cessful *ancoot* for a long time he may become a great *ancoot;* this necessitates a period of fasting, and then, as the story goes, an animal they call *amarook* (the same word is used for wolf, and for an animal which is probably mythical, unless it can be a *Gulo*) comes into his hut and bites the man, who immediately falls to pieces; his bones are then conveyed to the sea, where he lives for some time as a walrus; he finally returns among his people, a man in appearance, but a God in power.

If the prophecy of an *ancoot* does not come to pass as he had said it would, any phenomenon of nature, as a halo, corona, aurora, etc., is sufficient to have broken the spell, and the *ancoot* loses nothing of his reputation by the failure, for it is then believed that the measure, whatever it might have been, was not pleasing to *Torngarsuk*.

The people come to these soothsayers after all manner of information. We knew of one case where a young woman asked an *ancoot* if her yet unborn child would be a boy or girl. He retired outside the hut for a few moments, and when he returned he said it would "be a boy"; but he adds, "If it is not a boy, it will be a girl"! For this valuable information he charged three seal skins and a knife. As a general thing, the *ancoots* are paid according to their reputation; still, it is very seldom they refuse to give them what they ask for in return for their valuable services.

They seem to have an idea of a future state, but what we denominate as the region down below they consider as the best place. In Egede's "Grœnlands nye Perlustration, year 1741," is given a legend which is almost exactly the same as one that is found among the Cumberland Eskimo at the present day. But Egede says, in the Danish translation, "Himmel," heaven, as though this was the equivalent for the Greenlander's word; the Eskimo of Cumberland say "topani," which means simply "up." They do not distinguish any difference in the soul's condition after death, or rather of the two places where they expect to live hereafter; one differs from the other only in this wise, that if death is caused by certain means they go to the one, and if they die a natural death they go to the other.

The following is their idea of the future: "In the spirit-land *all* will have it as good or better than they had it on earth." Yet they designate two places where the soul goes after death, viz: "Some go up; others far down into the earth." But the lower place is considered preferable. This is described as a beautiful land, with everlasting sunshine, where the seal and reindeer abound in fabulous quantities, and food is consequently abundant. To this latter place go only such as are killed by other Eskimo, women who die in child-birth, such as drown in *salt* water, and *whalers;* they think, this being the better place, it is a sort of recompense for the suffering they underwent on earth; all the rest go up.

In this connection, we will mention that the Cumberland Eskimo think the *aurora borealis* is the spirits of dead Eskimo dancing and having a good time generally. It has even considerable influence over them, and they are well pleased to see a bright *aurora*. The Greenlanders, on the other hand, say it is the spirits of dead Eskimo *fighting*.

MULTIPLE SPECTRA[1]

III.

I have endeavored to show in the previous articles that there are many facts which justify the conclusion that the same elementary substance in a state of purity can under different conditions give us spectra different in kind. To those spectra to which special reference is now made the names of *lined* and *fluted* have been given to mark their chief point of difference, which is that in lined spectra we deal with lines distributed irregularly over the spectrum; while in fluted spectra we deal with rythmical systems.

This was the first point, and I showed that the idea was suggested that the lined and fluted spectra, though produced by the same substance, were produced by that substance in a different molecular condition.

I have pointed out that both in lined and fluted spectra taken separately there was evidence of still further complication, that is, that a complete lined spectrum of a substance and a complete fluted spectrum of a substance, was the result of the vibration not of one kind of molecule only, but probably of several.

So that in this view we have to imagine a series, in some cases a long series, of molecular simplifications brought about by the action of heat, and ascribe the spectral changes to these simplifications.

To understand my contention, and one objection which has been taken to it, in the clearest way, let us suppose that there is a substance which gives us, under different conditions, three spectra, which we will term *a*, *b*, and *c*. My view is that these spectra are produced by three distinct molecular groupings brought about by successive dissociations. On the other hand, it is objected that they are produced by *one and the same molecule* struck, as a bell might be struck, *in different ways* by the heat waves or the electric current passing among the molecules.

In my memoir entitled "Discussion of the Working Hypothesis that the so-called Elements are Compound Bodies," I remarked as follows :—

"I was careful at the very commencement of this paper to point out the fact that the conclusions I have advanced are based upon the analogies furnished by those bodies which, by common consent and beyond cavil and discussion, are compound bodies. Indeed, had I not been careful to urge this point, the remark might have been made that the various changes in the spectra to which I shall draw attention are not the results of successive dissociations, but are effects due to putting the same mass into different kinds of vibration or of producing the vibration in different ways. Thus the many high notes, both true and false, which can be produced out of a bell with or without its fundamental one, might have been put forward as analogous with those spectral lines which are produced at different degrees of temperature with or without the line, due to each substance when vibrating visibly with the lowest temperature. To this argument, however, if it were brought forward, the reply would be that it proves too much. If it demonstrates that the *h* hydrogen line in the sun is produced by the same molecular groupings of hydrogen as that which gives us two green lines only when the weakest possible spark is taken in hydrogen inclosed in a large glass globe, it also proves that calcium is identical with its salts. For we can get the spectrum of any of the salts alone without its common base, calcium, as we can get the green lines of hydrogen without the red one.

"I submit, therefore, that the argument founded on the over-notes of a sounding body, such as a bell, cannot be urged by any one who believes in the existence of any compound bodies at all, because there is no spectroscopic break between acknowledged compounds and the supposed elementary bodies. The spectroscopic differences between calcium itself at different temperatures is, as I shall show, as great as when we pass from known compounds of calcium to calcium itself. There is a perfect continuity of phenomena from one end of the scale of temperature to the other."

Not only is what may be termed the bell hypothesis op-

[1] Continued from p. 107.

posed to the law of continuity, as I endeavored to show in the last paragraphs quoted, but it appears never to have struck the objectors that it is also opposed to the theory of exchanges as it is generally enunciated, on which the whole of our supposed knowledge of extra-terrestrial matter depends. If vapors, when relatively cool, do not absorb the same wave-lengths which they give out when relatively hot, what becomes of some of the most noted exploits of our nineteenth-century science?

Take the case of sodium. Three distinct spectra have been mapped for it. There is first the yellow line seen in a Bunsen flame, then the green line seen alone in a vacuum tube when the vapor is illuminated by an electric glow, and again there is the fluted absorption spectrum, without any lines, seen when sodium is gently heated in hydrogen in a glass tube. If we have here the same molecule agitated in different ways, I ask which is the true spectrum of sodium? And what right have we to say that sodium exists in the sun because the yellow line is represented? Why do we not rather say that sodium does *not* exist in the sun because the fluted spectrum is *not* represented.

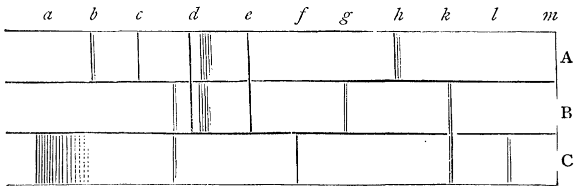

FIG. 1.—A. Highest temperature. C. Lowest temperature.

It is not necessary to enlarge upon this point because the difficulty in which the theory of exchanges is thus landed is obvious, while, if we acknowledge different molecular groupings in the vapors of the same chemical substance, and apply the theory of exchanges *to each grouping*, then the teachings of that theory become more numerous and important than before.

It is of course of the highest importance to see whether there is any *experimentum crucis*—any mode of inquiry—by which the theory can be settled one way or the other.

I submit that the results of experiments based on the following considerations ought to be accepted as throwing light on the question.

1. At different temperatures the brilliancy of the spectral lines of the same substances as ordinarily observed changes enormously. See if these changes can be produced *at the same temperature* by employing those experimental conditions which will be most likely to bring about different molecular conditions if such exist.

2. At a low temperature some substances give us few lines while at a high one they give us many. Vapors, therefore, already glowing with full lines at a low temperature, say in a flame, should give us all their lines when the vapor is suddenly subjected to a high one, say by the passage of a high tension spark. On the bell hypothesis the spectrum should change with the mode of striking. On the dissociation hypothesis this should only happen for the lines of those molecular groupings which are *from other considerations* held to be more simple. If the flame has brought the substance to its lowest state, the passage of the most powerful spark should not cause the flame spectrum to vary.

Now what are the "other considerations" above referred to? This necessitates a slight digression.

In the *Phil. Trans.* for 1873[1] I gave an historical account, showing how, when a light source such as a spark or an electric arc is made to throw its image on the slit of a spectroscope, the lines had been seen of different lengths, and I also showed by means of photographs how very definite these phenomena were. It was afterwards demonstrated that for equal temperatures chemical combination or mechanical mixture gradually reduced the spectrum by subtracting the shortest lines, and leaving only the long ones.

On the hypothesis that the elements were truly elementary, the explanation generally given and accepted was that the short lines were produced by a more complex vibration imparted to the "atom" in the region of greatest electrical excitement, and that these vibrations were obliterated, or prevented from arising, by cooling or admixture with dissimilar "atoms."

Subsequent work, however, has shown[1] that of these short lines *some* are common to two or more spectra. These lines I have called basic. Among the short lines, then, we have some which are basic, and some which are not.

The different behavior of these basic lines seemed, therefore, to suggest *that not all of the short lines of spectra were, in reality, true products of high temperature.*

That some would be thus produced and would therefore be common to two or more spectra we could understand by appealing to Newton's rule: "Causas rerum naturalium non plures admitti debere quam quæ et varæ sint et earum phænomenis explicandis sufficiant," and imagining a higher dissociation. It became, however, necessary to see if the others would also be accounted for.

Now if not all but only *some* of the short lines are products of high temperature, we are bound to think that the *others* are remnants of the spectra of those molecular groupings first to disappear on the application of heat.

At any particular heat-level, then, some of the short lines may be due to the vibrations of molecular groupings produced with difficulty by the temperature employed, while others may represent the fading out of the vibrations of other molecular groupings, produced on the first application of the heat.

In the line of reasoning which I advanced a year ago,[2] both these results are anticipated, and are easily explained. Slightly varying Fig. 2 of that paper, we may imagine furnace A to represent the temperature of the jar spark, B that of the Bunsen burner, and C a temperature lower than that of the Bunsen burner (Fig. 1.)

Then in the light of the paper the lines *b* and *c* would be truly produced by the action of the highest temperature, *c* would be short and might be basic, while of the lines *h* and *m*, *m* would be short and could not be basic, because it is a remnant of the spectrum of a lower temperature.

So much then by way of explanation; it is clear that to make this reasoning valid we must show that the spark, or better still the arc, provides us with as ummation of the spectra of various molecular groupings into which *the solid metal which we use as poles* is successively broken up by the action of heat.

We are not limited to solid metals; we may use their salts. In this case it is shown in the paper before referred to[3] that in very many cases the spectrum is one much less rich in lines.

The experimental work has followed two distinct lines. I shall refer somewhat in detail to the results obtained along each. The first relates to the extraordinary and beautiful phenomena and changes observed in the spectra of vapors of the elementary bodies when volatilized at different temperatures in vacuum tubes. Many of the lines thus seen alone and of surpassing brilliancy, are those seen as short and faint in ordinary methods of observation, and the circumstances under which they are seen suggest, if we again apply Newton's rule, that many of them are produced by complex molecules.

In this case the appeal lies to the phenomena produced when organic bodies are distilled at varying temperatures; the simplest bodies in homologous series are those volatilized at the lowest temperatures; so that on subjecting a mixture of two or more liquids to distillation, at the beginning a large proportion of the more volatile body comes over, and so on.

The novelty of the method consists in the use of the luminous electric current as an explorer and not as an agent for the supply of the vapors under examination; that is to say, the vapors are first produced by an external source of heat, and are then rendered luminous by the passage of the current. The length and bore of the tube therefore control the phenomena to a certain extent.

1 Phil. Trans., 1873, p. 254.

1 *Proc. R. S.*, vol. xxviii. p. 159. 2 *Proc. R. S.*, vol. xxviii. p, 162. 3 *Phil. Trans.*, 1873, p. 258.

A form of apparatus which I have found to answer very well is shown in the accompanying woodcut (Fig. 2).

A is the tube or retort containing the metal experimented on in its lower extremity, and having a platinum wire sealed into it at a distance of about two inches from the lower end, the other end being drawn out and connected by a mercury joint to an ordinary Geissler tube, which is connected by another mercury joint to the Sprengel pump C.

Another form of tube which I have used is prepared by inserting two platinum poles into a piece of combustion tubing sealed at one end, and after inserting the metal to be experimented on, drawing out the glass between the platinums to a capillary tube.

I have also tried inserting the platinum pole at the end of the retort, so that the spark passes from the surface of the metal, but this arrangement did not answer at all.

Some other modifications have been tried, but the first form I have described is that which I have found to answer best, so far as the trials have yet gone.

D is the spectroscope.

E is the lens used for focussing the image of the Geissler tube on the slit.

off can be found by examining the spectrum of this capillary tube.

I now give an account of the phenomena observed when we were working with sodium, in order to show the kind of phenomena and the changes observed.

After a vacuum has been obtained the retort is heated gradually. The pump almost immediately stops clicking, and in a short time becomes nearly full of hydrogen. The spectrum of the capillary then shows the hydrogen lines intensely bright. After some time the gas comes off far less freely, and an approach to a vacuum is again obtained. Another phenomenon now begins to show itself : on passing the current a yellow glow is seen, which gradually fills the whole space between the pole in the retort and the metal ; its spectrum consists of the lines of hydrogen and the yellow line of sodium, the red and green line being both absent until the experiment has gone on for some time.

As the distillation goes on, the yellow glow increases in brilliancy, and extends to a greater distance above the pole, and the red and green lines presently make their appearance as very faint lines.

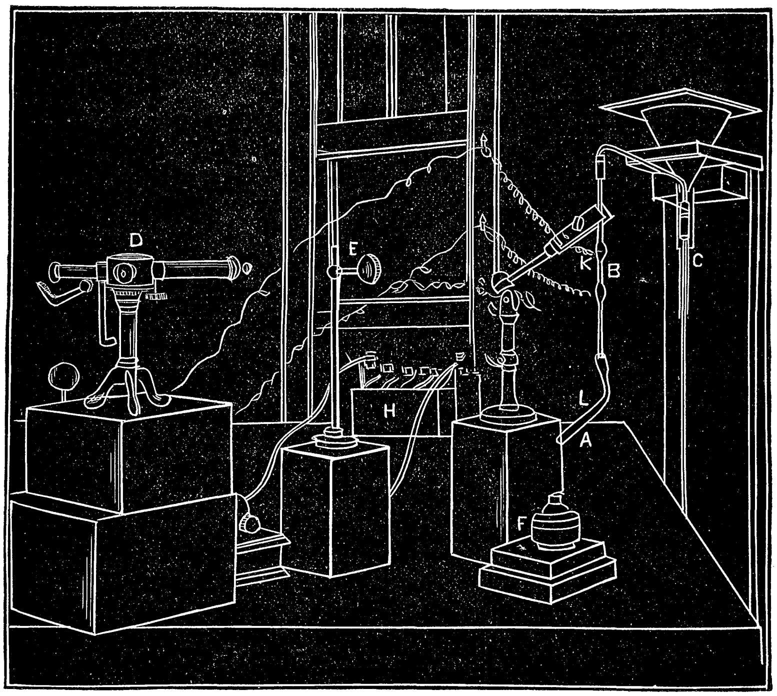

Fig. 2.—Distillation Apparatus.

F is the spirit lamp for heating the retort.

H is the battery.

K and L are the wires connected with the coil.

In the second cut (Fig. 3) the method of observing the spectrum of the vapours close to the surface of the metal is indicated ; the same letters apply, D′ being, however, in this case a direct-vision spectroscope, which was sometimes employed for convenience.

For determining the exact positions of the lines in the spectrum of the vapor in any part of the retort, a larger spectroscope, with its illuminated scale, was used in the place of the direct-vision spectroscope.

The secondary wires of the coil were connected, one with the pole in the upper bulb at B, and the other with the platinum at A.

B is an ordinary Geissler tube with two bulbs separated by a capillary tube. The great advantage of this arrangement is that this capillary portion can be used for ascertaining what gases or vapors are carried over by the pump without any interference with the retort, both wires being connected with the Geissler tube. If, for example, we are working with sodium which contains an impurity of hydrocarbon, the moment at which it begins or ceases to come

The upper boundary of the yellow is quite sharp, the lines and fluted spectrum of hydrogen appearing above it.

After the yellow glow-giving vapor (which does not attack the glass) has been visible for some time, the pump is stopped and the metal *heated more strongly*. On passing the current a little while afterwards, a very brilliant leaf-green vapor is seen underlying the yellow one, and connected with it by a sap-green vapor. The spectra then visible in the tube at the same time are—

Leaf-green ...	Green and red lines of sodium and C of hydrogen ; D absent.
Sap-green ...	Green, red, and yellow sodium lines of equal brilliancy and C of hydrogen.
Yellow	D alone and C.
Bluish-green	C and F and hydrogen structure.

To observe the green sodium line alone it is necessary to point the direct-vision spectroscope just above the surface of the metal where the green is strongest. It is also necessary to guard against internal reflections from the glass, as this may sometimes cause the D line to be seen by reflection from the surface.

This method of inquiry has been tried also with potassium, calcium, and some other metals, and with metallic salts.

With potassium and calcium we get the same inversion of phenomena, the yellow-green lines of potassium being seen without the red; while in the case of calcium the blue line alone was seen.

The fact that in these experiments we get, as before mentioned, vapors which at one and the same time exhibit different colors and different spectra at different levels in the tube, at once suggests the phenomena of fractional distillation.

It is also suggested, as a result of the application of this new method, that in the case of a considerable number of chemical substances not only the line spectrum is compound in its origin, as I suggested many years ago, but that a large number of the lines is due to molecular groupings of considerable complexity, which can be kept out of reaction by careful low temperature distillation.

So much then for one method. Now for the other.

In this I have attempted to gain new evidence in the required direction by adopting a method of work with a spark and a Bunsen flame, which Col. Donnelly suggested I should use with a spark and an electric arc. This consists in volatilizing those substances which give us flame spectra in a Bunsen flame and passing a strong spark through the flame, first during the process of volatilization, and then after the temperature of the flame has produced all the simplification it is capable of producing.

The results have been very striking; the puzzles which a comparison of flame spectra and the Fraunhofer lines has presented us find, I think, a solution; while the genesis of spectrais made much more clear.[1]

[1] I allude more especially to the production of triplets, their change into quartets, and in all probability into flutings, and to the vanishing of flutings into lines, by increasing the rate of dissociation.

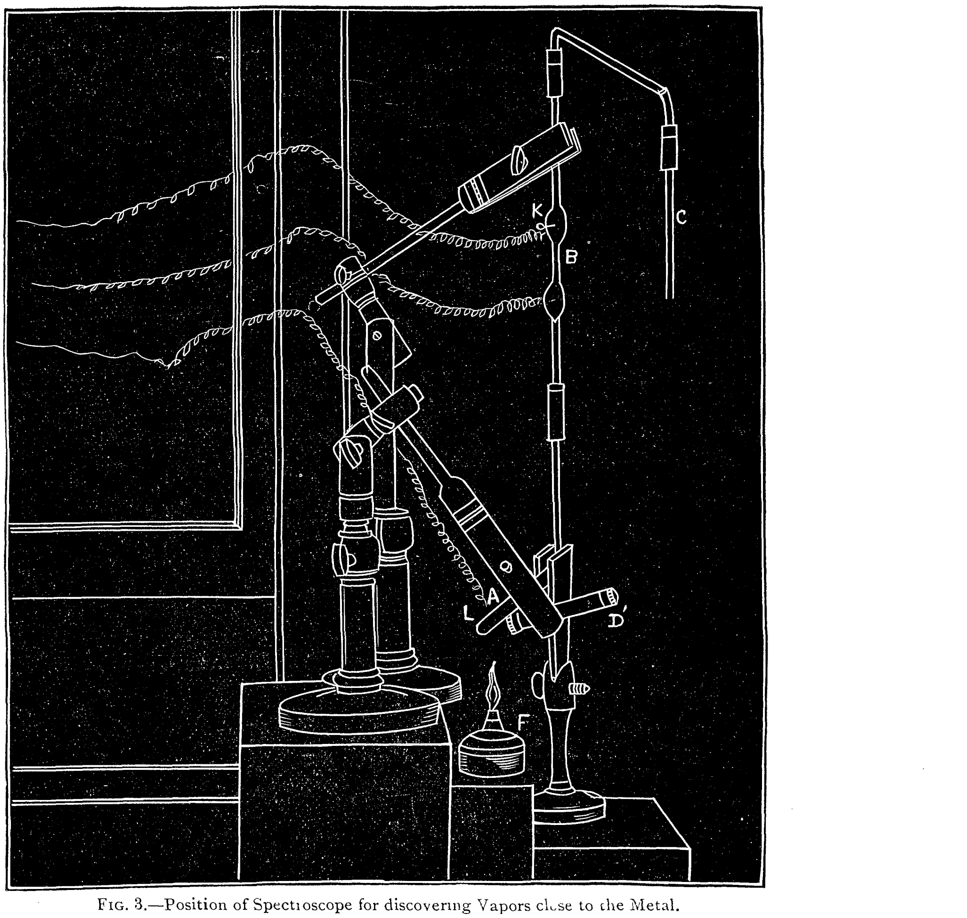

FIG. 3.—Position of Spectroscope for discovering Vapors close to the Metal.

To take an instance, the flame spectrum of sodium gives us, as its brighest, a yellow line, which is also of marked importance in the solar spectrum. The flame spectra of lithium and potassium give us, as their brightest, lines in the red which have not any representatives among the Fraunhofer lines, although other lines seen with higher temperatures are present.

Whence arises this marked difference of behavior? From the similarity of the flame spectrum to that of the sun in one case, and from the dissimilarity in the other, we may imagine that in the former case—that of sodium—we are dealing with a body easily broken up, while lithium and potassium are more resistant; in other words, in the case of sodium, and dealing only with lines recognized generally as sodium lines, the flame has done the work of dissociation as completely as the sun itself. Now it is easy to test this point by the method now under consideration, for if this be so then (1) the chief lines and flutings of sodium should be seen in the flame itself, and (2) the spark should pass through the vapor after complete volatilization has been effected without any visible effect.

Observation and experiment have largely confirmed these predictions. Using two prisms of 60° and a high-power eyepiece to enfeeble the continuous spectrum *of the densest vapor produced at a high temperature*, the green lines, the flutings recorded by Roscoe and Schuster, and another coarser system of flutings, so far as I know not yet described, are beautifully seen. I say largely, and not completely, because the double red line and the lines in the blue have not yet been seen in the flame, either with one, two, or four prisms of 60°, though the lines are seen *during volatilization* if a spark be passed through the flame. Subsequent inquiry may perhaps show that this is due to the sharp boundary of the heated region, and to the fact that lines in question represent the vibrations of molecular groupings more complex than those which give us the yellow and green lines. The visibility of the green lines, *which are short*, in the flame, taken in connection with the fact that they have been seen alone in a vacuum tube, is enough for my present purpose.

With regard to the second point, the passage from the heat-level of the flame to that of the spark after volatilization is complete, produces no visible effect, indicating that in all probability the effects heretofore ascribed to *quantity* have been due to the presence of the molecular groupings of greater complexity. *The more there is to dissociate, the more time is required to run through the series, and the better the first stages are seen.—Nature.* J. NORMAN LOCKYER.

THE RICHMOND DIATOMACEOUS EARTH.

The stratum of fossiliferous earth underlying the cities of Richmond and Petersburg, in Virginia, when first discovered by Prof. Wm. B. Rogers, in 1842, was supposed to be peculiar to those localities; the further investigations of geologists have shown it to be a material constituent in various parts of the great Tertiary formation which bounds the continents of North and South America, and, perhaps, those of the Eastern Hemisphere also. To Mr. Charles Stodder we are indebted for the interesting and suggestive fact, that a stratum of infusorial earth, apparently the same as the Richmond deposit, has been struck at a depth of five hundred feet at Fortress Monroe, in boring an Artesian well.

The deposit at Richmond has long been famous with microgeologists for the great variety of beautiful forms it contains; the illustrious Ehrenberg having assigned to it one hundred and twelve species—nearly double the number to be found at any other place on the Atlantic coast; and the subsequent researches of microscopists have shown it to be perhaps the richest deposit of the kind in the world, every new preparation of the earth revealing some forms not before noticed, many of the most interesting remaining unnamed or described to the present day. The stratum varies in thickness from twenty to forty feet, and Major Bolton, engineer of the Church Hill tunnel, at Richmond (which runs through the deposit for three-fourths of a mile), informed me that at certain points of that excavation it reached a maximum thickness of eighty feet. In addition to an inexhaustible supply of the Diatomaceous earth, that work brought to light thousands of fossil remains of the gigantic marine monsters that, long ages ago, swam in the deep ocean over the spot where the city now stands.

An observation of the sections made by the various water courses which cut through the plateau on which Richmond is built, shows the deposit to be nearly level—its upper surface about fifteen or twenty feet below the top of the ground, and perhaps one hundred feet above tide-water. The Petersburg deposit was regarded by Prof. Tuomey as belonging to a different geologic era from that at Richmond, as evinced by the fact of his finding the casts of Pectens and other Meiocene fossils below that deposit, while at Richmond they are found above. The great difference in the character of the two deposits would also indicate this, the Petersburg Diatoms being generally much more transparent than the Richmond forms, and differing also materially in species. Upon exposure for some time to the weather, this earth assumes an almost snowy whiteness, and crumbles to a fine powder, but as first dug from the depths of the earth it resembles bituminous coal in color and solidity—so tough and hard is it, that in removing it from the tunnel it was blasted with gunpowder just as any other rock. Its composition, as nearly as can be estimated in a general way, is—10 per cent. unbroken forms of the Diatomacæ, 25 per cent. fine white sand, and the balance fine clay, formed, perhaps, mostly of the decomposed and broken Diatoms, the whole mass interspersed with many sponge spicules and a few Polycistena, and so strongly impregnated with alum that many of the wells and springs in Richmond are injured by it. To the microscopist this deposit is a source of unfailing interest, whilst the most inexperienced in such matters, upon being shown the wonderful forms found in it, are struck with surprise and delight. Had the pre-historic man possessed a microscope it might have been supposed that the forms seen in this deposit may have suggested the forms of many of his appliances, as in it may be found models of almost all the implements used by savages, whether for war, the chase, or in domestic life; witness, for instance, his stone hatchets, arrow and spear heads, knotted clubs, boomerangs, &c.; a catalogue of such matters used by civilized people would embrace plates, dishes, cups, saucers, knives, forks, scissors, balls, tops, spectacles, watches, anchors, dumb-bells, cannon, coin, musical notes and many other articles; the investigator being constantly startled by the strange resemblance which hundreds of these ancient natural forms bear to things in every day use. Certain varieties, however, predominate, and their distribution varies with level and locality, the upper portion of the stratum being comparatively poor in forms, while they increase in number and variety as we descend to the lower levels. The genus Coscinodiscus seems to characterize this earth, and of it there are dozens of varieties varying from the (microscopically) enormous C. gigas to the minute and elegant C. stelliges which resembles closely a finely polished opal, requiring a lens of wide aperture and considerable power to show its areolations. Orthosira marina is everywhere abundant, whilst many beautiful forms of Navicula are found in every gathering. Amongst these we may specially note two kinds of Pleurosigma, one of which, P. angulatum, is a favorite test Diatom, and the other, which it is is proposed to call P. Virginica, (as it is the most common form of Pleurosigma in the Virginia earths), is remarkable for the beauty of its contour, which exactly copies a willow leaf, and the want of uniformity in its striæ, which are much coarser in the middle than at the ends of the valves, It can be easily resolved with a good ¼ in. Objective, without the aid of oblique light. The genus Triceratium, is also well represented by many beautiful varieties, the handsomest of which is, perhaps, T. Maylandica, which can be resolved with almost the same ease as P. Virginica, Isthmia enervis, Biddulphia Tuomeyii, Terpsinæ musica, Anlacodiscus crux, Navicula lyra, Gonphonema, Heliopelta, Asterolampra Concinna, Asteromphalus, Brookeii, and Synedra, are more rarely met with.

From the great variety in the markings on these valves, a slide of the earth, properly prepared, becomes one of the best and most interesting tests for the performance of objectives, from the lowest to the highest powers in general use. On some of them, for instance, the areolations may be seen with a simple triplet, whilst on others a first-class objective of wide angular aperture, aided by all the modern refinements of illumination, is needed to show them.

Mr. C. L. Peticolas, of 635 Eighth street, Richmond, Va., has sent us for inspection a few of his recently mounted slides of the Richmond earth, prepared by a new process for separating the Diatoms from the extraneous matter. We have pleasure in stating that these slides show the leading characteristics of this deposit very clearly and beautifully. To those who are studying these forms of fossil diatomaceæ, the slides of Mr. Peticolas will be very acceptable, and they should be added to the cabinet of all who possess a good microscope.

A USEFUL list of the Longicorn beetles, or wood borers, constituting the vast number of insects injurious to our forest, shade, and fruit trees, may be found in the October number of *The American Entomologist*, briefly arranged in the order of their most recent classification.

THERE are two beetles in the United States, both commonly called "*Fire-flies*," which are now known to be luminous in their larval as well as in their perfect state; the one *Photurus Pensylvanica*, De Geer, the other species *Photurus pyralis*, Linn. Both the males and females of these species have wings, and therein they differ from the true Glow Worm of England (*Lampyris noctiluca*), the female of which is wingless and emits a much more brilliant light than does her winged mate.—C. V. Riley.