der Erde." The second volume, dealing with salt in Asia, Africa, America, and Oceania, appeared recently, and the first volume, which will be concerned with Europe, is in the press.

THE prominence now given to geometrical and machine drawing in the curricula of schools and colleges has led to an increased demand for trustworthy mathematical drawing instruments. The recent catalogue, with its numerous illustrations, published by Mr. W. H. Harling, of Finsbury Pavement, London, showing the instruments he is prepared to supply, may be commended to the attention of teachers and students. In it they will find particulars concerning a great variety of instruments designed to meet every want.

OUR ASTRONOMICAL COLUMN.

COMET 1906e (KOPFF).—In addition to those published by Herr M. Ebell, elliptic elements have been calculated for the orbit of Kopff's comet by Messrs. Crawford and Champreux, and are published in No. 100 of the Lick Observatory Bulletins. They are as follows:—

Elements.

T = 1906 May 2·0877 G.M.T.
Epoch = 1906 Sept. 5·67091 ,,

$$\left.\begin{array}{rl} M = & 18^\circ\ 41'\ 54''\cdot6 \\ \omega = & 19\ \ 28\ \ 44\cdot9 \\ \Omega = & 263\ \ 45\ \ 23\cdot6 \\ i = & 8\ \ 44\ \ 09\cdot8 \end{array}\right\} 1906\cdot0$$

$$\log q = 0\cdot230114$$
$$\log e = 9\cdot716356$$
$$\log a = 0\cdot549258$$
$$\mu = 532''\cdot255$$
$$\text{Period} = 6\cdot66633 \text{ years}$$

The first decimal place of the period is determinate, and as this agrees with Herr Ebell's, who gave 6·617 years, it may be taken as fairly established. An ephemeris which accompanies the elements gives the following positions for the remainder of this month:—

Ephemeris (12h. G.M.T.).

1906	α (true) h. m.	δ (true) ° ′	1906	α (true) h. m.	δ (true) ° ′
Oct. 17·5	22 28	5 3	Oct. 25·5	22 30	4 30
21·5	22 29	4 45	29·5	22 32	4 17

JUPITER'S SEVENTH SATELLITE.—From a telegram from Prof. Pickering to the Kiel Centralstelle, published in No. 4123 of the *Astronomische Nachrichten*, we learn that Jupiter's seventh satellite was re-observed by Prof. Perrine at the Lick Observatory on September 25. The position-angle and distance at 1906 September 25·9962 were 119°·1 and 2578″ respectively.

OBSERVATIONS OF VARIABLE STARS.—Bulletin No. 8 of the Laws Observatory, University of Missouri, contains the results of some variable-star observations made at the observatory during 1905–6. A grant of five hundred dollars from the Gould fund of the National Academy of Sciences has enabled the director, Prof. F. H. Seares, to engage an assistant observer, Mr. E. S. Haynes, for this work with gratifying results.

The star B.D. + 55°·2817 has been shown to be a variable of the continuous variation type, with a range of 0·4 magnitude and a period of 5·4 days. Observations of V Lacertæ, V Vulpeculæ, and 108.1905 Capricorni are also recorded. In the case of the last-named, the rise to maximum is very rapid, an increase of 1·5 magnitudes taking place in 1⅔ hours, and the observations show that this star is probably not of the Algol type.

SUN-SPOT SPECTRA OBSERVATIONS.—In No. 2, vol. xxiv., of the *Astrophysical Journal*, Mr. W. M. Mitchell, of Princeton Observatory, records the results of his sun-spot spectra observations made during the period October, 1905, to May, 1906. Mr. Mitchell found that during the more recent observations the number of "weakened" lines in the spot spectra has increased considerably; many lines previously recorded as "reversed" are now "weakened," and new lines of the latter type are recorded. A suggestion that this change may be a result of the passing of the sun-spot maximum awaits the confirmation of further observations. Numerous cases of abnormal "reversals" are referred to in the paper. From the observations of reversed lines Mr. Mitchell deduces a temperature for the gases producing these lines of 4700°, and a further deduction gives 0·38 as the ratio of the sun-spot radiation to the radiation from the unaffected photosphere. The spectrum and construction of the chromosphere are also discussed at some length.

CONDENSATION NUCLEI.[1]

PROF. Barus has written more upon the subject of condensation nuclei than any other physicist. In the present memoir, as in those which have preceded it, he arrives at conclusions which are not in agreement with the work of others who have investigated the properties of ions and nuclei. If his investigations are to be trusted, the determinations which have hitherto been made of the charge carried by the ions by means of the condensation method must be regarded as quite untrustworthy. The matter is of sufficient importance, therefore, to justify an examination of Prof. Barus's methods.

The first three chapters, and the greater part of the sixth and concluding chapter, are concerned with experiments upon the production of clouds by the sudden expansion of dust-free air initially saturated with water vapour, the air in most cases being exposed to the action of X-rays or radium. As described by Prof. Barus, the phenomena are exceedingly complicated and irregular. This is not surprising, however, being largely a result of complication in the experimental conditions.

The expansion was brought about by suddenly opening communication between the "fog chamber" and another much larger, partially exhausted vessel, a measured fall of pressure being thus produced. By means of the coronas formed, an estimate was obtained of the size, and hence indirectly of the number of the drops; filtered air was then re-admitted to bring the pressure back to that of the atmosphere. This method of effecting the expansion is not a suitable one for investigations of the kind attempted. For the rate of fall of pressure must diminish as the expansion approaches completion; it is probable that with a suitable width of connecting tube no great error will be introduced into the measurement of the least expansion required to produce a cloud (*i.e.* that the expansion may be made practically adiabatic), but it is unlikely that the maximum degree of supersaturation resulting from expansions greater than this approaches at all closely to that calculated from the pressure fall. For the condensation on the nuclei which first come into action will, by reducing the amount of vapour remaining uncondensed and by the heat set free, prevent the full supersaturation corresponding to the pressure fall from being attained. The larger the number of easily caught nuclei, the more will the maximum supersaturation attained fall short of the theoretical. The method is thus not a suitable one for obtaining information about the number of nuclei corresponding to various degrees of efficiency.

If we produce a cloud in dust-free air upon nuclei which require a high degree of supersaturation to make water condense upon them, the drops which are formed, if caused to evaporate by compression of the air, appear to leave behind nuclei requiring only a slight supersaturation to make water condense upon them. Unless these are removed before expansions large enough to catch the original nuclei are again attempted confusion is sure to follow. The result of neglecting this precaution is not merely that these residual nuclei give rise to drops as well as those under investigation, but unless the apparatus is such as gives exceedingly efficient expansion the supersaturation necessary for the capture of the nuclei under investigation may not be attained, the number of drops produced being thus too small in contrast to what might at first sight be expected. The experiments of Prof. Barus's investigation were performed under conditions which made this effect

1 "The Nucleation of the Uncontaminated Atmosphere." By Prof. Carl Barus. Pp. 152. (Published by the Carnegie Institution of Washington January, 1906.)

conspicuous, the result in many cases being a remarkable alternation of larger and smaller coronas, corresponding to variations in the number of the drops, for successive expansions of equal amount. It is easily seen how, under the appropriate conditions, such an alternation may arise, for the second expansion may remove the greater number of the residual nuclei due to the first, so that the third takes place under conditions similar to those of the first expansion. A large amount of space is given to the study of these alternations, and they are finally traced to their true source after many hypotheses have been suggested for their explanation, "the solutional enlargement" of the nucleus, as the author calls it, being then apparently regarded as a new discovery. Besides incidental references to these residual nuclei in earlier papers, he would have found them described in Thomson's "Conduction of Electricity through Gases," p. 139, or in a review of the subject of condensation nuclei presented to the International Electrical Congress of St. Louis in 1904, and a great deal of labour might have been saved. That small drops of pure water might be expected to cease to evaporate, even in an unsaturated atmosphere, beyond a certain minimum size (related to the thickness of minimum surface tension of thin films) is pointed out by Thomson in the same chapter, p. 153; and a theory (having a similar basis), which explains the permanence of certain slow-moving ions requiring a negligible degree of supersaturation to make water condense upon them, has been given by Langevin and Bloch.

By exposing to intense X-rays the moist air in a "rectangular condensation chamber of wood impregnated with resinous cement," the front and rear faces being of plate glass, persistent nuclei requiring only a very slight expansion to cause water to condense upon them were obtained. The only nuclei hitherto observed in dust-free air exposed to X-rays require large expansions to capture them. That such nuclei should, under the appropriate conditions (the occurrence of chemical action giving rise to soluble products), grow into larger bodies is what might be expected; such a growth has, for example, been observed in the case of the ions arising from a point discharge. It is quite likely that sufficiently intense X-rays or radium rays might bring about in moist air the chemical action necessary for such a growth of the nuclei, as intense ultra-violet light certainly does; but results, obtained with a chamber of wood impregnated with resinous cement and not rigorously shielded from all possible direct electrical effects from an X-ray bulb placed a few cm. from it, are not free from ambiguity.

Apart from this effect of very intense radiation, the conclusions arrived at by the study of the effect of X-rays and radium rays appear to differ from those of other observers. Prof. Barus holds original views, not only upon the relation of "nucleation" to ionisation, but as to the nature of the radiation from an X-ray tube. These are best given in his own words:—

Chapter vi., p. 133: "Let the X-radiation to which the dust-free air is exposed be relatively weak, so that the density of ionisation may remain below a certain critical value. The nuclei observed on condensation are then very small, and they require a high order of exhaustion, approaching but always below the fog limit of non-energised air. They are usually instantaneously generated (within a second) by the radiation, so that their number is definite independent of the time of exposure. They decay in a few seconds after the radiation ceases, *i.e.*, roughly, to one-half their number in 2 seconds to one-fifth in 20 seconds, in the usual way. I fancy that these nuclei are what most physicists would call ions; but nevertheless the particles are not of a size, the dimensions depending on the intensity of the penetrating radiation to which they are usually due, and they pass continuously into the persistent nuclei, as shown in the next paragraph, where decay of ionisation and of nucleation are very different things. They are abundantly produced by the γ rays, which though weak ionisers, become from this point of view strong nucleators."

Chapter vi., p. 142: "While the phosphorescent, photographic, and electric effects of X-radiation decrease rapidly with the distance, D, from the tube, the nucleating effect (N, nuclei generated per cubic centimetre, instantly) is nearly constant over relatively enormous distances. Thus to give two examples among many ($\partial p = 25$ cm.):—

D=	... 6	... 200	... 600	... 6	... 200	... 600 cm.
$N \times 10^{-3}$	88	... 83	... 83	... 79	... 79	... 79 ,,

The law of inverse squares would predicate a reduction of 10,000 to 1 between these limits; and in fact, at 6 cm. the phosphorescent screen is intensely luminous, at 200 cm. very dim, at 600 cm. quite dark as in the case of any ordinary illumination. The leaves of an electroscope within a glass bell jar collapse in a time which is directly as the square of the distance from the energised X-ray bulb. The result obtained with nuclei is astonishing; the nuclei-producing radiation would, at first sight, seem to be of an extremely penetrating kind, akin to the gamma rays of radium, and distinct from the ordinary phosphorescence-producing X-rays."

Chapter vi., p. 144: "To the eye of the fog chamber therefore the walls of the room are aglow with radiation, and no matter in what position the bulb may be placed (observationally from 6 cm. to 6 m. between bulb and chamber) the X-illumination as derived from primary and secondary sources is constant everywhere. It is to be understood that the X-illumination here referred to may be corpuscular. In fact, so far as I see, the primary and secondary radiation here in question may be identical; for the corpuscles may come from the circumambient air molecules shattered by the shock of gamma rays."

Chapter vi., p. 145: "It has been shown that for very short exposures (sections 101 and 102) the nucleation is the same, whether the bulb is placed at 6 cm. or 6 m. from the fog chamber. But only in the former case (D=6 cm.) is the effect cumulative; only for very short distances will persistent or very large nuclei appear if the exposure is prolonged several minutes. I have therefore suspected that the radiation from the X-ray bulb is twofold in character; that the instantaneous effect (fleeting nuclei) is due to a gamma-like ray, quick moving enough to penetrate several millimetres of iron plate appreciably even for D=6 metres; furthermore that the cumulative effect (persistent nuclei) is due to X light, properly so called, which produces the usual effects subject to the laws of inverse squares; but it is noteworthy that while the penetration of X-rays is relatively small, and the distance effect negligible (section 101), they are both large for the radiation from radium (section 104)."

The conclusion that the nucleus-producing radiation from an X-ray bulb is constant over distances varying from 6 cm. to 6 m. (or as elsewhere expressed that "the whole medium within the room is almost equally energised throughout") is somewhat startling. One would not expect the number of nuclei present at a given moment in any case to fall off inversely as the square of the distance; the number of ions might under suitable conditions be expected to vary inversely as the distance; but the fact that there is no falling off at once suggests that there is something wrong with the experiments or the interpretation put upon them. Possibly the observed constancy is partly due to the failure of the method to deal with more than a limited number of nuclei. Some of the results, however, suggest that it may have been partly due to the failure to shield off the rapidly changing electric field produced by the working of the coil.

There is more danger of the statements of the first paragraph quoted above leading to confusion. The expression "fog-limit" apparently indicates the smallest pressure fall which produces a sufficiently large number of drops to admit of a corona being observed. Previous expansion experiments, in which a sudden definite volume change was produced, have shown three critical or limiting values of the expansion (measured by the ratio of the final to the initial volume). These are 1·38, beyond which dense fogs begin to be produced in dust-free air under normal conditions; 1·25, the least expansion required for the capture of negative ions; and an intermediate one in the neighbourhood of 1·31, the least expansion required for the capture of positive ions. Certain apparently uncharged nuclei require an expansion of about the same amount as do the positive ions. Ions of both kinds are always present in small numbers in the air of a closed vessel unless an electric field is present to remove them as they are set free; an expansion exceeding 1·25 gives, in the absence of such a field, fog or rain, according as the air is exposed to external ionising agents or not. The above three limits would correspond to adiabatic pressure falls of 27·7, 20·5, and 24·1 cm. of mercury respectively, if the initial pressure was 76 cm., and would vary with the initial pressure. The fog limit obtained by Prof. Barus for air exposed to X-rays or radium rays, except under conditions such that persistent nuclei resulted, generally lay between 19 and 21 cm., except when the radiation was exceedingly weak, when the limit approached that which he obtained for "non-energised" air, about 24 cm., which may be compared with the intermediate critical expansion mentioned above. The results of Prof. Barus are accounted for if we suppose that his method failed to detect the comparatively small number of drops formed on the spontaneously produced negative ions; such variation of the limit as was observed in air exposed to external radiation, as the intensity was varied within moderate limits, being what might be expected with a method in which the "fog limit" is only reached when a certain minimum number of drops is exceeded. It is true that the ions are not at any one moment all in an equally favourable condition for helping condensation, a certain range of expansions (not very wide, however) being required, for example, to catch all the negative ions; but there is no evidence that the efficiency of the ions as nuclei increases with the intensity of the ionising rays, if we leave out of consideration the possible effect of exceedingly intense rays; for the weakest radiation (that responsible for the "spontaneous" ionisation), as well as for radiation of very considerable intensity, the efficiency of the most favourably situated ions remains the same. Prof. Barus has apparently failed to notice that the limits found by him are, if properly interpreted, in fairly good agreement with those of previous observers—quite as good agreement as could be expected from the comparative roughness of his methods. Possibly some explanation of this omission is afforded by a passage on p. 50, where the volume change corresponding to a given pressure fall has been wrongly calculated, as if the expansion were isothermal instead of being nearly adiabatic.

It is a matter of some difficulty to know what views Prof. Barus really holds upon the relation of the ionisation as determined by electrometer measurements and the "fleeting nuclei" which "most physicists would call ions." That he does not regard such nuclei as identical with the ions is plain from the statement that the gamma rays, though weak ionisers, are strong nucleators, as well as from the suggestion that the fleeting nuclei produced by an X-ray bulb may be due to "a gamma-like ray," and only the persistent nuclei to the "X-light properly so called, which produces the well-known effects subject to the law of inverse squares" (the ionisation as determined by electrometer measurements being one of these, as another of the passages quoted seems to indicate). Prof. Barus seems to have entirely failed to realise how complete is the evidence of the identity of the nuclei produced, in the investigations of previous observers, by X-rays or any of the various types of Becquerel rays with the ions the existence of which has to be postulated to explain the phenomena of the conduction of electricity through the air exposed to such rays. Not only has it been shown by direct experiments that the nuclei are positively and negatively charged bodies having properties such as have to be assigned to the ions to explain the phenomena of conduction through gases, but a still more direct proof of the identity is furnished by the agreement of the two methods by which the charge on the ions was determined, that of J. J. Thomson and that of H. A. Wilson. For the former gives the ratio of the ionisation (the product of the number of the ions per c.c. and the charge carried by each), as determined by electrical methods, to the number of the nuclei, while the latter gives directly the actual charge of a single nucleus. Thus the number of nuclei, multiplied by the charge on each nucleus, is equal to the product of ionic charge and number of ions deduced from electrical measurements. The ionisation accounted for by the nuclei in question is thus equal to the ionisation determined by the electrical method.

Chapters iv. and v. contain an account of observations made at Providence and in the comparatively uncontaminated atmosphere of Block Island upon the variations in the number of nuclei in unfiltered atmospheric air. The nuclei are here such as may be caught with smaller expansions than are required by the ions; they are Aitken's "dust" particles. Their number was estimated, not by Aitken's method, but by observing the coronas seen through the fogs produced on expansion of the air in an apparatus of the same type as that used in the investigations already discussed. In the present case, where only easily caught nuclei are involved, the objections brought above against the method do not apply, and there can be no doubt about the importance of such investigations.

C. T. R. WILSON.

BOTANICAL CONGRESS AT HAMBURG.

THE Society of Applied Botanists held its annual conference at Hamburg in September, and the Society of Systematic Botanists held its meeting there at the same time. Some 150 botanists in all, mostly interested in applied botany, attended. The choice of place of meeting was a happy one, as in Hamburg, the chief Continental port, the closest connection can be seen between commercial and scientific activities.

All the botanical institutions are under the direction of Prof. Zacharias, and while the educational requirements are well cared for, everything that the botanical scientific staff can do to foster the trade of the city is done. The seed-testing station is under the direct charge of Prof. Voigt, who, with six assistants, tests some 1500 samples of seed, oil-cake, &c., each year. An important export seed trade with the Argentine Republic is carried on, the certificates required by the Republic being supplied from the station. Another important institution is the Station for Plant Protection, founded some seven years ago as a means of protection for the vineyards and orchards of Germany against the San José scale insect and other pests liable to be imported into Germany on American apples, fruit-trees, &c. This station is in charge of Dr. Brick, who, armed with the necessary staff, library, and apparatus, must report on every barrel of apples coming into port. The rejected apples, dangerous to Germany, find a ready market in England and elsewhere.

In the Botanical Museum the collections are arranged in two sections. One part follows the usual lines—the specimens are arranged in systematic order, according to their natural affinities, and serve more especially for educational purposes. The other part of the collection appeals to commercial interests. The fibres of commerce, the chief rubbers, gums, resins, cereals, &c., are in each class grouped together, regardless of natural affinities, and solely for trade purposes. A new and more commodious museum in the Botanic Gardens is just reaching completion. The museum is regularly visited by schools and their teachers, and a large piece of ground is set apart in the suburbs to supply the specimens required in the schools for teaching purposes.

Everything that could be was done by the local botanical staff and others to make the meetings of the societies a success. The Hamburg Government granted a sum of 4000 marks toward expenses, and in other different ways showed a practical interest in the proceedings. One important feature was the first International Conference on Seed Testing. Most of the seed stations in the world were represented, and attempts to establish a uniform system of testing, applicable in different countries, were discussed. It was generally felt that it would be premature to seek to go further at present than simple discussion. Many valuable papers were contributed. Dr. Stebler gave the results of twenty years' investigation in the station at Zürich as to the country of origin of the seeds of commerce, judged sometimes from the particles of soil found in the impurities (!), but more usually from the weed-seeds present. This paper was fully illustrated by dried plants and seeds. Dr. von Weinzierl, of Vienna, dealt with sugar-beet and mangel seeds; Dr. Degen, of Budapest, with dodder in clover; Prof. Rodewald, of Kiel, with the sources of error in seed-testing; while Prof. Voigt, of Hamburg had pre-