The second important advance was made at the December meeting of the American Association for the Advancement of Science, when, at the instigation of Prof. W. H. Hobbs, of Ann Arbor, Mich., a committee on seismology was appointed. The gentlemen selected, who represent all sections of the country and the more important institutions likely to be engaged in seismological research, are as follows: L. A. Bauer, Carnegie Institution of Washington; W. W. Campbell, Lick Observatory; Major C. E. Dutton, U. S. Army; G. K. Gilbert, U. S. Geological Survey; J. F. Hayford, U. S. Coast and Geodetic Survey; W. H. Hobbs, University of Michigan; L. M. Hoskins, Stanford University; T. A. Jaggar, Massachusetts Institute of Technology; Otto Klotz, Ottawa Observatory, Canada; A. C. Lawson, University of California; C. F. Marvin, U. S. Weather Bureau; W J McGee, St. Louis Public Museum; H. F. Reid, Johns Hopkins University; C. J. Rookwood, jr., Princeton University; and R. S. Tarr, Cornell University. In the preliminary organization of the committee Dr. G. K. Gilbert was chosen chairman and Dr. W. H. Hobbs, secretary.

Some of the objects in view in forming the committee on seismology in America are as follows:

1. To be available for, and to initiate counsel in connection with, legislation which provides for investigation of earthquakes or the means for mitigating their dangers.
2. To bring into harmony all American and Canadian institutions doing seismological work, and to guard against unnecessary duplication of studies.
3. To organize, if thought best, a correlated system of earthquake stations, which should include the outlying possessions and protectorates.
4. To advise regarding the best type or types of seismometers for the correlated stations.
5. To disseminate information regarding construction suited to earthquake districts.
6. To collect data regarding the light as well as the heavy shocks, and to put the results upon record.
7. To start investigations upon large problems of seismology.
8. To advise with some weight of authority when catastrophic earthquakes have wrought national calamity.—*C. F. M.*

THE METEOR OF MARCH 14, 1906, OVER CENTRAL NEW YORK.

By Prof. HENRY A. PECK. Dated Syracuse University, Syracuse, N. Y., May 1, 1907.

About 8 p. m., March 14, 1906, a large meteor past over the western-central part of New York State. Press notices appeared in the majority of the daily papers between Rome and Buffalo. In an attempt to secure more reliable data requests were sent from the Central Office of the Weather Bureau to the officials in charge at Oswego, Ithaca, Syracuse, and Rochester, asking them to send all good accounts of the meteor, together with apparent angular altitudes and bearings. Scattering observations were obtained from the three first named stations. In response to advertisements in the Rochester papers, Mr. L. M. Dey, the local forecaster, was enabled to obtain a large amount of material which has been of great value in roughly outlining the territory over which the meteor was observed, as well as in determining the general character of the phenomenon. A complete list of those who have contributed to secure the following results is here given, the places of observation being arranged in order of longitude west of Greenwich:

Henry B. French, Rome.	Robert J. Purdy, Ovid.
J. W. Blood, Rome.	Floyd Thomas, North Rose.
L. W. Griswold, Oneida.	Louis H. Albright, Newark.
H. A. Peck, Syracuse.	J. A. Rose, Lyons.
Jennie Whaley, Oswego.	C. J. Andrews, Sodus Center.
Olive E. Templeton, Oswego.	Fred Webler, Sodus Center.
F. R. Monk, Fair Haven.	Professor LeRoy, Penn Yan.
S. D. Colgate, Townsendville.	Olive R. Tobey, Penn Yan.
Benjamin Christian, Wolcott.	V. C. Washburn, Clifton Springs.
F. W. Clark, Williamson.	F. T. Ellison, Rochester.
Rev. J. Menlendyke, Palmyra.	S. F. Gould, Rochester.
J. Van Arsdale, Canandaigua.	A. E. Benjamin, Rochester.
Mrs. Addie Eddy, Middlesex.	Edgar Shantz, Rochester.
C. D. Gilbert, Despatch.	C. J. Trumeter, Rochester.
B. A. Plimpton, Victor.	Louis P. Hof, Rochester.
Mrs. Jesse A. Wheeler, Holcomb.	F. W. Green, Rochester.
Benjamin G. Wedd, Mortimer.	H. H. Butler, Rochester.
William B. Mason, Lima.	Frank J. Schantz, Rochester.
Jesse L. Vanderpool, Rochester.	Milton J. Tripp, Rochester.
L. M. Dey, Rochester.	Mrs. H. H. Turner, Rochester.
F. L. Hunt, Rochester.	B. L. Pope, Rochester.
Kate E. Collins, Rochester.	Leman Gibbs, Livonia Center.
Julia F. White, Rochester.	George V. Witzel, Coldwater.
H. B. McEnbee, Rochester.	F. Hanford, Scottsville.
Mrs. T. Tewilliger, Rochester.	W. J. Stocum, Adams Basin.
Mrs. F. B. Albro, Rochester.	John Denton, M. D., Retsof.
Mrs. Chas. T. Axelson, Rochester.	Ames Belden, Albion.
Mrs. George Heberling, Rochester.	Georgianna A. Nichol, Medina.
Adaline I. Jones, Rochester.	Mrs. Thomas R. Griffith, Aurora.
Katherine L. Hoyt, Rochester.	Thomas Rooney, Lockport.
Mrs. G. T. Le Boutillier, Rochester.	F. A. Keltinger, M. D., Lockport.

When it is remembered that the air-line distance from Rome to Lockport is over 160 miles, it is evident that the meteor was a remarkable object from a popular as well as from a scientific standpoint.

The apparent path of the meteor thru the atmosphere began about 4 miles to the southeast of Geneva on the eastern shore of Seneca Lake, at an altitude of 70 miles above the surface of the earth. The time of flight was about five or six seconds, and it disappeared over Lake Ontario northeast of Manitou Point, about 8 miles from the nearest land. At first it appeared as a rosy red star of not inconsiderable brightness, but in the latter part of its flight various observers estimated its size as from that of quarter to the full size of the moon. The light cast at places near its path was evidently as strong as that of the moon, or, as one observer says, "the beam of a strong searchlight". Some doubt might be cast on its having been one large, solid body from the fact that reports from places widely apart state that fragments seemed to leave the main mass and pursue separate paths. As suggested by Mr. L. M. Dey, official in charge of the Weather Bureau office at Rochester, this may be the cause of some of the conflicting accounts as to its course, some observers having seen fragments of the parent body. A trail that persisted for several seconds followed the flight. A number of observers report that it made a sound as of some heavy body rushing thru the air. After passing over Lake Ontario it exploded twice, the detonation being heard 40 miles, while within 25 miles the concussion was so great as to cause a slight shaking of houses. The sound at Rochester and vicinity is compared to the sound of distant cannon or blasting, or to the rolling of thunder.[1]

To obtain the orbit of such an object, using as the basis the conflicting observations and estimates of persons who, for the most part, are unskilled in such work, is no easy task. It must be remembered in the present instance that the greater share of the accounts were not compiled from notes made at the time of observation, but were compiled from memory about three weeks later. Under such circumstances the observer will often unconsciously and in perfect good faith prolong the true path in either direction.

Our work falls into two divisions. We must first find the most probable path thru the atmosphere, assuming that path as a straight line, from which, in any event, it can not deviate very materially during the short time of flight. This straight line is fixt if we know its end, its length, and its direction. The known time of flight furnishes the velocity. The second

[1] A great noise is sometimes heard shortly after a large meteor passes the observer, and as meteors are frequently seen to break into two or more portions such noises are spoken of as concussions or explosions, especially because they are so loud as to resemble cannonading. However there is generally no explosion, properly so called, even when the noises are very loud; and the exact mechanism by which the noises are produced is worthy of further study.—*C. A.*

part of the work is the computation of the orbit pursued by the body before it encountered the earth. This can be accomplished by the well-known formulas of theoretical astronomy, provided we know the velocity and direction of its motion when it fell under the earth's attraction.

The end of the flight is very definitely fixt by the observations made at Rochester. Mr. Vanderpool was making his evening observation at the weather station when the flash of light was noted by him at seven hours and fifty-six minutes, eastern time. He estimated that the detonation was heard ninety seconds later. This is confirmed by Kate E. Collins, who estimated the time as eighty-five seconds, and later verified her estimate by walking again the distance she past over between the flash and the subsequent report. This places it 18 miles from Rochester. Mr. L. M. Dey, the official in charge of the Weather Bureau office at Rochester, states that its course was nearly due north, and that the disappearance took place 20° above the horizon. This makes the geographic coordinates of the point of disappearance

$$\lambda = 77^\circ\ 37' \text{ west of Greenwich,}$$
$$\varphi = 43^\circ\ 24' \text{ north,}$$

and the geocentric coordinates

$$\log.\ \rho \sin \varphi' = 3.434$$
$$\log.\ \rho \cos \varphi' = 3.461$$

the reduction of the latitude to geocentric position being eleven and one-half minutes, and the siderial time

$$\theta = 108^\circ\ 6',$$

while the height above the lake was 6 miles.

This completely defines one point on the line described by the meteor. As soon as another point is found the direction of this line is also established.

If one were at the place where a meteor fell to the ground, he would see it approach as a rapidly brightening and enlarging object, but would not see it describe any apparent path on the sky. The projection of the straight line would be reduced to a point, and this point from which it would seem to approach is called the radiant. It is apparent that the place where the meteor first encountered the atmosphere must be in the direction of the radiant. The apparent curve seen by an observer at any other station is the projection of the line joining the radiant and the point at the end of the flight. As the plane of this projection must always contain the line that is projected, the real path of the meteor must lie in the planes of all the apparent paths, i. e., it must be their common line of intersection. This is the underlying idea in Galle's classical method of computing a meteor orbit. A corollary to this proposition is that the great circles of which the various observed apparent paths are arcs must have a common point of intersection. This point is the radiant, and its determination completely establishes the direction of flight.

In the present case, after careful consideration of the observations, I have chosen those made at Rochester and Syracuse as the basis of the computation. The Syracuse observation must have been made very nearly at the instant when the meteor entered the earth's atmosphere. The azimuth was 67° west of south and the altitude was 60°. Since the point of disappearance is so well established we may abandon all observations of this portion of the path and compute by well-known formulas the direction in which the meteor should have been observed the instant before extinction. As viewed from Syracuse this point had the coordinates

$$\text{Right Ascension} = \alpha = 9^\circ\ 54'$$
$$\text{Declination} = \delta = +\ 17^\circ\ 9'.$$

and the azimuth and altitude of the point of first appearance is equivalent to

$$a^1 = 78^\circ\ 36'$$
$$\delta^1 = +\ 26^\circ\ 38'$$

In order to find the plane of the great circle defined by these two points the requisite formulas are

$$\tan \gamma \sin (a^1 - \Gamma) = \tan \delta^1$$
$$\tan \gamma \cos (a^1 - \Gamma) = \frac{\tan \delta - \tan \delta^1 \cos (a - a^1)}{\sin (a - a^1)}$$

where γ represents the angle between the plane of the great circle and the plane of the equator while Γ is the right ascension of the node. In the case of the Syracuse observation we have

$$\gamma = 150^\circ\ 33'$$
$$\Gamma = 153^\circ\ 28'$$

The question as to whether the node is ascending or descending is settled by the fact that its general course was from south to north and the ambiguity as to the tangent of γ is removed by its course being retrograde in right ascension.

Treating the Rochester observation in the same manner we have

$$a = 288^\circ\ 6'$$
$$\delta = +\ 66^\circ\ 50'$$

Mr. L. M. Dey states that the meteor past Rochester a "little to the east of the zenith, and had an angular altitude of 60° or 70°". I have preferred to take his estimate rather than any that I could form from the conflicting reports of observers, as he had a chance of interviewing persons soon after the meteor was seen. Reducing this estimate,

$$a^1 = 140^\circ\ 42'$$
$$\delta^1 = +\ 38^\circ\ 19'$$

and, therefore,

$$\gamma = 79^\circ\ 53'$$
$$\Gamma = 132^\circ\ 38'$$

The fact that at Rochester the projection was to the east of the meridian changes the quadrant of γ.

The mathematical condition that the radiant shall lie on the great circle is exprest by the condition

$$\sin \Gamma \sin \gamma \,.\, \cos D \cos A - \cos \Gamma \sin \gamma \,.\, \cos D \sin A + \cos \gamma \,.\, \sin D = 0$$

In the present instance we have two such equations and therefore A and D, which are the right ascension and declination of the radiant, become definitely known. If more than two observations are used there arises a condition which must be solved along the lines of the least square method. If we place

$$\text{cotan } D \cos A = x$$
$$\text{cotan } D \sin A = y$$

the equations reduce to the form

$$ax + by + c = 0.$$

For the two observations under discussion the equations are

$$+\ 0.206\,x + 0.412\,y - 0.887 = 0$$
$$+\ 0.724\,x + 0.667\,y + 0.176 = 0$$

and from the solution results

$$A = 134^\circ\ 26'$$
$$D = +\ 9^\circ\ 32'$$

The direction of the line in space being found, its length may then be computed, which is 86.7 miles.

The time of flight was estimated in Syracuse at from five to six seconds. This is confirmed by other observers. Assuming it as five and one-half seconds, the velocity thru the atmosphere was 15.8 miles per second.

The direction and velocity just found are not those that the meteor possest in space before it felt the attractive force of the earth. These must be found before the orbit with regard to the sun can be determined. The orbit described after the body has fallen under the influence of the earth is a conic section, whose focus is the center of the terrestrial sphere. The apparent velocity differs from the true velocity also because the earth is itself in motion. When these two causes are taken into consideration the true radiant is found to be the point whose celestial longitude and latitude are, respectively,

106° 2′
+3° 42′

and the true velocity is 31 miles per second.

As will be noticed, the velocity is about 20 per cent in excess of that to be ascribed to parabolic motion, and places the meteor in the hyperbolic class. I am perfectly aware that the burden of proof rests upon the person that assumes hyperbolic velocity for cosmic bodies, but as the assumption of a parabola would prolong the time of visible flight by two seconds, I have preferred to retain the velocity as above given. Computing the elements by the known formulas of theoretical astronomy we have

Longitude of ascending node	351° 31′
Inclination to ecliptic	4° 0′
Longitude of perihelion	209° 1′
Logarithm of perihelion distance	9.9434
Eccentricity	1.696

If one is disposed to reject the hyperbolic velocity from general principles, the orbit is not varied more than might easily arise from the uncertainty of the observations, and there results

Longitude of node	351° 31′
Inclination to ecliptic	2° 58′
Longitude of perihelion	206° 21′
Logarithm of perihelion distance	9.9597

COOLING BY EXPANSION AND WARMING BY COMPRESSION.

By CHARLES EMERSON PEET. Dated Lewis Institute, Chicago, Ill.

(Reprinted from School Science and Mathematics, April, 1907, page 263.)

The following method of cooling by expansion and condensation of the water vapor of the air into a visible cloud of water particles may be of interest to instructors in physiography. It is a method which I have used with success for several years. The apparatus necessary is: (1) an air pump. (2) a bell jar. (3) a bottle with a snug fitting cork, coated with vaseline. The bottle is corked and placed under the bell jar and the air is exhausted from the bell jar. The cork is pushed out of the bottle by the air inside. The sudden expansion causes cooling enough to condense the water vapor into a cloud which remains visible for a considerable time. Slow leakage of the air into the bell jar may produce warming by compression enough to reevaporate the water. This warming by compression is made more striking if the bell jar is provided with a stop-cock by which the air may be admitted more rapidly and in a manner which is apparent to the class. The success of the experiment varies with the humidity of the air, but under the most unfavorable circumstances it is never an entire failure. The size of the bottle to be used and the force with which the cork should be forced into it can easily be determined by trial. The cloud in the bottle may be made more clearly visible by providing it with a proper background.

ESPY'S NEPHELOSCOPE.

The experiment above described by Professor Peet implies the use of an air pump, whereas the following method, which has often been used by the Editor, not only requires no expensive apparatus, but has several other advantages. A bottle (A) properly corked, has inside of it an ordinary elastic-rubber toy balloon (B), which, when but slightly distended, occupies only two or three cubic inches. A glass (or preferably a rubber) tube enters the mouth of the balloon, and also passes outward air-tight, thru the cork. On blowing thru the tube, or forcing air by any other method into the balloon, the latter is distended, and of course the air within the bottle is comprest. Wait until this comprest air has lost its warmth, which it quickly does by conduction and radiation to the sides of the bottle, then remove the finger from the rubber tube and allow the comprest air of the bottle to push the air within the balloon outward thru the rubber tube. The work done by this expansion cools it enough to produce the most delicate cloud of condensed vapor, which is visible until the radiation of heat from the sides of the bottle evaporates the globules of water. The experiment may be repeated over and over with the same air always in the bottle; and if a thermometer be added, together with some way of measuring the volume of comprest air, then really instructive computations may be made. If a little water be kept in the bottle, but outside the balloon, we may arrange so to deal always with saturated air, and the haze will be more easily visible to a large class. If no water be present then we have to deal with unsaturated air, and may make a large variety of experiments.

One of the first phenomena that the teacher and scholar will note is the fact that after a few trials it becomes more and more difficult to secure any visible haze. This is the phenomenon first recorded by Espy, and was a mystery to him and everyone else until Aitken showed that vapor condenses most easily on minute solid nuclei, and by its weight carries them to the bottom or sides of the jar, where they stick fast, so that after a few trials no more nuclei remain. Then comes the phenomenon first studied by C. T. R. Wilson, of Cambridge, England, who showed that in dustless air a greater expansion and therefore a greater cooling is necessary in order to produce visible globules. This may lead us on to the consideration of ions, if the scholar is far enough advanced for the subject. At least it is proper to call his attention to the fact that the interior of a cloud is dustless, and that here greater expansion seems to be necessary, and consequently greater cooling, and that therefore a greater liberation of latent heat occurs within the interior of a thundercloud than in that same air when it first rises high enough to become cloudy.

Instead of water one may introduce other liquids into the experimental bottle, which is in fact a modification of Espy's single nepheloscope, and may thus experiment upon carbonic acid gas, the vapors of alcohol, ammonia, etc.

The double nepheloscope devised by Espy may be imitated by connecting two clear glass bottles (C) and (D) by means of two rubber tubes to a central bottle or receiver (E), from which the air can be exhausted. By a spring clip close one tube so that the air may be exhausted from the receiver (E) and one bottle (C), while not exhausted from the other bottle (D). Then remove the clip from (D) and allow its air to pass over into (E) and (C). The student will be surprised to find that no cloud is formed. This experiment troubled Professor Espy very much about 1850, as he had up to that time been reasoning on the general principle that the atmosphere is cooled by the act of expansion, but here he evidently had expansion without cooling. It was Prof. William Thomson, of the University of Glasgow, now Lord Kelvin, who, by his work on thermodynamics, first gave the true explanation, namely, that it is not the mere expansion that produces cooling but the work done by expansion. When the air expands from (D) into the vacuum (E) and (C) there is no work done except the moving of about one-half the mass of air in (D) over into the empty jars (E) and (C), and the cooling is too slight to produce a visible haze; it was, in fact, too slight for Espy to measure with his most delicate thermometer. On the other hand, when the comprest air in the bottle (A) pushes the air in the balloon (B) out into the open air it is doing heavy work by pushing against the outside atmospheric pressure, just as does the steam in the cylinder and boiler of an engine.—*C. A.*