21 inches, in diameter, the stroke being 30 inches. Each cylinder is fitted at each end with separate steam and exhaust valves of the drop-piston type. A steam engine uses considerably more steam than is shown by the indicator to be present in the cylinder at any part of the stroke. This loss has been generally attributed to initial condensation, but more recently the belief has been held that valve leakage is responsible for much of the extra steam used. It is hoped that the trials upon this engine may be used to supplement the work done in other laboratories in elucidating this point. Thus the Armstrong College engine has slide valves; the Manchester Municipal School of Technology engines have permitted of work being done upon Corliss, double-beat drop, and slide valves; the drop-piston valves fitted to the new Glasgow engine should therefore afford opportunities of making useful comparisons.

OUR ASTRONOMICAL COLUMN.

Cometary Orbits.—Messrs. Crawford and Meyer give new elements for Halley's comet in Bulletin No. 179 of the Lick Observatory, based on observations made on September 17 and December 16, 1909, and February 28, 1910. The perturbations due to Mars in January were found to be ineffective, and the time for perihelion is finally given as April 19·67760 G.M.T.

When it became known that other computers found great difficulty in computing an orbit for comet 1910*a*, Miss Levy and Mr. Meyer, of the Berkeley Astronomical Department, decided to test a method devised by Prof. Leuschner. For this purpose photographic observations secured by Dr. Curtis, with the Crossley reflector, on February 1, 2, and 5, were selected, and a very satisfactory result obtained from the direct solution for an approximate orbit. Other observations were then considered, covering the period January 18 to March 13, and final parabolic elements calculated by the same method. These are given, with an ephemeris, in Bulletin No. 179, and the ephemeris indicates that the comet is still a little west of the Great Square, and is very faint. Observations by Dr. Aitken on April 13 gave corrections of $-0{\cdot}9$s. and $-4''$. Elliptic elements for Daniel's comet, 1909*e*, published by Sturla Einarsson and R. Young in the same Bulletin, give a period of 6·48 years.

Recently published elliptic elements for comet 1910*a* give periods of 202·6 and 41 years respectively.

Measures of Double Stars.—No. 175 of the Lick Observatory Bulletins contains the measures of 136 double stars made by Mr. Olivier with the 12-inch and 36-inch refractors of the Lick Observatory. Generally, the stars measured are neglected pairs in the southern hemisphere, such as can be observed from lat. 38° N., or pairs which show signs of motion. Eleven new doubles are included, and of the 136 stars observed, 15 are separated by less than $1''$, 56 between $1''$ and $2''$, and 30 between $2''$ and $3''$. It is interesting to note that the 12-inch refractor was generally employed, and leaves nothing to be desired as regards definition; a power of either 500 or 625 was always used, and doubles down to $0{\cdot}6''$ in distance could be readily measured.

Maximum of Mira, 1909.—*Astronomische Nachrichten* No. 4403 contains two notes on the most recent maximum of Mira. The first is by Herr May, of the Kasan Observatory, who finds that the maximum took place on September 9, 1909, the magnitude being 3·14. The second is by Herr Landwehr, Münster, and gives September 4·7 and 3·15 respectively. According to Guthnick's ephemeris, the epoch of maximum was September 6·9, and the magnitude should have been 3·27.

Parallax of the Planetary Nebula G.C. 4373.—From a photographic determination, Dr. Bohlin finds that the parallax of the planetary nebula G.C. 4373 (H iv. 37) is $-0{\cdot}170''\pm0{\cdot}042''$, and the correction for the aberration constant is $-0{\cdot}043''\pm0{\cdot}042''$ (*Astronomische Nachrichten*, No. 4406, p. 232).

HALLEY'S COMET AND METEOROLOGY.

Proposed Meteorological Observations during Progress through the Tail of Halley's Comet.

The International Commission for Scientific Aëronautics had arranged a series of ascents of kites and *ballons-sondes* for May 11–13, but seeing that it is possible that the earth may pass through the tail of Halley's comet on May 19, the members of the commission have agreed to postpone the ascents to May 18–20. A circular from Prof. Hergesell, the president of the commission, gives particulars of the proposed ascents, the times mentioned being as follows:—May 18, 7 a.m. and 10 p.m.; May 19, 2.30 a.m. and 7 a.m.; and May 20, 7 a.m. Observations should be made at the earth's surface, and *ballons-sondes* should be sent up about half an hour before these times, so that the balloon for the principal ascent should reach its greatest height about the time when the earth passes through the tail of the comet; one ascent should also precede, and one should follow, the principal ascent by precisely similar intervals of time.

Messrs. Assmann and Teisserenc de Bort suggest that it might be possible to carry out ascents of manned balloons as well as of *ballons-sondes*, and it is suggested that the aero clubs of different countries should cooperate in the observations. A letter has also been sent out by M. Teisserenc de Bort describing the apparatus he has designed and used for several years for collecting samples of air from great heights. The use of Aitken's dust counter is recommended in connection with the ascents of manned balloons, and similar observations should be made at the earth's surface. Though it is unlikely that the passage of the earth through the tail of a comet will cause any measurable change of temperature in the upper air, yet it is felt by those engaged in the investigation of this subject that such a rare occurrence should not be allowed to pass without some notice.

Meteors from Halley's Comet.

Mr. Denning writes:—

"During the first week in May the weather was unsettled and stormy, and Halley's comet could not be well observed, nor could its supposed meteoric shower from Aquarius be suitably watched. Several meteors were seen, however, at places where the sky was clear or partially so, and they were directed from the radiant point of the comet, though no brilliant display of these phenomena seems to have been witnessed in England.

"There is a probability of an abundant display of meteors on the morning of May 19, when the earth may encounter the comet's tail, but this is doubtful. The sky should be carefully watched, however, on the morning named with the view of observing any meteors or peculiar auroral effects that may be visible.

"A rich display of meteors is reported to have been witnessed at Cape Town on the morning of May 7 between 2 and 5 a.m. There was no very active shower seen in England on the date mentioned, and further particulars will be awaited with interest.

"A fireball, presumably connected with Halley's comet, was noticed at Guernsey and other places on the morning of May 3 at about 2.50 a.m. As viewed from the Channel Islands, it had a long path ascending from just under β Pegasi to under β Cassiopeiæ, with a duration of four seconds.

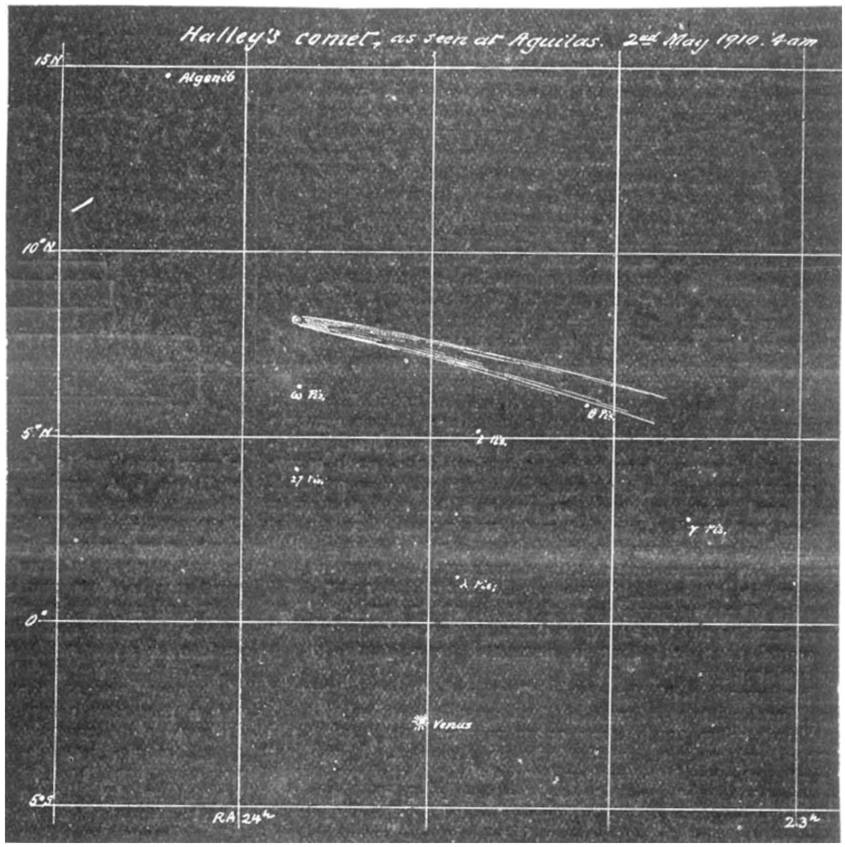
"The real path of the meteor was from sixty-seven to forty-six miles in height, and its position over the English Channel from near Dieppe to south-west of the Isle of Wight, and its course, of some 137 miles, was traversed at a velocity of about thirty-four miles per second. This is a slower rate of speed than calculation implies to the Aquarids, but atmospheric resistance evidently moderated the meteor's native velocity. From the south coast of England—especially Sussex and Hampshire—the object must have been a splendidly luminous one, presenting a very long and graceful flight along the southern sky, but I have not hitherto received any observations from this particular part of the country.

"That the meteor was really a fragment of Halley's comet cannot be absolutely proved, but it is suggestive and significant that it was directed at the correct date from the computed radiant of the famous comet now visible. It is hoped that further observations will be furnished of this and of any similar objects which made their apparitions at the important time when the earth passed near the cometary orbit."

Observations of Halley's Comet.

Mr. Gustave Gillman, writing from Aguilas on May 2, says:—

"I enclose a chart showing Halley's comet as seen at 4 a.m. this morning, and the extent to which the tail could be traced, *i.e.* to slightly beyond θ Piscium. I have seen it on two previous days, but there were too many clouds to be certain of the extent of the tail. I could see no bifurcation."



Halley's Comet as seen at Aguilas on May 2, 1910, at 4 a.m.

Dr. A. C. Jordan writes:—

"At Broadstairs yesterday morning, Sunday, May 8, I had a good view of Halley's comet. There was a slight mist over the horizon, but I was able to keep the comet in view from 2.50 until 3.25. It was easily visible to the unaided eye, and was brighter than Algenib (γ Pegasus), the nearest bright star. Through an ordinary binocular the contrast between this clearly defined star and the nebulous-looking comet was very well marked. Toward 3.30 the approach of day rendered this part of the sky so bright that it was no longer possible to keep the comet under observation."

Further details as to the appearance of Halley's comet, as seen at Malta with naked eye and field-glasses, are sent to us by Mr. C. Leach. The comet was seen by several people, and Mr. Leach found that both nucleus and tail were easily picked up without optical aid on April 24, 25, 26, 27, and 30. He states that it was seen best between 3.45 and 4 a.m., and faded in the dawn at 4.10 a.m. The tail is described as lengthening and getting more elegant, its length being a little greater than the distance separating the comet and Venus; this would mean an apparent length of about 7° or 8°, and an actual length of about ten million miles. The nucleus, on April 30, is described as being sharply defined and at the very beginning of the comet, its brightness being about equal to that of α Andromedæ (mag. 2·1). A rough sketch sent by Mr. Leach represents the comet as having a straight, narrow, bifurcated tail, reminding one of the Paris drawing of the great comet of 1843.

Mr. Gruning, of Ealing, reports having seen the comet on several occasions with field-glasses, and twice, on May 7 and 8, with the naked eye. To know where to look for it the first time, he observed Altair emerge from behind a chimney the previous evening, and then, by a simple calculation, found the time, and the position with regard to the same chimney, for the comet's appearance next morning.

Mr. Bellamy reports to the *Daily Mail* that the comet was observed at Oxford University Observatory from 2.40 to 4 a.m. on May 9. It was visible without a telescope, and was estimated to be about as bright as a second-magnitude star. Observations were also made at Greenwich with the altazimuth.

According to a correspondent of the *Daily Chronicle*, observations at the Milan Observatory, on May 8 or 9, showed a straight tail some twenty degrees in length, or, actually, about 14½ million miles long. A tail of this length would probably reach to the earth at the time of transit.

Observations of the comet during its near approach to Venus on May 2 were prevented, at English observatories, by bad weather, so that the possible magnetic-attraction phenomena mentioned by Prof. Birkeland could not be looked for.

In an address delivered on Monday evening at the annual meeting of the Victoria Institute, Mr. Crommelin directed attention to one or two possible references to the comet in historical writings, citing the "almond rod" mentioned in Jeremiah i., 11–14, as a possible allusion to the comet's tail seen rising before the head. He also directed attention to the improbability of our being able to detect the presence of the tail should the earth pass through it. In suggesting that the comet would afford a good display during the evenings of the last ten days in May, he warned his hearers not to expect such a spectacle as was afforded by the great comet of 1882.

In the *Atti della Pontificia Accad. Romana dei Nuovi Lincei* (February 20) Dr. Pio Emanuelli points out that the velocities of Halley's comet at perihelion and aphelion are often exaggerated, and, using Mr. Crommelin's elements, he determines the true values. These he finds to be 55 km. and 0·9 km. (35·6 and 0·56 miles) per second respectively. Dr. Smart, using Pontecoulant's elements, obtained 31·3 and 0·62 miles per second.

Messrs. Cowell and Crommelin have been awarded, jointly, the Janssen medal of the Société astronomique de France, for their precise determination of the orbit of the comet for this present apparition.

A number of interesting representations of comets, some certainly of Halley's, are reproduced in the May number of the *Bulletin de la Société astronomique de France* from the "Theatrum Cometicum" of Lubienietz. Each drawing is accompanied by a note explaining it, and directing attention to contemporary occurrences; in concluding the article, M. Flammarion suggests that great comets were of more frequent occurrence in early times than they are now.

A NEW TELEPHONE RELAY AND ITS APPLICATIONS.[1]

EVER since the introduction of the telephone a real need was felt for a telephone relay, for the distance over which telephones could be used was found to be comparatively limited. Edison, soon after his invention of the carbon button transmitter, caused an electromagnet to act upon the iron diaphragm, and thus turned it into a relay, but it was not a success. Hughes (Proceedings of the Royal Society, vol. xxvii., p. 362, 1878), in his paper before the Royal Society in 1878, describing his extremely delicate microphones, stated that a telephone receiver, if included in the microphone circuit and placed upon the resonant board, caused a continuous sound to be produced. It follows, he said, that the question of providing a relay for the human voice in telephony is thus solved. Unfortunately, it was not solved; he had shown how to make a relay that would magnify a noise or musical note, but not one that would intensify articulate speech.

Sir Oliver Lodge (Journal of the Institution of Electrical Engineers, vol. xxvii., p. 799, 1898), in a paper read in December, 1898, before this society, described a relay consisting of three or four reeds or tuning-forks, each carrying carbon contacts and working in series with one another. Each reed was arranged to resonate to one particular musical note, and when this note was passed through the string of relays it was multiplied in power to a considerable extent. An instrument of this character, however, is not effective in intensifying speech. An articulate relay must have its vibrating parts damped, or, in other words, possess no resonating properties; it is therefore far more insensitive to sound than one that is arranged to resonate to one particular note.

The invention of the powerful granular transmitters of the Hunning type stimulated further efforts to obtain the speaking relay, and some progress was made with this type of microphone, particularly in America. I will not describe these relays further than to say that they consist in combining the telephone receiver and the granular carbon transmitter; both of these are designed as efficiently as possible, and in some cases automatic means are provided to shake up the granules should they become packed. These relays are only partially successful. Their advantages are not decisive. They require relatively powerful currents to work them; that is to say, when the telephone currents become sufficiently feeble to require their services, it is at this point that the carbon instrument fails to work. The telephone relay to be successful has to magnify in a continuous manner varying currents that are too feeble to affect properly a Bell telephone receiver. Such currents would be of excessive weakness, say of the order of the one one-hundred millionth of an ampere (10^{-8} ampere), and the mechanical movements produced by such currents, which have in their turn to bring about the increased electrical changes, are therefore microscopic in dimensions.

The author's telephone relay has had to be developed along quite new lines. It takes as its basis the researches of J. J. Thomson, Earhart, Kinsley, and others, with regard to the flow of electrons across a microscopic air-gap between two conducting surfaces at different potentials (see "Conduction of Electricity through Gases," J. J. Thomson, chap. xv.). Earhart made a series of experiments on the difference of potential required to produce sparks the length of which is comparable with the wave-length of sodium light, and he found that when the distance between the metal electrodes falls to less than about 3×10^{-4} cm., the spark potential falls off rapidly with the distance, and seems to become proportional to the distance; that is to say, when the electrodes are placed very close together, within a distance such that the average intensity of force F between the electrodes reaches a value of about a million volts per centimetre, the discharge or

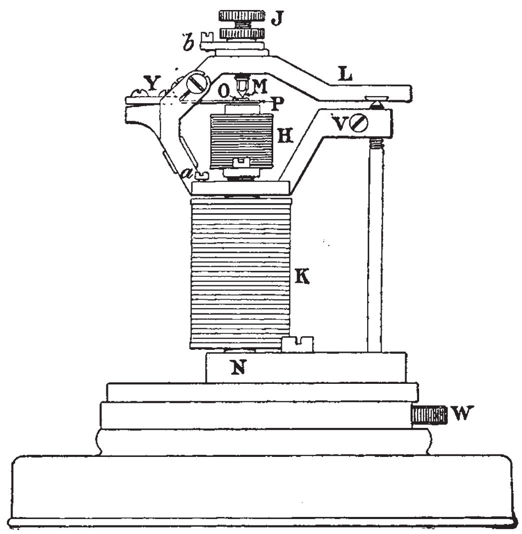


FIG. 1.

current passing is determined by the condition that F, which is V/d, reaches this value (where V is the potential difference and d the distance between the electrodes). If the metallic circuit of a dry cell be interrupted by a minute opening or space of the order of 5×10^{-7} cm., the metal at the point of interruption being platinum, the current will continue to flow round the circuit and across the opening, and any slight alteration in the length of the space, which I shall call the conduction space, will vary its resistance and greatly affect the value of the current that flows round the circuit. This conduction space is therefore exactly what is wanted for the current-varying device of a telephone relay, where microscopic mechanical movements are to be transformed into large current changes. The dimensions of the conduction space are so small that it is difficult to ensure and maintain it by direct mechanical means. The current that flows across the space was therefore made to do its own adjustment, very much in the same way as the current that passes through the arc of an arc lamp is made to strike and maintain the length of the arc.

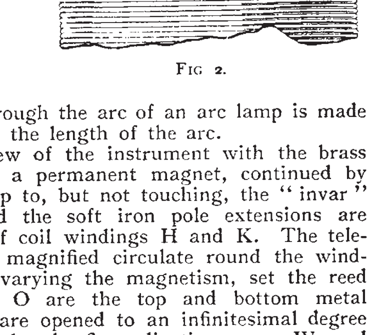


FIG 2.

Fig. 1 is a side view of the instrument with the brass cover removed. N is a permanent magnet, continued by soft iron poles right up to, but not touching, the "invar" steel reed P. Round the soft iron pole extensions are wound the two sets of coil windings H and K. The telephone currents to be magnified circulate round the winding H, and thus, by varying the magnetism, set the reed P in vibration. M, O are the top and bottom metal contact-pieces, which are opened to an infinitesimal degree to form a microphone by the fine adjusting screw W and

[1] From a paper read before the Institution of Electrical Engineers on May 5 by Mr. S. G. Brown.