THURSDAY, SEPTEMBER 29, 1892.

THE SPEECH OF MONKEYS.

The Speech of Monkeys. By R. L. Garner. (London: Heinemann, 1892.)

IT is somewhat unfortunate, and is certainly not a little embarrassing to the critic who desires to take Mr. Garner seriously, that he has chosen to present to the world "this first contribution to science on the subject" of the speech of monkeys in the form of popular and chatty anecdotes, with reflections thereon suitable for the delectation of elderly spinsters. This is the style of writing to which we refer, and of which the book before us largely consists:—

"I shall long remember how this dear little monk (Pedro the Capuchin) would cuddle up under my chin, and try so hard to make me understand some sad story which seemed to be the burden of his life . . . . I have frequently been entertained by a like speech from little Dodo, who was the Juliet of the Simian tribe. She belonged to the same species as the others, but her oratory was of a type far superior to that of any other of its kind that I have ever heard. At almost any hour of the day, at the approach of her keeper she would stand upright and deliver to him the most touching and impassioned address. The sounds which she used, and the gestures with which she accented them, as far as I could determine, were the same as those used by Dago and Pedro in their remarks to me as above described, except that Dodo delivered her lines in a much more impressive manner than either of the others. . . . . I have not been able up to this time to translate these sounds literally, but their import cannot be misunderstood. My belief is that her speech was a complaint against the inmates of the cage, and that she was begging her keeper not to leave her alone in that great iron prison with all those big, bad monkeys who were so cruel to her."

This is the anecdotal style; the heading of the chapter in which Dodo is introduced running thus: "Dago talks about the Weather—Tells Me of His Troubles—Dodo in the 'Balcony Scene,'" &c. It is not easy, we repeat, to deal with this kind of thing in a spirit of serious criticism. And then we have passages of which the following is a sample:—

"I assert that all mammals reason by the same means and to the same ends, but not to the same degree. The reason which controls the conduct of a man is just the same in kind as that which prompts the ape. . . . That same faculty which guided man to tame the winds of commerce, taught the nautilus to lift its tentacles and embrace the passing breeze. . . . That psychic spark which dimly glows in the animal bursts into a blaze of effulgence in man. The one differs from the other just as a single ray of sunlight differs from the glaring light of noon. If man could disabuse his mind of that contempt for things below his plane of life, and hush the siren voice of self-conceit, his better senses might be touched by the eloquence of truth. But while the vassals of his empty pride control his mind, the plainest facts appeal to him in vain, and all the cogency of proof is lost. He is unwilling to forego that vain belief that he is Nature's idol, and that he is a duplicate of Deity. Held in check by the strong reins of theology and tradition"—and so forth for another page and a half.

These be the reflections suitable for the delectation of elderly spinsters. We must excuse ourselves from criticising Mr. Garner's remarks on reason in animals, for there is no evidence in his book that he has, by a careful training in psychology, earned for himself the right of expressing a scientific opinion on this difficult question.

And yet Mr. Garner is at work upon an interesting and important problem in the elucidation of which scientific results will be of great value; and he is working on the right lines, namely, those of experiment and observation in close contact with phenomena. It is worth while therefore, to dig out from his volume the few results of scientific value he has at present reached, to endeavour to set them in their true light, and to encourage him in the further prosecution of his labours.

It is well known to all observers that animals emit sounds expressive of their emotional states, and that these sounds convey, and are often apparently intended to convey, an intimation to their fellow-creatures of such emotional states. No one who has watched a dog growling, a cat swearing, or a lamb bleating, can question this elementary fact. The present writer has lately been observing and making experiments with young chicks Towards the close of the first week there were at least five well-distinguished sounds: the soft "cheep" of contentment, the more excited note of unusual satisfaction, the complaining "weep-weep" of slight discomfort, the sharper cry when they were caught up, for example, by a strange hand, and, quite distinct from all the rest, the danger "churr." There can be little doubt that these several sounds, as emitted by one of the chicks, were of suggestive value to its little brothers and sisters. And they were quite spontaneous and not the result of imitation, for the chicks had never seen any of their kind. Had these chicks been reared in the ordinary way, and not as experimental orphans, their hen mother would no doubt have given opportunity for observing that by certain sounds she could call her brood's attention to things good to eat. And there can be little doubt that a dog can call its companion's attention to something worriable, though whether there are differentiations, *e.g.*, for cat and rat, we cannot say. We have ourselves been unable to detect such differences in our own dogs.

It is thus a matter of familiar observation that animals emit sounds which are of suggestive value, and that these sounds are in some cases suggestive of emotional states, and in others of external objects. It is to such sounds as emitted by monkeys that Mr. Garner has mainly directed his attention. Let us give in his own words some of his results:—

"Standing near the cage of a little Capuchin, I imitated a sound which I had translated 'milk,' but from many tests I concluded it meant 'food,' which opinion has been somewhat modified by many later experiments which led me to believe that he uses it in a still wider sense. It is difficult to find any formula of human speech equivalent to it. While the Capuchin uses it relating to food and sometimes to drink, I was unable to detect any difference in the sounds. He also seemed to connect the same sound to every kindly office done him, and to use it as a kind of 'shibboleth.' More recently, however, I have detected in the sound slight changes of inflection under different conditions, until I am now led to believe that the meaning of the word depends somewhat, if not wholly, on its modulation."

Again:—

"I approached the cage [of another Capuchin], and uttered the sound which I have described and translated 'drink.' My first effort caught his attention and caused him to turn and look at me; he then arose and answered me with the same word, and came at once to the front of the cage. He looked at me as if in doubt, and I repeated the word; he responded with the same, and turned to a small pan in his cage which he took up and placed near the door, through which the keeper usually passed his food, returned to me, and uttered the word again. I asked the keeper for some milk, which he did not have, but brought me some water instead. . . . I allowed the monkey to dip his hand into the glass, and he would then lick the water from his fingers and reach again. I kept the glass out of reach of his hand, and he would repeat the sound earnestly, and look at me beseechingly, as if to say, 'Please give me some more.' I was thus convinced that the word which I had translated 'milk,' must also mean 'water,' and from this and other tests I at last determined that it meant 'drink' in its broad sense, and possibly 'thirst.' It evidently expressed his desire for something with which to allay his thirst. The sound is very difficult to imitate, and quite impossible to write exactly."

We submit that these passages seem to indicate that Mr. Garner has not yet, in this matter, reached results which have much definiteness and precision. It would seem that the Capuchin emits sounds which are mainly expressive of a craving for something, and perhaps vaguely indicate that this something is water or other drink; though with regard to this objective implication we must remember that one of the capuchins "seemed to connect this sound to every kindly office done him."

This is one of the nine words or sounds belonging to Capuchins. Another is the sound which Mr. Garner has translated "food." Of it he says:—

"I observed that this sound seemed to be a salutation or peace-making term with them, which I attributed to the fact that food was the central thought of every monkey's life, and that consequently that word would naturally be the most important of his whole speech."

Another sound which was emitted by a monkey when a storm was going on, and which, when reproduced by the phonograph, made the little fellow look out of window, Mr. Garner translated "weather," or thought that it "in some way alluded to the state of the weather." But he does not seem quite clear about it.

"I am not sure," he says, "how far it may be relied upon as a separate word. It was so closely connected to the speech of discontent or pain, that I have not been able since to separate the sounds, and I finally abandoned it as a separate word; but reviewing my work, and recalling the peculiar conduct of this monkey and the conditions attending it, I believe it is safe to say that he had in mind the state of the weather."

Three other sounds are plainly emotional in their nature—(1) an alarm sound, used under stress of great fear, high in pitch, shrill and piercing; (2) a sound written thus "e-c-g-k" expressive of apprehension; and (3) a sound which is like a guttural whisper "c-h-ī" expressive of the approach of something which the monkey does not fear.

Such are some of the sounds which Mr. Garner misnames (as we think) the "speech" of monkeys, and concerning which he exclaims:—

"Standing on this frail bridge of speech, I see into that broad field of life and thought which lies beyond the confines of our care, and into which, through the gates that I have now unlocked, may soon be borne the sunshine of human intellect. What prophet now can foretell the relations which may yet obtain between the human race and those inferior forms which fill some place in the design, and execute some function in the economy of nature?"

This, however, is one of those reflections which savour of the prattle of the parlour tea-table rather than the sober discussion of the study. We should rather say that Mr. Garner's investigations, if followed up in a spirit of critical accuracy, give promise of enabling him to extend our knowledge of the sounds emitted by monkeys—sounds which, we gather from his descriptions, are mainly, if not entirely, of emotional origin, but which may perhaps carry with them a more or less definite objective import. We are of opinion that such extension of our knowledge of these emotional or other sounds may prove a definite and valuable contribution to science, and we therefore heartily wish Mr. Garner all success in the prosecution of his inquiry.

C. Ll. M.

BEE-KEEPING.

Bees for Pleasure and Profit. By G. Gordon Samson. (London: Crosby Lockwood and Son, 1892.)

"HOW doth the little busy bee, &c.?" asked Dr. Watts a hundred and fifty years ago. So long as straw skeps predominated, the problem was insoluble. The bees improved each shining hour in perfunctory fashion, building crooked combs, confusing brood with honey, exhausting their republic with superfluous swarms, dying finally in the smoke-reek of an old pair of corduroys, enriched for malarious exhalation by more than one generation of bucolic wearers. With frame hives came an Earthly Providence to answer the pious query; to control the economy of the hive, to prescribe the number of drones, multiply or restrict the queens, straighten out the combs, combine defective stocks into a single opulent society, disintegrate an overgrown community into new and independent nuclei, supplement the tardy growth of brood or honey, increase fourfold the productiveness of every hive. It is as an adept in Providential operations that Mr. Samson writes. He renounces scientific erudition; and his allusion to "powerful microscopes," his reliance on "wonderful provisions of Nature," his belief that by confining their visits to one kind of flower in a single journey the bees prevent the hybridization of species, show his disclaimer to be correct; but apiarian science was brought up to date last year in Mr. Cowan's admirable book (NATURE, vol. 43, p. 578), leaving room for just such a practical treatise on manipulation and management as Mr. Samson is competent to give.

No repetition can exhaust the interest attaching to the strange life-history of the hive-bees. While the solitary bees are created male and female, there appears in the gregarious bees a third sex, the workers or neuters (not *neutrals*, as Mr. Samson calls them), having rudimentary ovaries and spermatotheca, incapable of laying eggs, with the ovipositor modified into a sting; themselves, in queenless hives, sometimes developed into more advanced yet still imperfect females, known as fertile workers, and producing only drones. In ordinary cases a single queen is the mother of the entire hive, bearing drone eggs only in her virgin state, fecundated once for all by a solitary nuptial act for the production of more than half a million of offspring. During twenty-one days as egg, larva, pupa, the infant bee resides in the comb, fed by its older sisters on a paste of brood-food or chyle, to which in the case of workers honey is added after the first three days. For a week after emergence the young bee remains at home in order to secrete wax, which is detached from the wax pockets by others; it is then promoted to the office of nurse; for a fortnight or three weeks afterwards it gathers honey, spends its maturity in the difficult work of comb-building, dies at the end of six or seven weeks, unless winter hibernation arrests its labour and prolongs its life. The moral of its unique biography has been pointed by many writers; the social lesson of its communistic orderliness, the industrial ideal flowing from its co-operative toil and profit, the political example impressed by the curious completeness with which, at once a red republican and an ardent cavalier, it combines extremest democratic sturdiness with devoted personal loyalty.

The common hive bee, as distinguished from the Bumble, Carpenter, Mason, and other bees, belongs to the genus Apis, of which one species only, *A. mellifica*, is indigenous to Britain. During the last few years the Ligurian, Carniolian, and Syrian bees have been largely introduced, from amongst which the cross known as Syrio-Carniolian bears the palm for fecundity, docility, honey-gathering, and hardiness through the winter. With a swarm of these and a ten-frame hive the tyro may begin bee-keeping. In manipulating he must not wear gloves; they make the fingers clumsy, and the sting, painful at first, causes diminishing inconvenience on each successive infliction, till the system is inoculated by the acid, and the sting is harmless. In creating their new home the bees require assistance; one or two frames of brood-comb from the parent hive, with a limited number of drone cells, must be inserted. As the frames fill, the master, utilizing the fact that honey is always stored above the brood, places "supers" over the frames, removing them as fast as they are filled, while the full-charged combs from below are placed in an extractor and the liquid honey is withdrawn. As much as 100 pounds of honey have sometimes been thus obtained in one season from a single hive. The honey harvest begins with the blooming fruit trees in early spring, and slackens after the lime trees fade, but in heather districts a rich autumn store is raised, and Scottish bee-keepers, having reaped the early crop from bean and clover, send their hives by rail or boat to a considerable distance, to be placed upon the heath-clad moors in early August. When an unfavourable winter has depopulated the hives, it is possible to build up one strong colony out of two or more weak stocks, retaining only the youngest and most prolific queen. The bees will resent the coalition, and a general fight will impend; but if sprinkled with thin syrup and with flour their power of discerning Trojan from Tyrian is cancelled by the identity of appearance and o scent.

> "Just so the prudent husbandman, that sees
> The idle tumult of his factious bees,
> Powders them o'er, till none discern his foes,
> And all themselves in meal and friendship lose.
> The insect kingdom straight begins to thrive,
> And all work honey for the common hive."

Mr. Samson does well to press the economic value of bees not only as honey-makers, but as fruit-setters. In cold sunless springs their agency is essential to the fertilization of the bloom; in districts adjoining a large apiary the fruit trees are invariably laden with heavy crops, deteriorating as we remove further from its neighbourhood; and instances are well authenticated from the cider counties in which a general destruction of bees by a long and variable winter has been followed by the loss of the apple crop. Both fruit and honey are at present for the most part imported from abroad; if fruit is to be largely cultivated in the small holdings of the future, it must be sustained and enriched by bee-keeping.

In this, as in other industries, there are occasional difficulties baffling to all but experts. Queens will refuse to be reared, supers will remain unfilled, stocks will need stimulation in the spring and building up in early winter, foul brood, deadliest of bee maladies, will infect the hive. In all such complications and for many more Mr. Samson offers full and clear instruction. Portable in form and cheap of cost, his book should form part, along with "smoker," bee veil, queen cage, "driving irons," and "doubling box," of every bee-keeper's equipment.

W. TUCKWELL.

A NEW COURSE OF CHEMICAL INSTRUCTION.

A New Course of Experimental Chemistry, with Key. By John Castell-Evans, F.I.C. (London: Thomas Murby.)

THE basis of the course of instruction here put forward consists in making the student perform an experiment with a definite object in view. The result of the experiment is carefully withheld, and must be discovered by the student himself. In this way he is led to acquire knowledge by his own exertions, and theoretically at least such a method has more to recommend it than any other. In practice, however, the time required to rigorously carry out this system is no doubt an obstacle to its general adoption.

If with the author we lay down the law that "the student must not be allowed to use any chemical *name* or *term* until he has discovered for himself the *thing* or *process* represented by it," to acquire but a moderate knowledge of the chemistry of to-day appears well-nigh an impossibility. It was thus a matter of interest to see how a work based on this system could be comprised within reasonable limits of space. The author, however, does not seem to intend the above restriction to be literally enforced. To go no further than the first lesson, we find the student employing the ordinary chemicals, phosphorus, ammonium nitrite, potassium chlorate, &c., things which he makes no attempt to discover; only in the case of the more important processes and substances usually met with in a chemical course is any such attempt made.

The book consists of two parts. The first part contains a series of experiments and problems; the latter being set upon a course of lectures which are intended to be given concurrently with the laboratory instruction, and which deal more especially with the physical aspect of the subject. Outlines of these lectures, results of the experiments, and full solutions of the problems are to be found in the Key, which may be obtained separately or bound up with the two parts. The experiments start off with the commonly occurring phenomena of combustion, and lead up to the laws of chemical combination, the determination of chemical equivalents, vapour densities, &c.

Part II. consists of qualitative and quantitative analysis taken together, no attempt being made to separate the two. The results of the experiments are here carefully withheld from the student, and are given in the Key. A useful table for the detection of the positive radicles is published separately, and may be used in connection with this part.

The book can be recommended as a trustworthy one, and, apart from the novelty of the system adopted, as a storehouse of knowledge useful to the chemist, it will be appreciated by many a teacher.

The problems are actual examples met with in the laboratory, and appear to be free from the artificial exercises so common in text-books. It is also noteworthy that they, as well as the lectures, are concerned to a considerable extent with the energy changes as well as with the material changes which constitute chemical phenomena.

In glancing at the tables of physical constants to be found as answers in the Key, it is frequently noticeable that these magnitudes are given to an accuracy which is altogether fictitious. For example, to express heats of vaporization or absorption coefficients to one part in thousands of millions, or to give a boiling point such as that of bromine to one thousandth of a degree Fahrenheit, tends to create an erroneous idea of the accuracy with which such determinations can be made. In one or two instances the information is not quite up to date. Hydrofluoric acid, for instance, is still formulated H_2F_2, and Bunsen's values for the absorption coefficients of hydrogen and oxygen are still given, although they have been superseded by the observations of Winkler and Timoféef. Van der Waals's work might have been included in the otherwise serviceable account of the kinetic theory of gases, and it is somewhat unfortunate that the author insists upon the narrow view that specific gravity has no other meaning than that which is perhaps more correctly attributed to relative density.

The printing and the woodcuts are hardly up to the standard usually attained in books of this kind.

J. W. R.

OUR BOOK SHELF.

Die Pflanze in ihren Beziehungen zum Eisen. Von Dr. Hans Molisch. Iron in its Relations to Plant-life. 8vo, 119 pages, with one coloured plate. (Jena: Gustav Fischer, 1892.)

AN interesting essay on the presence, function, and form of iron in plants, embodying the results of previous investigators and of the author's experiments and researches extending over several years. Though the outcome of much labour, Dr. Molisch regards it as preliminary to more extended inquiries, and the whole subject as being yet in its infancy. He discusses the determination of the presence in the vegetable cell of iron in loose combinations and in dense combinations, or what he terms the masked condition. He then describes the occurrence and distribution of iron in plants in loose and dense combinations, and enters somewhat fully into the description of a new method he claims to have discovered for proving the existence of iron in the masked condition, even when it is present only in infinitesimally small quantities. This is done by soaking the objects one or more days or weeks in saturated aqueous liquor potassæ, and then, after quickly washing them in pure water, subjecting them to the usual reagents. He further claims to have proved that iron is not one of the constituents of chlorophyll. There is also a short chapter on healing vegetable chlorosis by the use of chloride of iron, sulphate of iron, and other salts of iron.

W. B. H.

Up the Niger. By Captain A. F. Mockler-Ferryman (London: George Philip and Son, 1892.)

SEVERAL years ago complaints were made about the conduct of various British subjects in the territories placed under the Royal Niger Company. The British Government accordingly sent Major Claude Macdonald to inquire into the matter. He was accompanied by Captain Mockler-Ferryman, who in the present volume gives a full account of the proceedings of the Mission. During the entire journey, which extended over more than 3000 miles, nothing "of a blood-curdling nature" occurred, so that any one who is attracted to books of travel mainly by the chance of finding them full of sensational narratives, need not trouble himself with Captain Mockler-Ferryman's pages. On the other hand, those who like to read about remote regions and their native inhabitants, will find in this book much to interest them. The author is an accurate observer, and notes in a clear and unpretending style the facts by which his attention has been most strongly attracted. His descriptions of the native tribes of the Niger country, so far as he himself observed them, are particularly good, and will not only please the general reader, but be of service to ethnologists and anthropologists. A capital chapter on music and musical instruments, prepared from materials collected by the members of the mission, is contributed by Captain C. R. Day, and the value of the volume as a whole is much increased by a map and illustrations.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Density of Nitrogen.

I AM much puzzled by some recent results as to the density of *nitrogen*, and shall be obliged if any of your chemical readers can offer suggestions as to the cause. According to two methods of preparation I obtain quite distinct values. The relative difference, amounting to about $\frac{1}{1000}$ part, is small in itself; but it lies entirely outside the errors of experiment, and can only be attributed to a variation in the character of the gas.

In the first method the oxygen of atmospheric air is removed in the ordinary way by metallic copper, itself reduced by hydrogen from the oxide. The air, freed from CO_2 by potash, gives up its oxygen to copper heated in hard glass over a large Bunsen, and *then* passes over about a foot of red-hot copper in a furnace. This tube was used merely as an indicator, and the copper in it remained bright throughout. The gas then passed through a wash-bottle containing sulphuric acid, thence again through the furnace over *copper oxide*, and finally over sulphuric acid, potash, and phosphoric anhydride.

In the second method of preparation, suggested to me by Prof. Ramsay, everything remained unchanged, except that the *first* tube of hot copper was replaced by a wash-bottle containing liquid *ammonia*, through which the air was allowed to bubble. The ammonia method is very convenient, but the nitrogen obtained by means of it was $\frac{1}{1000}$ part *lighter* than the nitrogen of the first method. The question is, to what is the discrepancy due?

The first nitrogen would be too heavy, if it contained residual oxygen. But on this hypothesis something like 1 per cent. would be required. I could detect none whatever by means of alkaline pyrogallate. It may be remarked the density of this nitrogen agrees closely with that recently obtained by Leduc, using the same method of preparation.

On the other hand, can the ammonia-made nitrogen be too light from the presence of impurity? There are not many gases lighter than nitrogen, and the absence of hydrogen, ammonia, and water seems to be fully secured. On the whole it seemed the more probable supposition that the impurity was hydrogen, which in this degree of dilution escaped the action of the copper oxide. But a special experiment appears to exclude this explanation.

Into nitrogen prepared by the first method, but before its passage into the furnace tubes, one or two thousandths by volume of hydrogen were introduced. To effect this in a uniform manner the gas was made to bubble through a small hydrogen generator, which could be set in action under its own electromotive force by closing an external contact. The rate of hydrogen production was determined by a suitable galvanometer enclosed in the circuit. But the introduction of hydrogen had not the smallest effect upon the density, showing that the copper oxide was capable of performing the part desired of it.

Is it possible that the difference is independent of impurity, the nitrogen itself being to some extent in a different (dissociated) state?

I ought to have mentioned that during the fillings of the globe, the rate of passage of gas was very uniform, and about $\frac{2}{3}$ litre per hour. RAYLEIGH.

Terling Place, Witham, September 24.

Recent Spectroscopic Determinations.

IN the September number of the *Philosophical Magazine* Mr. Michelson has published determinations, by a most interesting method, of very close double and multiple lines. In any attempt to interpret his results, it is neccesary to bear in mind the profound modifications which the internal motions of a gas—the rectilinear motions of the molecules between their encounters, as well as the motions going on within each molecule—had undergone within the Geisler's tubes upon which he experimented.

In a gas under ordinary circumstances the rectilinear journeys of the molecules take place indifferently in all directions, and where this is the case it follows from the well-known relation between the surface of a sphere and that of its circumscribing cylinder, that the effect of the velocities which happen to lie between ν and $\nu + \delta\nu$ is to substitute for each line of the spectrum of the gas a band of uniform intensity and without nebulous edges, the width of which can be calculated. This width, for example, is ·04 of an Ångström or Rowland unit (the tenthetmetre), in the yellow part of the spectrum and for velocities of the molecules which lie in the neighbourhood of two kilometres per second, which is about the average velocity of molecules of hydrogen at atmospheric temperatures. Hence with all the velocities that prevail among the molecules, the effect of the rectilinear motions under ordinary circumstances is that each line will be symmetrically widened and rendered nebulous. To this effect Mr. Michelson calls attention.

But in the residual gas of a Geisler's tube through which electricity is passing, the case is altogether different. Here the rectilinear motions of the molecules are not alike in all directions, but preponderate in some: a state of things which must at least double the lines, and may introduce greater complications.

Moreover, different lines may be differently affected, since the behaviour of the gas varies according to its position between the electrodes; as is evidenced by the observed differences in the form and colouring of the striæ, &c., in the several parts of a Geisler's tube.

We must also be on our guard in another respect, when we attempt to interpret the results, since the distribution of the heat energy of a gas between the rectilinear motions of its molecules and the motions within the molecules, which in the case of ordinary gas is a fixed ratio, is certainly largely departed from in gas through which electricity is passing. Until the laws of the new distribution are understood, the temperature of the gas, judged of by its behaviour to neighbouring bodies, will give us little information.

It is to such events as are referred to above, or others which like them may arise from the special circumstances under which the vapour of sodium was in Mr. Michelson's experiments, that we must apparently turn for an explanation of the doubling of the constituents of the principal pair of sodium lines which he has detected; since he found that "the width of the lines, their distances apart, and their relative intensities vary rapidly with changes in temperature and pressure."

The method of investigation which Mr. Michelson has so successfully applied appears to be by far the most searching means yet discovered of experimentally investigating the intricate and obscure phenomena which present themselves in Geisler's tubes, and we seem justified in hoping for great results from it.

G. JOHNSTONE STONEY.

9, Palmerston Park, Dublin, September 22.

Printing Mathematical Symbols.

EVERYONE who has had to correct printers' proofs of mathematical formulæ must be painfully alive to the pitfalls into which the non-mathematical compositor continually blunders. To such as know the extreme difficulty of getting such formulæ properly set up, there have doubtless occurred from time to time suggestions for such simplifications of notation as shall render the composition less liable to derangement. One most sensible step of the kind I allude to is the introduction by Sir G. Stokes of the solidus notation for quotients, whereby

$$\frac{dy}{dx} \text{ is now written } dy/dx.$$

The immediate purpose of this letter is not to propound any wholesale scheme of reform, but to advocate one other simple step, and to induce some of my *confrères* to give the world their own suggestions.

Exponentials are a continual stumbling-block to the compositor, and to the printer's reader, who, when he comes to an expression like

$$A\epsilon^{-ax},$$

does his best to make it look a little straighter and turns it into

$$A\epsilon - ax,$$

or into

$$A_\epsilon - ax,$$

or perhaps worse.

The reform I advocate is to write the thing as follows:—

$$A\ exp[-ax],$$

the square brackets being possibly omitted in all cases when their omission would occasion no confusion. One gain in this notation is the reduction of the whole of the symbols to one level, so not breaking the line of type.

Another useful reform, though one on which I fear the probability of agreement is less likely, is the use of the Continental notation for inverse trigonometrical functions, writing, for example,

$$\text{arc} \tan x,$$

instead of

$$\tan^{-1} x$$

for the angle whose tangent is x. Our notation is not only liable to continual misprinting, but is very confusing to Continental readers, who again and again read the latter expression as meaning

$$(\tan x)^{-1}, \text{ or cotan } x.$$

I have even seen it reprinted in a German technical journal as

$$\tan - 1x.$$

SILVANUS P. THOMPSON.

Technical College, Finsbury, September 22.

A so-called Thunderbolt.

DURING a short storm in Liverpool this summer, I noticed one flash as peculiarly sharp and noisy, and subsequently in the correct bearing from my house the ground was reported as having been struck by a thunderbolt. I examined the place, which was on the greensward of a lake, where the ground was penetrated by a number of fairly clean-cut almost vertical holes down which a walking-stick could be thrust. People sheltering near the lake reported a ball of fire and a great splash up of the water. The odd circumstance about the damage was that it occurred on a simple grass slope, about half way between a tall boat-house on the one side and a drinking fountain standing on more elevated ground on the other. Small trees also were in the neighbourhood, and there was no apparent cause why the flash should have selected this particular spot; though indeed it was not within any of the ordinarily accepted "areas of protection." A gentleman—Mr. Hewitt—proposed digging for the meteor, and although fairly convinced that it was nothing but an ordinary flash, we thought it just possible that an accidental meteorite might have fallen during the thunderstorm; in which event a flash down the rarefied air of its trail would be a natural consequence. It may be just possible that the popular belief in thunderbolts has some such foundation.

At any rate the excavation was made, with the result of proving that it was an ordinary flash and that the lightning made use of a surface drain-pipe, about four feet deep, to get at the water of the lake.

I enclose Mr. Hewitt's report. OLIVER J. LODGE.

DURING a thunderstorm on the afternoon of Sunday, July 3, 1892, what is described as a "ball of fire" was seen by several persons to descend to the ground, near the south end of the lake in Sefton Park; and immediately afterwards a column of water, about sixty feet high, was shot up from the lake. On examining the spot where the ball of fire was seen to descend, several clean-cut holes were observed, and a sod was also found at a little distance from the spot.

A few days afterwards an excavation was carefully made. The sod being removed, the holes were traced down to a surface drain pipe four feet below the surface. At this drain the holes terminated, and the pipe was found shattered. The important holes were found to be six, the largest being seven inches in diameter, the others about two inches. No meteoric matter was found, but it seems curious that this effect was brought about by a flash of lightning only, in an open space of sloping grass, when there were trees and houses close by.

Aigburth, Liverpool. GEORGE H. HEWITT.

Peripatus Re-discovered in Jamaica.

MRS. E. M. SWAINSON has been so fortunate as to find on Beacon Hill, near Bath, three specimens of *Peripatus*, which she has sent to the Institute of Jamaica. The species is doubtless identical with that found by Gosse many years ago at the other end of the island. Of the two specimens which we have studied, one has 36 pairs of legs, and is dark pinkish-brown, with the ends of the antennæ pure white, in striking contrast; the other is smaller and darker, without white ends to the antennæ, and with only 29 pairs of legs. The third example, which we have still alive, is larger, but dark in colour. Full details will be given elsewhere later on, and it may suffice for the present to state that the species is very closely allied to *P. Edwardsii* from Venezuela, as described by Sedgwick, but differs in the greater number of legs and the white-tipped antennæ of certain individuals (probably the females), in the only slightly curved (not hooked) claws, in the differentiation of the papillæ into two distinct kinds on the dorsal surface, and apparently in other minor matters. There is no dark dorsal line. The genital orifice is between the penultimate pair of legs; and the jaws are almost precisely as in *Edwardsii*. The Jamaican species being evidently new, it is proposed to call it *Peripatus jamaicensis*.

M. GRABHAM.
September 5. T. D. A. COCKERELL.

Reflection on Valley Fog.

A LETTER from an observer at the Lick Observatory appeared in NATURE on August 25, reporting the reflection of mountains in a valley fog. I was therefore much interested to note the following in the *Yorkshire Herald* of September 7:—

"SIR,—Possibly it may interest your readers to hear of a natural phenomenon I noticed this morning before 6 a.m. Overlooking, from Leyburn, the valley of Wensleydale, it appeared as though more than half of the dale was filled with water, like a great lake with rising hills on either side, and these hill-sides, above the level of the (apparent) flood, were distinctly reflected in it. The sun was shining brightly at the time, but almost immediately the mist began to disperse, and the mirage faded away. What struck me as unusual was the extraordinary distinctness of the reflection. Yours, AN EARLY RISER. September 5, 1892."

In both cases the reflecting film seems to have been near its vanishing point. J. EDMUND CLARK.

Impure Water in Bread.

SOME accurate answers to the following questions would be desirable, in view of public health.

(1) What bacilli—if any—can survive in the amount and duration of the heat of baking in the interior of unfermented bread?

(2) What is the further effect of the carbonic acid of fermentation?

(3) What is the effect of the water being highly carbonated without fermentation, as in aerated bread?

W. M. F. P.

The Comets of Brorsen (1846 VII.) and Brooks (1892 "*d*").

THE elements of Brooks's comet "1892 *d*," as computed by Berberich from four observations made between August 31 and September 5, bear a strong resemblance to those of Brorsen's comet of 1846, calculated by Oudemans, the figures being—

		Comet Brorsen (1846 VII.)		Comet Brooks (1892 *d*)
T	...	1846 June 5·479	...	1892 Dec. 19·727
		° ′ ″		° ′ ″
ω	...	260 12 50	...	269 24 27
☊	...	261 53 12	...	261 2 55
i	...	29 18 47	...	27 57 8
Log q	...	9·80188	...	9·84455

Brorsen's comet of 1846 was visible to the naked eye on May 14 of that year. It was supposed to be revolving in an elliptical orbit, with a period of about 400 years. W. F. DENNING.

Bristol, September 22.

NOTE ON THE PROGRESS OF THE DIOPTRIC LENS AS USED IN LIGHTHOUSE ILLUMINATION.

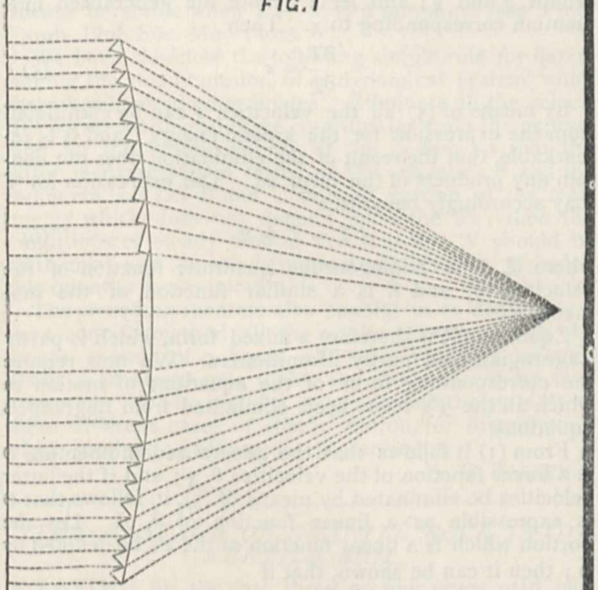
FRESNEL, in 1820, devised and constructed a lens for first order lights of 920 mm. radius. It was composed of a plano-convex lens, with five refracting prisms concentric with it, and four segments of rings in the corners all gradually decreasing in breadth as they receded from the centre. The separate pieces of which these lenses were made up were cemented together and mounted in metallic frames 30 inches square.

In 1835, the late Mr. Alan Stevenson introduced the French apparatus into Great Britain. In doing so he made several improvements, one of which was that he increased the height of the lens from 30 to 39 inches, at the same time diminishing the thickness of the glass. This refractor had eight prisms above and eight prisms below the central lens. From that time Alan Stevenson's lens was almost universally used until a comparatively recent date, when a revolution in the size of lenses took place.

A few years ago inventors were trying to obtain greater power by increasing the diameter and volume of the flames; but Messrs. Stevenson pointed out, in 1869, that after a certain point an increase of diameter of the luminary not accompanied by a corresponding increase of the radius of the apparatus was a mistake, as the light became ex-focal and divergent, and that the proper way to secure greater power was to enlarge the *diameter* of the apparatus. In 1885 they had a lens made to their design of 1330 mm. radius, and having a height of 5 feet. This lens, which was named "Hyper-radiant," was tried at the South Foreland against other lenses, and with a large 10-ring gas burner it was found to give a light from one and a half to twice as intense as the ordinary lenses which were pitted against it, with the same large burners in their foci, thus proving conclusively that to get the power out of large burners it was imperatively necessary to increase the diameter of the apparatus. In 1883 Messrs. Stevenson got an offer from Messrs. Barbier for a lens of 1840 mm. focal distance.

All refracting lenses from the day of Alan Stevenson were cylindrical for fixed lights and plano-convex for revolving lights, and no alteration of any moment has been made in the mode of their construction until 1888, when, instead of making the lenses cylindrical or plano-convex, I proposed to give them a spherical form, that is to say, circular not only in the horizontal but also in the vertical section. This design was carried into practice in the apparatus for one of the Fair Isle Lighthouses. The introduction of the spherical refractor has made practicable the construction of very much larger and consequently more powerful apparatus, and occupying much less space both in the daylight size and diameter of lantern, and, hence, diameter of tower. It has rendered practicable the quadrilateral arrangement with hyper-radiant lenses which have already been erected at Fair Isle, the lenses being cut so as to give two flashes from each side of the quadrilateral. An experimental lens made for Mr. Wigham is to be tried in Ireland. It is 2m. focal distance, and the spherical refractor is 7 feet 6 inches diameter, and will give one flash from each side of the quadrilateral. M. Barbier says that in making this lens he was attempting to give the most powerful flash possible, and he adopted the spherical refractor. In this case, however, the spherical refractor has been carried, in my opinion, rather far, except in the view of economy in keeping the angles of the whole apparatus within reasonable limits, which is only possible (in an apparatus of 4m. diameter) by the use of the spherical refractor, and by its being made to subtend a great angle. When I proposed this form I pointed out that there was a loss of efficiency if it subtended more than 40°; now M. Barbier has made the spherical portion subtend 64°, or 24° farther, and 8° farther than any spherical refractor yet made. The great amount of light which I experimentally found re-

FIG. 1

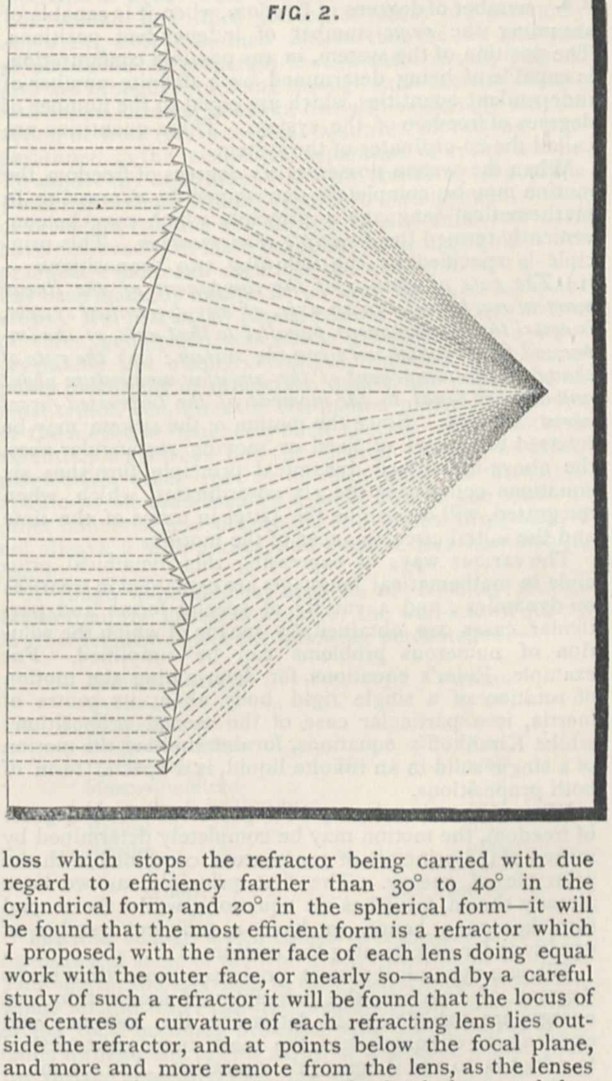


turned from the inner face of the spherical refractor made for Fair Isle, however, shows that up to 20°, and perhaps farther, it is ample to make up for any loss of light caused by the greater divergence which takes place *in* the spherical refractor, and which would be a *small* source of loss in a revolving light, but would better illuminate the nearer sea in a fixed arc.

Equiangular Refractor.

To obviate the loss of light at the outer face of the lenses, especially those remote from the focal plane—a

FIG. 2.



loss which stops the refractor being carried with due regard to efficiency farther than 30° to 40° in the cylindrical form, and 20° in the spherical form—it will be found that the most efficient form is a refractor which I proposed, with the inner face of each lens doing equal work with the outer face, or nearly so—and by a careful study of such a refractor it will be found that the locus of the centres of curvature of each refracting lens lies outside the refractor, and at points below the focal plane, and more and more remote from the lens, as the lenses are more and more remote from the focal plane, and that the inner face of the refractor ought, in fact, to be a parabolic curve (Fig. 1). This can very closely be approximated to by a circular curve with a suitably chosen centre on the focal line produced, but the centre is so far distant that when the spherical form and the equiangular form are used in combination (Fig. 2), the inner face of the equiangular prisms above and below it may, with sufficient accuracy, be made straight and leaning outwards in place of being vertical as in Fresnel's form. By the combination of the spherical refractor and the equiangular, or a refractor of the equiangular form alone, the defect in Fresnel's refractor, namely the loss of light at emergence from the lenses, especially those remote from the focal plane, is avoided, and the refractor may thus be made to subtend an angle which has hitherto been considered inexpedient, with glass of the ordinary refractive index of 1·53. The equiangular prisms cause less loss of light by absorption and reflection than either the spherical or Fresnel refractors, and also act on the light so that ex-focal light is better dealt with, thereby reducing the divergence.

CHARLES A. STEVENSON.

MODERN DYNAMICAL METHODS.

A DYNAMICAL system is said to possess a *given* number of degrees of freedom, when it is capable of assuming the *same* number of independent positions. The position of the system, in any possible configuration, is capable of being determined by a definite number of independent quantities, which are equal to the number of degrees of freedom of the system. These quantities are called the co-ordinates of the system.

When the system possesses *six* degrees of freedom, the motion may be completely determined by expressing in mathematical language a principle which may be conveniently termed the *principle of momentum.* This principle is specified by the following two propositions:—(i.) *The rate of change of the component of the linear momentum, parallel to an axis, of any dynamical system, is equal to the component, parallel to that axis, of the impressed forces which act upon the system;* (ii.) *the rate of change of the component of the angular momentum about any axis, is equal to the moment of the impressed forces about that axis.* Since the motion of the system may be referred to any set of fixed or moving rectangular axes, the above-mentioned dynamical principle furnishes six equations connecting the six co-ordinates, which, when integrated, will determine the latter in terms of the time and the initial circumstances of the motion.

The various ways of expressing this dynamical principle in mathematical language are explained in treatises on dynamics: and a variety of special forms and particular cases are obtained, by means of which the solution of numerous problems can be simplified. For example, Euler's equations, for determining the motion of rotation of a single rigid body about its centre of inertia, is a particular case of the second proposition; whilst Kirchhoff's equations, for determining the motion of a single solid in an infinite liquid, is a special form of both propositions.

When a conservative system possesses seven degrees of freedom, the motion may be completely determined by means of the principle of momentum combined with the principle of energy. The first principle, as we have already shown, furnishes six equations, whilst the second furnishes one; hence, we have a sufficient number of equations for determining the motion.

When a dynamical system possesses more than seven degrees of freedom, the principles of momentum and energy are insufficient to determine the motion; and under these circumstances, the most convenient method to adopt is to use Lagrange's equations; but inasmuch as these equations are double-edged tools, which are apt to cut the fingers of the unwary, their employment requires considerable care.

The kinetic energy of a dynamical system can be expressed in a variety of different forms, but it will only be necessary to mention the following three. In the first form, it is expressed as a homogeneous quadratic function of velocities, which are the time-variations of the co-ordinates of the system. This form, which will be denoted by T, is called the *Lagrangian form;* it is the only one which it is permissible to use when employing Lagrange's equations, and many mistakes have been made by persons who have attempted to use some other form.

In the second form, which is called the *Hamiltonian form,* the kinetic energy is expressed as a homogeneous quadratic function of the momenta of the system. If θ be any co-ordinate, and Θ the generalized momentum of type θ, it is known that

$$\frac{\partial T}{\partial \dot{\theta}} = \Theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

whence Θ is a linear function of the velocities. Hence, if the velocities be eliminated from the Lagrangian expression for the kinetic energy by means of (1), it follows that the latter will be expressible as a homogeneous quadratic function of the momenta Θ, which is the Hamiltonian form. We shall denote this form by $\mathfrak{T}$.

Lagrange's equations are

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{\theta}}\right) - \frac{\partial T}{\partial \theta} = -\frac{\partial V}{\partial \theta} \quad . \quad . \quad . \quad (2)$$

where V is the potential energy; and if the elimination be performed, we shall obtain

$$\frac{d\Theta}{dt} + \frac{\partial \mathfrak{T}}{\partial \theta} = -\frac{\partial V}{\partial \theta} \quad . \quad . \quad . \quad . \quad (3)$$

we have also the reciprocal relation

$$\frac{\partial \mathfrak{T}}{\partial \Theta} = \dot{\theta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Equations (3) and (4) are Hamilton's equations of motion.

The third form of the expression for the kinetic energy is of special importance in hydrodynamics and other branches of physics. It sometimes happens that a quantity occurs which can be recognized as a momentum, or as a quantity in the nature of a momentum, whilst the velocity corresponding to this momentum is either unknown or would be inconvenient to introduce. This occurs in problems relating to the motion of perforated solids in a liquid, when there is circulation, and is a particular case of Dr. Routh's theory of the "Ignoration of Velocities."[1] We therefore require a form of Lagrange's equations in which certain velocities are eliminated, and are replaced by the corresponding momenta.

Let the co-ordinates of the system be divided into two groups, θ and χ; and let κ denote the generalized momentum corresponding to χ. Then

$$\frac{\partial T}{\partial \dot{\chi}} = \kappa \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

By means of (5) all the velocities $\dot{\chi}$ can be eliminated from the expression for the kinetic energy; and it is remarkable, that the result of the elimination does not contain any products of the form $\kappa\dot{\theta}$. The expression for T may accordingly be written

$$T = \mathfrak{T} + \mathfrak{K} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where $\mathfrak{T}$ is a homogeneous quadratic function of the velocities $\dot{\theta}$, and $\mathfrak{K}$ is a similar function of the momenta κ.

Equation (6) is therefore a mixed form, which is partly Lagrangian and partly Hamiltonian. We now require the corresponding form of the equations of motion in which all the $\dot{\chi}$'s have been eliminated from Lagrange's equations.

From (1) it follows that the generalized momentum Θ is a linear function of the velocities $\dot{\theta}$, $\dot{\chi}$; and if the latter velocities be eliminated by means of (5), it follows that Θ is expressible as a linear function of $\dot{\theta}$, κ. Let the portion which is a linear function of the κ's be denoted by $\overline{\Theta}$; then it can be shown, that if

$$L = \mathfrak{T} + \Sigma(\overline{\Theta}\dot{\theta}) - \mathfrak{K} - V \quad . \quad . \quad . \quad . \quad (7)$$

the equation of type θ is

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{\theta}} - \frac{\partial L}{\partial \theta} = 0 \quad . \quad . \quad . \quad . \quad . \quad (8)$$

[1] Having regard to the object of the theory, I think the phrase "Ignoration of Velocities" is better than "Ignoration of Co-ordinates."

whilst that of type χ is

$$\frac{d\kappa}{dt} - \frac{\partial L}{\partial \chi} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

We have also the additional equations

$$\Theta = \frac{\partial \mathfrak{T}}{\partial \dot{\theta}} + \bar{\Theta} \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\dot{\chi} = \frac{\partial \mathfrak{K}}{\partial \kappa} - \Sigma\left(\dot{\theta} \frac{\partial \bar{\Theta}}{\partial \kappa} \right) \quad . \quad . \quad . \quad . \quad (11)$$

Equations (7) to (11) were first given by myself in a paper published in the Proc. Camb. Phil. Soc. for 1887; and it will be observed that they include the equations of Lagrange and Hamilton. A form of the modified Lagrangian function, which is equivalent to (7), was given by Dr. Routh a few years previously; but it is not of much practical use, owing to the fact that the elimination of the velocities $\dot{\chi}$ has not been performed.

It sometimes happens that the *co-ordinates* of the type χ do not enter into the expression for the energy of the system, in which case they are called *ignored co-ordinates*;[1] under these circumstances it follows from (9), that all the momenta κ are absolute currents. A top spinning about its point under the action of gravity is one of the most familiar examples of ignored co-ordinates, and one which illustrates several important dynamical theorems.

When there are ignored co-ordinates, the steady motion of the system, and the stability of the steady motion, can very easily be investigated. For if we suppose that all the co-ordinates θ have constant values, (8) reduces to

$$\frac{\partial \mathfrak{K}}{\partial \theta} + \frac{\partial V}{\partial \theta} = 0.$$

There are as many equations of this type as there are co-ordinates θ, and an examination of this system of equations will show whether steady motion is possible, and if so, will determine the necessary conditions which the co-ordinates θ and the constant momenta κ must satisfy.

It can also be shown that the steady motion will always be stable when $\mathfrak{K} + V$ is a minimum (see Proc. Camb. Phil. Soc. May 1892).

We have therefore the following simple rule for determining the steady motion of a dynamical system when there are ignored co-ordinates. Eliminate all the velocities corresponding to these co-ordinates from the expression for the kinetic energy of the system, so that the latter is expressed in terms of the velocities $\dot{\theta}$ and the momenta κ. Let $\mathfrak{K}$ and V be that portion of the *total* energy which does not depend upon the $\dot{\theta}$'s; then the conditions of steady motion are, that $\mathfrak{K} + V$ should be stationary, and the steady motion will be stable provided this quantity is a minimum.

The preceding theorem also enables us to deduce by a very concise method all the results connected with the steady motion of a liquid ellipsoid, which is rotating about a principal axis under the influence of its own attraction. It also enables us to examine the stability of these different cases of steady motion, for disturbances which produce an ellipsoidal displacement.

A. B. BASSET.

[1] I must confess that I do not like the phrase *speed co-ordinates*, introduced by Prof. J. J. Thomson, for it conveys absolutely no meaning to my mind. I have no sympathy with the attempts, which have occasionally been made, to introduce short words of Teutonic origin into scientific nomenclature, as the words in question appear to me to be singularly deficient in point.

THE PASSAGE OF GRANITE ROCK INTO FERTILE SOIL.

HAVING for the last three or four years paid particular attention to the natural formation of soil, I venture to believe that a concise account, or rather summing up, of the results of my researches, and of the mass of my observations—in one typical direction—may be of interest to the readers of NATURE. As indicated in the heading, the making of soil from granite is the only section of a very large subject which will be briefly considered in this paper.

The agents concerned with the turning of granite (or any other rock) into a fertile soil may be shortly classified as mechanical, chemical, and vital. The first-named produce the largest results in bulk, and the principal mechanical agent with which we have to deal is frost. The second and third classes of forces are extremely important, as it is by their actions that the raw material of plant-food is prepared, though unfortunately poisons also are brought into being through their activity. These last-named classes, however, likewise materially aid the action of frost (or, in tropical countries, of varying temperatures) in the mechanical separation of rocky matter. To render my descriptions as little confusing as possible I will endeavour, without regard to classification, order, or divisions, to trace the history of a granite soil as I have observed it in many localities in Scotland, from the practically unbroken rock into the condition in which it has been made by nature fit to bear the most luxuriant crops. But first of all I must remind my readers of two or three geological facts about granite. It is a holocrystalline (*i.e.* wholly crystalline) igneous rock, composed essentially of orthoclase, quartz, and mica. In its most typical condition the last-named mineral is always of the biotite or magnesia-mica species. Besides these essentials we always find (in Scotch granites at least) plagioclase, other species of mica than the essential, apatite as an endomorph, *i.e.* locked up in the mass of other minerals, and magnetite, and almost invariably, if not always, a little pyrites, and more or less hornblende, &c.

A rough mineralogical analysis of Kemnay granite taken from the lowest working of the well-known quarry in Aberdeenshire gave the following percentages:—

Orthoclase-felspar	42·00
Quartz...	22·00
Biotite-mica...	20·00
Plagioclase-felspar	9·00
Hornblende	3·25
Muscovite-mica	2·00
Magnetite (and Ilmenite)	1·00
Pyrites	0·50
Apatite	0·25
Total...	100·00

The first change which comes over granite is the peroxidation of some of the iron always present in its mass. This sets in, and increases to the greatest extent, of course, where air and water can most readily enter. The surface of the rock becomes browned with the hydrated ferric oxide formed, and brown skins, of a deeper colour than the surface generally, coat the walls of the original rock joints. But in the mass of the rock, away from these primary fissures, there are areas which are more permeable than others from the surface, and through these, streaks of ferric oxide—anhydrous first, afterwards hydrated—are produced. Those lines of rust are the beginnings of a new set of joints, which have not yet been properly recognized in geological literature, and which I will here call weather joints to distinguish them from the primary joints of consolidation and rock movements. The first oxidation streaks of the coming weather fissures are invisible to the eye, but can be determined under the microscope. They gradually increase in width above as they extend their lines beneath, and they afford passages through which water can more readily percolate than in the surrounding fresher areas, and as a consequence planes along which frost can more powerfully act. By the constant multiplying of the weather joints, which are first marked out by oxidation as already indicated, and afterwards made definite and widened from the most exposed rock surface inwards by frost, one of the first steps in soil formation is accomplished. As those fissures are increased the uppermost portion of the rock is separated by them into distinct pieces, which latter are again in their turn broken up by the formation of weather joints in the same way as the original. The great bulk of a soil has been produced in this way.

While the oxidation of the iron, as I have observed, is very likely the first change to set in in every case, it is never left for any lengthened period to promote, by itself alone, the decomposition of the rock. Very soon the work of carbonation is seen to be progressing alongside of it, though at a considerably slower rate. The carbonic acid gas of moist air, dissolved in the penetrating water, attacks the felspars, the biotite, and the hornblende. The way in which it brings about the decomposition of these minerals is interesting. Certain molecules succumb much more easily to the action of the carbonic acid than others, and the result is that scattered points of weakness from the thorough decomposition of these are brought into being in different parts of the mineral, and those decomposed portions warp round about the other and fresher molecules, as shown in the annexed diagram, which has been constructed from what I have observed in decomposed felspars.

The clay of decomposed felspar has great plastic and warping power. I have observed only 15 per cent. of pure clay in a mass hold the 85 per cent. of other and different constituents together in a plastic union as if the whole had been pure clay. There are two or three other hitherto unknown facts connected with the natural decay of felspars which I have ascertained from my researches.

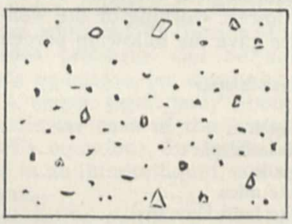


Diagram of kaolinized felspar × 260. The whole ground-mass is kaolin or pure clay; the bodies scattered through this are parts of the original felspar not yet decomposed.

I have noted two processes of decomposition—that which occurs when the carbonic acid is in excess or can obtain free access to the mineral, and that which takes place when either of the opposite conditions prevails. In the first case the felspar—supposing it to be *orthoclase*—has the molecules of its body which are affected completely broken up into clay, solid secondary or colloid silica, and carbonate of potash. In the second case, where for some reason a sufficient supply of carbonic acid cannot get within "chemical" distance of the felspar molecules, clay is produced as before—only more slowly—but the potash of the molecule is carried off in two sections, part as a carbonate, and part as a soluble silicate.[1] From the *plagioclase*-felspar the same conditions produce similar results, except that the soluble silica which would be produced here is of course in combination with sodium. I have found the soluble silica of soils *always* in the form either of silicate of potassium or sodium, and very frequently both of these occur mixed together.

Biotite, by the continued action of carbonic acid, oxygen, and water, loses magnesia (taken out as carbonate) and iron (removed either as oxide or carbonate) and becomes eventually the white or yellow muscovite variety which undergoes no further chemical change. In biotite, however, the chemical change usually takes place much more uniformly through the mineral body than ever happens in the case of the felspars.

Hornblende by carbonation, oxidation, and hydration yields lime as carbonate until the whole of that base is taken out, a trace of magnesia as carbonate (the bulk of this base is almost invariably left in the insoluble residue), the chief portion perhaps of its iron as oxide and carbonate, manganese as hydrated oxide, and any trace of sodium and potassium which it may contain as carbonates, or partially when conditions are less favourable as soluble silicates. The residue left after the hornblende has lost the above can generally be determined as some variety of chlorite (hydrated silicate of magnesia, iron, and alumina), which in the course of time by further loss of iron becomes an impure serpentine, and this later on a steatite or magnesia-clay, to which the greasy feel of soils is due.

The *pyrites* of the granite rock is slow to change, but it also is eventually acted on, by water and oxygen particularly, the latter combining with its substance here and there to form a sulphate, which has a great mission in the physiology of the soil.

I have said that the *apatite* occurs as an endomorph. It is set free to dissolve slowly without change in ordinary carbonated water when the minerals which hold its microscopic needles in their substance are broken up, mechanically or chemically. The *magnetite* and *ilmenite* grains of the granite rock are only altered with provoking slowness. Their function, however, in the work of the soil is, as far as I can see yet, of no importance. Traces at least of another mineral occur very frequently in granites. This is tourmaline, the history of which in soils I have been investigating for the last half-a-dozen years with some success.

The chemical changes which I have been mentioning begin first on the exposed surfaces of the rock and along the faces of the primary joints. Then oxidation occurs in streaks and bands through the rock mass, and around those areas carbonation is most active. In fact oxidation opens up the rock for further change, chemical as well as mechanical.

Frost is the principal agent of disintegration or mechanical breaking up in this country, but a relatively minute portion of the work is accomplished by heat and cold, the friction of percolating water, changes in the degree of humidity of the atmosphere, the pressure exerted by roots, and so on.

No sooner does a fraction of the surface percentage of the exposed rock portion undergo chemical change than a new element in the making of soil comes into play—that, namely, of organic matter, first living, and then dead and living. We will deal first with the living matter. On the partially decomposed surface of rock, fungal and algal spores (the latter of a lowly type) settle and live and grow in symbiotic union as lichens. There are many different kinds of rock-lichens, but the vegetative physiology of all is identical. The surface of the growth which lies next the stone is engaged in parts, during moist weather at least, in the imbibition of water, with the exceedingly meagre amounts of mineral matters dissolved in it from the surface of the rock. Those absorbing areas of the under surface appear to be also superficial breathing organs, for they certainly excrete carbonic acid gas, which of course will join with the atmospheric carbonic acid in helping the work of decomposition of mineral bodies. And it appears to me—though here I am not certain—that these absorbing areas are less generally found over the quartz of the granite, which is not capable of chemical change, than over the decomposable minerals. The lower absorbing areas of the lichens are in their functional relations common to internal fungal and algal

[1] See also in this connection my article on "The Action of Lime on Clay Soils," NATURE, Jan. 29, 1890.

members, and the upper surface of the colony is also a common absorbing (and transpiring) tissue, though here it is only the atmosphere gases which are taken in to the interior. There is not the slightest doubt but that the fungal members utilize the nitrogen of the air; there is none in the rock for them to receive; and that the algal members absorb carbonic acid gas from the air taken in, and combine it with the elements of water to make carbonaceous food, for that again is not presented to them from the rock; the lichen growth cannot any more than is the case with higher plants utilize the carbon of the mineral carbonates in the manufacture of carbohydrate or hydrocarbon food.

In reproduction, separate spores of algæ and fungi are produced from the lichen, and some of these may germinate above the parent community and unite to form a fresh colony upon the old, or a new colony may be produced from foreign spores. In any case we find generation after generation of lichens forming on the same favourable spot; but succeeding generations are partially parasitic and saprophytic in nature, as is shown by the manner in which their lower absorbing surfaces or prolongations act on the lichen growths beneath them. By and by, when perhaps a score of lichen colonies have formed one above the other—the newer slowly extinguishing the life of the older—a vegetable considerably higher in the scale of being comes forward and caps the last lichen. This is some variety of moss. Spores of mosses, carried to the stone surface, germinate there in moisture, and if upon lichens, the moss plantlet develops into the adult. Its rhizoids pierce their way through the substance of the lichens, and many get down to the decomposing stone surface, while some never leave the lichen bodies. The action of the moss rhizoids on living and dead lichens, also, I think, shows that that plant can be a parasite and a saprophyte as well as a normal vegetable feeder; and in this respect, except in its not utilizing the nitrogen of the air, resembles the later lichen growths.

In this way, by the succession of lichens and mosses (and afterwards higher plants), the essential organic element of soils becomes early incorporated with the mechanically and chemically disorganizing rock.

The dead organic matter changes in different ways: first, very slowly and very indifferently, by the action of air and water; and second, rapidly, by the spreading through its mass, where air has free access, of bacteria and other lowly fungi which are saprophytic, but can also assimilate nitrogen from the atmosphere, as is shown by their increasing, and not simply maintaining the original amounts of nitrogen left by their predecessors. By the first method of change the organic matter becomes the tougher former of humus, and humic and other related acids arise from it; by the second the mild, dry, or friable humus is produced and little or no humic acid. A very careful investigation shows that those bacteria which have the power of removing from the dead organic matter the elements of their nutrition give out by the decay (which occurs rapidly) of their bodies when they die the nitrogen and other elements in an active state. The nitrogen of the dead bacteria forms readily nitrate of lime or potash by contact with these bases.

Now to give a short summary here. Oxidation of iron is the first change perceivable in granite; then creation and multiplication of weather joints, and carbonation follows; next humus is formed by lichens, and then higher plants; following this, fungoid germs, capable of assimilating aerial nitrogen, become abundant; finally all the three processes, mechanical, chemical, and organic, go merrily on together and contribute all in their proper shares to the formation of an ever-deepening soil, capable of supporting the luxuriant life of the highest plants. The humic acid which is formed by the inorganic decay of humus has a certain decomposing action, but it gradually changes to carbonic acid, with the action of which, in this connection, we have already dealt. Well, to apportion the shares of the work done further. By disintegration, or mechanical action, the great rough mass of the soil is produced. By oxidation and carbonation, soluble minerals capable of entering the plant are prepared, and insoluble matters like secondary silica, pure clay, and steatite, are brought into being. By the action of living matter, rock decomposition is hastened, and nitrogenous substance is brought into the soil. By the presence and action of dead organic matter, rock decomposition is also forwarded, and a field for aerial nitrogen-assimilating germs is prepared. The table below gives a list of the materials found in the youngest granite soil on which nothing higher than rock-mosses are growing.

Granite minerals in fairly fresh condition	About 80 per cent.
Clay and insoluble secondary silica ...	About 3 per cent.
Soluble silica	Not determinable.
Carbonates of potash, soda, lime, magnesia, iron, and phosphate of lime	About 2 per cent.
Sulphates of above, except iron	Not determinable.
Sulphate of iron	Merest trace.
Peroxides of iron and manganese ...	About 3 per cent.
Humus	12 per cent.
Total	100 per cent.

Later on, as the soil deepens, we find some curious changes proceeding, which I will briefly indicate. Sulphates are now produced in considerable quantities. Wherever iron-containing minerals are brought into contact with organic matter, sulphate of iron tends to form as well as carbonate (humate ?), and possibly other compounds; and the pyrites which was slow to change at the beginning now produces sulphate of iron with greater rapidity. The dissolved sulphate of iron coming into contact with the carbonates of the alkalies and alkaline earths liberated from the felspars, hornblende, &c., as already explained, causes a double decomposition. The ferrous sulphate becomes a carbonate, and the carbonates of lime, potash, soda, &c., become sulphates. The iron carbonate, where exposed to air, readily oxidizes to ferric oxide, the chief colouring ingredient of the soil.

Now, in the finished soil, which, it must be remembered, is when produced from granite a loam, we have the following approximate composition, as fairly typical of a good granite soil such as may be found in the valley of the Don in Aberdeenshire:—

			Per cent.
Insolubles	Pure clay and steatite	about	10
	Quartz and secondary silica ...	,,	20
	Muscovite	,,	4
Substances capable of transformation	Orthoclase...	,,	30
	Plagioclase	,,	4
	Biotite	,,	9
	Magnetite?	,,	0·5
	Hornblende	,,	2
	Hematite and limonite (ferric oxides) and manganic oxide	,,	9
	Pyrites	,,	0·5
	Humus and animal organic matter, fungi, &c....	,,	5
Injurious solubles	Humic acid	,,	0·5
	Soluble silicate	,,	0·3
	Ferrous sulphate[1]	,,	0·5
Non-injurious solubles	Phosphates of lime, magnesia, potash, soda, &c.	,,	0·3
	Sulphates of lime, potash, soda, magnesia, &c.	,,	0·8
	Nitrates of lime, potash, soda, magnesia, &c.	,,	0·3
	Carbonates of lime, potash, soda, magnesia, &c.	,,	0·1
	Chlorides of above	,,	Trace.
Water and air (mechanically held) in dry summer perhaps about		,,	3·2
	Total		100·0

[1] More than 0·1 per cent. is injurious.

In conclusion I have to point out, as shown by my investigations commenced four years ago, that farmyard manure laid on to the land is only rendered properly available to the crops by the action of bacteria as indicated above in connection with the natural humus. The inorganic forces have little action upon it, except in producing humic acid and other injurious matters.

The most of the soluble mineral substances in a mature soil, it may also be mentioned, are in the form of sulphate. They originate from the primary minerals as carbonate, but are soon altered, mainly by the ferrous sulphate. The sulphate unfortunately is not the most suitable form in which minerals can be presented to plants for absorption, for the simple reason that, being so stable in chemical union, it causes the loss of too much of the plant's energy in the interior of its body before it can be decomposed. It must be remembered that green plants decompose the compounds which enter their system before they utilize their elements or simpler forms in the elaboration of food. ALEXANDER JOHNSTONE.

Edinburgh, August 5.

THE IMPERIAL INSTITUTE AT ST. PETERSBURG.[1]

IN November, 1885, some months after the publication of Pasteur's discovery for the treatment of hydrophobia, an officer of the Russian Guards was bitten by a rabid dog. This officer having been sent to Paris to undergo the treatment, his Highness Prince Alexander Petrowitch d'Oldenburg established, at his own expense, a provincial laboratory at St. Petersburg, where Pasteur's treatment could be duly carried out. This establishment, however, soon proved to be too small for scientific investigations to be properly carried out therein, and it was decided to build a large laboratory in which researches might be made under the best possible conditions; accordingly the same enlightened nobleman bought a piece of ground of 37,464 square metres in extent, on which the present Institute is built.

The buildings comprise physiological, pathological, chemical, bacteriological, and epizootological sections, with their laboratories, under the direction of such men as Neucki, Winogradsky, and others. There is also a department where Pasteur's treatment is carried out, together with a small hospital for infectious cases. Each section is complete in itself, and all the arrangements are on the newest principles and on a very large scale. The expenses are defrayed partly by the Prince of Oldenburg and partly by public subscription, and the whole Institute compares favourably with any Institute in France or Germany.

The directors of the Institute publish every two or three months a volume embodying the scientific results obtained in the laboratories, and the first two numbers have now been published. As might be expected after what has just been said, their contents are of wide and varied interest. Neucki publishes some chemical researches on the microbe producing inflammation of the mammary glands of milch cows and goats, and his paper will specially interest those who in this country have followed the remarkable researches of Dr. E. Klein. Winogradsky gives an account of the various nitrifying organisms discovered by him in the soil of different countries. This author quotes the researches of Prof. and Mrs. Frankland, and of Prof. Warington, and though to some extent contradictory, Winogradsky's researches agree with those of the English observers in all essential particulars. This paper is certainly the most important which has as yet appeared on this vexed question. The results obtained by Pasteur's treatment in St. Petersburg form the subject of a paper by Kraïouchkine, and it may be mentioned that the treatment appears to have been as successful at St. Petersburg as in Paris.

[1] "Archives de Sciences Biologiques publiées par l'Institut Impérial de Médecine Expérimentale à St. Pétersbourg," Vol. 1, No. 1 et 2.

The other papers refer to the chemical and physiological effects of tuberculin (Bujwid, Helman), to the transformation of nutritive media by the bacillus of diphtheria, and to the chemical composition of this micro-organism (Dzierzgowski and Rekowski), while Blachstein endeavours to draw a distinction between the bacillus coli communis and the bacillus typhi abdominalis, based on the chemical decompositions produced by these organisms in the media in which they grow. Lastly, Mizerski and L. Neucki give a critical *résumé* of the methods used to estimate the quantity of hydrochloric acid contained in gastric juice.

The researches which form the subjects of these papers are varied enough, and whilst congratulating their authors we may express the hope that the Institute will have a long and prosperous career. Our good wishes must be tinged with regret for ourselves—regret that there should not be a similar Institute in England, and regret also that there should be in this country a class of people who will oppose the establishment of such an Institute until a Bishop or Royal Duke has died of rabies.

M. ARMAND RUFFER.

NOTES.

LAST week much anxiety was felt as to the health of Sir Richard Owen. On Monday his condition was better, and the improvement, was maintained on Tuesday.

THE herbarium of the British Museum has acquired, by presentation from the widow, the very valuable collection of Muscineæ, made by the late Mr. George Davies, of Brighton. It comprises upwards of 20,000 specimens of mosses, hepaticæ, and lichens, partly gathered by Mr. Davies in Great Britain and on the Continent, partly communicated to him from New Zealand, Samoa, India, the West Indies, and America.

PROF. HIERONYMUS has been appointed curator of the Royal Botanical Museum at Berlin.

THE Exhibition of the Photographic Society of Great Britain was opened on Monday at the Gallery of the Royal Society of Painters in Waterco lours. It will remain open till November 10.

WE regret to have to record the death of Mr. George Croom Robertson. He was fifty years of age, and only lately, in consequence of ill-health, resigned the professorship of Mind and Logic at University College, London, to which he was appointed in 1866. Prof. Robertson was well known as a brilliant teacher of the subjects to the study of which he devoted his life, and as the editor of *Mind*. He was associated with Prof. Bain in the editing of Grote's "Aristotle," and was the author of the volume on Hobbes in Blackwood's series of "Philosophical Classics." He also contributed to the latest edition of the "Encyclopædia Britannica."

DR. GEORGE DIXON LONGSTAFF died at Wandsworth on Friday last in his ninety-fourth year. When a young man he was assistant to Dr. Hope, Professor of Chemistry at the University of Edinburgh, and he is believed to have been the first teacher of practical chemistry to medical students in this country. He was one of the founders and a vice-president of the Chemical Society of London.

Students of folklore will be sorry to hear of the death of Reinhold Köhler, librarian at Weimar, where he was born in 1830. He died on August 15. Dr. Köhler was a man of great learning, well known as an authority on the subject in which he was chiefly interested.

THE American Academy of Arts and Sciences has published an excellent "Memorial" of Joseph Lovering, who was a Fellow of the Academy from 1839 to 1892, Corresponding Secretary from 1869 to 1873, Vice-President from 1873 to 1880, and President from 1880 to 1892. Mr. Lovering was born on December 25, 1813, and died on January 18, 1892. The "Memorial" consists chiefly of speeches delivered, and letters read, at a meeting held for the commemoration of his life and services, with a biographical sketch by Prof. J. P. Cooke, Secretary of the Council, and a list of Prof. Lovering's publications. At this meeting the chair was taken by Dr. A. P. Peabody, who said that there was a certain fitness in his leading the proceedings, as Mr. Lovering had been his pupil. Speaking of Prof. Lovering as a teacher of physical science, Prof. J. P. Cooke said: "He was one of the best lecturers I have ever known, and I have known the greatest masters of my time."

DURING the past week the weather has been of a decidedly cyclonic type; large disturbances have reached us with considerable frequency from the Atlantic, and have mostly passed to the northward of Scotland. The winds have been moderate to strong from the south-west, but have at times attained the force of a gale at places in the north and west, while on Tuesday they were boisterous in all parts of the United Kingdom. The rainfall has been somewhat heavy in the north and west, but light in the southern parts of the kingdom, where, during the first part of the period, the weather was generally fine, with occasional mist or fog in the mornings. The temperature has, on the whole, been mild, the day readings ranging from 60° to 65° over most parts, while in the extreme south they have exceeded 70° on several occasions. The *Weekly Weather Report* published on the 24th instant shows that some of the night minimum temperatures during that week were very low for the time of year, the shade thermometer falling to 25° in the east of Scotland, and to between 28° and 31° in most other parts.

AMONG the valuable discussions which appear in the *Repertorium für Meteorologie*, issued under the authority of the St. Petersburg Academy of Sciences, is one in vol. xiv., by B. von Nasackin, on the Storms of the Baltic, being in fact a continuation of similar works (by other authors) for the Black and White Seas. The data used in the discussion are taken chiefly from lightkeepers' journals and stations on the coast. The general results show that the yearly frequency of storms differs considerably in different years, and the number of storms at individual stations also varies considerably. In the western part of the Gulf of Finland and in the south of the Baltic storms are much more frequent than in the other parts. The mean wind-direction lies between south and west, and the principal storms occur from the same direction, and also between west and north. The maximum number occurs almost everywhere in December, and the minimum in August.

Das Wetter for August contains an article by Dr. R. Assmann on the treatment of persons apparently killed by lightning. The different effects on persons struck would prove that the intensity of the flash is subject to considerable fluctuations, and recent photographs of lightning, in fact, show that in addition to the principal flash there are always weaker ones branching out in all directions, like the roots of a tree. It may therefore well be assumed that the intensity of the latter is considerably less than that of the principal current. He quotes a case near Berlin in the summer of 1891 where a number of soldiers were struck by lightning; among them an officer, and a bugler holding his horse, were both struck. The officer shortly afterwards recovered, while the bugler was to all appearances dead, but the officer at once adopted the method of artificial respiration as applied to the apparently drowned, by which means the bugler was gradually brought back to life. Dr. Assmann states that there can be little doubt that if this method were applied soon after the stroke, and continued for at least a quarter of an hour, many of those apparently killed might be restored to life.

A VALUABLE paper by Prof. E. W. Hilgard, on the relations of soil to climate, has been published by the U.S. Department of Agriculture. Soils being the residual product of the action of meteorological agencies upon rocks, it is obvious, as Prof. Hilgard says, that there must exist a more or less intimate relation between the soils of a region and the climatic conditions that prevail, or have prevailed, therein. Prof. Hilgard discusses, both from a theoretical and from a practical point of view, some of the more important phenomena dependent on this correlation, and their effects on the agricultural peculiarities of the chief climatic subdivisions.

HERR K. FLEGEL gives, in the *Allgemeine Zeitung* for September 12, an interesting account of archæological discoveries he has made this summer in the island of Kalymnos, near the coast of Asia Minor. At a height of about 220 metres, not far from Emporió, he found the remains of an ancient fortress which seems to belong to the same class of buildings as those of Mycenæ and Tiryns. The remains, which are comparatively well preserved, include Cyclopean walls and a tower. A gateway (1½ metre in breadth), the forecourt, a cistern, and a stone oil-press survive. In the valley of Vathy, Herr Flegel came upon the remains of walls of an acropolis, which he describes as older than the fortress of Emporió.

IN the new instalment of the proceedings of the Liverpool Geological Society (Part 4, Vol. VI.), Mr. J. J. Fitzpatrick has some interesting notes on the Deep Dale Bone Cave near Buxton. In a paper read before the society in 1890, Mr. Fitzpatrick called attention to this cave, and described the various objects of interest which had been found in it up to that time. In his present paper he gives an account of the results of more recent researches carried on by Mr. W. Millet, of Buxton, by whom the cave was discovered. At the entrance is a refuse heap, three feet thick at the top, extending ten feet on either side of the entrance, and sixty feet down to the stream at the bottom of the dale. Among the objects found in this refuse heap are bones of the horse, stag, Celtic shorthorn (*Bos longifrons*), dog, pig, sheep, goat, wild boar, three flint flakes, a piece of bronze with Celtic pattern, fragments of pottery, including Samian ware, pseudo-Samian ware, Romano-British ware, coins of the Emperor Claudius, and female ornaments, including fibulæ, earrings, brooches, and rings. At the bottom of the heap were found two flint arrow-heads. In the second chamber of the cave a hole, eight feet deep, has been dug. The upper bed, three feet thick, is composed of dark clay, with angular fragments of limestone. The second bed, which is from six to sixteen inches thick, consists of broken fragments of stalagmite, limestone, and gravel. In this a human jawbone has been found. The third bed, the thickness of which has not been ascertained, consists of a stiff yellow clay, containing large pebbles, two of which have been artificially pointed at one end. The human jawbone has twelve teeth, with the enamel and dentine in an admirable state of preservation. There were originally fourteen teeth, the two "wisdom teeth" not having been developed at the time of the death of the person to whom the jawbone belonged. The mark of the weapon which gave what was perhaps the death wound is distinctly visible. The weapon penetrated deeply into the bone in a slanting direction, with an upward inclination, and the blow must have been struck from behind. Another object found in the second chamber is a small bronze box, filled with grey ashes, supposed to be the ashes of a cremated person. The lid is moulded with the raised zigzag pattern common in Roman ornamentation, the hollow parts being let in with red and green enamel. In the lower chambers, as stated in Mr. Fitzpatrick's former paper, the following mammalian remains have been found:—A skull of the brown bear (*Ursus arctos*), a skull of the Celtic shorthorn (*Bos longifrons*), teeth of the reindeer (*Cervus tarandus*), and of the red deer (*Cervus elaphus*), part of the skull of the wild boar (*Sus scrofa*), and some human bones.

The July number of the *Korean Repository* opens with an article by the Rev. Dr. Edkins on the Persians in the Far East. He shows from native sources that at a very early period the influence of Persian ideas penetrated into China. The wide acceptance of these ideas was due in part to the doctrine of a future life, but Dr. Edkins attributes even more importance to the worship of the god of fire as the special ruler of the hearth and the god to be worshipped by newly married people. This, he says, is so adapted to the natives of Eastern countries with their strong family instincts, that it has easily kept its place and still has a firm hold on the popular mind. In another article a writer who signs himself "Viator" indulges in much enthusiastic admiration of Korea and the Koreans. He is especially emphatic in his praises of the scenery around Seoul, with its "grand amphitheatre of granite hills." "The city wall," he says, "climbing over the most precipitous ridges, the sentinel peaks of Nam San, with its chevelure of fine trees, and the bold castellated rocks of Poukan, which on the south and north respectively keep guard over the capital, with many other points both within and without the walls commanding varied and extensive views, would alone in any tourist-frequented land make Seoul a show-place of the guide-books." The ordinary Korean he describes as "a docile and happy creature."

We learn from *La Nature* that MM. Olivet, of Geneva, have brought out a new system of electric heating applied to conservatories, which may prove very useful where a motor force is at one's disposal. A dynamo, worked by some motor, sends the current into receivers of special metallic composition, which become rapidly heated, but without exceeding a certain temperature. A heated air current is set up as with steam-heating. The advantages of the system are: Absence of all unwholesome gas or vapour which might injure the plants, simplicity of construction in the parts conveying the energy, perfect safety as regards heat, which can be regulated at will, convenience and rapidity in starting and extinction, and cleanliness.

Mr. A. C. Macdonald, of the Agricultural Department of Cape Colony, refers with much regret (in the official publication of the Department) to the senseless way in which the ant-bear is being exterminated. This animal, he says, is one of the few indigenous four-footed friends of the Cape farmer. "Its food is the ant, more especially the white ant, an insect which feeds on our crops and the succulent herbage of the veld, and which does much greater damage than is generally supposed. Although the ant has numerous enemies (among which is reckoned the koran, a bird which I am happy to say is now being preserved on some farms solely for this purpose), yet none are so destructive to its welfare as the ant-bear. It is only when on the surface of the ground that the ant runs any danger from its winged foes, but above or below ground it is always within reach of the ant-bear. But it is not only as a destroyer of ants that the ant-bear is of value to the farmer. A large percentage of the seeds of our herbage, after they have dropped off the plant on the hard ground, lose their germinating power from being exposed day after day to the scorching rays of the sun. The ant-bear, as it goes scratching about for ants, covers a large number of seeds with loose earth, in which congenial bed they will retain their reproductive power for a long period, awaiting the moisture from the skies to shoot out and propagate their kind. And yet this animal, harmless in other respects, is being slowly but surely exterminated. For its skin, which is valued at about 15s., and also for its flesh, which resembles superior pork, it is sought after by the natives. With the white race 'sport' is the inducement, this fun taking the form at times of forcing the poor brutes out of their holes by flooding with water, or drowning them and digging them out afterwards."

Prof. G. C. Caldwell, of Cornell University, has been making oleomargarin a subject of careful investigation, and presents the results of his researches in a valuable paper in the September number of the Journal of the Franklin Institute. He thinks that if made of unsuitable materials oleomargarin may contain germs of disease, and that the process of manufacture ought to be carefully inspected by capable officials; but there is no positive proof, he says, that it is now, or ever has been, made of such materials, or that any disease has ever been communicated to man by its use. He is also of opinion that, when properly made from fresh and clean materials, it differs but slightly in healthfulness from butter. He records, however, a rather significant incident which has recently come to his knowledge. At an asylum for blind children, in Louisville, Ky., where good butter had been supplied, good oleomargarin butter was substituted. No notice was given of the change, and even if the appearance of the substitute would have betrayed it, the blind children could not have seen it. There was no evidence that they were in any way conscious of the change; but it was observed that they gradually ate less and less of the new butter and finally they declined it altogether. No bad effect on their health could be discerned. They made no complaint in answer to the inquiry as to the reason for not eating the butter other than that they did not care for it. It was as if it did not adapt itself to any need of the system. "This," says Prof. Caldwell, "certainly must be allowed to count against the complete fitness of oleomargarin as a substitute for butter."

A Field Naturalists' Club was formed last year in Trinidad, and seems likely to do much useful work. It publishes a journal, and in the third number, which we have received, gives reports of its meetings from the beginning. In the meeting on January 8 Mr. Mole announced that he had found a *Peripatus Edwardsii* in the St. Ann's Valley; and Mr. Urich stated that he also had found a specimen of the same species at Azouca.

The report of the Government Central Museum, Madras, for 1891-92, has been published. In an interesting appendix Mr. H. Warth, the officiating superintendent, gives an account, among other subjects, of the tin district in Burma. The tin-bearing deposits are, he says, of two kinds. First, there is the tin gravel which is found in all or most of the valleys, a mixture of rough white quartz pebbles with sand, garnet, black tourmaline, and grey cassiterite. The thickness of the gravel varies from 1 to 6 feet, and the yield of cassiterite may be put down as at least ¼ per cent. or 1 pound of cassiterite (tin dioxide) in 400 pounds of gravel. There are washings going on at many places, but some valleys have been more or less exhausted. The work suffers also under the disadvantage that the greater part of the country is quite uninhabited, that food has to be brought from a distance, and that there is always danger of sickness. Chinamen are the chief workers. The second kind of tin-bearing deposit is the original eruptive rock, which is weathered so that it is possible to wash out the grains of whitish cassiterite which it contains. Mr. Warth visited the principal deposits of this kind near Malewun in July 1891. He took samples from several excavations and washed them. The mean is a yield of only 0·04 per cent. of impure wash tin.

Thus one pound of impure tin dioxide requires 2500 pounds of weathered rock. The rock is traversed by a series of parallel veins of white quartz indicating the origin of all the white quartz pebbles in the tin-bearing gravels, these gravels being nothing but the accumulation, during probably thousands of years, of the washings from the elevated outcrops of tin-bearing eruptive rock. The original tin-bearing deposit of weathered rock has been washed during a good many years. It requires a very good supply of water and very large deposits, otherwise the labour would be far too great and such works could not compete with those in the gravels. Among the rock specimens of the district are also grey limestones from Mount Tampra, three days' canoe journey from Lenya. This mountain Mr. Warth found fringed with caves which most likely owe their origin to the action of the sea. As they are now 160 feet above the sea, it appears that the land has been raised that much in comparatively recent time. If so, then the time during which most of the tin gravels formed was also comparatively limited.

THE third part of the tenth annual report of the Board of Fishery for Scotland has just been issued. It deals with the scientific investigations carried on during 1891. First there is a general statement of the results achieved; then comes a series of general reports; and these are followed by papers recording biological investigations. Finally, Dr. T. Wemyss Fulton gives an account of contemporary scientific fishery investigations in this and other countries. The following are the papers dealing with biological investigations: On the food of fishes, by W. R. Smith; observations on the reproduction, maturity, and sexual relations of the food fishes, by Dr. T. W. Fulton; additions to the fauna of the Firth of Forth, part iv., by Thomas Scott; contributions to the life-histories and development of the food and other fishes, by Prof. McIntosh, F.R.S.; on two large tumours in a haddock and a cod, by Prof. Prince and Dr. J. L. Steven. We may note that the volume is enriched with many admirable plates.

MESSRS. R. FRIEDLÄNDER AND SON, Berlin, have just issued the sixth annual report (for 1890) of the ornithological stations of observation in the kingdom of Saxony. The report has been prepared by A. B. Meyer and F. Helm, who have evidently spared no pains to make their work thorough and accurate. In an appendix observations relating to other animals in Saxony, besides birds, are recorded. There is also a list of the birds which up to the present time have been observed in that country, with notes as to their geographical distribution elsewhere.

THE Clarendon Press has reprinted Mr. J. G. Baker's "Summary of New Ferns discovered or described since 1874."

A WORK on "The Great Barrier Reef of Australia, its Products and Potentialities," by Mr. W. Saville-Kent, is to be issued by Messrs. W. H. Allen and Co. The barrier reef of Australia, represented by a vast rampart of coral origin, extends for no less than twelve hundred miles from Torres Straits to Lady Elliot Island on the Queensland coast. Between its outer border and the adjacent mainland it encloses a tranquil ocean highway for vessels of the heaviest draught. To the naturalist, and especially to the marine biologist, the entire barrier is described as "a perfect Eldorado, its prolific waters teeming with animal organisms of myriad forms and hues, representative of every marine zoological group." The author's object will be to render an account, in clear and popular language, both from a commercial and from a biological standpoint, of the most attractive subjects connected with the barrier region. There will be sixteen plates in chromo-lithograph, with grouped illustrations produced from original water-colour drawings by the author, and forty-eight plates in photomezzotype from original negatives.

THE New Zealand Institute has published its Transactions and Proceedings during 1891 (vol. xxiv., seventh of new series). The volume is edited by Sir James Hector, and contains many papers of considerable interest and value. The papers presented in the Transactions are grouped under the headings of Zoology, Geology, Botany, and Miscellaneous. The Proceedings include those of the Wellington Philosophical Society, the Auckland Institute, the Philosophical Institute of Canterbury, the Otago Institute, the Westland Institute, the Hawkes Bay Philosophical Institute, and the Nelson Philosophical Society.

THE *Journal of Botany* for September gives an account of the results of M. J. Bornmüller's botanical exploring expedition in Persia. The flora of the district visited is a very abundant one, but not many new forms were gathered. The mountain sides of Kuh Jupar, at a height of between 2900 and 3000 metres, were covered with dense forests of an undescribed species of *Ephedra*.

THE number of the *Oesterreichische Botanische Zeitschrift* for September is almost entirely devoted to the discussion of the question of botanical nomenclature, and the opinions on the various disputed points, of the leading English and Continental botanists.

MESSRS. CROSBY LOCKWOOD AND SON announce the following works:—"The Microscope: its Construction and Management," by Dr. Henri von Heurck, Director of the Antwerp Botanical Gardens, translated from the French by Mr. Wynne E. Baxter, F.R.M.S.; "Electric Ship-Lighting: a Practical Handbook for Electrical Engineers and others," by J. W. Urquhart; "Toothed Gearing: a Practical Handbook for Office and Workshop," by a Foreman Pattern Maker, author of "Pattern Making," &c.; "The Mechanics of Architecture: a Text-book for Students," by E. W. Tarn; "The Visible Universe: Chapters on the Origin and Construction of the Heavens," by J. E. Gore; "The Health Officers' Pocket Book: for Medical Officers of Health, Sanitary Inspectors, Members of Sanitary Authorities, &c.," by Edward F. Willoughby, M.D. (Lond.); "The Art and Science of Sail Making," by Samuel B. Sadler, practical sail maker; "The Complete Grazier and Farmers' and Cattle Breeders' Assistant: a Compendium of Husbandry, originally written by William Zouatt, thirteenth edition, entirely re-written, considerably enlarged, and brought up to the present requirements of Agricultural Practice," by William Fream, LL.D.; "Farm Live Stock of Great Britain," by Robert Wallace, professor of Agriculture and Rural Economy in the University of Edinburgh, third edition, thoroughly revised and considerably enlarged; "Tramways: their Construction and Working," by D. Kinnear Clark, M.Inst.C.E., new edition, thoroughly revised, in one volume; "The Wood-worker's Handy Book: a Practical Manual embracing information on the Tools, Materials, and Processes employed in Wood-working," by Paul N. Hasluck; "The Metal-worker's Handy Book: a Practical Manual embracing information on the Tools, Materials, and Processes employed in Metal-working," by Paul N. Hasluck; "Practical Lessons in Roof Carpentry," by Geo. Collings; "The Steam Engine: a Practical Manual for Draughtsmen, Designers, and Constructors, translated from the German of Herman Haeder, revised and adapted to English Practice," by H. H. P. Powles.

MESSRS. BELL AND SONS are about to publish the following books:—"The Student's Hand-book of Physical Geology," by A. J. Jukes-Brown, with numerous diagrams and illustrations, second edition, revised and much enlarged (Bohn's Scientific Library); "Sowerby's English Botany," Supplement by N. E. Brown, of the Royal Herbarium, Kew (to be completed in eight or nine parts); "Fungus Flora," a classified text-book of Mycology, by George Massee, author of "The Plant World," with numerous illustrations, 3 vols., vols. i. and ii.; "The Framework of Chemistry," Part 1, by W. M. Williams.

UNIVERSITY COLLEGE, Liverpool, has issued its prospectus of day classes in arts and science, and of the evening lectures, for the session 1892-93.

PART 48 of Cassell's *New Popular Educator*, with title-page and contents to vol. viii., has been issued. The next monthly part of the work will form the first part of a technical series of Cassell's *New Popular Educator*, published under the title of Cassell's *New Technical Educator*.

MESSRS. DULAU AND CO. have published a catalogue of works on electricity, galvanism, and magnetism—works which they offer for sale.

FOUR lectures on Cholera will be delivered by Dr. E. Symes Thompson in Gresham College on October 4, 5, 6, and 7, at six o'clock p.m. The lectures will be free to the public.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus* ♂) from India, presented by Mrs. Trafford Rawson; a Green Monkey (*Cercopithecus callitrichus* ♂) from West Africa, presented by Mr. A. de Turckheim; two Tigers (*Felis tigris* ♂ ♀) from India, presented by the Maha Rana of Oodeypore; a Grey Ichneumon (*Herpestes griseus*) from India, presented by Mr. Hugo Marshall; a Three-striped Paradoxure (*Paradoxurus trivirgatus*) from Java; presented by Mr. Douce; a Jackdaw (*Corvus monedula*), British, presented by Lt.-Col. R. F. Darvall, F.Z.S.; a Common Fox (*Canis vulpes*), British, presented by Mr. Lucius Fitzgerald; an Indian Cobra (*Naia tripudians*), an Indian Rat Snake (*Ptyas mucosa*) from India, presented by Mr. Arthur H. Cullingford, F.Z.S; a Common Boa (*Boa constrictor*) from St. Lucia, W.I., presented by H. E. Sir Walter F. Hely Hutchinson, K.C.M.G; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Miss Withers; two Tarantula Spiders (*Mygale*, sp. inc.) from Demerara, presented by Mr. H. Strong; a Black-headed Lemur (*Lemur brunneus* ♀) from Madagascar, a Duyker-Bok (*Cephalophus mergens* ♂) from South Africa, two Demoiselle Cranes (*Grus virgo*) from North Africa, four Emus (*Dromæus novæ-hollandiæ*) from Australia, deposited; an Indian Chevrotain (*Tragulus meminna*) from India, two Violet Tanagers (*Euphonia violacea*) from Brazil, a Shag (*Phalacrocorax gracilis*) British, purchased; three Wild Swine (*Sus scrofa*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE VARIATION OF LATITUDE AT PULKOVA.—*Astronomische Nachrichten*, No. 3112, contains two communications on the variation of the latitude at Pulkova, the first by Mr. B. Wanach, who discusses some old observations, and the second by Mr. S. Kostinsky, who has continued the former's recent observations made before July, 1891. During the years 1890 and 1891, Mr. Wanach obtained some very definite results with regard to this question by using the large Pulkova transit instrument in the Prime Vertical, and the object of the present discussion is to find out if any like result can be discovered. The observations used are those of W. Struve made between the years 1840-55, O. Struve 1858-9, Oom 1861-63, and Nyren 1879-82. If we employ those made in the years 1840-42 it is at once noticed that to satisfy the conditions a variation in the height of the pole of $\pm 0''\cdot 1$ has to be assumed, while the maxima and minima occur at different months of the year, the latter on September, 1840, May, 1841, March, 1842, and the former on January, 1841, September, 1841, and October, 1842. The observations from 1843-63 present no direct fluctuations in the value of the mean pole height, but show that it remains constant or is proportional to the time during the whole period. Taking the values of the mean pole height for the years 1879-82, as obtained from a similar curve, it is found that a single sinus curve is not sufficient for the comparison; secondly, that the mean pole height is not the same as it was in 1841 and 1891, but is about $0''\cdot 15$ greater; thirdly, that the chief maximum on March, 1881 coincides with the chief minimum on September, 1880, that is, exactly coincides with the phases of the pole height. It also happens that the series, which take more than two years, give only one distinct maximum and minimum (instead of two, as would be expected). Coming now to Mr. S. Kostinsky's work, whose observations were made by W. Struve's method with the aid of a large transit instrument by Repsold, the variation of latitude is clearly shown. With the aid of the curve, which accompanies the paper, the maximum of the latitude occurs on October 4, 1891. Owing to the observations not being quite complete, the epoch of minimum is uncertain, but the curve shows that it will take place somewhere before the end of the month of May 1892. Comparing this curve with that obtained by Mr. Wanach in the year 1891, we have for the dates of the greatest and least values of the latitude—

Max. in 1890, September 14.	$\phi = 59^\circ\ 46'$	$18''\cdot 39$
Min. ,, 1891, April 15		$17\cdot 79$
Max. ,, 1891, October 4		$18\cdot 44$
Min. ,, 1892, May 20–31 (about).		

DOUBLE STAR OBSERVATIONS.—The second part of Appendix I. to the *Washington Observations for* 1888 contains the observations of double stars made at the United States Naval Observatory during the period 1880–1891, by Prof. Asaph Hall. These observations have been made with the intention of carrying on the work that was begun with the same instrument in 1875. The stars here observed are mostly known binaries. Some are of special interest on account of their short periods, while again the motion of others will be found to be very slow. This volume will be welcomed by all double star observers, for in such a work as this a strict comparison of observations is needful in such measurements as are here dealt with. The form in which the observations are printed is the same as was the case in 1881. The star's name is first given, followed by its right ascension and declination, and its magnitude. In the first column the date of observation in years and decimals of a year is given, while in parallel columns the sidereal time of observation to the first decimal of an hour, position angle, distance, and weight of observation are similarly inserted; in two other columns the magnifying power employed and occasional notes are added for reference. The volume concludes with an index of all the stars observed. The numbers of the stars are for the most part those of the Struves; but Prof. Hall, in recording those faint stars in the Pleiades, has referred them to Bessel's list of fifty-three stars in this group. Bessel's stars themselves he has numbered in the order they appeared in the *Astronomische Untersuchungen*, first volume, p. 237.

SOLAR OBSERVATIONS AT ROME.—In the August number of the *Memorie della Società degli Spettroscopisti Italiani*, Prof. Tacchini contributes, in tabulated form, the results of the solar observations made at the Royal Observatory during the second three months of this year. Considering first the faculæ, they seemed most numerous on the southern hemisphere, there being an excess of 13. Latitudes 20° to 10° north, and 20° to 30° south, were the zones of greatest frequency, the number recorded being 49 and 50 respectively. Taking the whole numbers for both hemispheres the table shows a distinct increase, the numbers for the three months being 71, 75, and 97. With reference to the spots, the two hemispheres seem to have been evenly distributed, the numbers seen amounting to 48 and 46 respectively. The zones of greatest frequency were found to be $\pm 10^\circ \pm 20^\circ$, the number of spots recorded being 29 and 22; but in zone $-20^\circ - 30^\circ$ as many as 19 were noted, the number in the corresponding zone of the northern hemisphere amounting only to eight. The record of eruptions for this period is not very high, six only being seen in the northern and three in the southern hemisphere; the zone of maximum frequency for the northern hemisphere is $+10^\circ + 20^\circ$, the same as that for spots, the six observations occurring in this zone alone; for the southern hemisphere the three eruptions were observed in each of the 10° zones included between -10° and -40°.

GEOGRAPHICAL NOTES.

As the result of recent explorations by Lieutenant Fromm in the southern part of German East Africa, it appears probable that the difficulties which beset navigation on the Rufiji and Rovuma rivers are not so serious as has hitherto been supposed. The resources of the country traversed by these rivers are reported to consist mainly of india-rubber in the forests. An examination of a coalfield reported by Arabs as existing on a tributary of the Rovuma showed that the valuable coal-seams were practically confined to the Portuguese side of the frontier.

IN a recent number of *Petermann's Mitteilungen*, Dr. Karl Grissinger publishes an interesting investigation of the physical conditions of the Weissensee in Carinthia. The paper is accompanied by a bathymetric chart, which shows that the lake belongs to the same class as the long, narrow, deep lakes of Scotland, and by a remarkable diagram of temperature changes. The latter is constructed so as to show the diurnal change of temperature at all depths from hour to hour for four consecutive days, and is in a high degree interesting and instructive. Diurnal change of temperature becomes imperceptible at a depth of 37 metres, and the hour of maximum temperature is retarded as the depth increases. Thus the surface maximum occurs about noon, while that at a depth of 25 metres is not attained until 8 a.m. of the following day.

A RECENT official estimate of the coast line of the United States, including islands, indentations, and estuaries, gave as the total 90,900 miles. Of this the Atlantic Ocean accounted for 36,500 miles, the Gulf of Mexico for 19,100, the Pacific Ocean for 8900, and Alaska for 26,400. Considering only the general coast lines, neglecting estuaries, bays, and islands, the Atlantic margin measured 2000 miles, the Gulf of Mexico and Pacific Ocean 1800 each, and Alaska 4800, a total of 10,400 miles.

M. J. GAULTIER has elaborated a system of photographic surveying, which is attracting considerable attention in France in view of the approaching revision of the cadastral survey of that country. By means of a specially mounted camera, a series of twelve views are taken from one point, so as to comprise the entire horizon. A set of signals, the position of which is carefully arranged, enable the various plates to be afterwards fitted together. The map is subsequently traced out on waxed linen by a sharp point, a faintly printed copy of the photograph serving as a basis.

THE uncertainty of communication with the Upper Nile valley makes it difficult to determine the precise weight to give to reports of events happening there. But it appears highly probable that an expedition from the Congo Free State has at last succeeded in establishing a station at Wadelai, or some other point within the British sphere of influence. The natural outlet of the region is of course down the Nile, and it is scarcely in accordance with the principles of geography that a prosperous development can ensue with so difficult an outlet as that to the Congo. The practical aspects of the case are in their present stage more political than physical, and in this stage they are likely to remain for some time.

ON Tuesday the *Times* printed the following telegram, dated September 26, from its Calcutta correspondent :—Mr. Conway's mountaineering party, which left Askoley on July 31, reached the foot of the Baltoro Glacier after four days' march, and proceeded up the glacier for four days. They then climbed a peak north of it 20,000 feet high, which they named Crystal Peak, and hoped to get a view of the great peak "K^2," but it was hidden by a neighbouring peak. They then went another day's march up the glacier and climbed a pass to the east of Crystal Peak 18,000 feet high. From this they saw "K^2," but discovered that the map was altogether wrong in the representation of the neighbourhood of that peak. They also found the Baltoro Glacier considerably longer than the map makes it. A high peak not marked on the map stands at the very head of the glacier. This Mr. Conway named the Golden Throne. They determined to try the ascent, and went one march further up the glacier and then were stopped by a snowstorm, during which they sent the coolies down to collect firewood. They reached the foot of the Golden Throne on August 18, and then worked up behind the peak, climbing over 2000 feet through a very broken icefall. It took four days to establish and victual a camp above the ice-fall, at a height of 18,000 feet. They moved next day to a camp 19,000 feet, and the day following to one about 20,000 feet high. Thence, on the 25th, they started for a real climb, and having reached a point over 23,000 feet high, they found they were on a mountain entirely cut off from the Golden Throne, which was still 2000 feet above them. The peak they ascended—which they named the Pioneer Peak—commanded a magnificent view, especially in the Hunza direction, where they could see to the distance of at least 200 miles. They suffered from the great altitude, but not severely, and they could have climbed at least a thousand feet higher, and perhaps more. They slept that night in their camp 20,000 feet above sea-level. They were obliged to descend next day as their provisions were exhausted. Bad weather commenced on the 27th, and continued, putting an end to climbing for the present season. Mr. Conway has gone to Leh, for the purpose of comparing his barometer with the standard there, and accurately reckoning the height of the Pioneer Peak. He expects that the comparison will show that they attained a height at least a thousand feet above Schlagintweit's 22,230 feet in Nepaul, which is the highest climb hitherto authentically recorded. He will then return to India.

THE IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held last week in Liverpool, under the presidency of Sir Frederick Abel. The meeting was fairly successful on the whole, although the weather marred some of the excursions, and the last day's sitting was simply wasted time. The following is a list of the papers read :—"On the Manufacture of Iron in its Relations with Agriculture," by Sir Lowthian Bell ; "On an Apparatus for Autographically Recording the Temperature of Furnaces," by Prof. W. C. Roberts-Austen ; "On the Alloys of Iron and Chromium," by R. A. Hadfield (Sheffield) ; "On the Liverpool Overhead Railway," by J. H. Greathead ; "On the Engineering Laboratories in Liverpool," by Prof. H. S. Hele-Shaw ; "On the Failures in the Necks of Chilled Rolls," by Charles A. Winder (Sheffield) ; "On a New Process for the Elimination of Sulphur," by E. Saniter (Wigan) ; "On the Elimination of Sulphur from Iron," by J. E. Stead (Middlesborough). A paper on the basic Siemens process, by Mr. Kupelwieser, of Witkowitz, was also on the list, but was adjourned until the Spring Meeting of next year.

Upon the members assembling in St. George's Hall, on Tuesday, September 20, they were welcomed by the Mayor of Liverpool, and the reception formalities being disposed of, Sir Frederick Abel gave a short address, in the course of which he commented on the papers about to be read, and also stated that Mr. E. Windsor Richards, of Low Moor, had been elected by the Council to be President of the Institute, in succession to himself, during the coming two years during which the presidential term lasts.

The first paper on the list was Sir Lowthian Bell's contribution, which he read from MS., the paper not having been prepared in time to be printed. Those who are accustomed to attending meetings of this kind know how difficult it is to follow the reading of a paper even when they have the help of a printed copy, but when one has to depend upon one's hearing only, in a large room and amidst many disturbances, the task is hopeless. So far as we could gather, the author treated his subject *ab ovo*, and much of the first part of the paper might be found in various elementary text-books. The main point of interest was a description of an apparatus which has been devised for arresting and securing certain products which are to be extracted from the fumes of blast furnaces using raw coal. The chief of these by-products is sulphate of ammonia, and the author pointed out how necessary it was to the harmonic working of an economic system that this sulphate of ammonia should be collected and returned to the earth as a fertilizer. Of course, there is no gainsaying this part of the argument, and, as it is perfectly possible to collect the fumes and products of combustion, the question resolves itself into one of profit and loss. Sir Lowthian quoted figures which would, in these lean times, make the ironmaker's mouth water, and almost convert the iron itself into a by-product, but unfortunately, as it appeared afterwards during the discussion, the selling prices which the author had taken were by no means those of the present day. Mr. Snelus spoke of the remarkable fertilizing properties of sulphate of ammonia and nitrate of soda. He had spread one half of a newly-sown lawn with a mixture consisting of one part of sulphate of ammonia to three parts of nitrate of soda—four cwt. to the acre—and had grass an inch long, whilst the unspread part was quite bare.

The next paper taken was that of Prof. Roberts Austen, in which was described a modification of the Le Chatelier pyrometer, which has been introduced for the purpose of securing autographic records of temperature. The apparatus was exhibited at the council table, and has been constructed under the directions of the author for Mr. E. P. Martin, of Dowlais, in order that a continuous record might be kept of the temperature of the stoves in which the blast is heated for the iron smelting furnaces. It will, of course, be understood that the apparatus is suitable for recording temperatures under other conditions, and it can hardly fail to afford valuable assistance to those engaged in many branches of manufacturing industry, and in the scientific investigating of processes; in fact, in many branches of metallurgical inquiry, and also in the study of steam engine economy, there has been no want more widely felt in times past than that of a trustworthy means of ascertaining high temperatures. The author had previously described an apparatus he had before devised, and that shown was the result of a desire to simplify the design. The original apparatus consisted of a camera containing a reflecting galvanometer of the Depretz and D'Arsonval type of about 200 ohms resistance. A thermo-junction is connected with this galvanometer, and the amplitude of the deflection of a spot of light from the mirror affords the basis in calculating the temperature to which the thermo-junction has been raised. An autographic record of the temperature may then be readily obtained if the spot of light from the mirror falls into a sensitized photographic plate actuated by an astronomical clock, or by other suitable mechanism. Such an appliance as this, though well adapted for conducting investigations, is not sufficiently simple for industrial purposes, and the author determined that it was necessary to simplify the part which receives and records the spot of light; and also to arrange for attaching several thermo-junctions, so that there would be one for each furnace, and each might be brought in connection with the recording apparatus in turn. In order to effect these changes the original moving plate was replaced by a clockwork-revolved cylinder, to which was attached sensitized paper. In the apparatus shown provision was made for placing any one of six centres of heat, such as hot-blast stoves or furnaces, in connection with the galvanometer, and for obtaining within the period of the revolution of the cylinder a record of the temperature of any one, or of all the six sources of heat. The records will, of course, be intermittent, the duration of the test in any particular case being subject to the will of the operator; or the shifting of the electrical contact from furnace to furnace could be carried on by clockwork. The apparatus would then be entirely independent of manual adjustment.

In the discussion which followed the reading of the paper the most important point was that raised by Dr. W. Anderson, the Director-General of Ordnance Factories, who asked what was the durability of the thermo-couple, and whether the intensity of the current would alter owing to changes in the metals after exposure to high temperature. It will be remembered that the metals used are platinum and rhodium. Mr. T. Parker also asked if the couple was protected. Sir Lowthian Bell, who has had considerable experience with the Le Chatelier pyrometer in practical use at the Clarence Iron Works, said that in regard to durability and constancy of record, the device was most successful. He had only had to renew three or four couples, and they certainly would give accurate readings for the space of several weeks. He had proved this by comparing new and old couples, and also by testing at known temperatures. The author subsequently stated that the couples were put naked in the blast, and did not require protection unless subject to the impact of a shower of metal, in which case they were placed in a porcelain sheath.

Mr. Greathead next read his paper on the Liverpool Overhead Railway. This is a new railway which follows the "Line of Docks," and extends for a distance of about six miles. It is composed, for the whole distance, with the exception of a length of a few hundred feet, of an iron viaduct of uniform height, and which is continuous from end to end; unless some of the swing bridges on its course be open. The railway itself has been previously described, but the rolling stock has not, we believe, before been dealt with. Electricity will supply the motive power, there being a generating station situated about the middle of the line, where there will be four engines working up to 400 horse-power, each driving a separate Elwell Parker dynamo. The current will be carried along the line by a steel conductor placed on porcelain insulators. Hinged collectors of cast iron, sliding upon this conductor, will make the connection between the motors on the train and the generating dynamos. There will be no separate locomotives, the motors being on the cars, two cars forming a train to seat fifty-six passengers, the total weight being about forty tons. The signals will be worked by the trains themselves through an automatic device. The total cost of the railway is to be £85,000 per mile.

The second day, Wednesday, September 21, was opened by the reading of Mr. Hadfield's paper. This is a production of the kind that brings despair to the heart of those who prepare brief notices of these meetings. It consists, with the appendices, of over eighty-three pages, besides numerous sheets of tables, diagrams, &c. It begins with Vauquelin, and ends with a bibliography—*ab ovo usque ad mala*, as the author himself says; but the difficult part of the matter is that throughout the whole treatise there is not a part that could well be left out without disadvantage to the reader. Having said so much it will be evident that we can give but a very faint indication of the contents of Mr. Hadfield's paper. It is well known that he has made a special study of the alloys of iron and chromium, generally known as chrome-steel, and his success as a practical steel maker has been most marked. He has now put the results of long research and experiment at the disposal of all steel makers, and we cannot do better than refer those interested in the subject to the original work, which will duly appear in the volume of the proceedings of the Institute. It is noteworthy that chromium appears not to be in itself a hardener of steel, but that it acts indirectly by influencing the action of carbon upon the iron. Some of the photographic reproductions of chromium steel projectiles attached to the paper are very interesting, as showing what punishment this metal will stand. The shells go through nine inches of compound armour and eight feet of oak backing without apparent damage, the points being as sharply defined as in the shell as it comes from the shops. At a range of eighty yards two six-inch shells went through the thickness of armour mentioned, the striking velocity being 1825 feet per second, and the energy 2250 foot tons. One projectile altered ·01″ in diameter and the second ·013.″ One of these projectiles was fired through another 9″ plate without apparent damage. A 13·5″ projectile, also of Hadfield's make, was fired at a target consisting of two armour plates with 20″ of oak between. The first plate consisted of 18″ of compound armour backed by 6″ of wrought iron. Next came the 20″ of oak, and then a 10½-wrought iron, and finally a 2″ wrought-iron plate. This gave a total of 36½″ of steel and iron, besides the oak. The penetration was complete, but the illustration shows the projectile to have been broken into three parts. The striking velocity was 1950 feet per second, and the energy on impact 34,280 foot tons. The weapon was a 63-ton B.L. gun.

In the discussion which followed this paper—which the author read in abstract, having previously distributed printed copies—Prof. Roberts-Austen pointed out that the author's researches supported the views taken by himself and Osmond as to the dual form in which iron exists. This was shown by the diagrams showing the rate of cooling which accompanied the report. In these, when the cooling was from a high temperature, 1320° C., the curve was continuous throughout, but when the cooling was from about a thousand degrees, there was a point of recovery indicating recalescence. The diagrams formed part of a report by Mr. Osmond on Hadfield's chromium steel, which the author had incorporated in his paper. Prof. Roberts-Austen said he had arrived at the same results working independently. Another point worth recording is that remarked upon by Mr. Vickers, who dwelt upon the difficulty of deciding whether the effects noted in the steel were due to carbon or chromium, as it seemed impossible to separate the one from the other, the chromium invariably disappearing with the carbon. Mr. Vickers also started the old question of hardening by oil or water, a process which he advocates. Dr. Anderson put the matter in its true light by pointing out the danger from untrustworthiness due to the hardening process, defects being sometimes set up of which there was no outward indication. This, of course, refers to metal in large masses, such as gun-hoops, &c. Mr. F. W. Webb, the Mechanical Engineer to the London and North-Western Railway, gave high praise to chromium steel, saying he used it entirely for springs and also with advantage for tyres. He likewise found it an excellent material for tool steel.

Mr. Winder next read his paper on the failure of chilled rolls. The breakage of rolls is one of the most annoying of the many troubles with which the producer of manufactured iron has to contend. This is a matter which has hitherto received too little attention, it being generally considered to be in the nature of rolls to break, and nothing man could do would prevent it. It is as evident as like produces like, that if some rolls will last for considerable periods of time, others of exactly similar description, and working under the same conditions, would stand equally long. Sometimes four or five rolls—the author instances eleven in a fortnight—will give out one after another, until at last one will be found to accomplish the work. Mr. Winder, as a roll founder, endeavours to bring some sort of order into the process of manufacture. He points out that when a train of rolls is hard at work in the present day they will turn out as much as 1000 tons a week, and the passing of this great weight of red- and white-hot billets or blooms will be almost equal to putting the rolls into a furnace. The necks of the rolls are, however, kept cool by water, so that the lubricant may not be burnt off, and the sudden cooling thus caused produces a molecular change in the metal which, the author considers, accounts for much of the mischief. In order to overcome this difficulty it is recommended that there should not be too sudden a reduction of the diameter of the body of the roll where the neck is formed. That, in brief, appears to be the author's opinion, and doubtless his advice is good; in fact, it follows one of the cardinal laws observed by good iron-founders in the casting of other articles besides rolls. A good practical discussion followed the reading of the paper. We think that foundry practice is a little behind in this country, and in this respect we might, with advantage, take a hint or two from American methods, perhaps more especially in regard to smaller castings than chilled rolls, which often fail unaccountably in the United States also. The advice to roll founders to cast with a bigger head should not be, but apparently is, necessary. Prof. Turner's remarks were to the point, and it would be of advantage if he would make his researches in this direction more fully public.

Prof. H. S. Hele-Shaw was the author of the last paper read on the Wednesday of the meeting. The Walker Laboratories form part of University College, Liverpool, and are among the most recent and best arranged establishments of the kind. They have been erected under the guidance of the author of the paper, who occupied the chair of Engineering Science when the school was in a far less magnificent form. We have not space to follow the author in his description of the buildings, or the method of instruction. The latter appears to be framed in a manner calculated to turn out good engineers, a class which cannot be too large for the welfare of the country, although complaints are growing daily that they are already too numerous for their own advantage.

The last day of the meeting was Thursday, September 22, when two papers were read. The first was the contribution of Mr. Saniter, and in it he described the process by which he proposes to remove sulphur from iron by calcium chloride and lime. The experiments quoted go to prove that lime alone removes a considerable quantity of sulphur from iron if the contact is sufficiently prolonged; and, further, that a mixture of calcium chloride and lime completely eliminated the sulphur in the space of half-an-hour. Chloride of calcium is a by-product of the manufacture of ammonia, of soda (by the ammonia process), and of Weldon's bleaching process. The author states that the production amounts to many thousands of tons, of which only ten per cent. finds useful employment, the remainder running to waste. The subject is one of considerable importance, and no doubt the process will be freely criticized when it comes up again for discussion at the next spring meeting.

Mr. J. E. Stead's paper on the same subject—the elimination of sulphur from iron—was a much more imposing contribution, covering 40 pages of the proceedings. It dealt broadly with the whole question, and forms a most valuable contribution to the literature of the subject. At the conclusion of the reading of his paper Mr. Stead said that since it had been written he had had further light thrown on the matter by experiment and otherwise. He therefore proceeded to read from a MS. certain fresh matter, which appeared to occupy as much space as the paper itself. No doubt Mr. Stead will weld the original paper and the additions into one harmonious whole, which will then form a standard work of reference on a subject which has come to the fore so much within the last year or two. We congratulate Mr. Stead upon his courage in dealing with this matter in the way he has, and especially upon the practical disclaimer of infallibility which the appendix to his paper supplied.

There was no discussion of these papers, their consideration being adjourned until the spring meeting of next year. The matter should be well thrashed out, as speakers will have had an opportunity of consulting authorities, marshalling facts, or even making fresh experiments. It is to be hoped that in the future more discussions will be arranged on similar lines.

The proceedings closed with the usual votes of thanks to those in Liverpool to whom the Institute was so largely indebted for the success of the meeting.

There were several excursions during the week. The chief of these were to the Manchester Ship Canal, the Vyrnwy Water Works, the Lancashire and Yorkshire engineering shops at Horwich, the Liverpool Overhead Railway, and Laird's shipyard. A visit was also paid to the Walker engineering laboratories, where Prof. Hele-Shaw had collected some very interesting models for the occasion. The most striking of these was an exceedingly intelligent chain-making machine which has recently come over to this country from the United States. The whole of the operations are automatic, reels of wire going in at one end of the apparatus, and coming out one continuous length of chain at the other, and this without human intervention of any kind. The machine may, in the ingenuity of its design, rank with Laycock's horsehair loom, which we described in connection with the visit of the Institution of Mechanical Engineers to Sheffield of two years ago. It is really surprising to see what complicated operations mechanism may be made to perform by means of cams, levers, and springs. Mr. Laycock's loom exhibited perhaps a higher intelligence than the chain-making machine, inasmuch that it would select suitable hairs from a bundle, and would refuse to continue the work unless the proper kind were supplied. The chain-making machine, on the other hand, has to deal with a more stubborn material and has to connect each link. We do not know the name of the inventor of this machine, but the chain is known as "Triumph Chain."

FUELS AND THEIR USE.

AT the annual meeting of the Society of Chemical Industry, held in London on July 20, the chair was occupied by Dr. J. Emerson Reynolds, F.R.S. He chose, as the subject of his presidential address, "The modern developments in regard to fuels and their use"—a subject, as he explained, which had occupied much of his attention. The address was one of popular, as well as of scientific, interest.

After some preliminary remarks, Dr. Reynolds said:—

The fuel question is one which concerns those of us who live on the western side of St. George's Channel even more seriously than it does you, as our coal beds have been washed away in ages past, and of native fuel there is practically none save peat; hence industries which require large quantities of cheap coal cannot flourish in Ireland under existing conditions. It is, therefore, our interest to watch closely the development of improved and economical methods of using such fuel as we can obtain from other countries, and apply them in the utilization of our bulky but abundant peat. It is evident that no other fuels need be considered save coal, peat, and petroleum; hence, my remarks can take somewhat the form of a trilogy, minus the dramatic element, precedence being given to the solid fuels, and the first place necessarily to coal. . . .

The Royal Commission on Coal Supply, which commenced its sittings in July, 1866, and reported in July, 1871, after inquiring into all probable sources of coal in Great Britain, arrived at the conclusion that not more than 146,480 million tons were available at depths not exceeding 4000 feet from the surface. Therefore, at our present rate of increase of population and of coal consumption, our supply would not last for 230 years. But Mr. Hall, one of Her Majesty's Inspectors of Mines, who has special experience of coal mining, forms a much lower estimate of the supply practically available with our present means, and considers 170 years as the more probable duration of our coal beds. This estimate is based on fuller information than that possessed by the Royal Commissioners; we are therefore justified in concluding that the inhabitants of Great Britain 170 years hence will have little, if any, home-raised coal to burn if we continue to use it in our present wasteful fashion.

It was pointed out by the Royal Commissioners in 1871 that we cannot suppose 'the production of coal could continue in full operation until the last remnant was used, and then suddenly cease. In reality a period of scarcity and dearness would first be reached. This would diminish consumption and prolong duration; but only by checking the prosperity of the country.' . . . . 'Much of the coal included in the returns could never be worked except under conditions of scarcity and high prices. A time must even be anticipated when it will be more economical to import part of our coal than to raise the whole of it from our residual coal-beds.' As the area of coal-bearing strata in North America is fully seventy times greater than ours, it is easy to see where our future supplies must come from. The rate of increase in the use of coal has been greater than the Commissioners anticipated in 1871, and Mr. T. Foster Brown, C.E., President of Section F of the British Association at Cardiff last year, has placed on record his opinion that at the end of only fifty years from the present time the increased cost of coal will be severely felt. Pessimism is never pleasant; nevertheless we cannot afford to ignore reasonable inferences from fairly ascertained facts.

I apprehend that there are few ordinary consumers likely to be influenced in avoiding waste by the knowledge that we are within measurable distance of the end of our store of British coal, as that calamity may still be some generations off. But the case is very different with large consumers; the inevitable, if gradual, increase in the cost of coal has effectually arrested the attention of those directly concerned in our great industries or anxious for the maintenance of that manufacturing supremacy to which this country chiefly owes its wealth and power. Keen international competition in trade has quickened the effort to get the utmost work out of fuel, and therefore to diminish waste.

No such considerations have, however, produced any effect on the domestic conscience. A spasmodic increase in cost of coal stimulates the use of various economical devices which are almost wholly given up when prices fall back nearly to their former level. A small residual effect is left, which, though slight, is on the right side. But that economy in the domestic use of coal which could not be effected by a patriotic desire to avoid the too rapid exhaustion of our coal beds, or by a fear of permanently dear coal, is likely to be brought about by the growing nuisance of large towns, namely, fog, for whose increase our 'hearths and homes' are in a greater degree responsible than the much abused factory chimneys. The primary consideration in seeking to cope with the fog demon no doubt is to avoid the production of solid particles during the combustion of any fuel we may use, hence that method which avoids the formation of smoke at any time, and is both more convenient and economical, must ultimately 'hold the field.' As you well know, various suggestions have been made for the purpose of avoiding the production of smoke, and it has even been proposed that the use of non-flaming coal should be made compulsory in all large towns, notwithstanding the difficulties known to attend the combustion of anthracite or similar substances in open grates. But even if the fog demon could be satisfactorily exorcised by such means, the fact would remain that the combustion of any solid fuel in an open grate is a most wasteful proceeding. On the other hand, closed grates or stoves have not been popular in these countries. How, then, can we combine economy in the use of coal with smokeless combustion and domestic convenience? The answer is sufficiently obvious—we must more or less completely gasify the coal prior to its complete combustion.

The late Sir William Siemens showed us long ago how to convert coal completely into gas by means of his great 'producer' furnaces, and demonstrated the applicability of the comparatively poor 'producer' gas to operations requiring very high temperatures as well as to the minor work of steam raising. Siemens showed that when so used one ton of coal can perform as much work as 1·7 tons directly burned. In such comparisons the 'producer' gas was, of course, burned at a short distance from its source and under the regenerative system. This mode of using coal seems to be the most economical of which we have practical experience; but the gas which is produced seldom contains less than 65 per cent. of useless nitrogen, and therefore is not rich enough in combustible matter for general distribution.

The Wilson method of gasifying coal and that employed by the Leeds forge, permit the production of a richer gas. The Wilson process involves the formation of a certain proportion of 'producer' gas in raising the temperature of the coal up to the point at which it can decompose steam, and then affords a mixture of carbon monoxide and hydrogen, or so-called 'water-gas.' The former can be used for steam raising or furnace work in the immediate vicinity of the producer, while the water-gas can be transmitted through mains as readily as ordinary town gas, and loses nothing by carriage save its initial heat. Thus one general method affords two qualities of fuel and gasifies the coal in an economical manner.

Whether by the Siemens method in its modern form or by the more or less complete conversion into rich water-gas, a great saving in coal can now be secured in almost all large operations requiring the command of high temperatures; and the use of such gaseous fuel is so steadily extending that we may expect in the near future to reach the maximum practicable economy of coal in our greater industries and of smoke abatement as well.

Between the complete conversion of coal into gas and the very partial process included in the production of ordinary illuminating gas is a wide gap which needs to be bridged over in the interests of the small manufacturer and the domestic consumer alike before we can secure that economy in the use of coal which we know to be necessary. For it must be granted at once that our ordinary 16-candle illuminating gas is seldom an economical fuel at an average price of 3*s*. per 1000 cubic feet, though it is capable of being so used as to effect distinct saving under special circumstances. As an example of its economical use, even near the price stated, I may cite the case of the kitchen of St. John's College, Cambridge, where gas and steam have been substituted for coal, and an annual saving effected amounting to about £80. But in establishments which cannot be systematically conducted coal-gas at 3*s*. is too expensive a fuel. Several solutions of this important practical problem have been proposed; one group of suggestions involving the supply of two distinct gases, an illuminating and a fuel-gas, and therefore requiring two sets of street mains; but the progress of electric lighting is so rapid that gas companies would not be justified in outlay of capital on a second set of mains. Another proposal is to supply one gas of high calorific value but low illuminating power at a cheap rate, and this gas, when used for lighting, to be charged at the point of consumption with vapours of suitable hydrocarbides. But the true solution involves a compromise much on the lines along which gas managers are at present apparently working.

You are aware that the average produce of 16-candle gas per ton of coal is about 9500 cubic feet. By the introduction of steam to a small extent the volume of gas can be materially increased, but at the expense of the illuminating power. In order to compensate for this loss, rock or other oils are injected along with the steam, and the illuminating power is maintained. An objection to this practice is that carbon monoxide is present in such gas, but it is also found in many samples of ordinary coal-gas, and provided the gas has a strong and characteristic odour, so that its escape can be readily detected, no risk need attend its use. The supply of the richer bituminous coals is steadily diminishing, hence the practice must grow of supplying a modified water-gas instead of coal-gas as we have hitherto known it. Better far, in the interests of producer and consumer alike, that the inevitable change in the character of the gas manufacture should be carried out with the full knowledge and assent of the public after due Parliamentary inquiry, and in such a manner as to secure the maximum advantage without undue interference with the great monopolies enjoyed by the gas companies. So many satisfactory methods are known by which the illuminating power of a gas can be increased at or near the burner, and gas as an illuminant is moreover being so certainly displaced by the electric light that the objections hitherto urged against the supply of gas of high calorific value but low illuminating power have almost ceased to have any practical force. On the other hand, the supply of a cheap gas of the kind I refer to would prove a great boon to small manufacturers as well as to the domestic consumer, and competent gas engineers inform me that no real difficulties lie in the way.

The rapid extension of electric lighting in our large towns brings us within measurable distance of some such sweeping change in the character of gas used, in its applications, and in its mode of employment, while the existing mains would serve for its conveyance, and comparatively trifling alterations in our domestic appliances would only be necessary.

It is in this direction, then, that the best prospect of solving a considerable part of the smoke fog difficulty seems to lie, and it is in the same direction that we are to look for true economy in the use of coal. The completion of the system of electric lighting in towns is therefore to be desired by the community, not only on account of its great and obvious advantages for illumination, but because it will render possible the provision and distribution of a cheap gas for heating purposes; and the shareholders in gas companies of such fortunate towns should specially rejoice, as herein lies a good prospect not merely of maintaining, but of considerably increasing, their dividends. Gas companies would not only become purveyors of heat energy for domestic use, but for manufacturing purposes as well, not excepting the production of the electric light.

Hence, our duty to posterity and our own immediate interests coincide in requiring the use of more economical methods of using coal, and that which gives promise of the greatest number of advantages involves the conversion of coal as far as possible into gaseous fuel.[1]

I turn now from coal to peat, which is, as you know, a much less mineralized solid fuel. It is obvious that the question of peat utilization is one of much importance in Ireland, as nearly one-seventh of the island is bog. About 1,250,000 acres are mountain bog, and 1,575,000 acres are occupied by flat bogs, which occur over the central limestone plain of the country and stretch away to the north-west. This store of peat is an asset which may become valuable when you shall have exhausted your coal-beds some 170 years hence. We would naturally desire to realize a portion of our assets at a much earlier date, as nearly all the coal used in Ireland must be brought from the eastern side of St. George's Channel. In this fact I think you have some explanation of the depressed industrial condition of the country, as manufactures involving the use of much fuel can only flourish in Ireland if the margin of profit be considerable; where the margin is small and competition keen (as in the greater industries), they must go under in the struggle with manufacturers having cheaper fuel at command. I grant at once that this is no adequate explanation of the absence of many chemical manufactures which do not involve large consumption of fuel, but it is the inevitable result in the cases to which my remarks apply.

Peat alone, however well prepared, compares very unfavourably with coal in several particulars:—

It is a very bulky fuel, in its ordinary condition occupying rather more than five times the space of an equal weight of coal.

2. It contains from 15 to 25 per cent. of water and seldom less than 10 per cent. of ash.

3. At least $2\frac{1}{2}$ tons of average peat are required to perform the same work as one ton of average Staffordshire coal in ordinary fireplaces or furnaces.

Hence the general use of ordinary peat is attended by the disadvantages of requiring much greater storage room than coal, of producing a light and troublesome ash, and requiring more than thirteen times the bulk of coal to produce the same thermal effect. The last-mentioned consideration practically precludes its use in ordinary furnaces where heat of high intensity is required.

Now the force of the first objection to the use of peat, that of bulk, can be materially diminished by mechanical compression. Many excellent examples of compressed peat have been produced at various times, the most coal-like product I have seen being that of Mr. Hodgson, of Derrylea, who compressed, thoroughly disintegrated, and dried peat in heated cylinders, and by partially carbonizing under pressure secured the cementation of the material. Moreover, the ash of such compressed peat was not so bulky as that of the ordinary fuel.

I need scarcely say that the intensity of the heat obtainable with compressed peat is greater than with the loose material, but the actual thermal effect is not much altered, save in so far as the material is drier and therefore less heat is lost in evaporating moisture.

Extended comparative trials of coal and of good dense peat in steam engines have shown that the work done by one ton of peat was not more than 45 per cent. that of one ton of coal; hence if coal were 18*s.* per ton, peat could not compete with it under the most favourable conditions unless delivered at not more than 8*s.* per ton. Now the peat used in these trials did not contain more than 12 per cent. of moisture, but as dug from the bog it seldom contains less than 35 per cent. of water, even when cut from a comparatively dry bog; it must then be stacked and air-dried. The present price of ordinary turf delivered at the bog is about 7*s.* per ton; when to this is added the cost of handling this bulky fuel, and carriage for fifty miles, the cost exceeds 45 per cent. of that of coal even at inland towns; hence there is no real economy in the use of peat of the common kind in ordinary furnaces and grates instead of imported coal.

[1] Since the above was written I have seen a short abstract of Mr. Valon's address to the Institute of Gas Engineers, in which I am glad to find that he takes a somewhat similar view of the situation to that expressed above.

But the public are led by promoters of peat-manufacturing companies, and others who should know better, to suppose that by certain processes of disintegration and compression peat can be made to approach very closely in fuel value to an equal weight of coal. There is no doubt that a better looking and denser product can be obtained by these means, and one which requires less storage room; but unless artificially dried as well, the actual heating effect of the fuel is not materially altered. I have no doubt that the cost of winning and treating the rough peat could be much reduced by the use of suitable labour-saving machinery; but all methods with which I am acquainted involving artificial drying as well as mechanical compression, have cost so much that the product could not compete with coal at the ordinary level of prices. As I have already said, the Irish peat forms a valuable asset, but one not capable of being realized on any considerable scale at present; at least when used as fuel in the ordinary way as a substitute for coal. But it is possible to so burn peat that it shall compare much more favourably with coal, and this solution of the problem is obtained by converting rough peat into gas.

You doubtless remember that in 1872 the cost of coal advanced even beyond the panic prices which prevailed for a week or two about the beginning of the present year. But the coal famine of 1872 lasted for a considerable time, and serious efforts were then made in Ireland for the utilization of peat. It soon became evident that the continuance of dear coal meant the suspension of several industries and their probable loss to the country; hence, leaving to others the attempts to convert peat into a suitable fuel for general domestic use, I took up the industrial side of the problem.

I saw that the best chance for economically applying peat for most manufacturing purposes lay in gasifying the material in a Siemens furnace, as two special and important advantages must obviously be gained thereby:—(1) The use of peat in the rough state without artificial drying; (2) The avoidance of the injurious effects of abundant ash by burning the peat-gas at some distance from its source, and under such conditions that the comparative value of coal and peat should be nearly in the proportion of their percentages of carbon. I therefore moved the Royal Dublin Society to appoint a committee of engineers and other scientific men to have the value of peat tested in the way proposed. The outcome was that the directors of the Great Southern and Western Railway of Ireland, acting on the recommendation of the able locomotive engineer, Alexander Macdonnell, C.E., decided to erect a complete Siemens regenerative gas furnace for working up scrap iron in their engine factory at Inchicore. This furnace was supplied only with rough peat, often containing as much as 38–40 per cent. of water, but no difficulty was found in keeping the welding chamber at a bright white heat for months at a stretch. The average consumption of fuel was 5·09 tons of peat for each ton of iron forged from scrap to finished work. Before the Siemens furnace was built the ordinary air furnace fed with coal was employed, and the average consumption per ton of iron was 4·96 tons of coal. I need scarcely say that peat is practically useless in such a furnace. Therefore peat used in the gas furnace as compared with coal in the ordinary welding furnace not only proved in practice to answer extremely well, but performed 97 per cent. of the work done by an equal weight of coal. As the price of peat was about half that of coal at the time, Mr. Macdonnell estimated that a saving of £4 7*s.* 9*d.* per ton of finished forgings was effected. If therefore the coal beds were exhausted we have a good substitute in peat for operations in which a very high temperature is required, provided the fuel is used in the gas furnace or according to some similar plan.[1]

The above remarks refer to work done twenty years ago. Now, thanks to the valuable investigations of Mr. Ludwig Mond, F.R.S., detailed in his Presidential Address of 1889, the pro

[1] Of course the comparison is more favourable to coal when the latter is used in the Siemens furnace, as it is found that a ton of iron required an average of three tons of coal, therefore the work done by peat was about 60 per cent. of that by coal under the same conditions.

duction of ammonia from peat along with gas according to his method will probably pay for gasifying the fuel and materially facilitate the utilization of peat.

Much to my surprise and regret this work remains the sole practical outcome of our efforts in the direction of peat utilization during the fuel famine of 1872, so far as Ireland is concerned. Manufacturers now know how they can economically use peat for high temperature operations, and Dr. Bindon Stoney, F.R.S., has suggested that peat should be gasified at the bogs and carried to convenient centres of industrial activity. This could undoubtedly be done, especially if instead of 'producer' gas a fuel were manufactured approaching water-gas in composition, and such a gas of good calorific power can be manufactured from peat. Thus, as in the case of coal, peat could be made economically to provide ight and heat energy as well for domestic use as for manufacturing purposes. Would that we could apply even a small portion of the energy stored up in peat to stimulate those who should be most active in utilizing in the best and most economical way the abundant material almost at their doors!

If, then, there are many and great advantages in converting our bulky solid fuels into gas and distributing them in that form for heating purposes or supplying power by means of gas engines, it is clear that such advantages must be confined for the most part to towns or special manufacturing centres unless the gases are condensed to the liquid form, and so rendered portable to considerable distances; but nature has already done a great part of this work for us in providing the wonderful material we call petroleum. I do not think 'wonderful' is too strong an adjective to apply to this material, whether we consider its nature, speculate as to its probable origin, or attempt to measure its value in the world's work; and in this, the concluding section of my address, I propose to sketch in broad outline the main points of public interest which relate to this, the most important of our liquid fuels. . . .

The views of geologists as to the nature of the general process by which petroleum is formed are elaborately discussed in the eighth report of the United States Geological Survey, and the conclusions are there carefully summarized (page 506). In substance they are as follow:—That petroleum is derived from organic matter by a process of slow distillation at comparatively low temperatures: that the organic matter was not in all cases of vegetable origin, but was in some instances derived from animal substances in contact with limestone; and, finally, that the stock of petroleum in the rocks is practically complete. It follows, of course, that the supply is exhaustible, but geologists do not even guess at its duration.

In contrast with all this is Mendeleeff's view that petroleum is not a product from organic material, but is chiefly formed by the action of water at high temperatures on carbide of iron, which he supposes to exist in abundance within or below the earth's crust. The cracks and fissures caused by the upheaval of mountain chains permit water to reach the heated carbide at great depths, and carbides of hydrogen result in accordance with the general equation—

$$3\,Fe_mC_n + 4\,mH_2O = mFe_3O_4 + C_{3n}H_{8m}.$$

The hydrocarbides then distil up and condense within the cooler sedimentary strata. The occurrence of petroleum in active volcanic areas, as in Sicily and Japan, is held to accord with this hypothesis, which latter is also consistent with the remarkable fact that rock oil is usually found in the vicinity of mountains. But my chief reason for referring to this attractive hypothesis is that it permits us to suppose the hydrocarbides are still being formed within the earth's shell, especially beneath the geologically modern mountain chains, and that the supply of petroleum is practically inexhaustible. Whether that view can be sustained we must leave further evidence to decide, and now return after this digression to the consideration of the material itself.

The porous strata saturated with petroleum often lie at considerable depths below the surface soil of the district, and the oil is in many cases prevented from rising by a bed or shell of almost impervious material. In boring for the oil this enclosing shell is penetrated and the result often is the ejection of a column of liquid rising as a fountain of several hundred feet into the air. This violent expulsion of petroleum is due in great part to the pressure of pent up gases, and the crude liquid always contains some of these gases in solution. In some instances gas only issues, and a so-called 'gas well' is obtained, from which are emitted enormous volumes of marsh-gas and its lower homologues, as well as hydrogen. Some of these American gas wells afford from 10 to 14 million cubic feet per day, delivered at a pressure of as much as 400 pounds to the inch. Such gas is a fuel of high value and, as you know, has been largely utilized for industrial and domestic purposes at such great industrial centres as Pittsburg.

One million cubic feet of the natural gas obtained from the Trenton limestone at Findlay, Ohio, are said to do the same amount of work in heating as about 60 tons of Pittsburg coal. Some of these gas wells have been exhausted, but others have continued in full productiveness for several years. Although this natural gas is compressed and transported in cylinders to considerabie distances, it evidently must remain of almost exclusively local value; not so the liquid petroleum which issues along with it or in its immediate neighbourhood. This is the most portable of all fuels obtainable in nature, and therefore is the most convenient means by which light and heat can be transmitted to all parts of the world—hence it is of greater practical interest to us than the natural gas.

You are aware that the hydrocarbides of which the American petroleum consists chiefly belong to the saturated group C_nH_{2n+2}, whereas those of Russian petroleum are mainly benzenoid hydrocarbides of the general formula C_nH_{2n}, isomeric with the olefines, but really hydrogenized aromatic compounds of the naphthene series. Petroleum from both sources affords some of the lower homologues of marsh-gas, hence in the process of refining crude petroleum by distillation the first products consist largely of butane, pentane, and hexane, which are separated and condensed by pressure, the product being used for refrigerating purposes, owing to its high volatility. Between 80° and 120° American petroleum affords a spirit of specific gravity about 0°·75, and above 130° the illuminating oils are obtained, whose gravities vary about 0·8, while the residue which is not vaporized at 300° includes the heavier lubricating oils, which are also admirably suited for use as fuel, and are cheaper than those generally used for lighting purposes. During this process of refining by simple distillation there is always more or less decomposition in progress, hydrocarbides of high molecular weight being resolved into simpler ones at a comparatively high temperature; and when crude petroleum or its constituents are rapidly heated, this resolution can be carried so far as to convert a large proportion of the oil into permanent gas, valuable alike for illuminating and heating purposes. Thus petroleum is a fuel which can be permanently gasified with facility, and is no doubt wholly converted into gas just prior to combustion in our common lamps.

Several methods are employed for the conversion of oil into rich gas, and storing the latter for distribution through tubes in the ordinary way. In one class of such processes the oil alone is rapidly heated to a temperature of from 800° to 1000° in iron retorts, as in the methods of Pintsch and Keith, thoroughly described by Dr. Armstrong in vol. iii. of our Journal. The yield of gas seldom exceeds 130 cubic feet per gallon, as liquid hydrocarbides of low boiling points are condensed chiefly during the compression of the gas into cylinders for use in railway carriages. The gas is rich in carbon compounds, including methane, ethylene, and crotonylene, and its illuminating power, even after compression, is seldom less than forty-five candles. I may add that Mr. Ivison Macadam has given in vol. vi. of our Journal (p. 199) a valuable series of observations on the gas-producing power of various oils treated by a process very similar in plan to that of Pintsch.

Another mode of converting petroleum into gas includes the use of steam, as in the process of Messrs. Rogers, of Watford, who inject the oil into red-hot retorts by means of steam, the latter appearing to facilitate the permanent change of the petroleum without the formation of much carbon monoxide. The gas so produced is said to amount to about 140 feet per gallon of heavy oil used, and has, according to Mr. Rowan (this Journal, vol. vii), the following composition:—

	Per cent.
Hydrogen	31·61
Marsh-gas	46·17
Illuminants	16·29
Carbonic oxide	0·14
Nitrogen	5·06
Oxygen	0·73

This gas is stated to have an illuminating power of fully 56 candles, and to lose little either by standing or by carriage to considerable distances.

As such petroleum gas has about 3·5 times the illuminating power of 16-candle coal-gas, it follows that, so far as illuminating purposes are concerned, the gas producible from one gallon of oil by this process is equal to some 525 cubic feet of coal-gas of 16-candle value. I shall later on refer to the heating value of this petroleum gas, but I have now justified the statement with which this section commenced, viz., that petroleum is virtually liquefied gas in a peculiarly portable condition. Hence in all states petroleum can be used as an illuminant as well as a fuel, whereas coal and peat can only be used as illuminants in so far as they can afford carburetted gas.

Let me now proceed to justify the further statement that petroleum is the most concentrated, and, on the whole, the most portable of all the natural fuels met with in considerable quantities.

Weight for weight the efficiency of liquid petroleum in steam-raising is much greater than that of coal. The estimates of relative value necessarily vary with different portions of the crude material used, and with the quality of coal employed in the comparative trials; hence some of the statements of results are often rather vague. Thus M. d'Allest found that one pound of refined petroleum evaporated 12·02 pounds of water, while only 6·5 pounds were evaporated per pound of a rather poor steam coal. The American results with crude petroleum and Pittsburg coal gave respectively 15 and 7·2 pounds of water per pound of fuel. Prof. Unwin has recently compared petroleum with Welsh coal in steam-raising, the oil being injected by a steam jet through a highly heated coil and then burned perfectly with a clear flame. In his trials with a not particularly efficient boiler he found that 12·16 pounds of water were evaporated per pound of petroleum, and this result he considers about 25 per cent. better than that afforded by the steam coal. These results agree with those of M. d'Allest so far as the effect of petroleum is concerned, but the coals compared were different in value for steam-raising. Hence for an average coal the proportion is nearly three to two; in other words the practical heating effect of one ton of coal can be obtained by the combustion of only two-thirds of a ton of petroleum, while the comparison with the heavy oils would probably be still more in favour of liquid fuel. Petroleum has another advantage over coal in the matter of storage room, as one ton of the liquid occupies only four-fifths of the space of the same weight of coal, so that the bulk of the petroleum required to perform the same work in heating as one ton of average coal is little more than half that of the latter. It follows that a steamer constructed to carry 1000 tons of coal could, if provided with suitable tanks, carry 1200 tons of petroleum, equal in fuel value to about 1900 tons of coal. In addition, the liquidity of petroleum permits it to be pumped and conveyed long distances by gravitation in tubes so that its transport in bulk and in detail is easy. Therefore petroleum is not only a much more concentrated fuel than coal, but it is eminently portable as well and convertible with much greater facility into permanent gas. Against these advantages must, however, be set the inflammability of petroleum, and consequent greater risk of fire.

Now we have to consider the question of relative cost of petroleum used as fuel in liquid or gaseous form as compared with coal—the latter being our standard for reference as in the case of peat. We have already seen that about two-thirds of a ton of petroleum can do the same amount of work in heating as one ton of coal; therefore petroleum, when burned directly, cannot economically replace coal unless two-thirds of a ton of the liquid can be purchased for less than the cost of one ton of coal. We know the cost of ordinary lamp petroleum in these islands is at present far beyond that limiting value; even the heavy oils which are not good enough for lamps, and yet are too 'thin' for lubricants, only compare favourably with coal where the latter has to be carried long distances, and is therefore dear. However, all practical difficulties having been overcome in the use of these heavy oils for steam-raising, a comparatively small advance in the general price of coal would at once render them economical for industrial use as fuel.

But when we compare petroleum gas with ordinary coal-gas the comparison is much more favourable to the liquid fuel; unlike coal, petroleum is already more than half-way on the road to conversion into gas. As you know, one ton of coal affords about 9500 cubic feet of 16-candle gas. On the other hand, one ton of oil of sp. gr. 0·85 can afford about 24,000 cubic feet of gas, having an average illuminating power of 60 candles, or the equivalent of 70,000 cubic feet of 16-candle value, and this rich gas admits of preparation on the small scale suited to country places, while the retorts used in the production of the gas can be heated by petroleum. The petroleum gas of some 60-candle power is said to be producible at about 6s. per 1000 cubic feet. If we were to assume that the calorific value of the gas is directly proportional to its illuminating power the cost would correspond to about 1s. 7d. per 1000 cubic feet of 16-candle coal-gas. But the facts do not justify the assumption, as the calorific value of methane is known to be greater than that of the heavier carbides to which the high illuminating power is due; hence the comparison is probably less favourable to petroleum gas by about 25 per cent., though further experimental evidence is wanting on this point. However, even after this deduction, petroleum gas is the cheaper fuel as well as illuminant.

The necessary links between the elements of the trilogy on coal, peat, and petroleum are now, I think, sufficiently evident. If we desire to use each fuel in such a way as to develop most economically and conveniently its store of heat energy, we must first partially or perfectly gasify it. The newest member of the triad—petroleum—is the one which lends itself most easily and completely to such treatment, in consequence of its physical condition and chemical characters. It is also the material that we must expect to facilitate the production of cheap gaseous fuels from coal and peat which shall at the same time possess sufficient illuminating power for most purposes. Chemical industries would probably benefit to a greater extent than others by the supply of cheap fuel of the kind in question; hence I have ventured to tax your patience by dwelling on this topic in your presence to-day.

SUGAR-CANE BORERS IN THE WEST INDIES.

MR. BLANDFORD'S report on sugar-cane borers, published in the *Kew Bulletin* for July and August last, deserves more than a passing notice.

The report contains a plate of the insects in question, which will render their identification easy.

The first is a caterpillar and moth, *Chilo saccharalis;* the second a weevil, *Sphenophorus sacchari;* but the principal attention in the report is paid to the shot borer, *Xyloborus perforans*, a beetle which has lately caused considerable loss to growers of sugar-canes in Trinidad. These losses have been so large that on some estates thirty per cent. of the sugar crop has been destroyed, and in some fields fifty per cent., presumedly by the devastations of this beetle.

This beetle *X. perforans* is to be found over a very large area in the tropics; it is the same species that has done so much damage to wine and beer casks; it has been found in India, the Malay Archipelago, Madeira, Mauritius, North and Central America, Brazil, Guiana, Peru, and probably in Australia, so that no sugar-producing country can consider itself free from the fear of its ravages.

Mr. Blandford's report is interesting and valuable, not only for the amount of information it gives relative to this most destructive insect; but also for the way in which he points out what remains still to be investigated on the subject; so that it not only furnishes valuable information to the planter in the West Indies, but also tells him what course his further investigations should take; and it might well serve as a model to future observers in drawing up similar reports.

"The chief subject for investigation," to quote Mr. Blandford, "is the relation of the insect's attacks to the health and condition of the canes, whether it (the shot borer, *X. perforans*) is a true destroyer, or merely a follower and manifestation of antecedent and more serious injury:" this question, Mr. Blandford says, "I do not attempt to solve; it can only be studied in all its bearings by observers on the spot;" and he further gives a list of definite points which require inquiry and solution.

There is no doubt that the presence of *X. perforans* is usually accompanied by the sugar-boring caterpillar, *C. saccharalis*, and the weevil, *S. sacchari*, and also with fungoid growths, which may of themselves account for the acidification of the juices of the cane, which is apparent in canes attacked by the shot borer; but whether or not the shot borer attacks healthy canes is a question on which there is much diversity of opinion, and we hope that bringing the question before our readers will lead to more observations and experiments to decide this important question, as "while there is no proof, there is a strong presumption that *X. perforans* cannot begin the attack." Still there is much difference of opinion, as the Trinidad Commission, which investigated the subject, "believes that the beetle is the primary cause of the disease, and that it is immaterial whether the cane is healthy or not;" others believe that it is only canes which are "already physically weakened by other causes which are attacked by it."

The Transparent Cane and Caledonia Queen enjoy an entire immunity from the attack, "even when growing side by side with badly infested Bourbon canes, and varieties raised by seed show no signs of being attacked." It is therefore suggested that perhaps the Bourbon cane, enfeebled by long cultivation on the same lands and degenerated by careless ways of propagation, has become powerless to resist the attacks, and planters in their investigation must consider the possibility of attacks "being favoured by constitutional weakness which in no way implies want of care in cultivation, but perhaps the reverse."

The enemies of the shot borer are still to be found.

An important lesson taught by this report to the planter is the necessity of varying the description of canes grown and the great value of the new seed canes raised in Barbados.

S. N. C.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, Sept. 19.—M. Duchartre in the chair.—On the white rainbow, by M. Mascart. This phenomenon, usually known under the name of Ulloa's circle, is explained, not on the untenable assumption of water vesicles, but of very minute drops as constituting the mist upon which it is seen. The diminution of the diameter of the drops causes a displacement of the first maximum of the interference fringes which produce the supernumerary arcs. The relative intensities of the various colours retain equal values long enough to make the rainbow appear achromatic, with perhaps a slight red coloration along the outside. The radius of such a circle has been known as small as 33° 30'.—Observations of the new planet Wolf (1892, Sept. 13), and of the planet Borrelly-Wolf (Erigone?), made at the observatory of Paris (west equatorial), by M. Bigourdan.—On a recurring series of pentagons inscribed to the same general curve of the third order, by M. Paul Serret.—On the production of the spark of the Hertz oscillator in a liquid dielectric instead of air, by MM. Sarasin and De la Rive. The two balls of 3 or 4 cm. in diameter, between which the Rubmkorff discharge takes place in the Hertz oscillator, were plunged into an insulating fluid. This was, in the first place, olive oil, contained in a cylindrical vessel, 20 cm. in diameter, pierced laterally to admit the end branches of the oscillator. Sparks 1 cm. long were obtained, giving a characteristic sound, louder than that of a discharge through air. The effect on the resonator is notably increased by the arrangement, most brilliant sparks being produced. The interferences of the electric force by reflection from a plane metallic surface give the same results as in air. During the discharge, the oil is carbonized and loses its transparency, but without affecting the intensity. Similar experiments were made with essence of terebenthine and petroleum, but the oil proved the safest and most advantageous medium.—The action of bromine in presence of aluminium bromide on the cyclic chain carbon compounds, by M. W. Markovnikoff. It has been shown that a small quantity of bromide or chloride of aluminium added to the bromine produces a vivid reaction with the carbon compounds of the aromatic series, usually resulting in substitution-products of a crystalline form. Further experiments show the generality of the reaction for all the hydrocarbons of the series C_nH_{2n} which were examined. It has been studied chiefly as regards the naphthene (hexacarbon) series, and may be expressed by the general equation—

$$C_6H_{12-n}B_n + Br_{12-n} = C_6B_{6-n} + 6HBr.$$

The rule seems to be that the action of the bromine on the naphthenes at the ordinary temperature takes place principally on the hydrogen atoms of the cyclic chain, transforming them into benzene nuclei, in which all the hydrogen atoms are replaced by bromine, whilst the lateral chains remain intact. It is found that besides the bodies of the aromatic and naphthene series, the hydrocarbons of the paraffin series also react easily in presence of $AlBr_3$.—The rotatory power of fibroin, by M Leo Vignon.—Experimental researches on the bulb centre of respiration, by MM. J. Gad sand G. Marinesco.—Influence of continuous and discontinuous electric light upon the structure of trees, by M. Gaston Bonnier. Out of three lots of plants, one was submitted to a constant electric illumination, another to an illumination alternating with twelve hours' darkness, and a third was left to develop in ordinary daylight. The experiments were carried out in the electric pavilion of the Central Markets at Paris. The temperature was pretty constant (between 13° and 15°); the light was given by arc lamps in shades, and the trees—pines, beeches, oaks, and birches—were surrounded by glass, the air being gradually renewed. It was found that continuous electric light produced considerable modifications of structure in the leaves and shoots of the trees. The plants breathed, assimilated, and secreted in a continuous manner, but they appeared as if encumbered by this continuity, and showed a simpler structure. The shoots were very green, the leaves more open, less firm, and smaller. Differentiation was less decided in every respect. In the specimens exposed to intermittent illumination the results were very similar to those obtained under normal conditions.—On the discovery of the line of no declination, by M. W. de Fonvielle. From an inspection of geographical maps preceding or contemporaneous with the discovery of America it appears certain that Columbus was the first to discover the variation of the compass. Indeed, it was the rapidity with which the observed declination diminished which produced consternation among his seamen, whom he could only save from a panic by persuading them that the pole star had changed its place, while the needle remained a true guide. The stratagem succeeded, but Columbus suspected that the radius of curvature of the earth was different at the Sargasso sea, and that the line of no declination represented a natural frontier between the territories of Europe and Asia. This natural frontier was adopted by the Pope Alexander VI. in his division of the new world between the rival aspirants. Columbus himself found that the line did not coincide with a meridian during his third voyage, but the illusion guided even Magellan, and was only dispelled by Halley's magnetic chart in 1700.

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