

A NEW APPLICATION OF SPECTRUM ANALYSIS.

We published some months since a brief notice of a lecture by President Morton on "Fluorescence," in which allusion was made to some very curious discoveries which owe their origin to an application of the spectroscope in connection with that peculiar action of light. This subject, however, possesses so much general interest that we have thought well to prepare, from various papers published by Dr. Morton, an abstract of the most important points. Assuming that, from the lecture above mentioned, our readers have been enlightened as to the meaning of fluorescence, we pass at once to the special application in hand.

As early as 1852, Professor Stokes, the real discoverer of fluorescence, had observed that, when the light emitted by certain fluorescing salts of uranium was examined with a prism, it gave a spectrum consisting of equidistant, brightly colored, shaded bands. He also observed that, in the case of two salts, the nitrate and the acetate, these bands occupied different positions. The spectroscope had not, however, at that time been invented, and no attempt at accurate measurement of these bands was made.

In 1859, the famous French physicist Edmond Becquerel, in the course of his elaborate investigation of phosphorescence, examined in a casual manner, with a spectroscope of simple form, a few of the uranium salts, together with other materials, and he gives two spectra as representing the appearances presented by these, one standing for nitrate of uranium and canary glass, the other for potassio-uranic fluoride, uranic chloride and the mineral uranite. He also figured the fluorescent spectrum of what he describes as "a hydrocarbon of the color of the uranium salts, obtained from Fritsche," who was the first to study anthracene and some of its kindred products.

So matters stood when, more than a year since, President Morton, while engaged in a general study of fluorescent phenomena, received from Professor E. N. Horsford a specimen of the last run of the still in certain petroleum refineries, which was remarkable for its strong fluorescence. A study of this material led to the elimination from it of a crystalline solid body, of a rich yellow color, and possessing the property of fluorescence in a degree quite unparalleled, and showing with the spectroscope a very characteristic spectrum. To this body President Morton has given the name "thallene," in allusion to its brilliant green fluorescence. Observing a striking resemblance between the thallene in a certain stage of its preparation and commercial anthracene, he was led to a similar special study of that body, which resulted in proving, among

tas, columns of rock, and pendent stalactites, and, in the foreground, the lecturer with his electric lantern, from which issues a jet of faint blue light, whose rays fall upon a group of figures bearing banners, whose devices are painted with the new fluorescent bodies, and which, invisible in the ordinary light, blaze out as with colored fires when thus illuminated.

Having seen this substance ourselves, we were not surprised to hear that Professor Tyndall, when he for the first

secured; and they may be briefly described as follows: The *porte lumiere*, A, Fig. 2, being attached to the shutter of a window facing toward the south, a beam of sunlight was thrown by it horizontally into the room, and concentrated by a lens of twelve inch focus placed at B. At C was placed an apparatus (Fig. 3) consisting of a circular horizontal table, adjustable up and down on a vertical rod, and turning with a click. Around the circumference of this table were eight little stalls, capable of holding test tubes or specimen bottles. By this means eight different specimens could be rapidly compared, each in succession, by the action of the click being brought into an identical position with reference to the exciting light and the spectroscope. This whole apparatus was so placed that an image of the sun was formed on the tube or bottle nearest to the lens, B. A glass tank, filled with a strong solution of ammonio cupric sulphate was placed between B and C, and to this was sometimes added a plate of violet glass. The fluorescent light emitted by the substance in C was examined by the spectroscope D.

For examining absorption bands everything else remained the same, except that the spectroscope was turned round into the position indicated at E in Fig. 4, and the stand for specimens was replaced by a plane table, D, on which the substance to be studied was supported, either in a cell of glass or in bottles. To study the optical behaviour of these substances under the influence of heat, a little oven, such as is represented in Fig. 5, was employed. In this, the substance to be examined was either placed in a small bottle, at E, surrounding the bulb of a thermometer, or between flat strips of glass. The openings through the oven were covered by a piece of thin mica kept

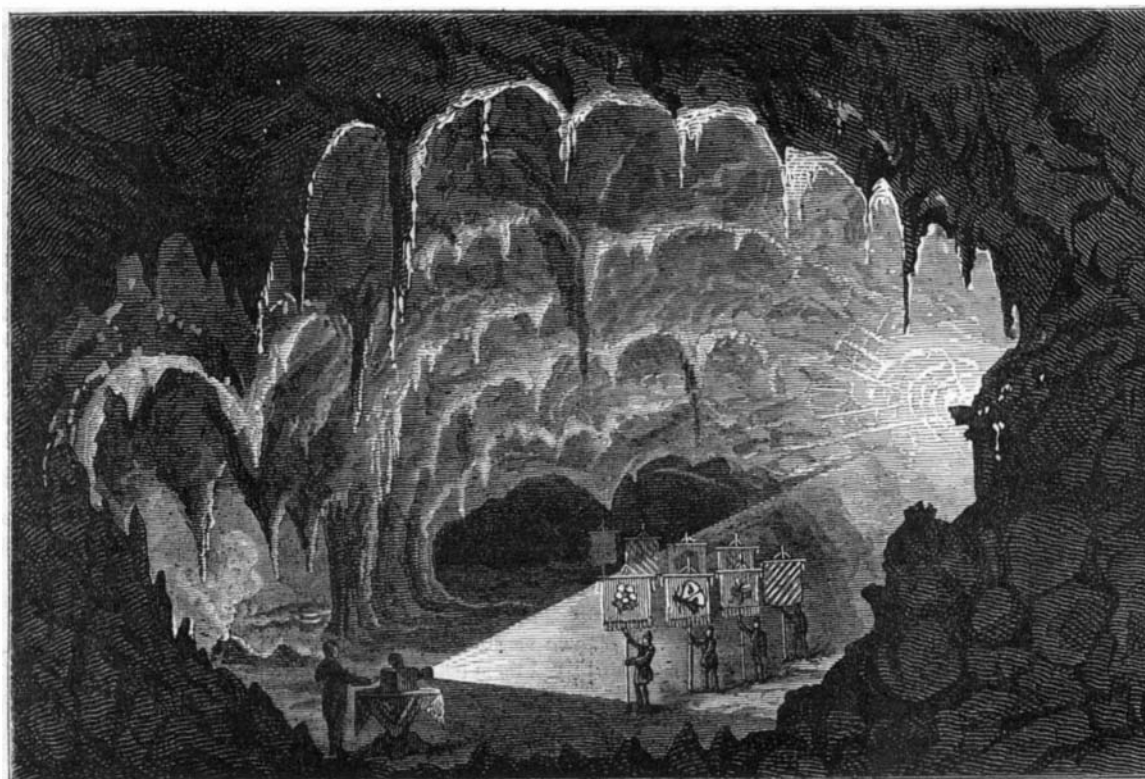


Fig. 1. FLUORESCENCE.—[From a Painting by James Hamilton.]

time witnessed its effect (during one of his own lectures, with a specimen which Dr. Morton had sent him), expressed his surprise and delight in a manner as emphatic as it was unpremeditated.

While work on the abovementioned substances was in pro-

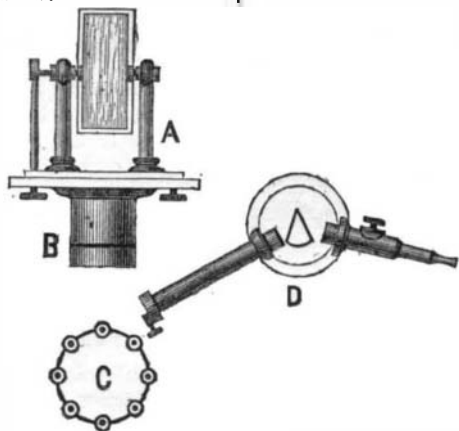


Fig. 2.

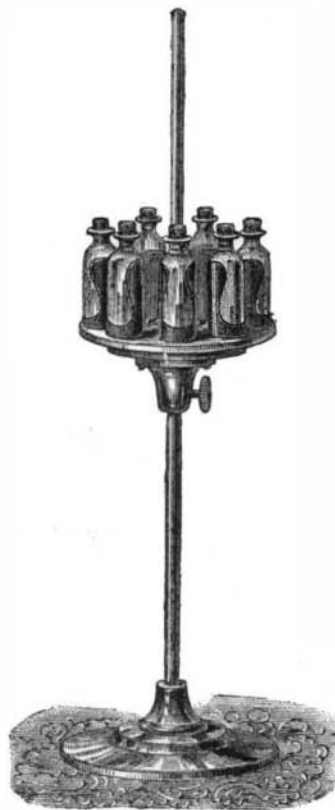


Fig. 3.

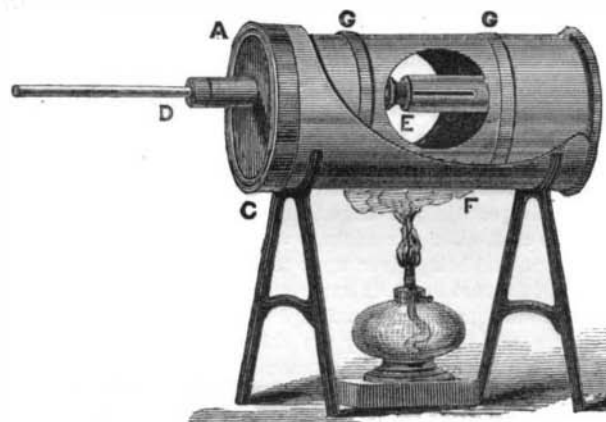
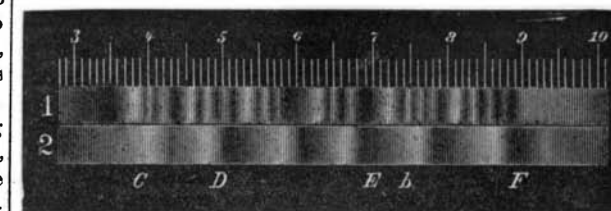


Fig. 5.

in place by the rings, G G.

Many hundreds of specimens of uranium salts, in different states and in solution, have been examined, and numberless experiments on the effects of heat have been made, with the development already of many curious results and the promise of others for the future.

Thus, in the first place, it appeared that while there were certain points of likeness, running through the spectra of many classes of salts, which are useful as a means of recognizing their relation, yet that, either by some obvious peculiarity of character or position, many may be at once recognized and identified, while others, by their various behavior on drying or heating, may be as certainly distinguished. It thus happens that the presence of impurities in some of the commercial uranium salts were recognized and identified without so much as opening the bottles which contained them.



Thus Fig. 6 represents, in 1, the spectrum of the potassio-uranic oxychloride, and, in 2, that of the uranic oxychloride.

In Fig. 7, 1 represents the spectrum of the normal uranic acetate, 2 that of the same salt deprived of its constitutional water, and 3 that of the sodio-uranic acetate.

But what is far more interesting in a scientific point of view, is the fact that a change in composition or the formation of a new compound may thus be optically recognized, and the actual progress or development watched, step by step. This can be best illustrated by a relation of the instance in which this method was first applied.

Having heated for a short time some of the ammonio-sulphate of uranium, Dr. Morton noticed that, in place of its

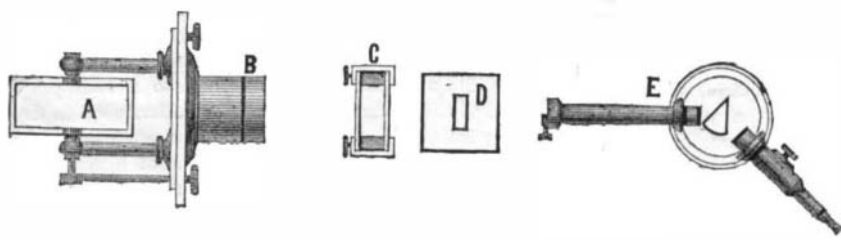


Fig. 4.

other things, that the hydrocarbon described by Becquerel must have been anthracene, but that the spectrum represented by him, and found with all ordinary specimens of anthracene, was due to the presence of a trace of another substance, in all probability identical with that described by Fritsche as chrysofen.

These and other results were mentioned in a paper read before the American Institute, March 29, 1872, and published in their transactions, 1871-2, page 910. After searching in various directions for a further supply of the thallene material, Dr. Morton detected it in some petroleum product brought by Dr. G. F. Barker, from the works of Mr. John Truax, in Pittsburgh; and from the last named gentleman, a large amount was obtained, with which a thorough study of its physical properties has been carried on.

For full details of these we must refer our readers to the *American Chemist* and other purely technical journals.

The wonderfully intense character of fluorescent action in this substance led Dr. Morton to apply it in a very striking manner during a lecture delivered by him in the Academy of Music, of Philadelphia; and, on this occasion, it so impressed Mr. James Hamilton, the eminent artist, that he made it the subject of a large oil painting, from which our artist has developed the accompanying engraving (Fig. 1). Here we see the stage set to represent a cavern with its vis-

gress, Dr. Morton naturally turned to account the same methods of examination with other bodies, and among them to the uranium salts; and in this work he was so fortunate as to secure the co-operation of Dr. H. C. Bolton, an able chemist, who had distinguished himself, among other things, by his investigations upon certain of these very uranium salts. Working together in this research, Dr. Morton conducting the physical and Dr. Bolton the chemical part of the labor, these gentlemen have attained results which promise to be of no little value, both in practical analysis and in the elucidation of obscure theoretical points.

It should be mentioned that, after this work of Drs. Morton and Bolton had made considerable progress, a new research by Becquerel, in the same direction, was published in the *Annales de Chimie et de Physique*. This, however, is so very brief and imperfect, as compared with the work of the abovementioned gentlemen, that, while of course depriving them of any claim to priority in the field, it in no respect detracts from the substantial value and importance of what they have done, which is in only a few points anticipated by anything in Becquerel's memoir.

The methods of observation, employed by Dr. Morton in all these observations, do not differ in any essential particular from those before used by Stokes, Becquerel, and others, but only in perfection of detail, and the accuracy thereby

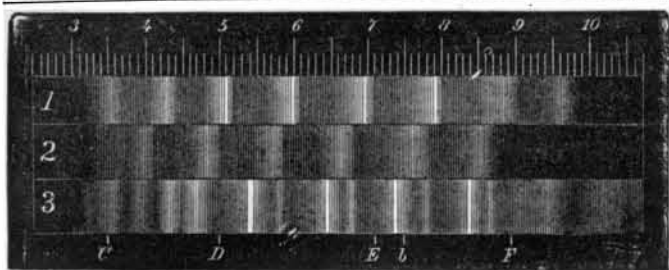


Fig. 7.

usual spectrum, shown at 1 of Fig. 5, it showed, as in 2 of Fig. 8, one in which, to the former bands, were added as many more, each located a little further down in the spectrum than its companion in the original spectrum. Now it was evident that water was being driven off from the salt in the process of heating, and therefore natural to suppose that these new lines belonged to a spectrum of the anhydrous salt which was being formed and mixing with the other. By continuing the heat until no more vapor escaped, the body was found to yield the spectrum shown in 3 of Fig. 6, which was thus probably the spectrum of the anhydrous salt; and, in fact, the salt in this state, being submitted to Dr. Bolton for analysis, proved to be the anhydrous ammonio-sulphate of uranium. But this was not all. On further heating to a

Yet, again in Fig. 11, we have, in 1, the spectrum of the normal potassio-uranic sulphate, and, in 2, that of the same salt in its anhydrous condition.

One of the most remarkable developments, however, is that which has been obtained by a comparison of the absorption bands seen in various salts and their solutions; thus seventeen double acetates have been examined, and a different arrangement of these bands has been discovered in each case; but when they are dissolved in water, all are exactly alike, and are likewise identical with the solution of the simple acetate, thus seeming to prove that no double acetate exists as such in solution, but that all are reduced to the simple salt.

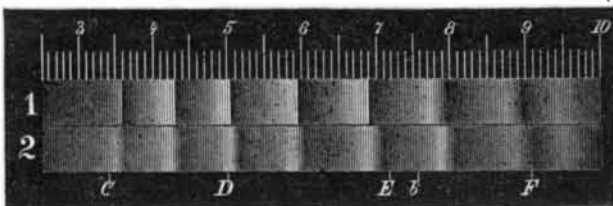


Fig. 11.

In Fig. 12, 1 represents the bands of the solid normal acetate; 2, those of the same salt when anhydrous, and 3,

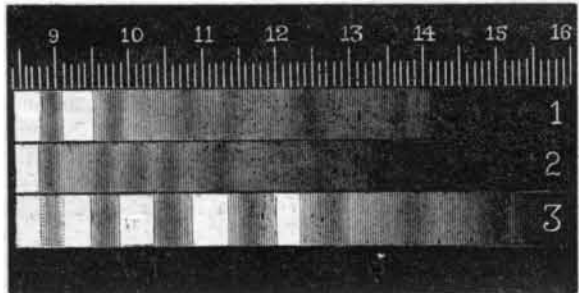


Fig. 12.

those given by a solution of the simple acetate or any of its double salts.

Another very interesting result was obtained in observing the effect of a rise in temperature upon the position of the fluorescent and absorption bands. It was found in a vast number of cases that a rise of temperature lowered the position of the bands both of absorption and fluorescence. When we remember that the heating of a tuning fork lowers its note, and that, wherever bodies change their color by heat without involving some chemical action, the tint is depressed in the spectrum, we see how this observation fits in with general theory.

There were no cases in which the displacement was opposite in direction; the exceptions were simply instances in which no displacement could be detected, and the observations were made as well with solutions as with the solid salts.

Another application of this method was to the determination of the moment at which combination in the case of double salts actually took place; and it was found that in all cases the spectrum of the simple salt changed into that of the double one only in the act of crystallization.

The effects of change of state by freezing solutions, of great pressure; and of solution in various solvents have been extensively studied; and indeed more has been done than we can well afford space to enumerate, and with results which, as we have shown, are already important and promise to be more so.

THE SHOE AND LEATHER CHRONICLE.—The already long list of contemporary journals devoted to special interests has, this week, been increased by the appearance of a well arranged and neatly printed sheet under the above title. The extent and importance of the shoe-making industry is a guaranty for its extended circulation. Mr. W. A. Van Benthuyzen, of 6 Ferry street, New York city, is the editor and proprietor, who will please accept our good wishes for its success.

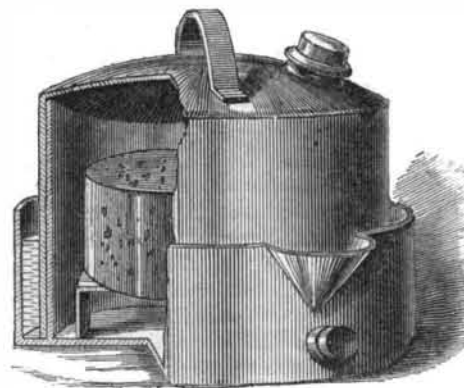
PARAFFIN GAS.—Paraffin oils are now produced at a very low price in Austria and Saxony, from peat. These oils may be used for the manufacture of illuminating gas instead of coal. The gas gives a light three times brighter than coal gas, and the apparatus for making gas from paraffin is simpler and less costly than the coal gas apparatus.

HOW TO MEASURE THE HEIGHT OF TREES.—When a tree stands so that the length of its shadow can be measured, its height may be readily ascertained as follows: Set a stick upright (let it be perpendicular by the plumb line). Measure the length of the shadow of the stick. As the length of its shadow is to the height of the stick, so is the length of the shadow of the tree to its height. For instance: if the stick is four feet above the ground, and its shadow is six feet in length, and the shadow of the tree is ninety feet, the height of the tree will be sixty feet (6:4::90:60). In other words, multiply the length of the shadow of the tree by the height of the stick, and divide by the shadow of the stick.

In the digging of a well at Newark, N. J., the other day, the workmen struck "oil." About two barrels of good oil were pumped the first day. The owner proposes to bore deeper with proper apparatus, in the hope of finding a more abundant supply of the valuable liquid.

CHEESE SKIPPER EXTERMINATOR.

Many and varied are the devices which human ingenuity has provided for the extermination of the "creeping things of the earth." We have set forth at length the lyric effort of the inventor whose muse gushed into poetry on the inspiring theme of mechanical cockroach traps; we have alluded to the "deadly bug buster," by which the offending insects are persuaded into a hopper, placed under the influence of an anæsthetic and stabbed in the back with a pitch-



jork, or else are dosed with large quantities of laughing gas so that they meet a hilarious death in violent hysterics. Brief mention has been made of the tumbler fly trap, in which the hapless fly meets his doom in an alkaline bath; and recently, in glancing over an ancient volume of the *English Mechanic's Magazine*, we discovered a valuable recipe for poisoning bugs by a material "which they will never fail to eat while they can get it, and will as surely die; it causes them to froth at the mouth and to split in the back occasionally."

Another inventor has now joined the great army which is ceaselessly waging war upon the noxious insect tribe, and the offspring of his genius is represented in the accompanying engraving. Its object is the slaughter or, more strictly speaking, the asphyxiation of cheese skippers. The cheese is placed upon a raised grating within a circular box, the bottom of which extends beyond the sides, and is provided with a rim. The intermediate annular space is filled with water. A tightly fitting cover inclosed the entire box, its edge reaching to the bottom of the projecting flange, and is rendered airtight by the water packing. Suitable vents are arranged for obvious purposes. The unhappy mites, thus deprived of fresh air and cut off from the light of day, in the words of the patent, "all leave the cheese and drop down dead." Why they should pursue such a course, or as to the nature of the malady with which they are seized, and which invites the approach of the fell destroyer, our original researches, into the physiological constitution of the cheese skipper, are as yet not sufficiently extended to enable us accurately to determine. Suffice it that, after a period of twenty-four hours, their bodies, once so athletic and active, are senseless clay upon the bottom of the box. Mr. Caleb Green, of Osseo, Mich., patented this useful device on February 4, 1873.

IMPROVED MILK REFRIGERATOR.

This is an English invention, made by Lawrence & Co., London, who say that, by the aid of these refrigerators, the milk intended for transit, or for the making of butter or cheese, may be cooled as soon as it leaves the cow, and before any injurious change can possibly have taken place. It has long been a well known fact that milk is preserved in proportion to the rapidity with which it is cooled. Why this is so has never been satisfactorily explained, but recent scientific investigations have proved beyond a doubt that, when milk is



suddenly cooled, the infusoria or vital organisms, the cause of rapid decomposition, are destroyed, and the milk is consequently preserved, whereas if cooled by slow degrees, living infusoria will still be found in it.

By passing warm water through the refrigerator, instead of cold, the temperature of the milk may be readily raised to any degree required, which, in cold weather, is an advantage in cheese making.

The warm milk is poured into the receiver, A, whence it passes through the refrigerating box, A, in which is a coil of pipes through which cold water enters at D, discharging at E, while the cooled milk is drawn off at C.

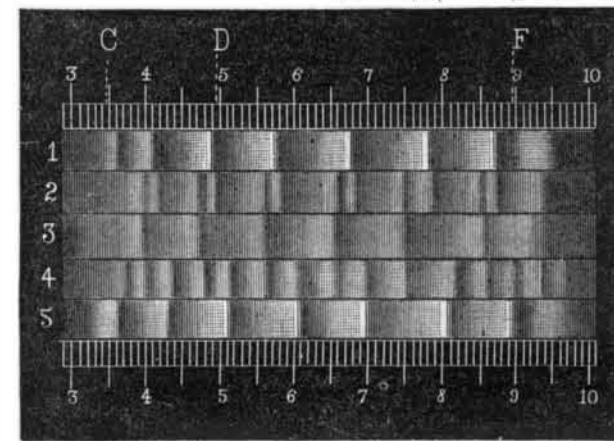


Fig. 8.

temperature approaching redness, the spectrum changed to the appearance shown at 4 of Fig. 6; fumes, evidently consisting of ammonium sulphate, being given off; and on continuing the heat until these fumes were no longer evolved, the spectrum assumed the character shown in 5 of Fig. 6. This material, again being submitted to Dr. Bolton, and analyzed by him, proved to be an ammonio-di-uranic sulphate, a salt not before known to chemistry.

Treatment, more or less parallel to the above, has developed a number of similar facts, and has shown that some of the spectra observed by Becquerel are not those of the salts named, but of mixtures of various hydrates, or even, in some cases, of different salts.

Thus, for example, the annexed engraving (Fig. 9) represents four distinct spectra, shown by perfectly pure sodio-

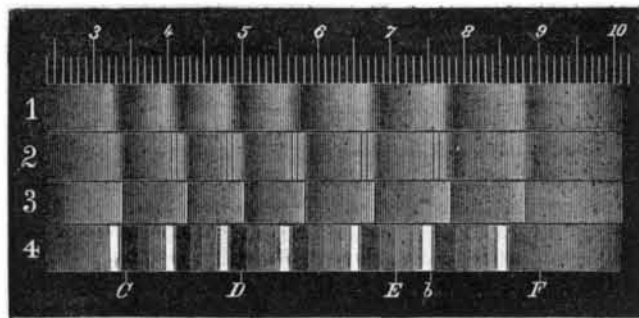


Fig. 9.

uranic sulphate. No. 1 is the spectrum of the normal salt, holding, in combination, five equivalents of water; 2 represents a mixture which was one of the first observed, and caused no little perplexity; it is now known, however, to owe its complex character to the overlapping spectra of several different hydrates. No. 3 is the spectrum of the mono-hydrated salt, or that containing only one equivalent of water; 4 is the spectrum of the anhydrous salt, or that from which all the water has been expelled.

Again, in Fig. 10, we have, in 1, the spectrum of the nor-

mal uranic sulphate which contains three equivalents of water; in 2, that of the mono-hydrate, while 3 is that of a mixture of the mono- and bi-hydrate into which the normal salt is apt to pass if suddenly heated, placed in a vacuum, or treated in several other ways.

Fig. 10.