latter were electrically heated, their temperatures being read by mercury thermometers. The zero positions of the small suspended system were deduced by noting the turning points as read by a distant telescope and scale. Thus the relative gravitative effects with the large masses cold and hot are found by observing the shift in each case on rotating the large masses from the one attracting position to the other.

Elaborate precautions were taken to avoid various disturbances or spurious effects. Those dealt with are electrostatic, magnetic convection, radiometer pressure, occluded gases, damping, radiation pressure, conduction of heat, and displacements of apparatus. Taking all circumstances into consideration, a pressure of 14 mm. was held to be most satisfactory and was adopted in many of the later experiments. The results of the experiments with the final form of apparatus are summarized in the table [not reproduced here]. From this it is deduced, for the given temperature range of the larger masses (of about 47 kg. each) if a linear relation be assumed, that

$$f = G(1 + a\theta)Mm/d^2,$$

where a is a temperature coefficient of value $(+1.20 \pm 0.05) \times 10^{-5}$ per degree C.—*E. H. B[arton]*.

GRAVITATION AND TEMPERATURE.[3]

By J. L[ARMOR].

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, §861.]

As the outcome of a very delicate systematic series of experiments, it is announced by P. E. Shaw [see above] that when one large mass attracts a small one the gravitative force between them increases by about 1/500 as the temperature of the large mass rises from, say, 15° to 215°C.; that is, it increases by about 1.2×10^{-5} of itself per degree C. This seems to be a very startling result, at any rate if temperature is merely the expression of internal molecular motions, as indeed the experimenter seemed to admit.

By Newton's principle gravitation between masses must act reciprocally; the result, therefore, means that the astronomical mass of a body must increase with temperature by 1.2×10^{-5} of itself per degree C.

The pendulum experiments of Bessel and recent determinations by Eötvös seem to establish proportionality between gravitational mass and mass of inertia, irrespective of temperature, well beyond these limits. Thus inertia also would have to increase with temperature, and when a freely moving mass is becoming warmer its velocity must be diminishing, for its momentum must be conserved. A comet like Halley's is heated upon approach to the sun; thus it should suffer retardation in the approaching, and acceleration in the receding part of the orbit, enough, probably, to upset existing astronomical verifications.

Electrodynamic theory does establish unequivocally an increase of inertia of a body arising from gain (SE) of thermal or electric energy; but this is only of amount SE/c^2, where c is the velocity of radiation, and so is minute beyond detection. The question whether there is also an equivalent increase in gravitational mass evades discussion until some link connecting gravitative and electric forces has been established.—*E. H. B[arton]*.

[3] Review in Nature, London, June 15, 1916, 97:321, of the paper by P. E. Shaw abstracted above.

ICE CRYSTALLIZATIONS FROM AQUEOUS SOLUTIONS.[1]

By R. HARTMANN.

[*Reprinted from* Science Abstracts, Sect. A, May 25, 1916, §628.]

The solutions contain cane sugar, glycerol, alcohol, NaBr, $MnSO_4$, NaOH, $FeCl_3$, or HCl, etc., in water, and are undercooled, with the two last-mentioned solvents to −38° and −40°C. The crystallites then separating are of four or five types: (a) The skeletons or nuclei are hexagonal or rectangular in outline, but the three or two (rectangle) axes cross in both cases at 60; (b) and (c) spherulites, radial or built up of plates; (d) feathery growths. With moderate undercooling (a) is obtained; (b) and (c) with heavy undercooling; (d) in very dilute solutions, whatever the cooling. In order to see whether the nuclei have all the same melting points, they were placed in water at −2° and then very slowly heated up, differences of 0.001 degree C. being observable; the melting points were always found normal. In the case of the two (a) types, the linear velocity of crystallization was further determined; no differences were observed. When, in the spontaneous crystallization, a nucleus happens to settle on the glass surface with its base, a hexagon seems to be formed; when with its triangular edge a rectangle is formed.—*H. B[orns]*.

THE KATA THERMOMETER AS A MEASURE OF THE EFFECT OF ATMOSPHERIC CONDITIONS ON BODILY COMFORT.[2]

By C.-E. A. WINSLOW.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, § 862.]

The readings of an ordinary thermometer afford a poor indication of the degree of comfort felt by the average individual, who in addition to feeling the effects of temperature is also sensitive to air movements. To obtain a more satisfactory measure of comfort L. Hill devised the kata-thermometer outfit, which consists of two thermometers with large bulbs and stems graduated from 86° to 110°F., one to be read as a dry- and the other as a wet-bulb thermometer. The bulbs are heated to about 110°F., and then, while they are freely exposed, the time taken to fall from 100° to 90°F. is noted. The author has taken three series of readings with the apparatus under different circumstances. At the same time a band of observers estimated the degree of comfort of the conditions on an arbitrary scale of 1 to 5, in which 3 represented ideal conditions and 1 and 5 extremes of cold and warmth, respectively. The comparative instrumental and personal results are set out in tables and on a diagram. As a result it seems clear that the instrument is of great value in measuring the actual influence of air conditions on the body and is greatly superior to the ordinary thermometer for this purpose. The curves show that conditions of maximum comfort are represented by falling times, from 100° to 90° F., of 45–60 seconds for the wet-bulb, and 150–180 seconds for the dry-bulb.—*J. S. Di[nes]*.

BALL LIGHTNING ON PUY DE DÔME.[3]

By E. MATHIAS.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, § 917.]

On April 15, 1916, the phenomenon of ball lightning was observed on three occasions—at $18^h\ 20^m$, $18^h\ 30^m$, and $18^h\ 50^m$—taking the form of a brilliant fireball with somewhat hazy contour, afterwards changing to an oval

[1] Zeitsch. f. Anorg. Chem., Aug. 6, 1914, 88:128–132.
[2] Science, New York, May 19, 1916 (N. S.), 43:716–719.
[3] Comptes rendus, Paris, Apr. 25, 1916, 162:642.

with long axis horizontal. The discharges appeared sensibly stationary and lasted for some 2 or 3 seconds. Their color was white, tinted slightly mauve.—*C. P. B[utler]*.

CENTRAL OBSERVATORY OF MEXICO REMOVED.

Under date of October 5, 1916, we are informed by J. Covarrubias, chief of the Mexican Meteorological and Seismological Service, that the offices of the Central Meteorological-Magnetic Observatory have been removed from their former location in the City of México and are now in the city of Tacubaya, D. F., where they are located in the same building as that occupied by the "Direction of Geographical and Climatological Studies."

The geographical position of the Central Meteorological Observatory is now:

Height above sealevel, 2,308.5 meters (barometer cistern).

Longitude, $6^h\ 36^m\ 46.67^s$ west of Greenwich.

Latitude, 19° 24′ 17.9″ north.

CLEVELAND ABBE, 1838–1916.[1]

Professor Cleveland Abbe died about 4 a. m. on October 28, 1916. He had been in ill health since June 4, 1915, when he was stricken by a paralysis of the right side, from which he had largely recovered.[2] Since July, 1916, however, he had suffered from a malignant degeneration of a mole, which rapidly became so extensive as to prevent his resting comfortably in other than one position. The resultant irritation and great loss of sleep, together with the restricted diet imposed by the conditions of his paralysis, drained his strength. He returned from Portland, Me., where he had spent the summer of 1916, about the middle of September and in a greatly weakened condition. For a few days he enjoyed the freedom of his home, but soon retired to the room which he kept until the end. Mentally but little change was observable, and even on the afternoon of October 25 he dictated a letter to the Secretary of the Smithsonian concerning the details of publication of a paper on meteors.

Professor Abbe had not taken an active part in the Weather Bureau's work since June 4, 1915, being on leave or on furlough from that time until he resigned on August 3, 1916.

His death will awaken a keen sense of personal loss in the minds of his former colaborers. Professor Abbe was not only a tireless and prolific worker in behalf of the science and the public institution to which he dedicated the best years of his life, but he was also, in a very unusual degree, endowed with the faculty of communicating his enthusiasm to others and stimulating their efforts, a faculty that made itself felt both in personal intercourse and through his writings.

Born in New York City in 1838, he was graduated from the Free Academy (now the College of the City of New York) in 1857, and studied astronomy with F. Brünnow at Ann Arbor, 1858–60, and with B. A. Gould at Cambridge, 1860–64. From Cambridge he went to Russia, where he spent two years as a student and assistant at the Observatory of Pulkova, under the distinguished astronomer Otto Struve. On returning to the United States he was connected for a short time with the Naval Observatory, and was called thence to the directorship of the Cincinnati Observatory.

[1] A longer notice of Professor Abbe's work will appear in a later issue of the REVIEW.
[2] See MONTHLY WEATHER REVIEW, October, 1915, 43:507.

Professor Abbe's work at Cincinnati will always remain a landmark in the history of meteorology, as it was here that he organized, in 1869, with the assistance of the Cincinnati Chamber of Commerce and the Western Union Telegraph Company, a system of telegraphic weather reports, daily weather maps, and weather forecasts, the first regular undertaking of this kind in America and the prototype of the weather service now maintained by the Federal Government. Indeed, the object lesson afforded by Professor Abbe's undertaking was the strongest argument in behalf of the establishment of a national weather service in connection with the Signal Corps of the Army, a project urged upon Congress by Dr. I. A. Lapham and others and put into effect in the year 1870.

In January, 1871, Professor Abbe was appointed a civilian assistant in the office of the Chief Signal Officer, where he organized the forecast work and began preparing the tri-daily synopses and "probabilities" of the weather. In the same year he began and urged the collection of lines of leveling and in 1872, by laborious analysis, deduced the altitudes of the Signal Service barometers above sealevel. In 1873 he inaugurated the MONTHLY WEATHER REVIEW, and he prepared 22 of the first 60 numbers of this publication, which was then only a brief bulletin of current weather statistics. September 1, 1893, he was appointed editor of an enlarged publication bearing the same title, and under his direction it soon became one of the leading meteorological journals of the world.

It was largely owing to Professor Abbe's advice that General Myer, the Chief Signal Officer, sought the cooperation of foreign governments and of the International Meteorological Congress of 1873 in establishing the "Daily Bulletin of Simultaneous International Meteorological Observations," and Professor Abbe took a leading part in organizing this remarkable enterprise. Worldwide systems of observations continued to be one of the chief objects of his interest and advocacy throughout his career. He was also specially instrumental in the organization of the State weather services, the predecessors of the present climatological service of the Weather Bureau.

Professor Abbe never ceased to urge the importance of meteorological research, and he organized a branch of the central office, known at first informally and later officially as the "study room," in which many fruitful investigations were carried out. He himself set the example in this field of activity. He collected on cards about 11,000 titles of papers on meteorological and allied subjects at considerable expenditure of private means and personal effort. This collection was purchased in 1881 by the Signal Service and further enriched by very extensive contributions from all over the world, becoming international in importance and scope. The four parts, which began to appear as mimeographed pages in 1889, have never been continued and the remaining cards lie somewhat neglected in their dusty drawers in the Bureau library. This bibliography was classified to be of help to the workers in the "study room" and has proved invaluable, as far as available, to many others also.

He prepared for publication as supplements to annual reports of the Chief Signal Officer a "Treatise on Meteorological Apparatus and Methods" (1887) and "Preparatory Studies for Deductive Methods in Storm and Weather Prediction" (1889), and he laid English-speaking meteorologists throughout the world under a special obligation by collecting and translating the leading contributions to the subject of dynamic meteorology (pub-