SUGGESTIONS ON THE CLASSIFICATION OF THE VARIOUS SPECIES OF HEAVENLY BODIES.[1]

II.

II.—CLASSIFICATION.

I. FORMER CLASSIFICATIONS OF STARS.

IN the various classifications of the celestial bodies which have been attempted from time to time, nebulæ and comets have been regarded as things apart from the stars; but from what I have stated in the first part of this paper, relating to the origin of the various groups of heavenly bodies, it is clear that it is not only unnecessary but unphilosophical to make such a separation; and indeed, if any such separation were needed, such a result would seem to indicate that the line of evolution is by no means so simple and clear as it really seems to be. But although it is no longer necessary to draw this distinction, it is important that I should state the various spectroscopic classifications which have been attempted in the case of the stars. With this information before us, we shall be better able to see the definite lines on which any new classification must be based to include all celestial forms.

Fraunhofer, Rutherfurd, and Secchi.

When we inquire into the various labours upon which our present knowledge of the spectra of the various orders of "stars" are based, the first we come across are those of Fraunhofer, who may be said to have founded this branch of scientific inquiry in the year 1814.

Fraunhofer not only instituted the method of work which now is found to be the most effective, but his observations at that time were so excellent that he had no difficulty in finding coincidences between lines in the sun and in Venus.

Fraunhofer's reference to his observations runs as follows:—

"I have also made several observations on some of the brightest fixed stars. As their light was much fainter than that of Venus, the brightness of their spectrum was consequently still less. I have nevertheless seen, without any illusion, in the spectrum of the light of Sirius, three large lines, which apparently have no resemblance with those of the sun's light. One of them is in the green, and two in the blue space. Lines are also seen in the spectrum of other fixed stars of the first magnitude; but these stars appear to be different from one another in relation to these lines. As the object-glass of the telescope of the theodolite has only thirteen lines of aperture, these experiments may be repeated, with greater precision, by means of an object-glass of greater dimensions."[2]

He did not attempt to classify his observations on stellar spectra, but, as pointed out by Prof. Dunér ("Les Étoiles à Spectres de la Troisième Classe," p. 3), those that he most particularly mentions are really remarkably diverse in their characteristics.

In these researches Fraunhofer was followed by Rutherfurd, who, in the year 1863, was the first to indicate that the various stellar spectra which he had then observed were susceptible of being arranged into different groups. His paper was published in *Silliman's Journal* (vol. xxxv. p. 71), and, after giving an account of the observations actually made, continues as follows:—

"The star spectra present such varieties that it is difficult to point out any mode of classification. For the present, I divide them into three groups:—First, those having many lines and bands, and mostly resembling the sun, viz. Capella, β Geminorum, α Orionis, Aldebaran, γ Leonis, Arcturus, and β Pegasi. These are all reddish or golden stars. The second group, of which Sirius is the type, presents spectra wholly unlike that of the sun, and are white stars. The third group, comprising α Virginis, Rigel, &c., are also white stars, but show no lines; perhaps they contain no mineral substance, or are incandescent without flame."

Soon afterwards Secchi carried on the inquiry, and began in 1865 by dividing the objects he had then observed into two types. These two types were subsequently expanded in 1867 into three ("Cataloge delle Stelle di cui si e determinato lo Spettro Luminoso," Secchi, Parigi, 1867): first, white stars, like α Lyrae; secondly, yellow stars, like Arcturus; and, thirdly, deeply coloured stars, like α Herculis and α Orionis. The order of these types was not always as stated, but I have not been able to find the exact date at which the order was changed (Dunér, "Sur les Étoiles," p. 128). Secchi subsequently added a fourth type, in which the flutings were less numerous. There is little doubt that Secchi was led to these types not so much by any considerations relating to the chemical constitution of the atmospheres of these bodies as in relation to their colours. His first classifications, in fact, simply separated the white stars from the coloured ones (see on this point "Le Scopirte Spettroscopiche," P. A. Secchi, Roma, 1865).

The fourth type included, therefore, stars of a deeper red colour than those of the third, and Secchi pointed out that this was accompanied by a remarkable change in the spectrum; in fact, of Secchi's four types thus established, the first and second had line spectra and the third and fourth had fluted ones. At that time the important distinction to be drawn between line- and fluted-spectra was not so well recognized as it is at present; and further the relation of spectra to temperature was not so fully considered. Secchi, as a result of laboratory work, however, at once showed an undoubted connection between the absorption flutings in the stars of the fourth type and those seen in the spectrum of carbon under certain conditions; and although this conclusion has been denied, it has since been abundantly confirmed by Vogel and others (see Vogel, *Publicationen*, Potsdam, No. 14, 1884, p. 31).

Relation to Temperature.

At the time that Secchi was thus classifying the stars, the question was taken up also by Zöllner, who in 1865 first threw out the suggestion that the spectra might probably enable us to determine somewhat as to the relative ages of these bodies; and he suggested that the yellow and red light of certain stars were indications of a reduction of temperature (Zöllner, "Photometrische Untersuchungen," p. 243).

In 1868 this subject occupied the attention of Ångström with special reference to the contrasted spectra of lines and flutings. On this he wrote as follows, showing that temperature considerations might help us in the matter of variable stars ("Recherches sur le Spectre solaire," Upsala, 1868):—

"D'après les observations faites par MM. Secchi et Huggins, les raies d'absorption dans les spectres stellaires sont de deux espèces: chez l'une, le spectre est rayé de lignes très-fines, comme le spectre solaire; chez l'autre, les raies constituent des groupes entiers à espaces égaux ou des bandes nuancées. Ces derniers groupes appartiennent vraisemblablement aux corps composés, et je mentionnerai, en particulier, que ceux trouvés dans le spectre de α Orionis ressemblent fort aux bandes lumineuses que donne la spectre de l'oxyde de manganèse. Supposé que ma théorie soit juste, l'apparition de ces bandes doit donc indiquer que la température de l'étoile est devenue assez basse pour que de telles combinaisons chimiques puissent se former et se conserver.

"Entre ces deux limites de température chez les étoiles, limites que l'on peut caractériser par la présence de l'une ou de l'autre espèce des raies d'absorption, on peut s'imaginer aussi un état intermédiaire, dans lequel les gaz

[1] The Bakerian Lecture, delivered at the Royal Society on April 12, by J. Norman Lockyer, F.R.S. Continued from p. 590.

[2] "On the Refractive and Dispersive Power of Different Species of Glass, with an Account of the Lines which cross the Spectrum," Fraunhofer, translated in *Edin. Philosophic Journal*, vol. x., October to April, 1823-24, p. 39.

composés peuvent se former ou se dissocier, suivant les variations de température auxquelles ils sont assujettés par l'action chimique même. Dans cette classe doivent probablement être comprises les étoiles dont l'intensité de lumière varie plus ou moins rapidement, et avec une périodicité plus ou moins constante."

In the year 1873, I referred to this subject in my Bakerian Lecture (*Phil. Trans.* vol. clxiv. pt. 2, 1873, p. 492), in which I attempted to bring to bear some results obtained in solar inquiries upon the question of stellar temperatures.

I quote the following paragraphs :—

I. The absorption of some elementary and compound gases is limited to the most refrangible part of the spectrum when the gases are rare, and creeps gradually into the visible violet part, and finally to the red end of the spectrum, as the pressure is increased.

II. Both the general and selective absorption of the photospheric light are greater (and therefore the temperature of the photosphere of the sun is higher) than has been supposed.

III. The lines of compounds of a metal and iodine, bromine, &c., are observed generally in the red end of the spectrum, and this holds good for absorption in the case of aqueous vapour.

Such spectra, like those of the metalloids, are separated spectroscopically from those of the metallic elements by their columnar or banded structure.

IV. There are, in all probability, no compounds ordinarily present in the sun's reversing layer.

V. When a metallic compound vapour, such as is referred to in III., is dissociated by the spark, the band spectrum dies out, and the elemental lines come in, according to the degree of temperature employed.

Again, although our knowledge of the spectra of stars is lamentably incomplete, I gather the following facts from the work already accomplished with marvellous skill and industry by Secchi, of Rome.

VI. The sun, so far as the spectrum goes, may be regarded as a representative of class (β) intermediate between stars (α) with much simpler spectra of the same kind and stars (γ) with much more complex spectra of a different kind.

VII. Sirius, as a type of α, is (1) the brightest (and therefore hottest ?) star in our northern sky ; (2) the blue end of its spectrum is open,—it is only certainly known to contain hydrogen, the other metallic lines being exceedingly thin, thus indicating a small proportion of metallic vapours ; while (3) *the hydrogen lines in this star are enormously distended*, showing that the chromosphere is largely composed of that element.

There are other bright stars of this class.

VIII. As types of γ the red stars may be quoted, the spectra of which are composed of channelled spaces and bands, and in which naturally the blue end is closed. Hence the reversing layers of these stars probably contain metalloids, or compounds, or both, in great quantity ; and in their spectra not only is hydrogen absent, but the metallic lines are reduced in thickness and intensity, which in the light of V., *ante*, may indicate that the metallic vapours are being *associated*. It is fair to assume that these stars are of a lower temperature than our sun.

In the same year, in a letter to M. Dumas, published in the *Comptes rendus*,[1] I again pointed out that, if we consider merely the scale of temperature, a celestial body with flutings in it would be cooler than one which had lines in its spectrum ; and I also pointed out that, taking the considerable development of the blue end of the spectrum in white stars as contrasted with its feeble exhibition in stars like our sun, we had strong presumptive evidence to the effect that the stars like α Lyræ, with few lines in their spectra, were hotter than those resembling our sun, in which the number of lines was very much more considerable, and I added an inference from this : "plus une étoile est chaude, plus son spectre est simple." This related merely, as I have said before, to the consideration of one line of temperature.

[1] "Il semble que plus une étoile est chaude, plus son spectre est simple. et que les éléments métalliques se font voir dans l'ordre de lines poids anatomiques. Ainsi nous avons :—

"(1) Des étoiles très brillantes, où nous ne voyons que l'hydrogène *en quantité énorme*, et le magnésium.

"(2) Des étoiles plus froides, comme notre soleil, où nous trouvons:—

H + Mg + Na.
H + Mg + Na + Ca . Fe, &c. ;

dans ces étoiles, pas de métalloïdes.

"(3) Des étoiles plus froides encore, dans lesquelles tous les éléments métalliques sont associés, où leurs lignes ne sont plus visibles, et où nous n'avons que les spectres des métalloïdes et des composés.

"(4) Plus une étoile est âgée, plus l'hydrogène libre disparait ; sur la terre, nous ne trouvons plus l'hydrogène en liberté."

Vogel's Classification.

In the year following my paper, the most considerable classification which has been put forward of late years was published by Dr. Vogel (*Astr. Nach.*, No. 2000), who, basing his work on the previous types of Secchi, and taking into account the inference I drew in my letter to Dumas, modified Secchi's types to a certain extent, but always along one line of temperature, the leading idea being, as I gather from many remarks made in Dunér's admirable memoir, to be referred to presently, that the classification is based upon descending temperatures, and that all the stars included in it are supposed at one time or other to *have had* a spectrum similar to that of α Lyræ.[1]

This classification is as follows :—

CLASS I. *Spectra in which the metallic lines are extremely faint or entirely invisible.*—The most refrangible parts, blue and violet, are very vivid. The stars are white.

(a) Spectra in which the lines of hydrogen are very strong.

(b) Spectra in which the lines of hydrogen are wanting.

(c) Spectra in which the lines of hydrogen and D_3 are bright.

CLASS II. *Spectra in which the metallic lines are numerous and very visible.*—The blue and violet are relatively weaker ; in the red part there are sometimes faint bands. The colour of the stars is clear bluish white to deep reddish yellow.

(a) Spectra with numerous metallic lines, especially in the yellow and green. The lines of hydrogen are generally strong, but never as strong as in the stars of Class I. In some stars they are invisible, and then faint bands are generally seen in the red formed by very close lines.

(b) Spectra in which besides dark lines and isolated bands there are several bright lines.

CLASS III. *Spectra in which besides the metallic lines there are numerous dark bands in all parts of the spectrum, and the blue and violet are remarkably faint.*—The stars are orange or red.

(a) The dark bands are fainter towards the red.

(b) The bands are very wide, and the principal are fainter towards the violet.

It is pointed out that if this classification be true, there must be links between all the classes given. Now it is perfectly obvious that if this classification includes in its view all the stars, and if there is a line of ascending as well as descending temperatures—that is to say, if some of the stars are increasing their temperatures, while others are diminishing them—the classification must give way.

It is not difficult to see, in the light of my communication to the Society of November 17, that it has given way altogether, and principally on this wise.

The idea which underlies the classification is that a star of Class I. on cooling becomes a star of Class II., and that a star of Class II. has as it were a choice before

[1] "Car selon la théorie il faudra que tôt ou tard toutes les étoiles de la première classe deviennent de la seconde, et celles-ci de la troisième" (Dunér).

it of passing to Class III.*a* or Class III.*b*. Thus under certain conditions its spectrum will take on the appearance of Secchi's third type, Class III.*a* (Vogel); on certain other conditions it will take on the appearance of Secchi's fourth type, Class III.*b* (Vogel). There is now, however, no manner of doubt whatever that Secchi's Class III.*a* represents stars in which the temperature is increasing, and with conditions not unlike those of the nebulæ—that is to say, the meteorites are yet discrete, and that they are on their way to form bodies of Class II. and Class I. by the ultimate vaporization of all their meteoric constituents. There is equally no manner of doubt that the stars included in Class III.*b* have had their day; that their temperature has been running down, until owing to reduction of temperature they are on the verge of invisibility brought about by the enormous absorption of carbon in their atmospheres.

Pechüle was the first to object to Vogel's classification, mainly on the ground that Secchi's types 3 and 4 had been improperly brought together; and my work has shown how very just his objection was,[1] and how clear-sighted was his view as to the true position of stars of Class III.*b*.

II. Proposed New Grouping of all Celestial Bodies according to Temperature.

Having, then, gone over the various classifications of stars according to their spectra, I now proceed to consider the question of the classification of celestial bodies from a more advanced point of view. I pointed out in the year 1886 that the time had arrived when stars with increasing temperatures would require to be fundamentally distinguished from those with decreasing temperatures, but I did not then know that this was so easy to accomplish as it now appears to be (Nature, vol. xxxiv. p. 228); and as I have already stated, when we consider the question of classification at all, it is neither necessary nor desirable that we should limit ourselves to the stars; we must include the nebulæ and comets as well, and the question of variability does not really concern us, because it is as a rule in its extremest form the passage of a body giving one spectrum to a body giving another even if of a different type, owing to sudden changes of temperature.

[1] "M. Vogel a proposé une classification suivant les diverses phases de refroidissement indiquées par les spectres, dans laquelle il fait des types III. et IV. de Secchi deux subdivisions d'une même classe, III.*a* et III.*b*. Mais je trouve certaines difficultés négatives contre cette classification relativement au rôle qu'y joue la III.*b*. En effet, il est admis que le IV. type de Secchi se distingue nettement du III. type, non seulement par la position et la quantité des zones obscures, mais aussi par le fait très-remarquable, que les principales de ces zones sont bien définies et brusquement interrompues du côté du violette dans le III. type du côté du rouge dans le IV. Or, si le IV. type doit représenter une des phases de refroidissement, par lesquelles passent les étoiles, on peut faire deux hypothèses. La première est que le spectre du IV. type soit coordonné au spectre du III. type, de manière qu'il ait des étoiles, qui passent de la phase représentée par le II. type, à la phase représentée par le III. type, et d'autres, qui passent directement du II. type au IV. Mais cette hypothèse est inadmissible. Car on connaît de spectres entremédiaires entre le I. et le II. type, et entre le II. et III.; mais on ne connaît pas, à ce que je sache, de spectres du II. type tendant au IV. Reste donc l'hypothèse, que la phase de refroidissement, représentée par le spectre du IV. type, soit postérieure à la phase représentée par le III. type, de manière que les spectres des étoiles passent du III. au IV. type. Si ce passage se fait peu à peu, il devrait avoir des spectres entremédiaires entre le III. et le IV. type; mais quoique Secchi par exemple le 17 Jan., 1868, ait déterminé le spectre de l'étoile 273 Schjell., comme semblant entremédiaire entre le III. et le IV. type, il l'a plus tard reconnu du IV. type, et l'existence de spectres du III.-IV. type n'est nullement prouvée. On pourrait objecter que les étoiles du IV. type sont peu nombreuses et en général si petites que leurs spectres sont difficiles à voir, et que par conséquent il pourrait y avoir parmi ces spectres quelques-uns, qui se rapprochassent du III. type. Mais je réponds à cette remarque, que les spectres du III.-IV. type, indiquant une phase moins refroidie, devraient au contraire en général appartenir à des étoiles plus grandes que celles ayant des spectres du IV. type. Si on veut supposer que le passage du III. au IV. type se fasse subitement, ou par une catastrophe, pendant laquelle apparaissent des lignes brillantes, cette supposition même constituerait une différence physique bien plus distincte entre le III. et le IV. type, qu'entre le II. et le III.; et le IV. type représenterait une phase bien distincte, la dernière peut-être avant l'extinction totale. Le rôle physique du IV. type est donc encore si mystérieux, que j'ai cru pouvoir encore me conformer à l'exemple de d'Arrest, en suivant la classification formelle de Secchi."—C. F. Pechüle, "Expédition Danoïse pour l'Observation du Passage de Venus, 1882," p. 25 (Copenhagen, J. H. Schultz, 1883).

In the first classification on these lines, which is certain to be modified as our knowledge gets more exact, it is desirable to keep the groups as small in number as possible; the groups being subsequently broken up into sub-groups, or, as I prefer to call them, species, as the various minute changes in spectra brought about by variations of temperature are better made out.

In my paper of November 17 (Nature, vol. xxxvii. p. 84), I gave a diagram of the "temperature curve," on which is shown the distribution of nebulæ and of stars as divided into classes by Vogel, on the two arms of the curve.

On one arm of this we have those stages in the various heavenly bodies in which in each case the temperature is increasing, while on the other arm we have that other condition in which we get first vaporous combination, and then ultimately the formation of a crust due to the gradual cooling of the mass in dark bodies like, say, the companion to Sirius. At the top we of course have that condition in which the highest temperature must be assumed to exist.

To begin, then, a more general classification with the lowest temperatures, it is known that the nebulæ and comets are distinguished from most stars by the fact that we get evidence of radiation. Absorption has been suspected in the spectra of some nebulæ,[1] and has been observed beyond all doubt in some comets.[2] But there are some stars in which we also get radiation, accompanied by certain absorption phenomena; but there is no difficulty in showing that these bodies are more special on account of their bright lines than on account of their absorption bands. We may therefore form the first group of bodies which are distinguished by the presence of bright lines or flutings in the spectrum.

The presence or absence of carbon will divide this group into two main divisions, which, however, we may neglect in the following very brief sketch which I give in advance of a more detailed treatment.

The first species in this group would contain the nebulæ, in which only the spectrum of the meteoric constituents is observed. In the second species we find the spectrum of hydrogen added.

Another early species would contain those bodies in which the nebula spectrum gets almost masked by a continuous one, such as Comets 1866 and 1867, and the great nebula in Andromeda.

In the second division will be more condensed swarms still, in which, one by one, new lines are added to the spectra, and carbon makes its appearance; while probably the last species in this group would be bodies represented by γ Cassiopeiæ.

The great distinction between the first group and the second would be that evidences of absorption now become prominent, and side by side with the bright flutings of carbon and occasionally the lines of hydrogen we have well-developed fluting absorption.

The second group, therefore, is distinguished from the first by mixed flutings—that is to say, the presence of bright and dark flutings as well as lines in the spectrum.

I give a detailed examination into the species of this group in the next part of this memoir.

[1] "Nebula [No. 117, 51h. 32 M. R.A. 0h. 35m. 5·3s.; N.P.D. 49° 54′ 12″·7. Very, very bright; large, round; pretty suddenly much brighter in the middle].—This small but bright companion of the great nebula in Andromeda presents a spectrum exactly similar to that of 31 M [the great nebula in Andromeda]. The spectrum appears to end abruptly in the orange; and throughout its length is not uniform, but is evidently crossed either by lines of absorption or by bright lines" (Huggins, *Phil. Trans.* vol. cliv. p. 441).

[2] "A dark band was noticed at wave-length 567·9" (Copeland, Comet III., 1881, *Copernicus*, vol. ii. p. 226).

"May 20.—With none of these dispersions could any bright bands, properly so called, be distinguished; but two faint broad *dark* bands, or what gave that impression, crossed the spectrum. . . . A third dark band was suspected near D on the blue side of that line" (Maunder, Comet α 1882 (Wells), "Greenwich Spectroscopic Observations, 1882," p. 34).

The dark bands were observed again, and their wave-lengths measured on May 31" (*ibid.* p. 35).

The passage from the second group to the third brings us to those bodies which are increasing their temperature, in which radiation and fluting absorption have given place to line absorption.

At present the observations already accumulated have not been discussed in such a way as to enable us to state very definitely the exact retreat of the absorption, by which I mean the exact order in which the absorption lines fade out from the first members to the last in the group. We know generally that the earlier species will contain the line absorption of those substances of which we get a paramount fluting absorption in the prior group. We also know generally that the absorption of hydrogen will increase while the other diminishes.

The next group, the fourth, brings us to the stage of highest temperature, to stars like α Lyræ; and the division between this group and the prior one must be more or less arbitrary, and cannot at present be defined. One thing, however, is quite clear, that no celestial body without all the ultra-violet lines of hydrogen discovered by Dr. Huggins can claim to belong to it.

We have now arrived at the culminating point of temperature, and now pass to the descending arm of the curve of temperature. The fifth group, therefore, will contain those bodies in which the hydrogen lines begin to decrease in intensity, and other absorptions to take place in consequence of reduction of temperature.

One of the most interesting problems of the future will be to watch what happens in bodies along the descending scale, as compared with what happens to the bodies in Group III. on the ascending one. But it seems fair to assume that physical and chemical combinations will now have an opportunity of taking place, thereby changing the constituents of the atmosphere; that with every decrease of temperature an increase in the absorption lines may be expected, but it will be unlikely that the last species in this group will resemble the first one in Group III.

The next group, the sixth, is Secchi's type IV. and Vogel's Class III.*b*, its distinct characteristics being the absorption flutings of carbon. The species of which it will ultimately be composed are already apparently shadowed forth in the map which accompanies Dunér's volume, and they will evidently be subsequently differentiated by the gradual addition of other absorptions to that of carbon, while at the same time the absorption of carbon gets less and less distinct.

To sum up, then, the classification I propose consists of the following groups:—

GROUP I.—Radiation lines and flutings predominant. Absorption beginning in the last species.
GROUP II.—Mixed radiation and absorption predominant.
GROUP III.—Line absorption predominant, with *increasing* temperature. The various species will be marked by increasing simplicity of spectrum.
GROUP IV.—Simplest line absorption predominant.
GROUP V.—Line absorption predominant, with *decreasing* temperature. The various species will be marked by decreasing complexity of spectrum.
GROUP VI.—Carbon absorption predominant.
GROUP VII.—Extinction of luminosity.

It will be seen from the above grouping that there are several fundamental departures from previous classifications, especially that of Vogel.

The presence of the bright flutings of carbon associated with dark metallic flutings in the second group, and the presence of only absorbing carbon in the sixth, appears to me a matter of fundamental importance, and to entirely invalidate the view that both groups (the equivalents of III.*a* and III.*b* of Vogel) are produced from the same mass of matter on cooling.

This point has already been dwelt upon by Pechüle. Another point of considerable variation is the separation of stars with small absorption into such widely different groups as the first and fourth, whereas Vogel classifies them together on the ground of the small absorption in the visible part of the spectrum. But that this classification is unsound is demonstrated by the fact that in these stars, such as γ Cassiopeiæ and β Lyræ, we have intense variability. We have bright hydrogen lines instead of inordinately thick dark ones; and on other grounds, which I shall take a subsequent opportunity of enlarging upon, it is clear that the physical conditions of these bodies must be as different as they pretty well can be.

It will be seen also that, with our present knowledge, it is very difficult to separate those stars the grouping of which is determined by line absorption into the Groups III. and V., for the reason that so far, seeing that only one line of temperature, and that a descending one, has been considered, no efforts have been made to establish the necessary criteria. I made this point in the paper to which I have already referred in connection with the provisional curve, and for purposes of completeness I introduce here the chief part of what I wrote on that occasion.

(*To be continued.*)

THE HITTITES, WITH SPECIAL REFERENCE TO VERY RECENT DISCOVERIES.[1]

V.

SOME months ago the Rev. Greville J. Chester brought to this country a quadrangular hæmatite seal found near Tarsus. Though this seal shows, in certain particulars, some analogy with the Yuzgât seal, yet it gives little or no additional aid in the decipherment of the inscriptions. It presents, nevertheless, features of very great interest. Prof. Sayce scarcely goes beyond the merits of the seal when he says that it possesses a "unique and splendid character; nothing like it has ever before been brought to the notice of European scholars."[2] The seal is engraved not only on the base (1), but also on the four sides, while opposite the base the stone was so cut as to serve the purpose of a handle. On four out of the five engraved faces are to be seen two figures—one seated and one standing. These may be supposed to represent men or deities, or possibly, in some cases, ideal personages. At first sight it may seem difficult to discern any general aim or connected purpose in the curious figures depicted. On more attentive examination, however, there is seen to be exhibited a pervading principle of *tri-unity*, especially as exemplified in the triangle and the trident. Moreover, while on three faces of the seal (1, 2, 5) there are figures with the "pig-tail" (an appendage which suggests a connection with the Hittites), it appears tolerably evident that the engraver of the seal intended to represent the personages with this appendage as destitute of the valuable knowledge and power connected with the mysterious three-in-oneness of the triangle and the trident. This is entirely in accordance with the position that the wearers of the pig-tail were still regarded as aliens and intruders when the seal was engraved.

On the base (1), a figure standing or advancing holds in the left hand a trident-like object, which is probably to be understood as a plant; though, like the curious symbols on the Boghaz-Keui bas-relief (*supra*, pp. 513, 514), it must be somewhat idealized. Certainly, it would seem

[1] Based on Lectures delivered by Mr. Thomas Tyler at the British Museum in January 1888. Continued from p. 593.

[2] *Archæological Journal*, December 1887. Prof. Sayce's paper is accompanied by an autotype representation of the seal. I may here mention, also, that impressions of this seal, as also of the Yuzgât seal and the seal of Tarkutimme, may be obtained at a small cost from Mr. A. Ready, of the British Museum.