OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN APRIL:—

April 1. 14h. Saturn in conjunction with moon. Saturn 2° 16′ North.
5. Pallas in opposition to the sun.
7. 16h. 30m. Transit (ingress) of Jupiter's Sat. III.
13. Perihelion passage of Swift's comet (1899 *a*).
15. Venus. Illuminated portion of disc = 0·750. Apparent diameter = 14″·6.
Mars. Illuminated portion of disc = 0·900. Apparent diameter = 7″·5.
15. 11h. 26m. to 12h. 8m. Occultation of μ Geminorum (mag. 3·2) by the moon.
15. 12h. 35m. Minimum of Algol (β Persei).
17. 10h. 44m. to 11h. 8m. Occultation of 3 Cancri (mag. 6·0) by the moon
18. 9h. 24m. Minimum of Algol (β Persei).
19. 9h. 10m. to 10h. 14m. Occultation of *h* Leonis (mag. 5·4) by the moon.
20. Epoch of Lyrid meteoric shower (radiant 271° + 33°).
22. 11h. 12m. to 12h. 20m. Occultation of B.A.C. 4006 (mag. 5·7) by the moon.
24. Ceres in opposition to the sun.
25. 7h. Jupiter in opposition to the sun. At this time the planet will be about 1° from λ Virginis (mag. 4·6).
Polar diameter of Jupiter = 41″·2.
26. Ceres about ½° N. of ϕ Virginis (mag. 5).
26. 9h. 53m. to 11h. 1m. Occultation of B.A.C. 5023 (mag. 5·8) by the moon.
27. Predicted date of perihelion passage of Holmes's periodical comet (1892 III.).
28. 11h. 56m. to 13h. 6m. Occultation of θ Ophiuchi (mag. 3·4) by the moon.

The planet Jupiter will be well visible during the month, though his position is about 12 degrees south of the equator. The remarkable hollow in his great southern equatorial belt, and the remains of the famous red spot of 1878–81, may be observed on or very near the central meridian of the planet at the following times:—

	h.	m.		h.	m.
April 7	11	31	April 19	11	23
12	10	38	24	10	30
17	9	45	29	9	38

Saturn will be conspicuously displayed in the morning sky, and rises before midnight after the middle of the month. Considered as a telescopic object, however, his low position, nearly 22 degrees south of the equator, is a disadvantage, and will seldom allow the details of his surface to appear well defined.

ORBIT OF COMET 1896 III. (SWIFT).—Prof. R. G. Aitken, of the Lick Observatory, has collected all the observations of this comet that were available, and, after a thorough discussion, has made a definite determination of the orbit (*Ast. Nach.*, Bd. 148, Nos. 3550–51). The elements prove to be hyperbolic, and are as follows:—

$$T = 1896, \text{ April } 17{\cdot}6473143, \text{ G.M.T.} \pm 0{\cdot}00057326\text{d.}$$

$$\left.\begin{aligned} \pi &= 179^\circ\ 59'\ 15''{\cdot}40 \pm 3''{\cdot}95 \\ \Omega &= 178\ \ 14\ \ 51{\cdot}48 \pm 6{\cdot}74 \\ i &= 55\ \ 34\ \ 24{\cdot}69 \pm 8{\cdot}88 \end{aligned}\right\}\text{M. Eq. } 1896{\cdot}0$$

$$q = 0{\cdot}5662857 \pm 0{\cdot}00001347.$$
$$e = 1{\cdot}0004757 \pm 0{\cdot}00009985.$$

SATURN'S NINTH SATELLITE.—A few further particulars respecting Prof. W. H. Pickering's important discovery are now to hand. The instrument used was the new photographic doublet, 24 inches aperture and about 160 inches focus, which was presented to the Harvard College Observatory by Miss Catherine Bruce. Attempts have been made in previous years to find satellites by photography, but these turned out unsuccessful in consequence of the relatively low rapidity of the lens. Last summer, however, the attempt was again made at the Harvard Observatory at Arequipa, Peru, with this new extremely rapid lens. The four successful photographs were taken on the nights of August 16, 17 and 18, 1898, each plate being exposed for about two hours. The number of stars shown on a plate is estimated as 100,000.

In searching for the satellite two plates were placed film to film, so that each star was indicated by two dots. On the first two plates examined an isolated point was found near the planet. A similar isolated point was found on each of the other plates but in different positions with respect to the stars. The plates having been taken at an interval of two days, Saturn had moved in its orbit, and the images on the plates being found to have moved in the same direction, this furnishes strong evidence of the reality of their being due to a satellite and not to accidental defects of the plates. The new satellite is so faint that there is little possibility of its observation with any but the largest instruments.

MEASURING EXTREME TEMPERATURES.[1]

II.

Extension of the Range of the Gas-Thermometer.

THE methods of measurement so far considered are in a certain sense *arbitrary* in so far as they depend on extrapolation of empirical formulæ. If all these methods could be reduced by direct comparison to perfect agreement with each other, a definite scale of temperature would be attained to which all measurements could be referred, and which would leave nothing to be desired from a purely practical point of view. It is probable that this scale would not differ much from the theoretical or absolute scale of temperature. For theoretical investigations, however, without which no true scientific advance can be made, it is a matter of such fundamental importance to refer every measurement to the absolute scale, that no opportunity should be neglected of extending the possible range of accurate observation with the gas-thermometer, because this instrument affords at present the closest approximation to the absolute or theoretical scale. A consideration of the difficulties of the methods of gas-thermometry at present in use will lead naturally to the best methods of extending the range and accuracy of the instrument.

Defects of Bulb-Methods.

In the ordinary method of gas-thermometry a *bulb* containing the gas is exposed to the temperature to be measured, and the observation consists in determining either the expansion of volume or the increase of pressure of the gas. The principle is very similar to that of the ordinary liquid in glass thermometer, but the apparatus is more cumbrous and difficult to use on account of the necessity of observing both the volume and the pressure of the gas. This method is very accurate at moderate temperatures, but the difficulties increase very rapidly above 1000° C. Above 1200° C. it is doubtful whether such measurements are of any greater value than those obtained by extrapolation. Apart from the difficulty, which is common to nearly all methods at high temperatures, of maintaining a uniform and steady temperature, the bulb-method of gas thermometry is liable to the following special sources of error.

(1) Changes in volume of the bulb.
(2) Leakage and porosity.
(3) Occlusion or dissociation.

In order to investigate these sources of error a special form of porcelain air-thermometer (Fig. 3) was designed by the writer, and was constructed in Paris in December 1886, under the supervision of W. N. Shaw, F.R.S., of Emmanuel College, Cambridge. A figure and description of this instrument were published in the *Phil. Trans.* A., 1887. The same form has since been adopted by MM. Holborn and Wien in their experiments on the measurement of high temperatures at the Reichsanstalt. Thick tubes of 3 sq. mm. cross section, marked AC, BD in Fig. 3, were connected at each end of the cylindrical bulb BA. The length CD could be directly observed at any time with reading microscopes, and the linear expansion of the bulb could be deduced. The volume of the bulb could also be gauged at any time with air, and the mean temperatures of the separate portions AB, AC, BD, could be determined by means of platinum wires extending along the axis of the instrument. This was a most essential part of the apparatus, as the wires afforded a means of accurately reproducing any given set of conditions, and of testing the performance of the gas-thermometer at high temperatures in respect of all the various sources of error above mentioned. (1) It was observed that the volume of the bulb underwent continuous changes, chiefly in the direction of contraction, and that the shrinkage was not symmetrical, being apparently greater in the circumference than in the length of the cylinder. (2) To prevent leakage, and to close the pores of the material, it is

[1] Discourse delivered at the Royal Institution, on March 10, by Prof. H. L. Callendar, F.R.S. (Continued from p. 497.)

necessary to have the porcelain bulb glazed both inside and out. The glaze becomes sticky, and begins to run at a temperature below 1200° C., and the bulb begins to yield slightly and continuously to pressure above this point. (3) With some gases there appear to be slight traces of chemical action or occlusion of the gas by the walls of the bulb at high temperatures. It is for this reason preferable to use the inert gases nitrogen or argon as the thermometric material. In any case, the limit of high temperature measurement would be reached when either the gas, or the material of the bulb, began to dissociate or decompose. Deville and Troost, employing CO_2 for filling the porcelain bulb, found the temperature of the B.P. of zinc nearly 150° higher than with air or hydrogen. This they attributed to a partial dissociation of the CO_2 at the temperature as low as 930° C. Some experiments made by the writer appeared, however, to indicate that the effect was due to chemical action between the gas and the porcelain.

For these and other reasons it appears very doubtful whether any improvement or extension of range can be expected from the use of glazed porcelain. If an attempt is made to employ any of the more refractory kinds of fire-clay, there is the difficulty of finding a suitable glaze, and of eliminating leakage and porosity. The writer suggested the use of bulbs of fused silica some years ago (*Proc.* Iron and Steel Institute, 1892), and endeavoured to get such bulbs constructed, but without success. This material possesses many of the requisite qualities, but is for this very reason extremely difficult to work. Metallic bulbs of platinum or platinum-iridium are by far the most perfect in respect of

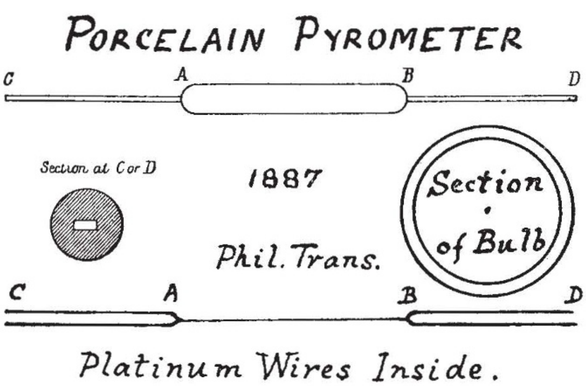

FIG. 3.

constancy of volume, regularity of expansion, and facility of accurate construction; but unfortunately, as Deville and Troost showed, they have such an inveterate tendency for occluding or dissolving gases at high temperatures, that the use of metallic bulbs has been practically discontinued, in spite of their obvious advantages in other respects.

Advantages of "Resistance"-Methods.

After making many vain experiments, the writer was forced to the conclusion that the ordinary bulb-methods did not promise any satisfactory solution of the problem of extending the range of the gas-thermometer, and that it was necessary to attempt a radically new departure. The optical method, depending on the measurement of the refractivity of a gas at high temperatures, and the acoustical method, depending on the observation of the wave-length of sound, although of great theoretical interest, did not appear to promise sufficient delicacy of measurement or facility of practical application. Experiments were therefore made on the methods of effusion and transpiration, which had been occasionally suggested by previous writers, but have not as yet, so far as the author is aware, been practically investigated as a means of measuring temperature on the absolute scale. The method of effusion consists in observing the resistance to the efflux of gas through a small hole or orifice in a thin plate. In the method of transpiration the gas is made to pass through a fine tube instead of a small orifice, and the resistance to its passage is observed in a similar manner. These methods may be called "resistance-methods" to distinguish them from the ordinary or "bulb-methods" of pyrometry. They are closely analogous to the now familiar resistance-method of electrical pyrometry, and possess many of the advantages of that method in point of delicacy and facility of application. One very obvious and material advantage, especially for high temperature work, is the smallness and sensitiveness of the instrument as compared with the bulb of an ordinary gas-thermometer. But the most important point of difference, which led the writer to the adoption of these methods, is that the measurements are practically unaffected by occlusion or evolution of gas by the material of the tubes. There is a *continuous* flow of gas through the apparatus. This flow is very large in proportion to any possible leakage, and it is therefore possible to employ platinum tubes with perfect safety.

The Method of Effusion.

The method of effusion may be very simply illustrated by means of a fine hole in the side of a large and thin platinum tube which is heated by an electric current. The current of air is heated in its passage through the tube before it effuses through the orifice. The heated air expands in volume, and the resistance to effusion is increased in proportion to the temperature to which the air is heated. The increase of resistance may be shown by means of a gas-current-indicator or "rheoscope," which consists of a delicately suspended vane deflected by a current of gas. A mirror is attached to the vane, and the deflection is measured by the motion of a spot of light reflected on to a scale, exactly as in the case of the mirror galvanometer, when used for indicating changes of electrical resistance. As a standard of comparison, to show the changes of temperature of the tube, the changes of electrical resistance of the same tube are simultaneously shown by means of a suitable ohmmeter.

The method of effusion is a beautifully simple method, and gives a nearly uniform scale; but it has two disadvantages, which it shares with the thermo-electric method of measurement. (1) It necessarily measures temperature at a point, namely at the point of effusion, and cannot be easily arranged to give the mean temperature throughout a space. (2) It is difficult to make the effusion resistance sufficiently large for purposes of accurate measurement. A large resistance means a very fine hole, and it is not easy to satisfy the theoretical conditions of the problem with sufficient accuracy and eliminate the effects of viscosity.

The Method of Transpiration.

The method of transpiration is more complicated, and does not give so uniform a scale, or so simple a formula. It has the great advantage, however, that the theoretical conditions of flow may be realised with unlimited accuracy, and that the transpiration resistance can be measured with a degree of precision very little, if at all, inferior to the corresponding electrical measurement.

The complication of the transpiration problem arises from the fact that the flow depends on the increase of the viscosity of the gas, as well as on its expansion. The viscosity of liquids in general decreases very considerably with rise of temperature. That of water, for instance, is six times less at the boiling point than at the freezing point. If the viscosity of gases diminished in a similar manner, it might happen that the transpiration resistance would decrease with rise of temperature. Maxwell was the first to give a theoretical explanation of the behaviour of gases in this respect. On certain simple kinetic assumptions, he showed that the viscosity should increase in direct proportion to the absolute temperature. Since the expansion follows the same law, the transpiration resistance on Maxwell's hypothesis should increase in proportion to the square of the temperature. This would give a fairly simple formula, and would make the transpiration thermometer a very sensitive instrument, but the scale would be far from uniform. Maxwell made some experiments on the temperature variation of the viscosity between 0° and 100° C., which appeared to give support to his mathematical assumptions; but his apparatus did not happen to be of a very suitable type for temperature measurement, and it is clear that he did not regard this part of his experimental work with great confidence.

The question of the viscosity of gases was next attacked with great vigour in Germany by a number of different physicists. They ultimately succeeded in proving that the law was not quite so simple as Maxwell had supposed, and that the rate of increase of viscosity was less than that of volume. A summary of some of the principal results obtained, over the range 0° to

100° C., is given in the following table, in which the rate of increase is expressed by finding the power n of the absolute temperature T to which the viscosity is most nearly proportional. The most concordant results were obtained by the method of transpiration, and gave an average of ·76 for the index n in the case of air. The more condensible gases gave larger values for the rate of increase, but the value for hydrogen appeared to be smaller.

TABLE III.—*Variation of Viscosity v with Temperature T. Formula, $v/v_0 = (T/T_0)^n$.*

Observers.	Dates.	Values of Index n (0° to 100° C.) Air.	O_2.	H_2.	CO_2.
Maxwell... ...	1866	1·00			
Meyer	1873	·61 – ·83			
Puluj	1874	·47 – ·65			
Obermayer ...	1875	·76	·80	·70	·94
Wiedemann ...	1876	·73			·93
Warburg ...	1876	·74 – ·77		·63	
,, and Kundt	1876	·72		·69	
Holman... ...	1876	·74 – ·80			

It will be observed that the results are not very concordant, but the experiments are much more difficult and liable to error than might be supposed. The most accurate method was that employed by Holman, but even in this case the margin of uncertainty is considerable. It would evidently be impossible to employ the method of transpiration to any advantage for the determination of temperature unless a far higher order of accuracy could be easily attained. After repeating the majority of the more promising methods in detail, including the original method of Maxwell, the writer came to the conclusion that they were entirely unsuitable for the purposes of thermometry, and would have abandoned the attempt entirely if he had not fortunately succeeded in finding a more perfect way.

Application of Electrical Analogies.

In studying the flow of electricity through conductors, which is in many respects analogous to that of a fluid through a fine tube, electricians have been compelled, from the intangible nature of the fluid with which they work, to elaborate the most delicate and powerful methods of investigation. One of the most useful of these methods is generally known as the Wheatstone-bridge method, and is used for measuring the resistance of a conductor to the passage of an electric current. The method is equally applicable and equally exact for determining the resistance of a fine tube to the passage of a gas. The writer was already very familiar with the application of this method in all its refinement of detail to electrical resistance thermometry. The suggestion for applying it to the closely analogous problem of transpiration was supplied by the researches of W. N. Shaw, F.R.S., who had already applied it, in connection with certain experiments on ventilation, to the effusion of air through large orifices at ordinary temperatures.

Shaw's Effusion Balance.

The apparatus used by Shaw (described in the *Proc. Roy. Soc.*, vol. xlvii., 1890) consisted of boxes to represent rooms, with apertures about half a square inch in area to represent ventilators. Two of these apertures were made in the form of adjustable slits. The circulation of air through two rooms in parallel was maintained by a gas burner, and the slits were adjusted to make the pressure in the two rooms the same, as indicated by the absence of flow in a connecting tube, containing a pivoted needle and vane as a current detector. The balance was shown to be independent of the air-current when that was varied from one to four cubic feet per minute. The effusion resistance of an aperture was also verified to be approximately proportional to the square of the reciprocal of the area, with apertures of similar shape. This method of investigation was admirably adapted to problems in ventilation, in which the phenomena depend mainly on effusion through relatively large apertures. It would, however, be difficult to adapt to the problem of temperature measurement. It would not be easy to make an aperture which could be continuously varied without changing its shape, and at the same time to measure the change of area with sufficient accuracy, if the area were small enough to prevent appreciable cooling of the thermometer by the current of air flowing through it. There is also the disadvantage that the pressure-difference varies as the square of the current; so that, if very small currents are used, the effects of viscosity become more important, and the balance ceases to be independent of the current, unless everything is symmetrical and at the same temperature in corresponding parts.

For these reasons it seemed preferable, in applying the Wheatstone-bridge method to air-currents, to employ fine tubes as resistances, and to eliminate the effects of effusion as completely as possible, at least in the resistance-measuring part of the apparatus. With transpiration resistances the current is directly proportional to the pressure difference, the electrical analogy is much closer, and the theoretical conditions can be very accurately realised.

The Transpiration Balance.

The Wheatstone-bridge method of measurement proved to be so exact and so perfectly adapted to the problem of transpiration thermometry, that, after some preliminary experiments, the writer had a very elaborate apparatus constructed, in the year 1893, which was in every detail the exact analogue of an electrical resistance thermometer. The fine wire resistances of the electrical apparatus, in terms of which the change of resistance of the thermometer is measured, are replaced in the transpiration box by a graduated series of fine tubes, which can be

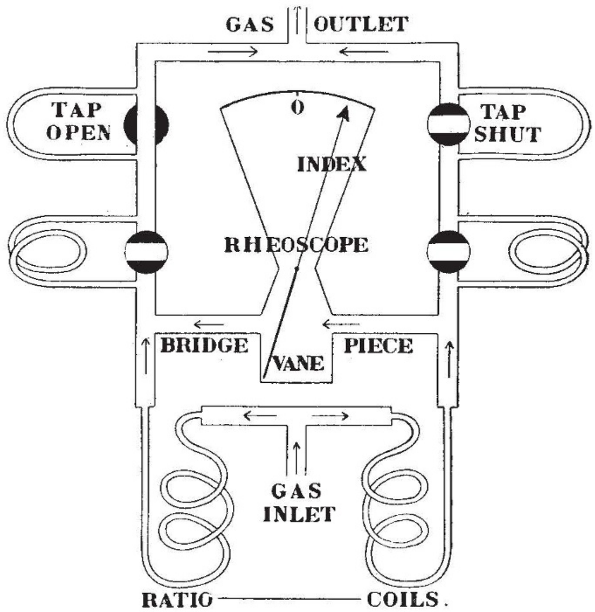

FIG. 4.—Diagram of transpiration balance.

short-circuited by means of taps of relatively large bore, corresponding to the plugs of negligible resistance in the electrical resistance box. The galvanometer is replaced by a rheoscope, constructed after a pattern devised by Joule for a different purpose, which can be made to rival in delicacy the best modern electrical instruments. The pyrometer itself consists of a fine tube of platinum instead of a wire, and is fitted with "compensating leads" to correspond with those of the electrical instrument. All the details of the methods of observation and calibration are faithfully copied from the electrical apparatus, and the result, so far as the measurement of transpiration resistance is concerned, are equally satisfactory.

Fig. 4 is a diagram of a working model of the transpiration balance, which was exhibited at the lecture. This model has a vertical needle for index, and a pivoted mica vane, which is deflected when a current flows through the bridge piece. It is constructed to work on the ordinary lighting-gas pressure, and to give its maximum deflection for a 10 per cent. change of resistance with the gas about half off. With all the taps off, the resistances on either side are equal, and there is no deflection. In the diagram the balance is supposed to have been disturbed by opening one of the taps. The apparatus actually used for temperature measurement has sixteen taps, and a mirror. rheoscope, and is a thousand times more sensitive.

Variation of Viscosity with Temperature.

In order to apply the method to the measurement of extreme temperatures, it is not sufficient to be able to measure resistance. It is also necessary to determine the law of the variation of viscosity with temperature. Here, again, recourse must be had to the method of extrapolation. Fortunately, in the present instance, the temperature can be measured through a very wide range, and the range of extrapolation, being limited by the melting point of platinum, is not very great in comparison. It should be possible therefore, by sufficiently varying the conditions of the experiments, and by comparing the behaviour of different gases throughout the whole range of temperature, to arrive at a very fair degree of certainty with regard to the essential nature of the phenomenon. Owing to want of leisure for the work, the author's experiments have not as yet extended over a sufficient range of temperature, except in the case of air, to warrant the publication of any general conclusions with regard to the law of variation of viscosity, or of any results at high temperatures obtained by the method of extrapolation. It may be stated, however, that the formula above quoted, according to which the viscosity varies as some power n of the temperature, though fairly exact over a moderate range of temperature, fails entirely when tested at higher points. The results of Obermayer appear to be the most accurate for the different gases between 0° and 100° C., but if the same formula is retained, the value of the index n diminishes as the temperature is raised. Taking the average value between 0° and 100° for air as being 0·76, the value falls to 0·70 between 100° and 450°. A result of this nature was found by Wiedemann, but the rate of diminution which he gives appears to be far too great. He gives, for instance, the value $n = 0{\cdot}67$ for air between 0° and 184°, which implies a rate of diminution of the index many times greater than that which actually occurs. It would be very difficult by the method which he employed to make sure of *any* deviation whatever from the formula over so small a range, and since the error of his determination is much greater than that of the formula, he can hardly be said to have disproved the index law.

The problem is seriously complicated by the failure of the simple formula; but since the measurements are capable of great exactitude, and since it is possible to obtain many independent checks by comparing the results of the two methods of effusion and transpiration, and also by examining the behaviour of different gases, the author is confident of ultimate success. The method of experiment here described has already led to many promising and interesting results, and it is probable that the complete solution of the problem when attained, besides leading to more accurate determinations of extreme temperatures, may also throw light on dissociation and on many other points which are at present obscure in the theory of gases.

CENTRAL AMERICAN ARCHÆOLOGY.[1]

OWING to difficulties raised by the Honduras Government, the directors of the Peabody Museum have unfortunately been obliged, since the year 1895, to suspend work at the ruins of Copan, and Mr. Gordon, the leader of their expeditions in Honduras, was directed to turn his attention to other points of antiquarian interest in the neighbourhood. His reports to the Museum are now published.

In April 1896, and June 1897, an examination was made of some caverns which had been discovered in the limestone cliffs rising abruptly from the rocky bed of a mountain stream, distant about four miles from the ruins of Copan. The nature of the ground made the entrance of the caves very difficult and somewhat dangerous of approach.

In one of the chambers, nearly circular in shape and measuring 150 feet in diameter, "an excavation 20 feet long and 3 feet wide was made. After the surface layer of dust came a thin crust, which must have been caused by the presence of moisture at some period. It was only a few inches in thickness, and beneath it the material was very dry, soft, and loose, so that the men were able to remove it easily without the use of picks. In the surface crust and beneath it to a depth of three feet were found ashes, charcoal, and potsherds. The latter are not numerous, and are of a coarse quality. At a depth of three feet the potsherds and ashes and all signs of occupation disappeared; the material excavated grew lighter in colour, softer and looser. In appearance and behaviour it resembled quicklime, of which it largely consisted. Throughout the whole excavation the material removed rose in the air in thick clouds of suffocating dust. The excavation was carried to a depth of fifteen feet, where the bottom of the cavern was reached in part of the excavation. On the rock floor were absolutely no traces of occupation."

In a long passage, measuring about 80 by 20 feet, where the floor seemed to be more uneven than in the other chambers, and gave way to the pressure of the feet with a crushing sound, Mr. Gordon discovered that he was walking over the crumbling human bodies mingled with ashes and lime. A mass of charred and calcined bodies occupied the entire floor to the depth of about two feet, and the thick clouds of unsavoury dust, added to the stifling heat, made the work of examination most difficult and disagreeable. The chamber appears to have been used as a place for depositing the remains after they had been partly cremated elsewhere. None of the caves show any signs of recent occupation, but the condition of bones and of a wooden object, which was discovered, do not seem to Mr. Gordon to indicate any great antiquity. The excavations yielded no specimens of personal ornaments, or of carved stonework, and the pottery, of which several pieces were preserved entire, proved to be entirely different in character from that found in the neighbouring ruins of Copan. Mr. Gordon does not, however, think that the facts disclosed from the examination of the caves suffice to prove the existence of another race. "May it not be," he says "(to hazard a guess), that these cave relics belong, after all, to the same period as Copan itself, and are remains of the Copan people, or the devotees of some old cult among them whose temples were the caves, and whose vessels used in the ritual were of a design and character exclusively their own?"

In May and June 1896, and from March to June 1897, Mr. Gordon was occupied in examining the valley of the Uloa River, which flows northward through a forest-covered plain to the Gulf of Honduras. Above ground only a few vestiges of a former population are to be found, and the principal group of mounds, which was examined, yielded only one example of sculpture—namely, a very rough stone idol similar to the rude stone sculptures found in Nicaragua. However, during the rainy season the river cuts into its banks, and frequently leaves exposed to view cross sections of unconsolidated strata of sand and clay about thirty feet in height, which in some cases "present the continuous spectacle of broken pottery and fragments of bone from the surface of the water to within a few feet of the top. In places these objects are very numerous for stretches of several hundred feet, then diminishing gradually and almost disappearing for miles."

The principal excavations were made near the village of Santana, about twenty-five miles in a straight line from the mouth of the river. The objects found, consisting chiefly of fragments of pottery, were met with in distinct layers a few feet in thickness, separated by other layers, which also contained a few objects, but in much smaller numbers. In excavation No. 3, for instance, there were three principal layers at depths of twelve, twenty, and twenty-five feet; the last, in this case, by far the most extensive of the three. The pottery shows no signs of water-wearing, and it seems probable that the various articles "must have been put underground in the customary way in connection with burials, but not to the depth at which they are found at present. These burials must have been made during successive periods of occupation, separated by a series of inundations, each of which raised the general level of the ground several feet by the deposition of detritus from the mountains."

From an examination of the large collections which were made, Mr. Gordon is of opinion that the natives of this valley had attained a proficiency in the art of pottery not exceeded in any other part of Central America, and although the specimens display great variety in character, it is evident that the dominant influence was Maya. The absence of architectural remains, the most familiar and remarkable feature of Maya culture in other regions, he attributes to the absence of any available supply of building-stone in the valley of the Uloa.

"It is among the pottery vessels that the Maya affinities are

[1] "Memoirs of the Peabody Museum of American Archæology and Ethnology, Harvard University," Vol. i., Nos. 5-6. Researches in the Uloa Valley, Honduras; Caverns of Copan, Honduras. By George Byron Gordon.