after the sun. The later positions in Prof. Oppölzer's ephemeris are as follows:—

	12h. Berlin M.T. R.A.	N.P.D.	Log. distance from Earth.
	h. m. s.	° ′	
January 16 ...	21 29 12 ...	109 41·4 ...	0·2836
18 ...	21 38 18 ...	109 9·7 ...	0·2875
20 ...	21 47 12 ...	108 36·9 ...	0·2916
22 ...	21 55 54 ...	108 3·2 ...	0·2959
24 ...	22 4 23 ...	107 28·6 ...	0·3002

SWIFT'S COMET.—Mr. Common, with his reflector of three feet aperture at Ealing, has observed this comet for position as late as January 5, when it was not yet considered the *extremum visible* in the instrument. Accurate observations were made by Mr. Lewis Boss at the Dudley Observatory, Albany, U.S., on October 11, the night after discovery, so that there will be a good extent of observation upon which to determine the orbit at this appearance.

MINIMA OF ALGOL.—The following epochs of geocentric minima of Algol are deduced from Prof. Schönfeld's elements. That very sensible perturbations have taken place during the last few years is shown by a comparison of these elements with the observations of Prof. Julius Schmidt of Athens; thus the mean errors since 1875 are, for 1875·76 − 4·8m.; 1876·76 + 19·4m.; 1877·73 + 40·8m.; 1878·78 + 21·3m. The star is well deserving of attention during the present year.

	G.M.T. h. m.		G.M.T. h. m.
January 21	18 20	February 13	16 54
24	15 9	16	13 43
27	11 58	19	10 32
30	8 48	22	7 22
February 2	5 37		

CERASKI'S VARIABLE IN CEPHEUS.—A series of minima of this star visible in Europe commences about January 13, continuing until May. The period may be taken = 2·492913d. or 2d. 11h. 49·795m., and if we reckon from the second minimum completely observed by Prof. Schmidt on October 18, 1880, we shall find a minimum on January 18 at 17h. 41m. G. M. T., and successive visible epochs may be inferred by adding 4d. 23h. 39·59m.

ELONGATIONS OF MIMAS.—According to the elements previou ly adopted in this column for indicating approximately the times of greatest elongations of this very difficult object, the satellite would be at the western extremity of its apparent orbit at the following Greenwich times:—

	h. m.		h. m.
January 19 ...	11 5	January 22 ...	6 56
20 ...	9 42	23 ...	5 33
21 ...	8 19		

The elements upon which Prof. Newcomb's manuscript tables adopted in the *American Ephemeris* for 1882 and 1883 are founded appear to give the times of the elongations later by some forty minutes.

THE ACADEMY OF SCIENCES, PARIS.—The recent election of Dr. Warren De La Rue as Correspondent of the Academy of Sciences of the Institute of France, Section of Astronomy, in place of the late Sir Thomas Maclear, nearly completes the usual number of correspondents in this section, upon which several vacancies had existed for some time. The roll is now as follows, taking the names in alphabetical order:—Adams (Cambridge), Cayley (Cambridge), De La Rue (London), Gyldén (Stockholm), Hall (Washington), Hind (London), Huggins (London), Lockyer (London), Newcomb (Washington), Oppölzer (Vienna), Plantamour (Geneva), Roche (Montpellier), Schiaparelli (Milan), Stephan (Marseilles), and Struve (Pulkova). The Astronomer- Royal is one of the eight Foreign Associates of the Academy.

GEOGRAPHICAL NOTES

WE are glad to learn that the rumour of the murder of Herr Hildebrandt in Madagascar is unfounded.

THE first number of the memoirs (*Zapiski*) of the West Siberian Branch of the Russian Geographical Society contains valuable papers by M. Kostroff on witches in the Government Tomsk; by M. Grigorovsky, on the peasantry in the Narym district; by M. Pyevtzoff, on his journey through Djoungaria, with a map; and by M. Balkashin, on trade *viâ* the Ob River with Europe during the years 1877 and 1878.

AT one of its recent meetings the Russian Geographical Society discussed the proposal of Mr. Fleming, transmitted to the Society by the Governor-General of Canada, as to the adoption of a universal time and of a universal first meridian. As to the suggestion to have a cosmopolitan noon at the same moment over the surface of our globe, the Society thinks that it would meet with a mass of difficulties as to its application in daily life; but the advantages which a universal time would afford being very great, the Society expresses the wish that the whole question be earnestly discussed and studied by learned societies. As to the first meridian, the Society, which already discussed the question in 1870, maintains its former resolution, namely, that the meridian of Greenwich, or at least that of Behring Strait, 180° distant from that of Greenwich, should be accepted by the whole civilised world as a first meridian.

WE have received the annual reports for 1879 of the Siberian, Orenburg, and Caucasian branches of the Russian Geographical Society, which has had the happy idea to publish all the reports together in one volume, thus rendering accessible for the general reader who knows Russian this most valuable geographical information, formerly disseminated in local publications. The oldest of these branches, the East Siberian, has endured heavy losses during the great fire at Irkoutsk. Its rich zoological, botanical, geological, and ethnographical collections were all destroyed by fire: the beautiful head of a *Rhinoceros tichorhinus*, just received from Verkhoyansk, the rare collection of samples of gold from all the gold-mines of Eastern Siberia, palæontological collections not yet described, and so on, as well as the 10,230 volumes of its rich library, and collections of old records, were all destroyed by fire. Several scientific bodies, Russian and foreign, have already sent their publications and duplicates from their libraries, so that the museum and library already are in way of reconstitution.

THE third volume of the "Rajputana Gazetteer" has just been issued from the Government press at Simla. The various sections into which it is divided are contributed by Capt. C. E. Yate, Major C. A. Baylay, and Major P. W. Powlett, and treat of general topography, history, population, trade, towns, &c. Mr. J. F. Baness, the chief draughtsman in the geographical and drawing branch of the Survey of India, has in the press at Calcutta a work entitled "Index Geographicus Indicus." It will be published in one volume, with eight coloured maps, and will comprise a list, alphabetically arranged, of the principal places in our Indian Empire, accompanied by much statistical, political, and descriptive information.

A SERIES of papers is commenced in last week's issue of *Les Missions Catholiques*, on the manners, customs, and religion of the races of the Caucasus.

The new number of the *Bulletin* of the Commercial Geographical Society of Bordeaux contains a useful paper on Japan, by M. E. Labrone.

THE Palestine Exploration Society have decided to undertake the exploration of Palestine east of the Jordan.

OBSERVATIONS ON ANTS, BEES, AND WASPS[1]

Power of Communication by something approaching to Language.

IN my previous papers many experiments have been recorded, in which I have endeavoured to throw some light on the power of communication possessed by ants. It is unquestionable that if an ant or a bee discovers a store of food her comrades soon flock to the treasures, although, as I have shown, this is by no means always the case. But it may be argued that this fact taken alone does not prove any power of communication at all. An ant observing a friend bringing food home might infer, without being told, that by accompanying the friend on the return journey she might also participate in the good things. I have endeavoured to meet this argument in my third paper (*Linn. Journ.* vol. xii. p. 466) by showing that there was a marked

[1] By Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., D.C.L., LL.D., Vice-Chancellor of the University of London. Read at the Linnean Society, June 17. Abstract.

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difference in the result, if on experimenting with two ants one had access to a large treasure, the other only to a small one.

It also occurred to me that some light would be thrown on the question by compelling the ant who found the treasure to return empty handed. If she took nothing home and yet others returned with her, this must be by some communication having passed. It would be a case in which precept was better than example.

I selected therefore a specimen of *Atta testaceo-pilosa*, belonging to a nest which I had brought back with me from Algeria. She was out hunting about six feet from home, and I placed before her a large dead bluebottle fly, which she at once began to drag to the nest. I then pinned the fly to a piece of cork, in a small box, so that no ant could see the fly until she had climbed up the side of the box. The ant struggled, of course in vain, to move the fly. She pulled first in one direction and then in another, but, finding her efforts fruitless, she at length started off back to the nest empty-handed. At this time there were no ants coming out of the nest. Probably there were some few others out hunting, but for at least a quarter of an hour no ant had left the nest. My ant entered the nest but did not remain there; in less than a minute she emerged accompanied by seven friends. I never saw so many come out of that nest together before. In her excitement the first ant soon distanced her companions, who took the matter with much *sang froid*, and had all the appearance of having come out reluctantly, or as if they had been asleep and were only half awake. The first ant ran on ahead, going straight to the fly. The others followed slowly and with many meanderings; so slowly, indeed, that for twenty minutes the first ant was alone at the fly, trying in every way to move it. Finding this still impossible, she again returned to the nest, not chancing to meet any of her friends by the way. Again she emerged in less than a minute with eight friends, and hurried on to the fly. They were even less energetic than the first party; and when they found they had lost sight of their guide they one and all returned to the nest. In the meantime several of the first detachment had found the fly, and one of them succeeded in detaching a leg, with which she returned in triumph to the nest, coming out again directly with four or five companions. These latter, with one exception, soon gave up the chase and returned to the nest. I do not think so much of this last case, because as the ant carried in a substantial piece of booty in the shape of the fly's leg, it is not surprising that her friends should some of them accompany her on her return; but surely the other two cases indicate a distinct power of communication.

Lest however it should be supposed that the result was accidental, I determined to try it again. Accordingly on the following day I put another large dead fly before an ant belonging to the same nest, pinning it to a piece of cork as before. After trying in vain for ten minutes to move the fly, my ant started off home. At that time I could only see two other ants of that species outside the nest. Yet in a few seconds, considerably less than a minute, she emerged with no less than twelve friends. As in the previous case, she ran on ahead, and they followed very slowly and by no means directly, taking in fact nearly half an hour to reach the fly. The first ant, after vainly labouring for about a quarter of an hour to move the fly, started off again to the nest. Meeting one of her friends on the way she talked with her a little, then continued towards the nest, but after going about a foot, changed her mind, and returned with her friend to the fly. After some minutes, during which two or three other ants came up, one of them detached a leg, which she carried off to the nest, coming out again almost immediately with six friends, one of whom, curiously enough, seemed to lead the way, tracing it, I presume, by scent. I then removed the pin, and they carried off the fly in triumph.

These and other experiments certainly seem to indicate the possession by ants of something approaching to language. It is impossible to doubt that the friends were brought out by the first ant; and as she returned empty-handed to the nest, the others cannot have been induced to follow her merely by observing her proceedings. I conclude, therefore, that they possess the power of requesting their friends to come and help them.

Recognition of Relations.—In my last paper (*Linn. Journ.* vol. xiv. p. 611) I recorded some experiments made with pupæ, in order if possible to determine how ants recognised their nest companions. The general result was that pupæ tended by strangers of the same species, and then after they had arrived at maturity put into the nest from which these strangers had been taken, were invariably treated as interlopers and attacked. On the other hand, if they were tended by ants from their own nest, and then after arriving at maturity put back in their own nest, they were invariably recognised as friends; and lastly, if as pupæ they were tended by strangers, but then after arriving at maturity put back in their own nest, they were generally received as friends. In all these experiments, however, the ants were taken from the nest as pupæ, and though I did not think the fact that they had passed their larval existence in the nest could affect the problem, still it might do so. I determined therefore to separate a nest before the young were born, or even the eggs laid, and then ascertain the result. Accordingly I took one of my nests, which I began watching on September 13, 1878, and which contained two queens, and on February 8, 1879, divided it into halves, which I will call A and B, so that there were approximately the same number of ants with a queen in each division. At this season, of course, the nest contained neither young nor even eggs. During April both queens began to lay eggs. On July 20 I took a number of pupæ from each division and placed each lot in a separate glass, with two ants from the same division. On August 30 I took four ants from the pupæ bred in B, and one from those in A (which were not quite so forward), and after marking them as usual with paint, put the B ants into nest A, and the A ant into nest B. They were received amicably and soon cleaned. Two, indeed, were once attacked for a few moments, but soon released. On the other hand, I put two strangers into nest A, but they were at once killed. For facility of observation I placed each nest in a closed box. On the 31st I carefully examined the nests and also the boxes in which I had placed them. I could only distinguish one of the marked ants, but there were no dead ants either in the nests or boxes, except the two strangers.

Some further experiments led to similar results.

These observations seem to me conclusive as far as they go, and they are very surprising. In my experiments of last year, though the results were similar, still the ants experimented with had been brought up in the nest, and were only removed after they had become pupæ. It might therefore be argued that the ants having nursed them as larvæ, recognised them when they came to maturity; and though this would certainly be in the highest degree improbable, it could not be said to be impossible. In the present case, however, the old ants had absolutely never seen the young ones until the moment when, some days after arriving at maturity, they were introduced into the nest; and yet in all ten cases they were undoubtedly recognised as belonging to the community.

It seems to me therefore to be established by these experiments that the recognition of ants is not personal and individual; that their harmony is not due to the fact that each ant is individually acquainted with every other member of the community.

At the same time the fact that they recognise their friends even when intoxicated, and that they know the young born in their own nest even when they have been brought out of the chrysalis by strangers, seems to indicate that the recognition is not effected by means of any sign or password.

Workers breeding.—In my last paper I brought forward some strong evidence tending to show that when workers laid eggs they always produced males. This is, however, a physiological fact of so much interest that I have carefully watched my nests this year also, to see what further light they would throw on the subject. In six of those which contained no queen eggs were produced, which of course must necessarily have been laid by workers belonging to *Lasius niger*, *Formica cinerea*, *Formica fusca* and *Polyergus rufescens*.

The result was that in five of these nests males have been produced, and in not a single case has a worker laid eggs which have produced a female, either a queen or a worker. Perhaps I ought to add that workers are abundantly produced in those of my nests which possess a queen. Again, as in previous years, so this season again, while great numbers of workers and males have come to maturity in my nests, not a single queen has been produced. We have, I think, therefore, strong reason for concluding that, as in the case of bees, so also in ants, some special food is required to develop the female embryo into a queen.

As to Hearing and Experiments with Telephone.—In order to ascertain if possible whether ants made any sounds which were audible to one another, I thought I would try the telephone. Accordingly I looked for two ants' nests (*Lasius niger*) not far from one another, and then, after disturbing one of them, had a telephone held just over it. I then held the second telephone close over the other nest, each telephone being

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perhaps one to two inches above the ground. If the disturbed ants made any sound which was transmitted by the telephone, the ants in the other nest ought to have been thrown into confusion. I could not, however, perceive that it made the slightest difference to them. I tried the experiment three or four times, always with the same result. I then put some syrup near a nest of *L. niger*, and when several hundred ants were feeding on the syrup I blew on the nest, which always disturbs them very much. They came out in large numbers and ran about in great excitement. I then held one end of the telephone over the nest, the other over the feeding ants, who, however, took not the slightest notice. I cannot, however, look on these experiments as at all conclusive, because it may well be that the plate of the telephone is too stiff to be set in vibration by any sounds which ants could produce.

On the Treatment of Aphides.—Our countryman Gould, whose excellent little work on ants[1] has hardly received the attention it deserves, observes that "the queen ant [he is speaking of *Lasius flavus*] lays three different sorts of eggs: the slave, female, and neutral. The two first are deposited in the spring, the last in July and part of August; or, if the summer be extremely favourable, perhaps a little sooner. The female eggs are covered with a thin black membrane, are oblong, and about the sixteenth or seventeenth part of an inch in length. The male eggs are of a more brown complexion, and usually laid in March."

Here however our worthy countryman fell into an error, the eggs which he thus describes not being those of ants, but, as Huber correctly observed, of Aphides.[2] The error is the more pardonable, because the ants treat these eggs exactly as if they were their own, guarding and tending them with the utmost care. I first met with them in February, 1876, and was much astonished, not being at that time aware of Huber's observations. I found, as Huber had done before me, that the ants took the greatest care of these eggs, carrying them off to the lower chambers with the utmost haste when the nest was disturbed. I brought some home with me and put them near one of my own nests, when the ants carried them inside. That year I was unable to carry my observations further. In 1877 I again procured some of the same eggs, and offered them to my ants, who carried them into the nest, and in the course of March I had the satisfaction of seeing them hatch into young Aphides. M. Huber however does not think these are mere ordinary eggs. On the contrary he agrees with Bonnet "that the insect, in a state nearly perfect, quits the body of its mother in that covering which shelters it from the cold in winter, and that it is not, as other germs are, in the egg surrounded by food, by means of which it is developed and supported. It is nothing more than an asylum of which the Aphides born at another season have no need; it is on this account some are produced naked, others enveloped in a covering. The mothers are not then truly oviparous, since their young are almost as perfect as they ever will be, in the asylum in which Nature has placed them at their birth."[3]

This is, I think, a mistake. This is not the opportunity to describe the anatomy of the Aphis; but I may observe that I have examined the female, and find these eggs to arise in the manner so well described by Huxley in our *Transactions*,[4] and which I have also myself observed in other Aphides and in allied genera.[5] Moreover I have opened the eggs themselves, and have also examined sections, and have satisfied myself that they are true eggs containing ordinary yelk. If examined while still in the ovary the germ-vesicle presents the usual appearance, but in laid eggs I was unable to detect it. So far from the young insect being "nearly perfect," and merely enveloped in a protective membrane, no limbs or internal organs are present. These bodies are indeed real ova, or pseudova; and the young Aphis does not develop in them until shortly before they are hatched.

When my eggs hatched I naturally thought that the Aphides belonged to one of the species usually found on the roots of plants in the nests of *Lasius flavus*. To my surprise, however, the young creatures made the best of their way out of the nest, and indeed were sometimes brought out by the ants themselves. In vain I tried them with roots of grass, &c.; they wandered uneasily about, and eventually died. Moreover they did not in any way resemble the subterranean species. In 1878 I again attempted to rear these young Aphides; but though I hatched a great many eggs, I did not succeed. This year however I have been more fortunate. The eggs commenced to hatch the first week in March. Near one of my nests of *Lasius flavus*, in which I had placed some of the eggs in question, was a glass containing living specimens of several species of plant commonly found on or around ants' nests. To this some of the young Aphides were brought by the ants. Shortly afterwards I observed on a plant of daisy, in the axils of the leaves, some small Aphides very much resembling those from my nest, though we had not actually traced them continuously. They seemed thriving, and remained stationary on the daisy. Moreover, whether they had sprung from the black eggs or not, the ants evidently valued them, for they built up a wall of earth round and over them. So things remained throughout the summer; but on October 9 I found that the Aphides had laid some eggs exactly resembling those found in the ants' nests; and on examining daisy-plants from outside I found on many of them similar Aphides, and more or less of the same eggs.

I confess these observations surprised me very much. The statements of Huber have not indeed attracted so much notice as many of the other interesting facts which he has recorded; because if Aphides are kept by ants in their nests, it seems only natural that their eggs should also occur. The above case however is much more remarkable. Here are Aphides, not living in the ants' nests, but outside, on the leaf-stalks of plants. The eggs are laid early in October on the food-plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, where they would be exposed to the severity of the weather and to innumerable dangers, but brought into their nests by the ants, and tended by them with the utmost care through the long winter months until the following March, when the young ones are brought out and again placed on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter, but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer.

No doubt the fact that our European ants do not generally store up food in the usual way is greatly due to the nature of their food. They live, as we know, partly on insects and other small animals which cannot be kept fresh; and they have not learnt the art of building vessels for their honey, probably because they are not kept in cells like those of the honey-bee, and their pupæ do not construct firm cocoons like those of the humble-bee.

Moreover it is the less necessary for them to do so, because if they obtain access to any unusual store of honey, that which they swallow is only digested by degrees and as it is required; so that, as the camel does with water, they carry about with them in such cases a supply of food which may last them a considerable time. They have moreover, as we know, the power of regurgitating this food at any time, and so supplying the larvæ or less fortunate friends. Even in our English ants the quantity of food which can be thus stored up is considerable in proportion to the size of the insect; and if we watch, for instance, the little brown garden-ant (*Lasius niger*) ascending a tree to milk their Aphides, and compare them with those returning full of honey, we shall see a marked difference in size.

We have, indeed, no reason to suppose that in our English ants any particular individuals are specially told off to serve as receptacles of food. W. Wesmael, however, has described[1] a remarkable genus (*Myrmecocystus mexicanus*), brought by M. de Normann from Mexico, in which certain individuals in each nest serve as animated honey-pots. To them the foragers bring their supplies, and their whole duty seems to be to receive the honey, retain it, and redistribute it when required. Their abdomen becomes enormously distended, the intersegmental membranes being so much extended that the chitinous segments which alone are visible externally in ordinary ants seem like small brown transverse bars. The account of these most curious insects given by MM. de Normann and Wesmael has been fully confirmed by subsequent observers; as, for instance, by Lucas,[2] Saunders,[3] Edwards,[4] Blake,[5] Loew,[6] and McCook.

[1] "An Account of English Ants." By the Rev. W. Gould, 1747, p. 36.
[2] My lamented friend Mr. Smith also observed these eggs (*Entom. Annual*, 1871). He did not however identify the species to which they belonged.
[3] "The Natural History of Ants." By M. P. Huber, 1820, p. 246.
[4] *Trans.* Linn. Soc., vol. xxii. 1859.
[5] *Philosophical Transactions*, 1859.

[1] *Bull. de l'Acad. des Sci. de Bruxelles.*
[2] *Ann. Soc. Ent. de France*, v. p. 111.
[3] *Canadian Entomologist*, vol. vii. p. 12.
[4] *Proc.* Californian Academy, 1873.
[5] *Ibid.* 1874.
[6] *American Nat.* viii. 1874.

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On one very important point, however, M. Wesmael was in error; he states that the abdomen of these abnormal individuals "ne contient aucun organe; ou plutôt, il n'est lui-même qu'un vaste sac stomacal." Blake even asserts that "the intestine of the insect is not continued beyond the thorax," which must surely be a misprint; and also that there is no connection "between the intestine and the cloaca"! These statements, however, are entirely erroneous; and, as M. Forel has shown, the abdomen does really contain the usual organs, which, however, are very easily overlooked by the side of the gigantic stomach.

I have now the honour of exhibiting to the Society a second species of ant, which has been sent me by Mr. Waller, in which a similar habit has been evolved and a similar modification has been produced. The two species, however, are very distinct, and the former is a native of Mexico, while the present comes from Adelaide in Australia. The two species, therefore, cannot be descended one from the other; and it seems inevitable that the modification has originated independently in the two species.

It is interesting that, although these specimens apparently never leave the nest, and have little use therefore for legs, mandibles, &c., the modifications which they have undergone seem almost confined to the abdominal portion of the digestive organs. The head and thorax, antennæ, jaws, legs, &c., differ but little from those of ordinary ants.

CAMPONOTUS INFLATUS, n. sp.

Operaria. Long. 15 mill. Nigra, tarsis pallidioribus; subtiliter coriacea, setis cinereo-testaceis sparsis; antennis tibiisque haud pilosis; tarsis infra hirsutis; mandibulis punctatis, hirsutis, sexdentatis; clypeo non carinato, antice integro; petioli squama modice incrassata, antice convexa, postice plana emarginata.

Hab. Australian.

The colour is black, the feet being somewhat paler. The body is sparsely covered with stiff cinereo-testaceous hairs, especially on the lower and anterior part of the head, the mandibles, and the posterior edge of the thorax. The head and thorax are finely coriaceous.

The antennæ are of moderate length, twelve-jointed; the scape about one-third as long as the terminal portion and somewhat bent. At the apex of the scape are a few short spines, bifurcated at the point. At the apex of each of the succeeding segments are a few much less conspicuous spines, which decrease in size from the basal segments outwards. The antenna is also thickly clothed with short hairs, and especially towards the apex with leaf-shaped sense-hairs. The clypeus is rounded, with a slightly developed median lobe and a row of stiff hairs round the anterior border; it is not carinated. The mandibles have six teeth, those on one side being rather more developed and more pointed than those on the other. They decrease pretty regularly from the outside inwards. The maxillæ are formed on the usual type. The maxillary palpi are six-jointed, the third segment being but slightly longer than the second, fourth, or fifth; while in *Myrmecocystus* the third and fourth are greatly elongated. The segments of the palpi have on the inner side a number of curious curved blunt hairs besides the usual shorter ones. The labial palpi are four-jointed. The eyes are elliptical and of moderate size. The ocelli are not developed.

The thorax is arched, broadest in front, without any marked incision between the meso- and metanotum; the mesonotum itself is, when seen from above, very broadly oval, almost circular, rather broader in front and somewhat flattened behind. The legs are of moderate length, the hinder ones somewhat the longest. The scale or knot is heart-shaped, flat behind, slightly arched in front, and with a few stiff, slightly diverging hairs at the upper angles. The length is about two-thirds of an inch.

ON THE THERMIC AND OPTIC BEHAVIOUR OF GASES UNDER THE INFLUENCE OF THE ELECTRIC DISCHARGE [1]

PROF. E. WIEDEMANN has undertaken an exact calorimetric investigation of the electric discharge through gases, and in spite of the serious difficulties which he had to encounter, he has already obtained valuable and important results. As a source of electricity, Töpler's machine was used; but we must refer to the original paper for all details of experimentation.

Three series of observations were made. In the first the total heat generated in a given time in the whole vacuum tube was measured. In the second series the capillary part only was examined, and in the third the thermal behaviour of the regions in the neighbourhood of the electrodes was investigated. The result of the first series is summed up as follows:—With decreasing pressure the total quantity of heat generated at first decreases, reaches a minimum, and then increases again. In hydrogen the amount of heat generated is smaller than in atmospheric air.

A smaller amount of heat developed corresponds to a larger number of discharges in a given time, and hence to a smaller potential at the moment the discharge begins to pass. The results of Prof. Wiedemann are therefore, as he points out, in accordance with those of Messrs. De La Rue and Hugo Müller, who found that the difference of potential necessary to cause a discharge passes through a minimum as the pressure decreases.

Somewhat more complicated results were obtained when an air-break was introduced into the circuit. In that case the air-break determines the difference of potential necessary to produce a discharge; but if the whole quantity of electricity would pass suddenly when that potential has been reached, and before it has had time to sink, the amount of heat generated would be independent of the pressure in the vacuum tube. This however is not the case; but the result is intermediate between that obtained when no air-break exists, and that which would be obtained on the above supposition.

The following results were obtained in the experiments in which the capillary part of a vacuum tube only was introduced into the calorimeter:—

1. The heating effect in capillary tubes at pressures above 1 mm. is almost independent of the quantity of electricity passing with each discharge, and nearly proportional to the total amount of electricity which passes.

2. The heating effect is almost the same whether the positive or negative electrode of the tube is connected with the machine (the other electrode being connected with the earth), although the number of discharges passing in a given time is different.

3. With decreasing pressure the heat generated decreases very rapidly without passing through a minimum.

4. The heating effect is independent of the shape of the electrodes. Some results obtained by Prof. G. Wiedemann, who had found that in tubes of different widths the same amount of heat is generated by the same current, were confirmed.

Calorimetric measurements made near the electrodes showed:

1. The heating effect near the positive electrode decreases with decreasing pressure rapidly. At very low pressures a small increase is sometimes observed.

2. The heating effect near the negative electrode decreases first with decreasing pressure, and then increases rapidly.

The heating effect near the positive electrode shows some anomalies when an air-break is introduced, the amount of heat generated being considerably increased.

Some measurements were reduced to an absolute scale, and showed that the total amount of heat generated is very large. Taking account of the number of discharges, and assuming that after each discharge the gas returns to its original state, the temperature in the capillary part of the tube must have been about 2,000° C. at 15 mm. pressure, and about 1,100° C. at 5 mm. pressure. If the width of the tube was increased ten times, the temperature would only be about 100° C., and this confirms the result obtained by Prof. Wiedemann in a former investigation, that gases may become luminous under the influence of the electric discharge at a comparatively low temperature.

In another part of the paper Prof. Wiedemann treats of a very important problem. When his tubes were filled with hydrogen, and an air-break was introduced in the circuit, the spectrum of the luminous gas changed suddenly at a given point. According to a now generally accepted hypothesis this change of spectrum is always accompanied by a change in the molecular constitution of the gas; and it is to be expected therefore that heat is either absorbed or given out by a gas when its spectrum changes. This heat Prof. Wiedemann has endeavoured to measure. Let us imagine, for instance, that the current has to do the work of decomposing the molecules of a gas. The moment the discharge has passed, recomposition will take place, and the heat then generated was measured by Prof. Wiedemann. Some of the suppositions on which the calculations are based might require further investigation, but the assumptions made are supported, and to a certain extent proved by the fact that the heat necessary to change the band-spectrum into the line-spectrum was found to be *independent of the pressure and cross-section of the tube.* It is

[1] By Eilhard Wiedemann. (*Wied. Ann.*, x. p. 202.)

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