THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

BY HENRY MORTON, PH.D.

Any expert in the general use of the magic lantern, or, as we say now-a days, in "methods of projection," who attended Professor Tyndall's lectures last winter must have been struck by several things; in the first place, by the admirable management and efficiency of the electric light. This was largely due to the form of the galvanic battery employed, not to neglect, of course, the Foucault regulators and the still more important control of Mr. Cottrell and the Professor. This battery is made by Mr. Ladd, of London, and is remarkable in the first place for its compactness, which not only adapts it for transportation but greatly facilitates its handling when it is to be set up and dismounted. It involves nothing new in principle, being made up of the simple Grove elements of zinc and platinum; but to secure compactness, the cells are of a rectangular and flat shape, by which, not only are they made to pack well but, the elements being brought near each other, the internal resistance is reduced, and the efficiency thus increased. Forty of these cells will produce an excellent electric light, and Professor Tyndall never used more than fifty in one circuit. He sometimes had one hundred in use, but then one set of fifty produced one light (as, for example, in some of the dark heat experiments), while another set illuminated the galvanometer.

In justice to our readers, we must not neglect a warning. If they purchase any of these cells from Mr. Ladd, we would advise them to employ some one else to pack them. Many hundreds have been imported already, and have invariably been so packed as to secure the destruction of a large part. Out of sixty, the present writer received but forty sound ones, and the experience of Professor Wright, at Yale, and Professor Farrar, at Vassar, is identical. The method of packing is, in fact, such as to suggest the idea that the destruction of the articles was intended, the only other solution we can suggest being mental aberration on the part of the packer.

The second notable point in connection with Professor Tyndall's projections was the great beauty of those involving the use of small pencils of parallel rays, such as the production of Lissajous' figures with tuning forks, some experiments in diffraction, and the like.

Lastly, came a surprise that, with such unusual success in these difficult directions, those projections, which resembled in character the ordinary work of a magic lantern when throwing a picture, were decidedly inferior to what is generally accomplished with a lime light. The reason of all this will be at once clear, if we understand something about the action of a magic lantern, which does not seem as yet to have found its way into published accounts of that instrument.

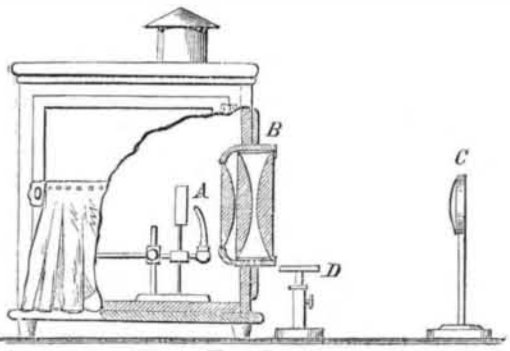


FIG. 1.

A magic lantern consists essentially of a box to inclose the source of light, say a lime light, as at A, a series of lenses called the condenser, whose office is first to collect the scattering rays, from A, that fall upon it and bring them into a common direction, and, secondly, to so converge or condense them as to make them all enter the object glass or objective, C.

In order that each of these conditions should be fulfilled in turn, it is evident that it would be desirable, in the first place, that some part of the condenser, B, say the first two lenses, should throw out, in parallel lines towards C, all the rays which fall on them from A. If the light all came from a single point, and the lenses were theoretically perfect, it would only be necessary to bring that point to a certain place, called the principal focus of the lens or lenses, to secure this object. For a single lens this point is found as follows: If the lens be plane on one side, the principal focus is at the extremity of a diameter of the curved surface drawn through the center of the lens. Thus, in Fig. 2, A B being a lens of ordinary glass, D would be its principal focus. If both surfaces are curved, we find the distance of the principal focus from the optical center of the lens by dividing twice the product of the radii of the curves by the sum of these radii minus the thickness of the lens. We give these simple examples merely as illustrations, and would refer our readers for full and exact statements to such works as Brewster's "Optics," Monkhoven's "Photographic Optics," Daguin's "*Traité de Physique,*" Young's "Natural Philosophy," and other similar books.

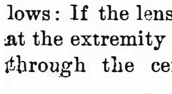


FIG. 2.

This all assumes a theoretical perfection or uniformity in the action of the various parts of the lens. In fact, however, the necessities of workmanship compel the use of spherical curves in lenses; and these occasion a greater relative action on the rays passing through the edges than on those traversing the center of the lens. As a result of this, it follows that, if the source of light were placed at the true focus for the central rays, those which passed from it through the margin of the lens would not only be bent enough to bring them parallel, but would also be converged so as to cross at some distant point, and thence proceed in a continually expanding circle of diffusion. Omitting the detailed discussion of this action, we may say that, as the result of calculation and experiment, with a certain combination (to be presently described) in which the difference of the central and marginal foci is about 0·1 of an inch, this circle of diffusion would be about 1 foot in diameter at the distance of 25 feet. Such, then, would be the error due to the spherical aberration of the lens alone, if the light came from a single point. In practice, however, the light comes from a surface of considerable magnitude which, in the lime light, for example, is not generally less than half an inch in diameter. Now we have already seen that a luminous point, located at E, Fig. 3, in the center line or axis of the lens, would produce a parallel beam, B H, A I, whose direction would be the same as that of the axis, or C F. But a further consideration of the general action of lenses teaches us that any luminous point, D, not in the axis of the lens, would produce a beam whose direction would coincide with that of the secondary axis (such as D C G), drawn from the said point through the optical center of the lens. Now, from the similar triangles, D E C and C F G, we see that EC: CF:: DE: FG; or, considering E C the focus of the lens or combination, to be 3 inches, C F, the distance to a screen, to be 25 feet, and D E, the radius of the luminous surface, to be ¼ inch, we have 3 inches, or ¼ foot: 25 feet or $\frac{100}{4}$ feet :: ¼ inch : $\frac{100}{4}$ inches, or 25 inches = FG. Now, it is evident that, to this, we must add the distance, G K, which is half the diameter of the lens. Let this be 2·5 inches, 5 inches being the usual diameter of condensers, then FK = 27½ inches. But F K, evidently, represents only the radius of the circle of light on the screen, and its diameter, or 2FK = 55 inches = 4 feet 7 inches.

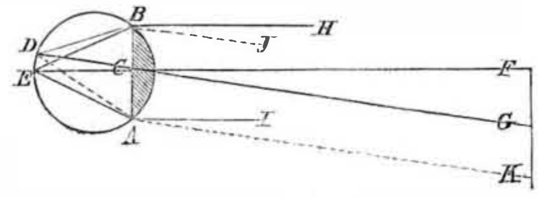


FIG. 3.

It thus appears that, with this form of condenser, the scattering of light due to the magnitude of the luminous source is more than four times as great as that caused by the aberration of the lenses, and that a lens with very much greater spherical error would work as well, practically, with such a source of light as an absolutely correct one, since the scattering produced by the magnitude of the source of light would outreach any which the lens would occasion.

This teaches us the value of such a source as the electric light, in all experiments where a parallel beam is needed, and the uselessness of any special correction of error in lenses to be used with a source of light of larger size. It may, however, naturally be asked if corrected condensers (corrected for spherical aberration) would not be of great value with an electric light. In certain cases they undoubtedly would, but in all the experiments to which allusion has been made so far, as requiring parallel rays, very small pencils of light only are used; and these being obtained by covering the condenser by a plate of brass pierced with a small hole (called technically a diaphragm or stop), the error of the lens, as affecting the small transmitted pencil, is reduced to that of a lens equal in size to the opening. This renders it quite insignificant. In fact the apparatus for projection used by Professor Tyndall, which was simply that made by Duboscq, of Paris, for the last fifty years, and a complete set of which was purchased by the Stevens Institute of Technology (in the Bancker collection) and may be seen in their optical cabinet, consists of the simplest possible combination of lenses, with no attempt at correction in this relation. Indeed, the spherical error in this apparatus is so great that, when the entire lens is used, it becomes, in its turn, a more serious element than the magnitude of the source of light.

Though what we have so far stated is far from covering the entire ground, or alluding to all the points involved, it will suffice to show, in some measure, what are the real advantages of the electric light, to what class of experiments it is essential, and in what direction it is worth while to work in improving the instrument which we are considering.

Were the electric light as convenient, economical, and regular in its action as the lime light, our methods of projection would be largely modified, for we would then adapt every thing to its essential conditions: but, notwithstanding all the improvements in batteries and regulators which have been recently made, the electric light is a costly, troublesome, and irregular source of illumination for such purposes as we are considering; and it should therefore be confined to those experiments only in which its defects are least apparent, and for which it possesses some special advantage. In all others the lime or oxyhydrogen light is greatly to be preferred, and for this our instruments should, as a rule, be adapted. It is in this light we shall consider the subject.

THE SOURCE OF LIGHT.

This we know is a piece of lime intensely heated by a jet of burning hydrogen mingled or supplied with oxygen. In place of hydrogen, it is very common to use the ordinary illuminating gas or mixture of light and heavy carbureted hydrogen. As regards the production of light, we do not think that there is any choice between hydrogen and illuminating gas, but would be guided in all cases simply by the question of convenience. The jet from which the gases are burned is a matter of some importance.

THE JET.

The simplest form to which this can be reduced we believe to be the best. This is what has been described as the diaphragm jet, and consists of a tube of copper, straight or slightly tapered, decidedly larger than the outlet in its end by which the gases escape. This outlet should be simply a smooth hole in a diaphragm or wall, and is easily made by hammering in the end of a soft copper tube and then boring a hole through it (Fig. 4). Into the lower part of this tube the two gases should enter freely, by different openings, as shown in Fig. 4, and no wire gauze or other so-called protection should be admitted above this point. Such a jet gives the most light with the least gas, and is less likely to retreat or snap than any other. Having used this for years I have almost forgotten what snapping is. The concentric jet, in which the gases mix only as they burn, is very inferior in economy to this, and on the other hand all mixing chambers and the like are simply useless.

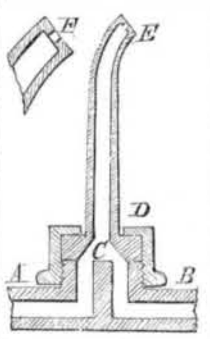


FIG. 4.

THE CONDENSER.

As we have already remarked, this portion of the apparatus may be theoretically divided into two parts, one collecting the rays and rendering them parallel, the other concentrating or condensing them so that they shall enter the object glass. This division is, however, not only convenient for the theoretical discussion of the subject, but, as we shall see, is of great convenience if practically realized.

A very excellent combination was developed and used many years since by Dr. Charles Cresson, of Philadelphia. Its collecting portion consisted of three lenses (see the engraving, Fig. 5), of which the first was a plano-convex, the second a meniscus, and the third a bi-convex lens. The surfaces of these were as follows: 1st, plane; 2d, 4·5 inches radius; 3d, 30 inches radius; 4th, 6 inches radius; 5th, 52 inches radius; 6th, 8·75 inches radius. The first lens is 4 inches, and the others are 4·5 inches in diameter. To complete this combination a lens of 12 or 15 inches focus was added at G H, according to the work to be done. The error of this combination is very small; in fact, the three first lenses do not show a difference in focus, for rays near the center and near the margin, of more than one tenth of an inch. It will be seen, from what has been already stated, that the correction of this combination has been carried far beyond what is available with a source of light half an inch in diameter. But where, as in a class room, a small jet and, consequently, a small ignited surface of lime can be used, and well concentrated or parallel rays are required, as in experiments in polarized light, this is a most satisfactory instrument.

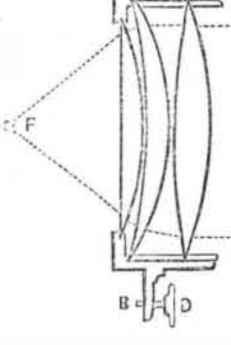


FIG. 5.

After a dozen years' constant experience with this and others, and with five other lanterns of the best forms at my command, I always experience a sense of satisfaction in the use of this instrument. The focus, F, is about three inches from the rear of the first lens, and thus the rays entering it are those included in a cone of about 65°. It is evident that, if the focus were nearer, a larger cone of rays would be received and rendered available by the lens, and thus a brighter illumination of the screen would be secured. To meet this requirement, I made, many years since, the following combination, which has proved in practice very efficient. All the lenses here used are plano-convex, and have for their curved surfaces the following radii: First, 18 inches; second, 14 inches; third, 16 inches. The first lens is 4½ inches in diameter, and the other two are 5 inches. The focus is about 2 inches from the rear surface of the first lens, and thus the light which it receives is that included in a cone of 95°, or about twice as great as that entering the former combination. Its correction for spherical aberration is, however, far less perfect, but is quite good enough for a powerful lime light, that is, one in which the jet is large, and therefore the ignited surface of lime considerable in area.

I have experimented with condensers of even shorter focus, and having the light, therefore, yet nearer to the lens. Thus, one in which three plano-convex lenses were used as before, with their curved surfaces of the following radii gave very excellent effects for ordinary picture projections: Radius of first lens, 3½ inches; of second lens, 3¾ inches, and of third, 4½ inches. The focus here was only about one and one half inches from the first lens; and, as a result, it was impossible to protect this lens from the intense heat. A glass plate could, of course, be interposed, but then this was, in its turn, constantly breaking, to the interruption of the experiment and the annoyance of the operator. After a faithful trial, I have abandoned this combination in favor of the one previously mentioned.

In both of these last combinations, the first two lenses had their plane surfaces turned towards the light and were permanently attached to the box of the lantern. The third had its curved side towards the light, and was so attached as to be easily removed. The first two lenses, acting alone, gave an approximately parallel bundle of rays, the third serving to converge these at its focus, which was, of course, 8 or 9 inches in front. The question is often asked: Could we not, by using very large condensers, obtain such an increase of light that an ordinary lamp or the like would serve in place of the intenser forms of illuminator? The reply to this involves several points. In the first place, unless the glass is specially ordered, it cannot be obtained much more than one and a quarter inches thick; from this, if we make large lenses, they will be of proportionally long focus, and so the light will be further off. To take an example, I have a set of condensers, 8 inches in diameter, consisting of three lenses made as thick and, consequently, of as short focus as the ordinary glass would allow. The curves are as follows, all the lenses being bi-convex:

1st surface	10	inches radius	7 inches diameter.
2d "	7	" "	
3d "	50	" "	8 inches diameter.
4th "	10	" "	
5th "	10	" "	
6th "	50	" "	

The focus is here about 4 inches from the first lens; and thus the amount of light transmitted is no greater than with the 5 inch combination whose focus was 2 inches from the first lens. Such a set of condensers is of great value in certain cases from its enabling us to employ large objects; but it requires as powerful a source of light as the smaller one to obtain with it an equal effect..

In the next place, however, let us suppose that, without regard to cost, we obtained a large lens of short focus. Then all the errors would be greatly increased, and a heavy loss of light would be experienced, by reflection at the surfaces on which the light would fall at angles unfavorable for transmission. Another yet more serious difficulty arises from the fact that all these less brilliant sources of light have a very large area, and this, with the error of the lenses, causes such a scattering of the light that much is lost before it can reach the objective. There are other drawbacks to the use of large condensers which will be noticed further on, and on the whole we find that such a plan as that above suggested is quite impracticable.

Correspondence.

Property in Inventions.

To the Editor of the Scientific American:

In giving your views, suggested by the inquiries of Secretary Fish, in answer to his first interrogatory, you say: "A patent is a private monopoly, an infringement of equal rights, and therefore untenable on the ground of justice;" and again: "Every man in every community is bound by the strongest natural obligations freely to contribute his best powers of mind and body to promote the common welfare." As an abstract view, of rights and duties, this is possibly correct; as a practical view, of society as it is, it is rank heresy. For the inventor has no more obligation to give the public the fruit of his labors, invention, than the capitalist has to give the public the fruit of his labor, money.

A and B start in life, each with about the same amount of education, with correct habits, and each with $1,000 capital. A devotes himself to some useful and honorable calling, and by industry and economy, has at the end of five years increased his capital to $10,000. B devotes himself to the invention of some new and useful machine; at the end of five years, he has perfected his invention and procured a patent therefor; but he has expended his $1,000, and all he has found time to earn besides. You can from your observation in life continue the comparison, between A, respected, honored, courted, and B, out at elbows, out of friends, and very likely condemned by his frugal, industrious neighbors. Now, read this, and then tell us that the law protecting the inventor in the fruit of his labors is tyranny and an infringement of equal rights.

There may be a case where a man has blundered on an invention worth $100,000; there may also be a case where a man has blundered on an oil well, which he sells for $100,000; yet the latter is protected in his find for all time, or until he uses it up; while the former has, as a favor, the protection of the Government for a few years, if he pays a special fee for it.

Prescott, Kan. L. G. Jeffers.

Deep Sea Soundings.

To the Editor of the Scientific American:

I am a constant reader of the Scientific American, and have been very much interested during the past three or four months with the articles written on the above subject. The following objections appeared to me to belong to all the methods proposed:

1. Sinking a vessel filled with air of atmospheric pressure, thereby requiring a vessel of great strength and lightness, as well as great weights of iron or sand, which would make the whole thing clumsy, and cause it to require too much space in the ship.

2. The whole contrivance for sinking is lost at each observation.

3. The difficulty of ascertaining where the apparatus is floating after it has reached the surface. A flag, smoke or flame, might answer, provided that there was no drift and the sea was without a ripple. The stick leaping out of the water would be something like the

"Borealis rays,
Which flit ere you can mark the place."

In order to overcome these objections, I propose constructing a small vessel with two empty gas bags attached, one of them only being required, when inflated, to support the apparatus in the water and the other arranged so that, by the expansion of the hydrogen with which it would be filled, it would disengage itself from the vessel until it reached the length of a cord, say, twenty or thirty feet long; this bag would be constructed of light material so that, when it reached the surface, it would continue to ascend in the atmosphere; thus one bag would float the apparatus, and the other would be a balloon floating twenty or thirty feet directly over the spot where the whole could be found. I would arrange the vessel so that gas would be generated directly it touched the bottom, and, of course, at the pressure to be found at that depth.

I would accomplish this by either of the two following methods: 1. By an arrangement of cells to form a battery sufficiently powerful to decompose water, so that acidulated water with platinum terminals could go down in the vessel, which, upon contact with the bottom, could be made to connect with the battery, and so we should have oxygen in one bag and hydrogen in the other. 2. By filling the vessel with dilute sulphuric acid and granules of zinc, so arranged that, upon contact with the bottom, they could be let fall into the fluid, when hydrogen would be formed, to inflate both bags alike. The heat generated by this process might also be economized by using it to raise the temperature of the gas.

You will see that I have only described the vehicle which would convey the apparatus to the bottom and back; of course a registering apparatus would have to be attached. I will not trespass further upon your space by describing that part of the subject; but taking advantage of hints thrown out, time after time, in your valuable paper, I do not doubt accomplishing the following results: 1. Registering the temperature of the ocean at specified depths. 2. Registering the depth and dredging the ocean bottom.

Be ore venturing so far as to rush into print on this subject, I decided upon asking the opinion of my esteemed friend, Professor John Tyndall, and the following is a copy of his reply:

My Dear Sir:—Your idea appears to me to be a very ingenious one. I can say no more, as my thoughts have never been turned to this subject. Faithfully yours,

July 27. John Tyndall.

I trust that something will be found effective in this important matter. W. Walton,

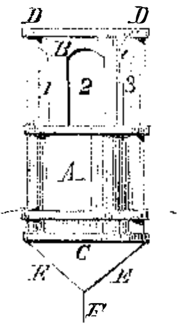
late of the Science and Art Department, South Kensington, England.

Williamsburgh, N. Y.

Balloon Valves.

To the Editor of the Scientific American:

Now that Professor Wise is going to demonstrate the practicability of the theory I have long cherished, I wish to propose an improvement in the construction of the safety valve of a balloon, nothing of the kind having ever been devised that would give me satisfaction. The engraving will, I think, represent my idea.



A flanged cylindrical tube, B, is placed within A, and is flanged at the lower end to keep it from blowing out; D, D, are guide rods which may pass through the flanges, to prevent the upper cylinder head from settling towards one side and to insure a perfectly airtight joint. B is represented as being forced up by the gas; and 1, 2, and 3 show the openings by which the excess of gas will escape. The lower flange, C, will be inside of balloon, the end being open to admit the gas; E, E, and F, are a device for holding down the valve with a force equal to the amount of buoyant pressure of the gas; and the device must be regulated by a weight, as are all other valves. The upper face of A, and the under face of the head of B must be ground to a perfect joint, and may be supplied with a flexible gasket to prevent all leakage. As C passes freely back and forth through A, the valve can never get foul or fast in it, as has so often been the case, causing many disasters. The dotted lines represent the apex of the balloon. A glance will show any scientist how the valve can be secured in position. The whole apparatus may be made of any suitable metal or of vulcanized rubber.

If made of brass or other metal, would it be likely to attract electricity from the clouds and set fire to the gas?

Elsah, Ill. S. W. Greer.

Mordants for Aniline Colors.

To the Editor of the Scientific American:

After perusing, on page 17 of your current volume, the article "Mordants for Aniline Colors," I am induced to make a few remarks on the subject. I have frequently used hot soap liquor as a mordant for aniline pinks, light and dark and found it to answer well. It is an easy, quick, and economical mode. For a deep, brilliant rose, I have generally found an annatto base, in combination with alum as a mordant, to be the best; it produces the most beautiful color. The sumach process is good for either light pinks or deep crimson shades, using it as a base for either double muriate of tin or tin crystals. In the hands of a skillful dyer, this process is very economical, for, by adding aniline in proportion to his shade, he can exhaust his dye bath. Tannin or sumach is the best known mordant yet for the aniline green. There is a mode of mordanting which has been much practiced in England and Scotland. It is the white liquor process, similar to the Turkey red, but not so complicated; it is, however, too tedious. It is claimed that it animalizes the cotton. Now this is the desideratum, namely, a cheap and quick mode of animalizing cotton, so that it would have as strong an affinity and absorb the aniline dyes, of all colors, as simply, quickly and easily as either silk or wool.

I have no doubt the Austerlitz mode is a very good one as to economy, but I scarcely think it will answer for all classes of fine yarns, as I am afraid it will stiffen or size the yarns too much. J. N.

Frankfort, Ky.

A New Explanation of the Origin of Nerve Force.

Those who are unacquainted with the principles of the modern doctrines of thermo-dynamics will readily perceive that a difference of temperature in two bodies is a source of power, when they consider that a low pressure steam engine depends, for its power of doing work, on the difference of temperature between its boiler and condenser; and that a current may be maintained through a copper wire, if it is connected with a thermo electric battery of which the two ends are kept at different temperatures. In what are termed hot blooded animals, that is, in mammals and birds, the difference of temperature between the surface and the interior is considerable under all natural circumstances, and in them there is a regulating action of the skin, by which they maintain a uniform internal temperature, always hotter than the surface, whatever that of the external medium may be. In the sluggish so-called cold blooded animals, the temperature of the interior of the body is but slightly different from that of the air or water in which they live; that it must be higher is evident from the fact that destruction of tissue is continually going on in their bodies, which is always necessarily attended with the evolution of heat.

Such being the case, it is evident that, in the difference of temperature between the surface and the interior of the living body, there is an available source of energy, which is almost certainly employed advantageously throughout the whole animal kingdom; and what is more, it may reasonably be supposed to be that which gives rise to the electrical nerve current, as only one assumption is involved, and that not an improbable one, it being that a thermo-electric current is capable of being generated between soft tissues of different composition or structure. Physicists will be able to decide this question experimentally, and if they do so, they will do a service to physiology.

For the distribution of a current so generated, the construction of the nervous system is perfectly suited. Two sets of conductors are necessary, the one to carry the currents from the skin to the central organ, which arranges the direction that they must take, and the other to send them on to their destination; these are to be found in the afferent and efferent nerves. As in the telegraph system, no return conductor is necessary; for as the ends of the wires are put into connection with the earth, by which they are able to communicate, so the terminations of the nerves in the skin, muscle-corpuscles and otherwise where they lose their insulated coverings, place the extremities of the afferent and efferent nerves in communication through the intervention of the mass of body tissue. The brain and minor ganglia would then act like greater and lesser offices for the reception and transmission of currents in the required directions, being in fact the commutators of the system.

There are several of the most important phenomena exhibited by the nervous system which are very satisfactorily explained on the above hypothesis. For instance, in cold weather the impulse to action is much more powerfully felt than in summer when the air is hot, and therefore the temperature of the surface is higher. It is well known that it is impossible to remain for more than a very short time in a hot water bath, of which the temperature is as high as, or a little higher than, that of the body, on account of the faintness which is sure to come on, and this may be reasonably supposed to be the result of the cessation of the nerve current, which is consequent on the temperature of the surface of the body becoming the same as that of the interior. This faintness is immediately recovered from by the application of a cold douche. When great muscular exertion has to be sustained, as in running or rowing, it is always necessary to have the clothes very thin, and it is felt, during the time that it is necessary for the continuance of the effort, that the surface of the body must be kept cool.

As the termination of the nerves in the skin must correspond, on this hypothesis, with the cooled end of a thermo-electric battery, therefore the brain, which is very abundantly supplied with blood, and is the part of the body to which most of the nerves are directed, must be compared with the heated end; and as it is by the conversion of heat into electric current that the nerve force is developed, it is evident that heat must, to a certain extent, disappear as such in the brain, and that that organ must consequently be colder than the blood which enters it. This is exactly what Dr. John Davy observed in the case of the rabbits he experimented on, and his results have not been shown to be incorrect.—*A. H. Garrod, in Nature.*

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New Style of Paper.—The English display at the Vienna Exposition an original manufacture, which is very strong and tough, and yet perfectly soft and pliable, like cloth. This is embossed and printed on, and is prepared for the purpose of hangings, curtains, etc., for which it seems very well adapted; some of the rooms of the British Commission are furnished with this. It is simply tacked to the walls, so that it can easily be removed at any time. In this case the curtains were of the same pattern as the walls, but lined with another style in light colors. It is handsome, cheap and durable.