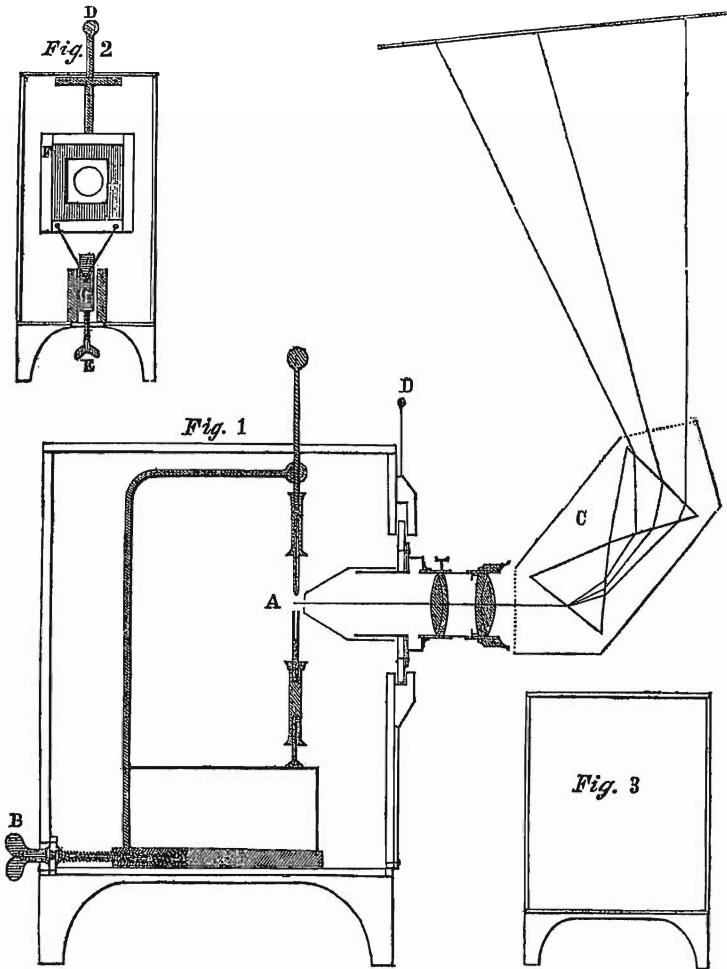


ART. XXVI.—*On the Projection of the Spectra of the Metals*; by
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SPECTRUM analysis has become, in all its bearings, a subject of so much importance both in chemistry and physics, that a simple and efficient method of exhibiting the phenomena to an audience is an important need to all teachers of physical science. Having tried several plans without obtaining the definiteness or brilliancy required, I finally devised the following, which has been completely successful. By placing my lantern at the distance of from 50 to 60 feet from the curtain, I obtain a spectrum from 20 to 25 feet in length and about 18 inches in breadth, with all the brilliancy that can be desired and without any diffused light, which greatly impairs the beauty and distinctness of

the phenomena as they have been hitherto exhibited. My apparatus may be best described under three heads: First, the electric regulator; secondly, the lantern with the adjustable slit and lenses; and, lastly, the prisms for dispersing the light.

The light is obtained by means of a powerful galvanic battery. I have found that fifty Bunsen cells of medium size (about 7 inches high) were quite sufficient. The metal whose spectrum is required, is volatilized in the voltaic arc and almost



any of the numerous electric regulators may be used for the experiment. I used for a long time a Deleuil regulator, and in fig. 1 a section is shown of this regulator in connection with the

rest of the apparatus. I now use, however, a regulator better adapted to the purpose, made by J. Duboscq, of Paris. The negative pole, which is the lowest, is formed of a small cylinder of hard coke, having a small cavity at the top to receive the metal. The positive pole is formed of a coke pencil such as is used in most electric lamps. The poles are so arranged that they can be raised or lowered at will, and the milled heads, which regulate the motion, are placed for convenience at the base of the instrument. The coke cylinder forming the negative pole is fastened to the rim of a circular brass disk, which also supports four other similar cylinders. So that, by turning the disk, one after the other may be brought under the positive pole, and different metals volatilized in the voltaic arc without further adjustment.

The electric regulator is placed within a dark lantern, as shown in fig. 1, resting on a movable platform, which can be moved backward or forward by the screw B. The lantern is made of wood like a square box, see figs. 1, 2 and 3, with doors on two opposite sides as large as the box will permit. The upper part of each door is made of wood and hung on hinges in the usual way; but from this is suspended a thick cloth curtain, which, while covering the lower part of the doorway, enables the experimenter to adjust the poles without opening the lantern. The wooden doors, moreover, are glazed with very deeply colored glass in double plates of blue over red through which the experimenter can see the carbon poles when ignited by the galvanic current.

The electric regulator is placed in the lantern so that the carbon poles shall be directly behind and within half an inch of an adjustable slit, which should be about half an inch high and $\frac{1}{16}$ th to $\frac{1}{8}$ th of an inch wide. This slit forms a part of a brass cap which slides on one end of a brass tube, while into the other end is screwed a camera tube such as is used by photographers for taking portraits. The lenses of the combination which I use are three inches in diameter, and the focal length is about $5\frac{1}{2}$ inches. This size cannot be advantageously exceeded, but the shorter the focal length of the combination the better. The slit is placed at the focus of the combination, and the position of the lenses with reference to the slit is adjusted by means of the rack and pinion usually attached to camera tubes. The brass tube with the slit and lenses just described is fastened to a thin board, which slips into a movable wooden frame on the front of the lantern, (see fig. 2), a portion of the tube with the slit projecting into the box, as shown in fig. 1. The object of the movable frame is to adjust rapidly the position of the slit with reference to the voltaic arc, so as to keep the slit constantly in front of the luminous flame, which, as is well known, shifts its

position from one side to the other of the carbon poles in a most irregular manner. The means of adjustment just referred to are shown in fig. 2.

The frame F is connected by iron bars with a pivot which turns in the wooden block G. Moreover, to the top of the frame there is attached a flat iron bar, which ends in the handle D, a stout steel spring attached to the front of the box serving to keep the bar in place although permitting a slight lateral motion. By moving then the handle D the slit with the lenses may be moved to one side or the other, as the position of the flame may require. Finally, the bar G slides between two grooved wooden bars, and may be moved by the screw E. Thus the frame may be raised or lowered, and the slit kept constantly midway between the carbon poles.

It remains now to describe the prisms, by which the light is dispersed. I use for the purpose two large sulphid of carbon prisms having a refractory angle of 60° . They were made from a large and thick glass tube three inches in diameter, with faces of ordinary plate glass cemented to the cells with a mixture of glue and molasses. They are securely fastened in a wooden box, which is made of such a shape that when the light passes at the angle of least deviation the rays will enter the box perpendicular to one side, and will leave it perpendicular to another. The box is closed except at the two ends, in which circular apertures are made three inches in diameter, and these can be closed with covers when the prisms are not in use. A section of the box and prisms is shown at C, fig. 1. It is here drawn on the same plane as the section of the lantern, but when in use it is at right angles to this plane.

Having a knowledge of the various parts of the apparatus, the method of using it can be readily understood. The lantern having been placed on an elevating stand with a revolving table¹ at a distance of 50 or 60 feet from a curtain or white wall, the prism box is placed at one side on a similar table, and adjusted so that, while the axis of one of the circular openings is perpendicular, or nearly so, to the screen, the axis of the other opening will coincide with the axis of the lenses when the lantern is turned on the revolving table through the required angle; see fig. 1. The lantern being now directed to the screen, the electric regulator having been adjusted so that the point of contact of the carbon poles is in the axis of the lenses and about two inches behind the slit, and the galvanic circuit having been closed so as to produce the electric light, the focal distance of the lenses is so adjusted as to form a distinct image of the slit on the screen. We then turn the lantern on the re-

¹ The stands used by photographers are well adapted for the purpose.

volving table so that the light shall pass through the prism, and we have at once the projection of the spectrum in all its beauty over 20 feet in length and 18 inches or more in breadth. To produce now the spectrum of a metal we first separate the poles, and then bring them, by the aid of the screw B, within half an inch of the slit. Having now placed a small piece of the metal selected for the experiment in the cavity of the coke-cylinder, we again bring the poles in contact and slowly separate them as the heat increases, until the light emitted by the ignited carbon is wholly intercepted by the edges of the slit and the lenses are illuminated only by the ignited vapor between the poles. We then have the spectrum of the metal, which continues in perfect purity so long as the space between the poles remains filled with the metallic vapor. When, however, the supply diminishes, either in consequence of the consumption of the metal, or on account of the failing strength of the battery, the bright bands, which distinguish the elements of the air, will appear at the same time with those of the metal. The metals which I have found best adapted to these experiments, are copper, zinc, brass (which gives the bands of copper and zinc together), mercury, thallium, sodium, lithium, potassium, cadmium, antimony, lead, gold and silver; and of these the first seven give the most characteristic and brilliant results. I use them all in the metallic state with the exception of lithium, which I use as carbonate, moistening the salt before placing it on the pole. It is important to have a separate coke cylinder for each metal, as otherwise, unless the cavity is most carefully cleaned out between the experiments—and for this there generally is no time—the spectra will be confused by the reappearance of the bands of the metals previously used.

These experiments can be varied by projecting on the screen the image of the carbon poles with the stream of glowing vapor between them, and thus showing the color of the light before it is decomposed; and for this purpose it is only necessary to direct the lenses to the screen, and, having removed the brass cap, which carries the slit, to re-adjust the focal distance of the lenses.

The reversal of the sodium band can also be readily shown. For this purpose we arrange the apparatus so as to produce a continuous spectrum, as first described. We then interpose between the poles and the slit the flame of a Bunsen lamp, and in this flame we insert a small spoon containing metallic sodium. A dark line soon appears crossing the yellow portion of the spectrum in the position of the sodium band. It is convenient to have a small shelf in the box, to support the lamp, so hung on hinges that it will drop out of the way when its support is removed.

Again, the formation of dark lines crossing the spectrum, similar in appearance to the solar lines, can be shown by interposing between the lenses and the prism a vessel with parallel glass sides containing hyponitric acid or iodine vapor. Such a vessel is easily made from a piece of glass tubing—three inches in diameter and four inches long—by cementing plates of glass to the open ends and drilling a hole through the sides, into which a glass stopper may be fitted.

Finally the apparatus may be with a little additional expense so constructed that it can also be used for projecting photographic transparencies after the principle of the magic lantern. Small photographs on glass may thus be used in place of diagrams and the great geological features of our globe, the glaciers for example, may in this way be brought before the eyes of an audience with almost all the vividness of the reality. The same method of illustration will be found of great value in teaching other sciences. For instance, the best way of giving an idea of the dark lines of the solar spectrum is to take a photograph of the more refrangible portion and project the image on the wall. Such photographic transparencies are easily made; but as few teachers have the means or time for such work, it would be well if some professional photographer would turn his attention to this department of his art. If the instrument here described is to be used as a magic lantern it is necessary to have, besides the regulator above described, a second adapted for giving continuous light. We have used for some time the regulator now made by J. Duboscq of Paris, after the plan of Foucault, and we find that it works very well.

Most of the apparatus here described is so simple that it can be made by any good mechanic and for this reason we have entered into more detail than would otherwise be necessary. The lenses and other accessories must of course be purchased. The apparatus can also be ordered from E. S. Ritchie & Co. of Boston.

Cambridge, August 8th, 1865.