBER 12TH-13TH.*

By PROF. DANIEL KIRKWOOD.

It is now well known that clusters of small meteors—the so-called shooting stars—move in elliptic orbits about the sun. Catalogues of fire-balls and meteoric stones indicate, moreover, that groups of larger bodies, somewhat widely dispersed, revolve in like manner about the center of our system, their orbits in certain cases intersecting that of the earth. The 12th and 13th of November is one of these aerolitic epochs, the date being nearly coincident with that of the great November shower of falling stars. The writer until recently supposed the meteorites of this epoch to revolve in the same orbit with the nebulous swarm which furnished the showers of 1833, 1866 and 1867.† Later study of the facts, however, has rendered the theory of this intimate relation extremely improbable. The principal phenomena of this epoch (not including star showers) are the following:

- (a.) 1582, meteoric phenomena at Zurich.
- (b.) 1765, an extraordinary meteor at Frankfurt.
- (c.) { 1820, a detonating meteor seen in Russia.
- (d.) { 1822, fall of aerolites at Potsdam and Leipzig.
- (e.) 1828, a great meteor seen in full sunshine in France.
- (f.) 1835, a fall of aerolites in France.
- (g.) { 1849, a fall of aerolites at Tripoli.
- (h.) { 1849, a large meteor seen in Mecklenberg.
- (i.) 1856, a meteoric stone fell in Italy.
- (j.) 1877, a brilliant meteor seen in Arkansas and another in Wisconsin.

REMARKS.

(a.) This so-called "fall of fire from heaven" occurred on the 28th of October, O. S., or November 7th, N. S. Making allowance for the precession of the equinoxes, the date corresponds at present to the morning of November 12th.

(b.) This bolide was observed November 11th, and is the only one in our list which occurred very near the epoch of the great star shower in November.

(c.) See Greg's catalogue of fire-balls and meteoric stones; also Quetelet's catalogue of shooting stars.

(d.) Several aerolites fell at this date near Potsdam, and also at Taucha, near Leipzig, about 75 miles distant.

(e.) See Quetelet's catalogue.

(f.) This fall of aerolites occurred on the evening of November 13th, in the department de l'Ain, France. The meteor was unconfined to the radiant of the Leonids, its motion being from southwest to northeast. A fragment is in the collection of Prof. Shepard, of Amherst, Massachusetts.

(g.) The meteoric phenomena of this date are thus described in the catalogue of Mr. Greg: "Seen in the southern sky. Varied in color; a bright cloud visible one and a half hours after; according to some a detonation heard fifteen minutes after bursting. Seen also like a stream of fire between Tunis and Tripoli, where a shower of stones fell—some of them in the town of Tripoli itself."

(h.) This fire-ball appeared on the same evening or night.—Greg's catalogue.

(i.) This aerolite fell at Trezano. A fragment is in the collection of Prof. Shepard.

(j.) A large meteor was seen by Professor Robert C. Hindley, of Racine, Wisconsin, on Sunday evening, November 11th, at three minutes past six o'clock (Chicago time). This meteor is thus described by Professor H. in the SCIENTIFIC AMERICAN for December 1, 1877: "Direction N. N. E.; altitude at commencement of course about 30°; length of course from 10° to 12°; time of falling about 8 seconds. It fell toward the west, making an angle in falling to the earth of about 65° with the vertical passing through the body. During the latter three-fourths of its course, its length, including the luminous trail, was about one-half of a degree. The nucleus was very brilliant; its color at first a yellowish-white, then a light green, and lastly, a greenish-yellow. Could its color have been due to boron, thallium, etc.? I find no record in any of the numerous analyses of meteoric stones of the presence of elements likely to give the green color."

On the following evening, November 12th, at 6h. 26m. (Memphis time), Frank L. James, Ph.D., M.D., of Osceola,

* Read before the American Philosophical Society, March 1, 1878.
† A list of stone-falls, detonating meteors and large fire-balls which have appeared about this epoch is given in *Meteoric Astronomy*, pp. 58-60.

* In fact Messrs. Ismay, Imray & Co. have just announced that they will take properly certified observers and bring them home again for the sum of £20 which is rather less than 1st class single fare; so that English observers will be carried to Denver or the Rocky Mountains and back again for the sum of £24.

* These are strontium, lead, cadmium, potassium, cerium, uranium, vanadium, palladium, molybdenum, indium, lithium, rubidium, cesium, bismuth, tin, lanthanum, glucinum, and yttrium or erbium.