Dines' anemometer, confirming the results of other observers that the factor 3 (the ratio of the speed of the wind to that of the cups) is too great. (2) The Director is able to report a clean bill of health in his little colony (numbering altogether about 100 persons, including servants and their families) during the plague epidemic. This satisfactory state is attributed to additional ventilation, by removal of tiles, &c., to fumigation twice a week by carbolic acid, to inoculation of every man, woman, and child with Dr. Haffkine's prophylactic serum, and to the daily inspection of the quarters and inmates.

THE additions to the Zoological Society's Gardens during the past week include a Servaline Cat (*Felis servalina*) from East Africa, presented by the Rev. Ernest Millar; a Vulpine Phalanger (*Trichosurus vulpecula*) from Australia, presented by Mr. M. A. Murray; a Common Squirrel (*Sciurus vulgaris*), British, presented by Lady Acland Hood; two Bateleur Eagles (*Helotarsus ecaudatus*), two Common Herons (*Ardea cinerea*) from East Africa, presented by Mr. Chas. Palmer; a Red-crested Cardinal (*Paroaria cucullata*) from South America, presented by Miss Edith M. Kenyon Welch; a Grey Monitor (*Varanus griseus*) from Egypt, presented by Dixon Bey; two Natal Pythons (*Python sebæ*, var.) from Natal, presented by the Hon. R. Carnegie; an Orang-outang (*Simia satyrus*, ♂) from Sumatra, deposited; two King Penguins (*Aptenodytes pennanti*) from the Antarctic Seas, purchased; a Burchell's Zebra (*Equus burchelli*, ♀), a Japanese Deer (*Cervus sika*, ♀), two Glossy Ibises (*Plegadis falcinellus*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

PERSONAL EQUATIONS IN TRANSIT OBSERVATIONS.—In the reduction of transit observations the question of personal equation is an important factor in the accuracy of the final star places, and it is on this account that investigations are always being pursued to determine the values of these equations for each meridian observer. A communication of importance in this respect appears in the *Monthly Notices* for May, by Prof. Truman Safford, who treats of the various forms of personal equation in transit observations which arise from the non-observance of the exact time of transit due to personality, magnitude of the star observed, and the apparent velocity and direction of movement. In his investigation Prof. Safford concludes that since the year 1795 most eye and ear observers anticipate the true time of transits, taking the average observed as a standard. At Greenwich, since 1885, the great majority of observers by the eye and ear method anticipate the time of their own chronographic transits, while the average chronographic observer registers transits after the time of their occurrence by an amount not greatly different from that which is required to register an impression on the senses. The personal error arising from the rate of movement of the star, or as it is termed the polar equation, amounts sometimes to a very considerable quantity, and several values are given in the paper showing the importance of a strict elimination of this variable. Dealing with faint stars an observer using the chronographic method registers its time of transit later than that when a more bright one is taken, while with the eye and ear method the time of transit is generally somewhat earlier. The change in direction of motion of stars due to their being observed sometimes north and sometimes south of the zenith, gives rise to a further personal equation discovered by Dr. Gill, but which is found generally very small. The investigation shows that the general theory thrown out by Bessel is thus confirmed, and Prof. Safford points out that the same is true with regard to Wundt's explanation of the eye and ear process from a psychological point of view.

PARIS OBSERVATORY REPORT.—In his annual report for the year 1896, M. Lœwy, after a brief reference to the loss the observatory sustained in the death of M. Tisserand, sums up the work of the past twelve months. Among some of the chief points to which reference is made, may be mentioned the two astronomical congresses that have been held at the Observatory, and the work connected with the great enterprise of the photographic chart of the heavens. Many of the difficulties connected with the latter have for the great part been overcome, but there still remain one or two important questions which have been left over for another meeting. M. Bigourdan's work on the determination of the accurate position of the nebulæ between declination 90° and −30° has made great progress, and it is expected that it will take him three years more to complete the whole region under survey. The work on the photographic atlas on the moon has been successfully continued, and besides the issue of the first portion of the atlas during the past year, a second one will be published in the present one. The report further gives a brief account of M. Deslandres' work on the motions of stars in the line of sight, and the results of the expedition to Japan to observe the solar eclipse of August last. The work done in other departments of the observatory during last year, such as the Bureau des Calculs, Service Meridien, &c., is also briefly described.

BELGIAN TIME-RECKONING.—Since the beginning of May, the hours in Belgium have been reckoned from 0 to 24, noon being represented by 12, and midnight by 0 or 24, according to circumstances. In the case of a train starting exactly at midnight, it is said to leave at 0 hour; and one arriving exactly at midnight is considered due at 24 hours, or, as we should say, at 24 o'clock. We learn from the *Journal* of the Society of Arts that on the time-tables the times between midnight and 1 a.m. are indicated by a zero, followed by a point and the letter H, the latter followed in turn by the number of minutes. The dials of existing clocks at railway stations are completed by the figures 13, 14, 15, &c., to 24, added below the existing figures of 1, 2, 3, &c., to 12. This change, which should have come into force with the new year, was deferred for three months, on account of the administrative difficulties which it involved, and also in the hope that the Greenwich meridian, now adopted in Belgium, might also be accepted by France at the same time, urgency having been voted for a measure to that effect by the Chamber of Deputies.

A NEW CLASSIFICATION OF STELLAR SPECTRA.[1]

MANY of the recent advances in our knowledge of the constitution of the stars are traceable to Prof. Pickering's revival of Fraunhofer's mode of investigating stellar spectra. The endowment of this research by Mrs. Draper as a memorial to her husband, Dr. Henry Draper, has enabled Prof. Pickering to apply this method in two principal directions. First, a series of photographs was taken on a small scale to indicate the chief characteristics of the spectra of a very great number of stars; second, in the case of the brighter stars, another series was taken with greater dispersion with the view of facilitating an inquiry into the more minute features of each type of spectrum. The results of the first investigation are comprised in the well-known "Draper Catalogue," giving particulars of the spectra of over 10,000 stars (NATURE, vol. xlv. p. 427), and the research has now been advanced another stage by the publication of the results obtained along the second line of inquiry.

The new series of photographs has been taken with one to four objective prisms of 15° each in conjunction with the 11-inch Draper telescope of 153 inches focal length.

When four prisms were employed, the spectra were 8 centimetres long from H_β to H_ϵ, and with one prism 2 centimetres. Since only the brighter spectra could be photographed with the highest dispersion, some of the more typical of these were also photographed with one and two prisms in order to give a proper term of comparison with the spectra of the fainter stars. In all, 4800 photographs of the spectra of 681 of the brighter stars north of declination −30° are included in the present discussion. By the use of plates stained with erythrosin the spectra of several stars have been photographed in the green and yellow.

As in all previous work involving considerable numbers of stellar spectra, it has been found that the spectra can be classified in large groups, between which there are intermediate varieties. "Large numbers of almost identical spectra are found, even when several hundred lines appear in each." The description of the spectra accordingly takes the form of an account of typical stars in the scheme of classification adopted, accompanied by tables of the lines which characterise the larger groups. No

[1] Spectra of bright stars, photographed with the 11-inch Draper telescope as a part of the Henry Draper Memorial, and discussed by Antonia C. Maury, under the direction of Edward C. Pickering. (*Annals of Harvard College Observatory*, vol. xxviii. part 1, 1897.)

attempt has apparently been made to assign chemical origins to the various lines, so that the endeavour to arrive at a natural and satisfactory system of classification may be regarded as the most important part of the discussion.

The classification of stars has another object besides that of the mere grouping together of those which have similar spectra. It is generally believed that the various types of spectra represent different stages of stellar evolution, but there are divergences of opinion as to the exact order in which the various types should follow each other. Dr. Vogel still holds, with some slight modifications, to the classification which he suggested in 1874, and believes that all the stars can be arranged along a descending line of temperature. Sir Norman Lockyer, who has adopted the same method of work as Prof. Pickering, and has also obtained large-scale photographs of stellar spectra, finds evidence that there are some stars which are getting hotter while others are becoming cooler, so that two series of spectra can be recognised.

For the Draper Catalogue a somewhat arbitrary and provisional classification was adopted, but this has not been found sufficient to meet the requirements of the more detailed results which are now available.

Among the stars with line spectra, as previous researches have shown, there are a few sets of lines which occur with various relative intensities in different stars, each set in some degree varying bodily, and the new classification is based chiefly upon the distribution of these sets. As will appear later, the classification adopted by Miss Maury also takes account of the appearance, as well as of the positions of spectral lines, and every care has been taken to eliminate instrumental sources of error.

Four distinct sets of lines are distinguished. The first includes the lines of hydrogen and calcium, and the remainder are thus described:—

"Another class of lines frequently mentioned comprises those which are characteristic of the solar spectrum, excluding the lines of hydrogen and calcium. They are called 'solar' lines, except when referring to lines not contained in the solar spectrum, in which case they are called metallic lines."

"A third class of lines includes those known as 'Orion lines,' from the fact that they are conspicuous in the spectra of many stars belonging to the constellation Orion. . . .

"Certain stars, such as α Cygni and δ Canis Majoris, have spectra in which the majority of the lines, though probably identical in position with lines belonging to the solar spectrum, differ greatly in intensity, while others apparently are not represented in the solar spectrum. The characteristic lines of such stars should perhaps be regarded as forming a class distinct from those already described."

Bearing in mind these different classes of lines, the new system of classification can readily be understood. Excluding "composite" spectra and bright line stars, "the stars were arranged in an apparently progressive series, which in the present case was made to include twenty-two groups. . . . But it also appeared that a single series was inadequate to represent the peculiarities which presented themselves in certain cases, and that it would be more satisfactory to assume the existence of collateral series."

Three lines of progression are recognised in the earlier stages, and are called "divisions." Stars of division *a* are characterised by lines having the appearance with which we are familiar in the solar spectrum; that is, they are fine and sharp, if hydrogen and calcium be excluded. Those of division *b* are uniformly hazy, as in α Aquilæ, but otherwise present no notable differences in relative intensity from corresponding lines which are sharp in division *a*, so that "there appears to be no decided difference in the constitution of the stars belonging respectively to the two divisions." In division *c* the hydrogen lines are narrow and sharp and less intense than in the other divisions, while several lines, some of which do not correspond with solar lines, are of unusually great intensity; these are especially marked in α Cygni.

Groups and divisions alike proceed by very gradual stages in some parts of the series, and it has frequently been found difficult to assign some of the stars their proper places.

In consequence of the adoption of the term "group," which has been in use for the last ten years in connection with Sir Norman Lockyer's classification, some confusion may possibly occur, as similarly numbered groups include different stars. To avoid ambiguity, it will therefore be necessary, in the case of the first seven groups at least, to specify the system of classification in question. In what follows, the Draper groups will be distinguished by the addition of the letter D to the number where necessary.

Of the twenty-two groups, the first five include stars in which the Orion lines are especially marked; the sixth contains stars intermediate between this type and the first type of Secchi, to which belong the stars in the seventh to the eleventh groups inclusive. The twelfth group is intermediate between Secchi's first and second types, and the stars included in groups thirteen to sixteen are of Secchi's second type. Groups seventeen to twenty inclusive correspond to Secchi's third type, and groups twenty-one and twenty-two to the fourth and fifth types respectively. Besides these, two unnumbered groups are recognised, one containing composite spectra, apparently resolvable into two or more, and the other including stars of the Orion type which also show bright lines. Nebulæ find no place among the numbered groups, but reference is made to a former paper (*Ast. Nach.*, vol. 127, p. 1), in which it was suggested that the Wolf Rayet stars probably form a connecting link between the spectra of nebulæ and those of the Orion type.

It is not possible within the limits of this notice to indicate the full details of the twenty-two groups with their sub-divisions, but the general course of development which is suggested may be briefly stated.

In Group I. D, of which ι Orionis is a type, the hydrogen lines are comparatively faint, while the Orion lines are strong, and "solar" lines are absent. Passing to Secchi's first type, through Groups II. D to V. D, the Orion lines become fainter and less numerous until in the spectrum of Sirius (Group VII. D) all but two or three are wanting. Meanwhile solar lines have become numerous, and the hydrogen lines reach their maximum intensity. The transition to succeeding groups is very gradual, hydrogen lines thinning out and solar lines becoming stronger. Arriving at stars like Capella and the sun (Group XIV. D), the intensity of the hydrogen lines is little more than a tenth of that shown in Sirius, and they afterwards continue to decrease, but less rapidly, down to the third type stars (Groups XVII. D to XX. D), where they are inconspicuous. In the third-type stars banded absorption appears, and becomes more marked in each succeeding group, while the majority of the lines fade out in the later groups. An important feature of the series is the manifestation of extensive absorption in the later groups of second type stars and in those of the third type.

For the present, the series is regarded as ending with the spectra of the third type, stars following the twentieth group not being considered as having a place in the series exhibiting the gradual development of stellar spectra.

Spectra of division *c* are not found after the thirteenth group, and those of division *b* disappear still earlier, "so that the series tends to become more uniform as it progresses."

In connection with the new classification, it is remarked (p. 11) that "while it will be generally admitted that the series represents successive stages in stellar evolution, it may still be doubted whether the arrangement beginning with the Orion type, and here adopted, is in fact the natural order. It is strongly indicated, however, by the gradual falling off of the more refrangible rays in the successive groups, by the corresponding increase in the less refrangible rays, and by the occurrence of marked absorption at the close of the series. The comparative simplicity of the Orion spectra and the increasing complexity shown throughout the series, lends additional weight to the argument. Finally, the prevalence of the Orion type in great nebulous regions, as in Orion and the Pleiades, indicates very emphatically that stars of this type are in an early stage of development."

It will be seen that the supposed evolutionary series has been arrived at without reference to temperature considerations. Nevertheless, a gradual reduction of temperature as the series progresses is suggested by the diminishing intensity of the more refrangible rays, so that, in the main series at least, the order is in all probability one of gradually reducing temperature.

As already remarked, the stars of Secchi's fourth type have been omitted from the supposed evolutionary series of spectra, for the reason that the few lines photographed "have not yet been identified with those of other classes of stars, owing to the total dissimilarity of the spectra." This dissimilarity is stated to extend to the yellow part of the spectrum, and is difficult to comprehend in the light of the more recent results obtained by Dr. McClean, who has shown that the spectrum of 152 Schj. contains many lines which are apparently identical with lines in

the spectrum of α Orionis (*Monthly Notices*, vol. lvii. p. 8). The existence of carbon absorption in the solar spectrum, however, is of itself, as Lockyer long ago insisted, a sufficient connecting link between stars resembling the sun and stars in which carbon absorption is predominant. A classification which excludes these stars from the evolutionary series cannot, therefore, be regarded as final.

It is perhaps unfortunate that the new classification was adopted prior to the discovery of terrestrial sources of helium. Many of the "Orion" lines are now known to be due to this gas, but not all of them, so that these lines may be sub-divided into groups. In the preface to the volume Prof. Pickering remarks: "As the investigations were made several years ago, they could not take account of the recent discoveries respecting the spectrum of helium, which, if known at the time, might have had an important influence upon some of the conclusions. Such modifications could not now be introduced without practically rewriting the treatise, which is therefore published without change. A discussion of the relation of the spectra of stars of the Orion type to that of helium has, however, been made, and is contained in the supplementary notes."

The question of classification, however, is not the sole feature of interest possessed by the spectroscopic work at Harvard. Besides this, there are several tables which give the wave-lengths of the lines depicted on the photographs, a general catalogue of the spectra, and copious remarks on the spectra of individual stars. In the case of the composite spectra it has been noted that in all but one, *o* Andromedæ, the spectrum of the earlier type was the fainter. The peculiarities of the spectrum of γ Cassiopeiæ, already recorded by Lockyer (NATURE, vol. li. p. 425), have been fully confirmed, and the additional fact observed that the entire region of the spectrum from λ 4154·7 to 3927·1 appears brighter than the rest of the spectrum, although the brightening is not homogeneous. The possible importance of this feature is suggested by its occurrence also in stars of the first two groups of the new classification.

The complex phenomena in the variable spectrum of β Lyræ are fully detailed, and the composite character of the dark line spectrum detected at Kensington by Sir Norman Lockyer receives independent confirmation. It is concluded that "the bright bands accompany a spectrum approximately of Group IV. D (*e.g.* γ Orionis), which oscillates periodically over one of Group VII. D, division *c*" (*e.g.* η Leonis), a result which agrees very closely with Lockyer's conclusion that the two dark line stars were not very unlike γ Orionis and β Orionis. It is pointed out that the supposition of a system of three bodies explains most of the spectral phenomena of β Lyræ, but not all of them, and the rapid and complex transformations require to be continuously followed before a complete explanation can be given.

While fully aware of the difficulty attending the satisfactory reproduction of stellar spectra, we think the value of the volume would have been greatly increased by some attempt to give copies of photographs of as many as possible of the typical stars. Without such reproductions the classification can scarcely be adopted by others taking up the work unless photographs of all the typical stars are first obtained. In spite of this drawback, the volume is a magnificent contribution to celestial spectroscopy, and will be of the greatest value to those pursuing similar investigations. Prof. Pickering and his assistants are to be congratulated upon the excellence of this additional contribution to the Henry Draper Memorial. A. FOWLER.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MOST of the arrangements for the approaching meeting of the American Association for the Advancement of Science have now been made, and are announced in the preliminary circular of the local committee. The meeting will be held at Detroit, Michigan, August 9–14. All the meetings, both general and sectional, will be held in the Detroit Central High School.

The chairman of the local committee is General Russell A. Alger, Secretary of War of the United States. The committee contains a great number of distinguished names, including seven or eight presidents of colleges, and several governors, senators, and foreign ministers.

The first session of the American Association, on Monday morning, August 9, will be opened by Prof. Theodore Gill, senior vice-president, owing to the death of President Edward D. Cope. The President-elect, Prof. Wolcott Gibbs, will be introduced, and addresses of welcome will be made by Mayor Maybury and by the ex-Minister to Spain, Mr. Thomas W. Palmer, after which the sections will meet. The addresses by the several vice-presidents of the sections will be as follows:—Prof. Carl Barus, to the section of physics, on long range temperature and pressure variables in physics; by Prof. Wm. J. McGee, to the section of anthropology, on the science of humanity; and by Prof J. C. White, to the section of geology and geography, on the Pittsburg coal bed (the latter to be read in his absence at the Geological Congress at St. Petersburg); Prof. W. W. Beman, to the section of astronomy and mathematics, on a chapter in the history of mathematics; by Mr. Richard T. Colburn, to the section of social and economic science, on improvident civilisation; and by Prof. L. O. Howard (nominated to succeed the late Prof. G. Brown Goode), to the section of zoology, on a subject to be hereafter announced; Prof. W. P. Mason, to the section of chemistry, on sanitary chemistry; by Prof. George F. Atkinson, to the section of botany, on experimental morphology; and by Prof. John Galbraith, to the section of mechanical science and engineering, on applied mechanics.

A general session will be held on the evening of the opening day and Prof. Theodore Gill will deliver, as the presidential address, a memorial of the life and work of the late president, Prof. Edward D. Cope, after which will follow a reception by the citizens of Detroit.

August 10–13 will be occupied as usual by section meetings, and to some extent by excursions of the sections. A new arrangement has been made by which the affiliated societies will occupy a portion of the time heretofore allotted to the sections; and these meetings will be open to members of the Association, as those of the several sections are to members of the affiliated societies. Only three societies meet this year in connection with the Association, namely, the Geological Society of America, the American Chemical Society, and the Society for the Promotion of Agricultural Science. These several societies meet on August 9–11. The Association of Economic Entomologists anticipates the others, holding its meetings on August 6 and 7. Of the other Societies usually affiliated with the Association, the American Mathematical Society will meet at Toronto on August 17–18; and the Society for the Promotion of Engineering Education on August 16–18.

The closing meeting of the Association will be held on the evening of August 13, followed by a reception.

There will be a general excursion by steamer to St. Claire Flats on August 14, the contemplated trip to Buffalo and Niagara Falls having been abandoned.

Attention is again called to the fact that members of foreign scientific associations of a national character are admitted without fee to the meetings of the American Association.

Matters relating to local arrangements, transportation, &c., are in the hands of the local secretary, Mr. John A. Russell, No. 401 Chamber of Commerce, Detroit, Mich. Hotel and boarding-house accommodation is arranged by Mr. Edward W. Pendleton, of the same address. Nominations to membership and letters relating to the general business of the Association should be sent to Miss C. A. Watson, assistant secretary, Salem, Mass., until August 3; after that date to the American Association, Detroit, Mich.

The circular repeats the announcement that after the close of the meeting it is expected that members of the American Association will go in a body to Toronto to join in welcoming the British Association to America. Special rates of fare will probably be secured for this purpose.

The several sections will issue preliminary circulars. The first to appear is that of the anthropological section, which states that Tuesday, August 10, will be devoted to folklore, to which the American Folklore Society has been invited. On Wednesday the report of the committee on the ethnography of the white race in America will be presented in the morning, to be followed by discussion; the subject of psychology will occupy the afternoon. Thursday forenoon will be devoted to the archæology and ethnology of Mexico and Central America; afternoon, to the United States. On Friday morning the report of the committee on anthropologic teaching will be received; and in the afternoon the subject for consideration will be somatology.