THE

ART OF PROJECTION

AND COMPLETE

MAGIC LANTERN MANUAL

BY

AN EXPERT.

INCLUDING A SYNOPSIS OF THE PERFECT MANIPULATION OF A TRIPLE LANTERN AND EFFECTS, HITHERTO NEVER PUBLISHED IN BOOK FORM, ALSO VALUABLE HINTS AND INSTRUCTIONS USEFUL TO AMATEURS AND PROFESSIONALS, ALSO THE ART OF SLIDE MAKING AND PAINTING, AND ENLARGING.

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THE MAGIC LANTERN.

THE LANTERN has long since ceased to be a toy, or regarded as a plaything; as an educator, it now stands in the front rank. Lecturers and teachers are now rapidly making use of it, dispensing with cumbrous diagrams, and by means of well illuminated pictures, attract the attention of the audience, in a manner quite unattainable by any previous method. Physical Geography, and the Natural Sciences, are taught in a more graphic and impressive style by the aid of the lantern, than was possible by the old routine. Teachers are fast recognising this fact, School Boards are slow to introduce lanterns generally, from no other cause, than the fear of it looking too juvenile, and also the unwillingness of teachers to take to anything new. In this respect our American cousins are far ahead of us. The impression made on the mind by seeing the actual place or object in front of the pupil, is without doubt the best means to help retention of the lesson.

The "Gilchrist trust" have taken the matter up, and send teachers suitable lanterns for this purpose (we shall refer to this later on).

The name which has been almost universally associated with the lantern from its very beginning, is that of Athanasius Kircher, a Jesuit priest, who flourished about the seventeenth century, and is mentioned in his work "Ars, Magna lucis et Umbræ," which shows a lantern or box with the oil lamp suspended by a chain, and the said lamp carries a rude reflector.

Little can be found on the Magic lantern between the seventeenth and nineteenth centuries, when we find it again mentioned by Sir David Brewster, in a book entitled "Cabinet Cyclopædia" in 1831. He states that the Magic lantern, has an argand burner, and that the light is increased by the aid of a powerful reflector, which appears according to the illustration larger than the entire lamp. He also states, the "Phantasmagoria" is nothing more than a Magic lantern, in which the images are received on a transparent screen, which is fixed in view of the spectator. The Magic lantern mounted upon wheels, is made to recede from, or approach the screen; the consequence of which is, the picture on the screen expands to a gigantic size, or contracts into an invisible object, or mere luminous spot, &c.

About this time Professor Phillipstahl, a German, introduced and used an oil-lighted lantern, using blacked opaque figures.

Mr. Childe, an artist and enthusiast, who afterwards played an important part in inventing and painting Mechanical effects, was waited upon by the Professor, and commissioned to paint him figures with mechanical motions, advantage of which was taken at a later date, combined with Dissolving, which led to the production of the excellent results at the Polytechnic Institution.

Lieut. Drummond, in 1826, used an ordinary oxyhydrogen blow-pipe, with the addition of a ball of lime, on to which the flame impinged, this was only used for signalling purposes, and enabled him to signal to a distance of 100 miles. Who first used it in the lantern it is impossible to say, several having made this claim.

The much-talked of "Phantasmagoria" was brought out in 1848, on a large scale, and was an immense success, the lime light was used as the illuminant in conjuction with oil lanterns. All the subjects at this time having opaque back grounds around the figures, it was brought out at the Lyceum Theatre. A description of this illusion is as follows:—

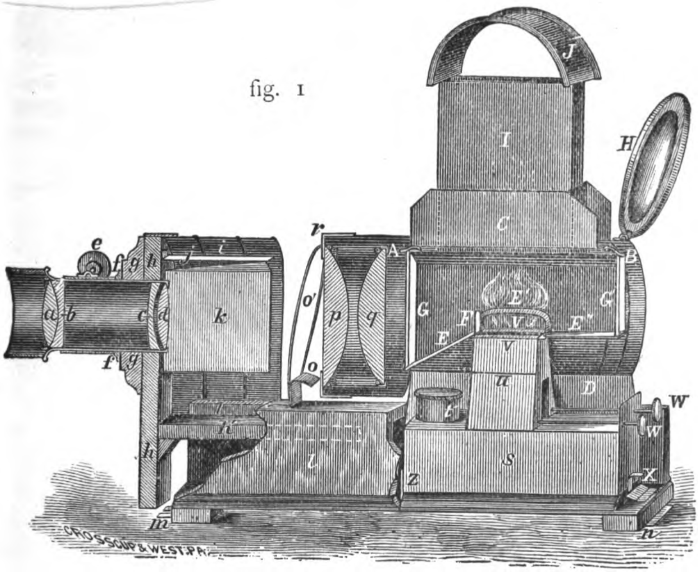
Professor Phillipstahl commenced his séance, by appearing on the dimly lighted stage with a small lighted lamp in his hand, saying "Hush de ghost, de ghost," with the idea of adding all possible mystery to the proceedings, he would then put the lamp out and retire. The Curtain then quietly rose, and disclosed a mass of clouds, which slowly opened exposing a ghostly figure, which appeared gradually to increase in size, and advancing, as though about to come amongst the audience, it finally retired, clouds covering the phantom, other figures then took its place; some of a horrible character appearing and vanishing in like manner. He informed his audience that he could produce any departed relative at will, and as the figure was so enveloped in drapery, there was no fear of recognition, or contradiction. This was a great success.

The Polytechnic at this time, spared no expense to continue the success, seven limelights and two oil lights were often used for some of the effects, which were originated and painted by Messrs. Childe & Hill, and about this time the same gentlemen introduced limelight on Drury Lane stage for the first time during the period of Monsieur Leon and Madame Plunket, who danced the shadow dance, the dissolving view being also used to show a vision in a piece then being performed.

After the introduction of the "Phantasmagoria" by Professor Phillipstahl, Mr. Childe invented the dissolving view, which he used for theatrical and public purposes and retained it to himself for many years. The effect of the dissolving view by the aid of two or more lanterns was not perfected till 1846. He introduced many mechanical effects for the lantern, and in 1844, invented and brought out the Chromatrope. When working his lanterns, he always had a screen surrounding him. And when using such effects as the vase of flowers, with butterflies hovering from flower to flower, had as many as five lanterns at work at one time, a small lantern being held in each hand by the assistants, to give the butterfly effect.

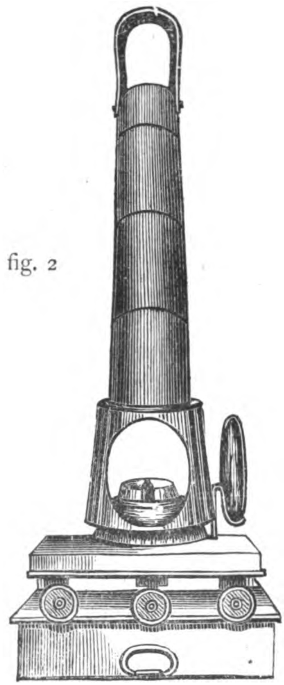
Previous to the introduction of the lantern at the Polytechnic, it was used in the production of the Flying Dutchman at the Adelphi Theatre, as

fig. 1



far back as 1811. Lanterns of the argand pattern at this period burnt sperm oil, the smell and mess of which, even now seem familiar. The Silber argand, burning paraffin was next introduced as an illuminant for the lantern, and was certainly a stride in the right direction. But the revolution in oil lamps, commenced at the invention of the Sciopticon (fig. 1), by Mr. L. Marcey, of Philadelphia, which burnt mineral oil, with two wicks 1¾in. wide, the upper portion of the lamp being a fixture in the lantern, the wick tubes and cistern alone being withdrawable, the only objection, and certainly it was a grave one, was that the glasses would not stand the heat. This lantern is still made, and is considerably improved. Then came the Triplexicon (fig. 2), having the wick two inches wide, with a blown conical chamber, fitting inside a cap made of tin, which was cut out back and front. These were found to fracture when suddenly heated, owing to the unequal expansion of the glass. This was guarded against later, by cutting these chambers into segments and using two pieces, back and front of the lamp (fig. 3). The centre wick was straight, but the two side ones curved inwards.

fig. 2



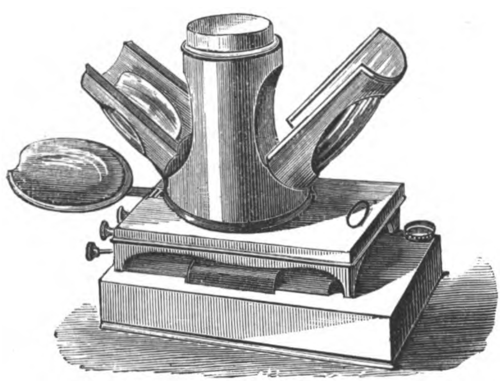
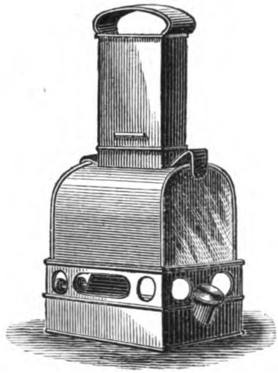


fig. 3

A third wick was then added to the Sciopticon form of lamp, which has now become, with a little alteration, a sterotyped pattern throughout the trade as fig. 4.

Fig. 4



The introduction of the Pamphengos may be considered the greatest success, the segments of glass, impervious to heat, without fracture, are a great improvement over the blown chamber of the original Triplexicon, and so far as an oil illuminant is concerned, appears to have reached the highest point of brilliancy; if any greater illumination is to be obtained with oil, it cannot be produced by the aid of wicks.

A Lantern is an optical apparatus, with its lenses and illuminant so arranged, that pictures or mechanical appliances may be projected or thrown upon a screen or white wall.

The Body.—The object of the body, or outer covering is to keep in the light, and to support the optical system. Lantern bodies are made of japanned tin, sheet iron, and wood—usually mahogany, the latter having an inner lining of japanned tin, or sheet iron. The best form of sheet iron is that known as planished Russian iron, coming from the Russian factories, and is frequently used for the bodies of single lanterns. It has a neat appearance when new, and saves japanning. The one great drawback to its use is the liability it has to rust, and in this humid climate it is next to impossible to keep it in its polished condition. For India and countries with a wet season, Russian iron cannot be recommended. An iron or tin body japanned has the advantage of always looking clean, and does not so often peal or chip off, as would be imagined, if the body is properly made, and allows a draught to pass through, it will last many seasons, without the faintest suspicion of cracking or peeling. When oil light is used, the heat is taken off by the chimney. When both oil and lime light are used, it is advisable to have a mahogany, or some substantial wood body, well framed up, with clumped and tongued side doors, so that if any one part shrinks, it will not affect any other portion of the body, or split, which is frequently the case with cheap and shoddy made bodies, which are often made of deal, stained to represent mahogany, rosewood, walnut, etc. A wood body lantern should have an inner lining of iron, or tin, and should be so constructed that an air space is left between the body and lining. An entirely metal body should not be used for limelight, if avoidable, especially if the body is very small, as it becomes much heated, and it is not a pleasant thing to catch one's fingers against in the dark. The writer has cause to remember a circumstance of this nature. An occasion occurred at which he had an opportunity of using one of the so-called portable lanterns, in which a blow-through jet was used; the lantern was constructed entirely of iron, without any lining of course, and as small as possible, in fact, just sufficient to hold the jet and condenser comfortably. Consequently, in less than half an hour, the lantern became so hot that it was impossible to touch the slide holder to introduce a fresh frame, as it became heated the metal expanded, and the greatest difficulty was experienced in moving the carrier, soon after the condenser cracked,—nothing less could be expected under the circumstances. Portable single lanterns are just now a craze, and the user, what our Yankee cousins would call a "crank," with an unlimited supply of cash, for renewing cracked condensers. With a Biunial or Triple, it is quite another thing, as you give the alternate lantern time to cool, and extra space for the radiated heat.

For use with oil light, a japanned iron body with proper means of ventilation is all that can be desired, as it has the advantage of being much lighter than wood. To clean a japanned body that has become finger marked and greasy: mix a little turpentine and vinegar together, into this dip a soft rag, rubbing the japanned-work until the grease is removed; when thoroughly dry, polish with a leather on to which has been dusted a little prepared chalk; when finished, the japan should be warmed in front of a slow fire, this giving the final gloss, allow it to cool before handling. If it is necessary to adapt limelight to a pre-existing oil lantern, all that is necessary is a lime-tray to carry the jet, and a flat dome chimney to keep the light in the body. Presuming there is a door at the side and an open back to the lantern for the insertion of the jet, &c.

It is very convenient to have a small curtain fixed to the back of the lantern when limelight is used, it can be so adapted that it in no way interferes with the working of the jet, or dissolving tap, and should be quite collapsable for travelling.

The best jet for a single lantern, is the cut-off jet, fitted with the simplex dissolver, which enables the jet taps to be fixed, and the supply of gases adjusted any length of time previous to commencing. When the lever *A* is brought down, the gases are burning on the bye-pass only. When recommencing, all that is necessary is to move the lever up; re-adjustment of gases at the jet is not required—the jet may thus be turned on and off *ad libitum* without trouble of relighting.

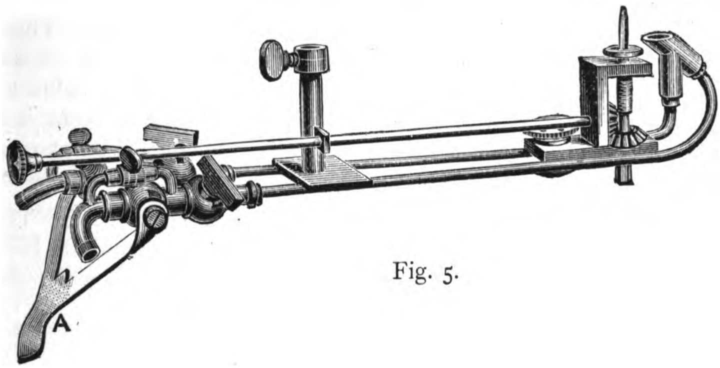


Fig. 5.

When using a front objective of a greater focus than six inches (equivalent) it is necessary to use a condenser of a longer focus, otherwise, the illumination on the disc is unequal. It is advisable, even when a short focus objective is adopted in a single lantern, to use a long focus condenser, as it allows the jet to be placed farther away from the source of heat. The shorter the focus condenser, the closer the light.

The most suitable carrier for a single lantern, is the "Presto," acting as it does, in a way that is as near an approach to dissolving views as possible; of course there are many other good carriers, which are mentioned later.

THE PRINCIPLES OF AN OPTICALLY CONSTRUCTED LAMP.

It is not generally understood that there is a limit to the amount of flame or illumination that may be used in a lantern. It has been supposed that the larger the volume of flame, and greater the number of wicks, the greater the light on the screen. This is quite an error, but an easy one to fall into. A lamp may be constructed with a dozen wicks, and yet not give any more light to the screen than a similar lamp with only two wicks.

A condenser can only take those rays which strike at a certain angle, this angle is determined by the curvature and refracting power of the condensing lens itself, or, to describe the matter more simply, there is only about one inch of a condenser, that takes up the rays of the illuminant, and that is around the central axis, all rays and illuminants outside the central axis are lost. If an argand lamp is placed in the centre of the condenser, its flame is entirely within the radius, but a flat two inch wick, placed broad-side to the lens, will give very little light in comparison; about a third only of this light is used, but if the wick is placed at right angles to the condenser, it is all but entirely absorbed. Those familiar with lime-light well know, that unless the jet is exactly central with the condenser, the light is not shown on the screen, or it lights up the disc unequally. From this it is seen what an important point it is that the wicks of an oil light are so centred and brought to a point as to be within the absorbing radius of the lens.

With the Triplexicon almost every conceivable method was tried. The combination with a straight centre and curved sides was found the best, and remained long in use, until a fourth wick was added, when the

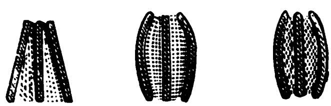


Fig. 6.

straight parallel form was found to give the best results. If the flames were allowed to burn straight up, it would be smoky or yellow; the flames being dispersed, instead of concentrated. To control the combustion and concentrate the flames, a cone is used (Fig. 7.) This is an

Fig. 7.

important factor in a lamp, and the part it performs is very considerable. By this is controlled the amount of air to be mixed and burnt with the wicks, and if not fitted in the exact position, will make an appreciable difference in the result. The cone of a lamp should never be interfered with, and if it becomes injured, should be sent to the maker for repair. Lamps have been put out of working order through parcels being stuffed into the lamp, pressing down the cone, this being the case the wicks refuse to rise. To remedy a cone that has become pressed too low, by some accident, a little pressure the reverse side with the thumb and finger will replace it in its original position.

We next come to the chamber, which holds the glasses and the air in

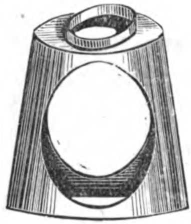


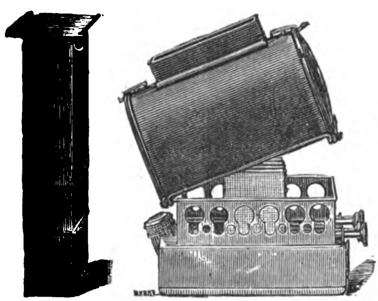
Fig. 8.

which the flames burn, the cone having bent the flames so that they all converge to the centre, they appear in the chamber as one, instead of four. The centre of this combustion chamber is on the level with the central axis of the condenser, this portion is taken up, as it were, by the condenser and transmitted to the screen. Supposing the number of wicks were doubled, when burning, the space they would occupy, would be outside that portion of the condenser where they would be of use. The smaller the illuminating point the better, by this means the rays are more centralized, and better definition is therefore obtained.

Thus it is easy to understand why some four wick lamps are no better than others with three, and why there is such a variation in the Russian iron lamps of the stereotyped pattern. The number of wicks is not of important moment, unless they can all be brought within the optical radius. Wicks placed angle-ways or flat side to the condenser as is proved above, lose three parts of their light.

RUSSIAN IRON AND OTHER LAMPS.

Fig. 9.



All these lamps are more or less, modifications of the original Sciopticon, with the difference that the hood or combustion chamber is attached to the reservoir.

There is a considerable difference in their make and burning powers. They were first made with two wicks (one inch and half wide only) converging towards the condenser, then a third wick was added after the introduction of the Triplexicon, sixteen years ago, by Mr. W. C. Hughes, and at the present time, a four wick lamp is made; although the idea of a

Fig. 10.

fourth wick was cried down by the trade. When the Pamphengos was first invented no doubt many of these commercial three wick lamps gave as much light as those fitted afterwards with quadruple wick tubes; as before mentioned, the quality of the light differs considerably in this class of lamp. Some appear to be constructed with care, and with an attempt to attain something like combustion; others are no better than bad cooking stoves, smoking and smelling in a similar manner, although they are not to be despised at the prices asked for them, they are principally made in Birmingham, France, and Germany, by the gross, and turned out in the same fashion as pots and kettles, and if used in a small room the effect must be very painful, if the contorted features of the audience are to be taken as a guide, saying nothing of the soot which comes from the chimney, covering everything. And the appearance of the lantern is looked upon by the *bonne famille* as a thing to be dreaded. The window glass used on the front, and often, on the back of the lamp, soon cracks, which means extinguishing the lamp and the introduction of a new glass, and this, frequently flying as soon as inserted, in the hurry of getting the flames up again. The reflector is often used as a substitute for the back glass, thus reducing the risk of an extra glass cracking. But the reflector is liable to tarnish and oxidise from the deposit of the products of combustion. A hole cut in the reflector to enable the operator to see the flame, may loose somewhat of its primary object. These few facts should be sufficient to put the purchaser on his guard against cheap oil lights. To say every lamp of this class is as bad as those previously mentioned, would be too wholesale a condemnation, but one of the weak parts generally is the glasses, which will not resist heat to the required extent. Nothing is gained by placing the wicks in any other form than parallel, otherwise the current of air is not equally distributed to each wick, and therefore perfect combustion is not obtained. Lamps have been made and introduced with a greater number of wicks than four, they were not successful, as they generated more heat, and the gain of light on the screen was *nil.*

The reason for this has been previously explained, it is not the number or the width of the wicks that produce the result upon the screen; lamps can be made and the wick tubes so constructed that not more than one-third of its illuminosity will pass the lenses.

A carefully constructed lamp needs no dampers to cause it to burn, it will do so as a rule without any artificial aid.

If in the case of emergency, the toughened plates have been lost or put on one side, talc or mica, in very thin sheets, is a very good substitute, but this retards the light considerably, giving the disc rather a yellowish appearance, which is detrimental in showing pictures.

DIRECTIONS.

Do not use wicks more than six inches in length, as they become entangled in each other; in inserting fresh wicks, which should be well dried in an oven or before a fire, turn the old wicks out of top of wick tube, the fresh wick is then placed in the tube and pressed downward, turning the wick spindle at the same time to the left, until the cogs on the spindle catch the cotton, turn it down in its place, and cut level with top of tube, and trim off the edges very carefully, so as not to allow any ragged pieces to stand out, as these may cause the flame to impinge on the glass. It is not always necessary to cut the wick for an exhibition, which, by the by, is not such an easy task as imagined, a little time spent in this direction is well repaid. After one or two occasions, it is only necessary to rub off the charred portion with the finger, but after several times of using, the charred portion should be cut off with sharp scissors or trimmers.

OIL.

Best rock, crystal, petroleum or kerosine, which should be emptied out of the lamp reservoir after each exhibition, and particular care used in filling, so that no oil is spilt over the lamp, or it will smell badly when lighted. Cleanliness is very necessary with all oil lamps, and to allow charred portions of wick, saturated with oil, to accumulate between the wick tubes, is to cause the lamp to smell unpleasantly, and to prevent the proper supply of air.

The lamp glass should fit loosely, allowing room for expansion, to prevent it cracking. Light up gradually, taking full ten minutes from the time of starting until the flames are at their full height, be sure the chimney is pulled out to its full length before placing on the lamp, and in no case must the flames be turned up until they smoke, stop just below the smoking point, gradually turn the side wicks up first, and then the centre ones, a little at a time. The flames are generally seen through the coloured glass fixed in the centre of the reflector.

In London there is not much difficulty in procuring good oil, but in the provinces or abroad, it is not always the case,—good oil gives a good light; bad oil is the more perceptible in the Pamphengos, because the lamp is adjusted to such a nicety. Any good mineral oil will burn in the Pamphengos. Young's paraffin, Strange's A1, Sunlight, and other known makes are good. Pure kerosine is the best, when this is good there is no smell whatever attached to it, it should be as clear as water. Many unscrupulous dealers will sell the commonest oil, and because the buyer is charged a big price for same, he imagines he has got the best. For the guidance of those who have no idea of the price, pure kerosine is obtained in towns at 1/- per gallon, and in the provinces 1/6, if procured specially. Bad oils contain naphtha, and others a very low volatilizing point, giving a yellow and smoky flame.

No camphor or any foreign substance should be mixed with the oil, camphor being of a resinous nature, soon fills up the meshes of the wick, preventing the proper capillary attraction. In places abroad where the oil is very crude, and no other can be obtained, it is sometimes improved by adding a tea-spoonful of common salt.

The Pamphengos (fig, 11) is constructed on entirely scientific principles, and the lamp itself requires considerable skill in manufacture, individual attention being necessary in its construction. It is so arranged with the object of giving "perfect combustion," which is the very ideal of oil lights. It has a pure white flame, free from smell or smoke.

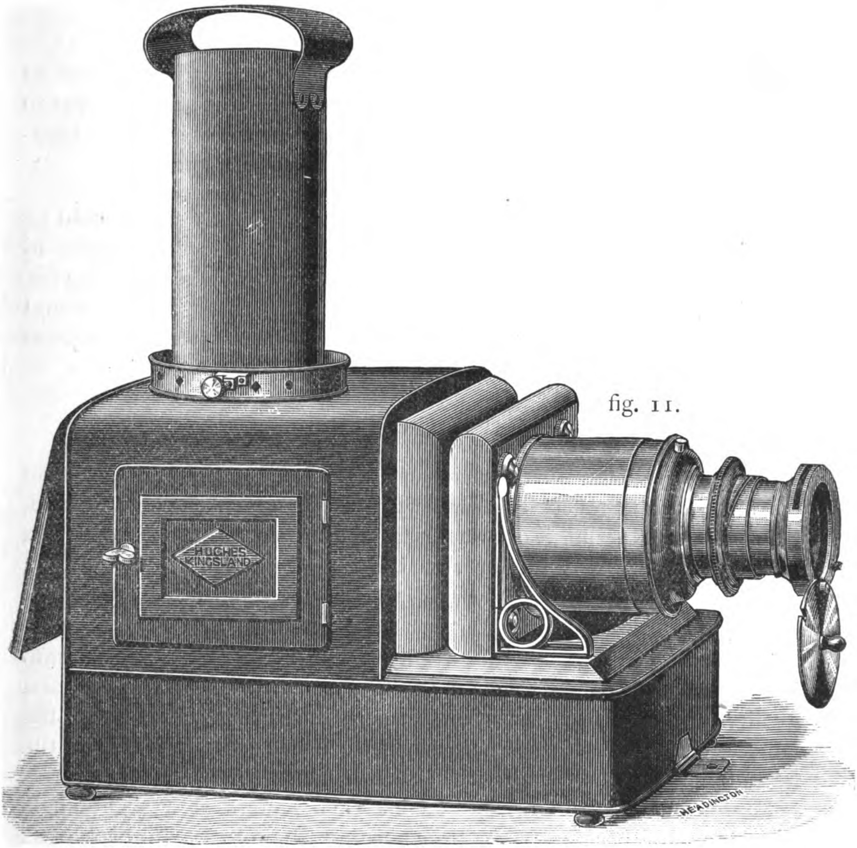


fig. 11.

The hood and cone are so constructed, that the maximum proportions of atmospheric air are consumed with the hydro-carbon of the oil. And no lamp without the chamber and the adjacent arrangements of the Pamphengos lamp, can ever bring about the same results. The lamp is perfectly safe with any mineral oil, as the connection between the lighted portion and the reservoir is minimised, a current of air being drawn up over the top of the cistern, and so through the wick tubes. When the

Triplexicon was first made it was thought necessary to make an arrangement to increase the draught when the lamp was used in a crowded room or impure atmosphere: the draught arrangement being abused, it caused smoke, and its use was entirely suspended, as the lamp was much improved. At the present time, the Pamphengos may be taken as being as near perfection in luminosity and combustion as it is possible to obtain.

The conoidal glasses in the Pamphengos have never been known to break under the heat, they are not toughened glass, as this is useless to resist heat, or mica which is yellow and obstructs the light. The Pamphengos glasses are blown and annealed under a special process.

The chimney is made collapsable for portability only, and should be pulled out to its entire length; although, should an occasion arise in which the draught is interfered with through the atmosphere becoming impoverished, the chimney may then be reduced; but this is rarely found necessary, even under the most trying circumstances, after ten minutes at the most, the full effect is generally obtained.

THE REFLECTOR.

The present pattern is the result of experiments without number, and the whole of the reflector fulfils its purpose as no part is cut away, and, being outside the lamp it does not become oxidised, as it soon would if it were unprotected from the fumes of the oil.

FITTING UP A PAIR OF PAMPHENGOS.

The lantern case, as a rule, is fitted with screw plates and thumb screws for holding the lanterns in position in the front, and in the best quality the case is fitted with thumb screws and plates, for securing the lanterns at the sides. In commencing, secure the two lanterns in the front, by passing the thumb screw through the hinged piece containing a hole in front of lantern, and incline each lantern at a slight angle towards each other, viz.:—the fronts nearest each other, with back parts farther apart, this is for securing coincidence of discs. After lighting lamps and focussing each lantern up sharp, take out slide and carrier, adjust each lantern in the required angle, until each white disc exactly overlaps the other, then secure by screwing tightly down in front. The best Pamphengos are fitted with brass side pieces on the left and right sides of lanterns respectively, in which there is a slot, pass the thumb screws through these, but do not screw down tight to plate until adjusted, they may then be secured tightly by the thumb-screws. To save a little time it is a good plan to make the top of box so as to indicate the angle at which they work, for future guidance, in the best quality this is not necessary as you have the back plates to guide you. The dissolver is now adjusted by screwing it on the front of box, with thumb screw

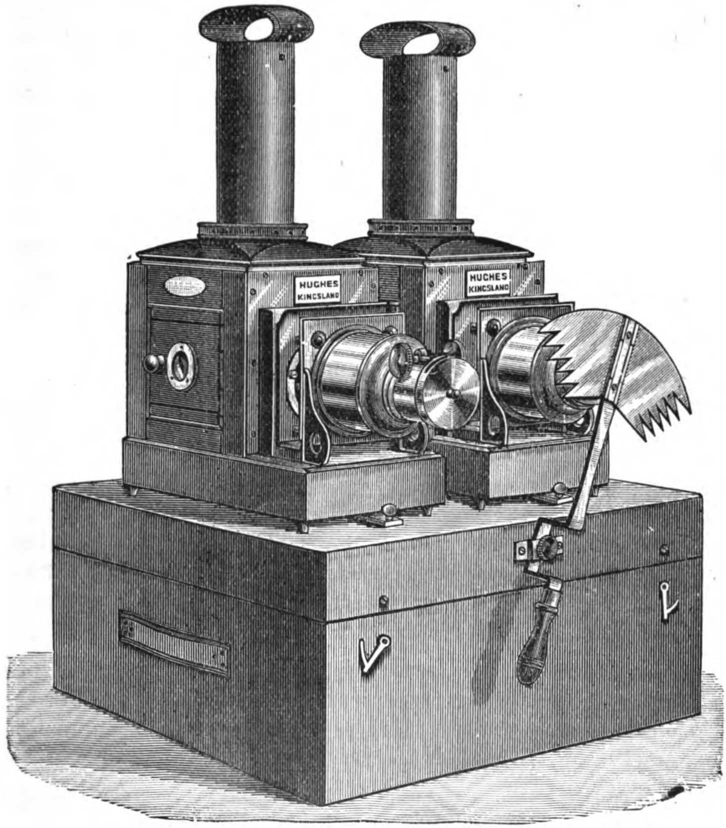


Fig. 12.

provided for the purpose, if anything should happen, that it does not cut off the light properly, dropping too much on one side or not sufficiently as the case may be, it is easily remedied by bending the brass wire stop on the dissolver.

Rolling diaphragm or curtain effect fits into the brass pockets, and, as a rule, the long end of diaphragm fits into left hand lantern when facing screen. The short side of diaphragm is fitted on to top brass work by the aid of two screws. The two slots in the diaphragm, through which the screws are fitted, are to allow of the diaphragm being adjusted from right to left to meet the angle at which the lanterns are placed.

The shutter works in the usual manner giving the illusion of the pictures rolling up and down.

A rolling effect for statuary leaving the proscenium always on, may be done by two lanterns; in this case, if the operator is at all handy with his tools, first a suitable single curtain must be chosen, one showing a proscenium at side and top, obtain a piece of brass, same size as the smallest side of diaphragm, cut the slots for screws, place the curtain exactly in the centre of condenser, mark off on the sides and bottom of brass piece, where the proscenium meets the inner curtain, then file the edges and bottom of brass plate to the mark, doing a little at the time, until you find that on the screen you block out all the curtain with the diaphragm except the proscenium, in other words, the light, instead of being entirely shut off when diaphragm is down, escapes at the side and bottom, so that when you have the statue showing in one lantern, you still have the proscenium of the curtain in the other.

It is well in first experimenting to make a cover for the inner part of curtain with a piece of cardboard, and when this is cut exactly, mark the brass from that.

DIRECTIONS FOR THE PAMPHENGOS LAMP.

When the lamp is to be lighted, throw back the hood or chamber. The front lenses should now be cleaned, taking care to replace them exactly the same as before. Clean the condensers, also taking care that in replacing them the holes in the cells are at the top.

When putting fresh wicks to lamps see that they are perfectly dry and free from moisture, fill the cistern with best paraffin, crystal, or kerosine, oils—do not use benzoline, colza, or sperm, oils. Cut cottons level with top of wick tubes.

Light the wicks, turned down very low, replace the hood after seeing that the conoidal glasses are fitted properly, and put the lamp in lantern, placing on metal chimney, which must be drawn out to its full length, 19 inches—this is very important—and is held firmly on the lamp by two brass thumb screws fitted to top of lantern body, which by screwing up holds chimney firmly in proper position on lamp. Turn up the wicks slowly and allow them to burn for at least ten minutes before they are turned up to their full height. Take care not to breathe into the lamp or the flames will not burn. The flames must then be seen above the sight-hole as high as possible, but not to smoke. Do all very gradually, because when the flames are at their full height, after hood and chimney have become heated, the oil volatilizes and the flames may run up; then a minimum turn of the pinions is quite sufficient to keep them in their place, rough handling of the pinions at this point will either raise or lower the flames too much. A delicacy of touch is all that is necessary to produce the best results. Keep the lamp well back in the body, so as not to touch, or be too close to the condenser, otherwise it will be likely to crack. If too far back a shadow is cast at the bottom, or if too close, a shadow at the top.

When the slide is placed in the Pamphengos lantern slide holder, focus with the rack and pinion, and at any time should longer focus lenses be used, roughly focus with the large tube first; pull this out until you get the rough focus; final focus is obtained with the rack.

The reflector should be so inclined towards the light that its top shall touch the glass.

To protect the eyes of the operator from the intensity of the light, a blue glass sight hole is introduced in the door at the back of the lantern, which allows the operator distinctly to see how to adjust the flames by placing the reflector back a little on its hinge.

Always clean the metal chimney inside, as a foul chimney produces a smoky flame; also look to the perforations and see that they are clear and free from dirt or charred wick, these can be removed by means of a small brush.

If the flames do not come up it is in consequence of the oil being of an inferior quality, stale, or the cottons being hard and too closely woven. Gradually turn up the centre wicks full, till hood and chimney become hot, this volatilizes the oil and increases the capillary attraction, then turn up the sides to their full, although the centre ones may go down, but as a rule with humouring they will rise again; should they not do so, re-trim wicks and substitute fresh oil of the best kind, as inferior oil will not burn in this lamp with success—but with good oil and proper wicks not the slightest difficulty will be found. Pure kerosine oil is the best and is without smell.

Remove all oil from cistern after use, and before using again refill with fresh oil.

In the case of those having lanterns with rotary focussing lenses. The lens is made to slide into front by simply pressing small button fixed to O.G. flange fitted to front tube.

EXTRA DIRECTIONS FOR THE PAMPHENGOS LAMP.

The special points of the Pamphengos and Triplexicon, are their perfection, combustion, and purity, to obtain which, the air supply is limited to that drawn through the perforations. Therefore at some time or other an occasion may happen, where a difficulty may arise, in getting the flames up to their proper standard, if the flames do not rise, so that the points of light are seen flickering up the chimney (in ten minutes from the time of lighting), it is very certain, that something is at fault, the cause of failure can always be attributed to the following, viz. :—Bad oil, imperfect trimming of the wicks, wicks left standing in the oil, or wicks that have grown hard with constant use, cottons woven too tight, it often happens that they have become damp. In fact, the wicks are a very important item, and play a prominent part in all oil lights and deserve special attention, if woven too tight, the oil cannot make its way freely up the meshes, in other words, the proper capillary attraction is absent. It is always best to obtain fresh wicks from the maker of the lamp, not looking at it from a commercial point of view, but because it is an essential item to have the proper woven cotton. That usually sold at oil stores, is far too hard, and often too common for this purpose.

Before inserting fresh wicks, be sure they are well dried, evaporating every particle of moisture, by drying in front of a fire, or in the oven for an hour or so, taking care not to scorch them, spare wick which has been carried about in the lantern case, must not be used, until it has been dried, in the above manner. In changing the old wicks turn them up, and pull out with the fingers, introducing fresh wicks from the top of the tubes and notice that they occupy the entire space of the tube, if not of the proper width the oil accumulates at the corners, causing a flickering and an uneven flame. Do not attempt to light them until they have become saturated with the oil for at least ten minutes, if this is attempted they will become charred, when once charred no coaxing whatever will induce the flames to rise; turning the wick too high above the combustion line also produces charring. To prevent clogging or sticking it is advisable not to have the wick longer than six inches, nor to keep the cogs of the spindles working on one part of the wick for any length of time. After three or four exhibitions, turn the wick up and cut off at least half an inch, so that the cogs may work in a fresh place, this is mentioned because lamps have been sent to the maker to be put in order, because the pinions have been said to catch, or have been bent through straining. The real cause of this is, that the cogs continually working in one place, have worn the wick away, drawing little strands of cotton out, which have become entangled and wound around the spindles. If instead of forcing the spindles and so bending them, about an inch of the cotton had been cut off the top, the evil would have at once been remedied.

THE PAMPHENGOS LAMP.

It is imagined by many that the Pamphengos flames to burn at their best should rise up solid and even, as in the case of an ordinary table lamp; also that the flames should be of an equal height in burning. Whereas, practically, this must not be with the Pamphengos because of its perfect combustion and whiteness of light, and this only can be obtained under certain conditions, which is by admitting the proper quantity of air through the perforations under the cone, the flames necessarily burn in a forked or zigzag manner. This is exactly what is required, as by this arrangement the flames are made white and dazzling.

The only portion of the flame that is of any optical importance, and alone taken up by the condenser is that portion dotted in the illustration.

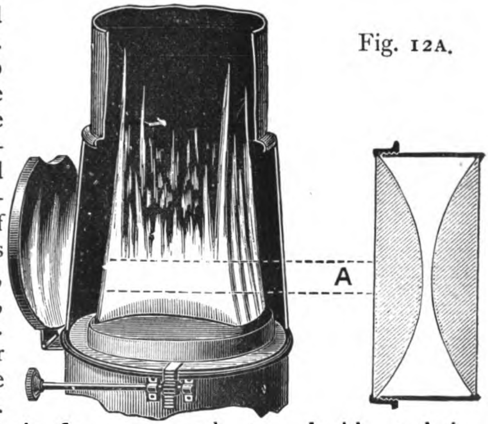


Fig. 12A.

The points of flame above and the portions below are useless. The condenser only taking up those central rays. If the flames were required to come up solid and even, as a gas-burner, more oxygen would be needed, this can be illustrated by raising the hood of lamp whilst burning, the flames are then seen to run up, but are feeble and yellow, with a tendency to smoke. The flames when at their fullest should reach up the chimney as shown in fig. 12B. There is a point beyond which the flames cannot be turned without their dropping down, and care is required not to turn them beyond that point.

Fig. 12B

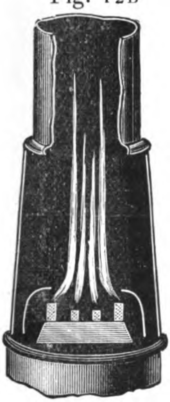


Fig. 12B shows a section of the lamp, as seen at the back, with flames at their full height (just entering the chimney.) Notice also that the wicks are some little distance out of the wick tubes, although the wick is only alight at the top, more especially the two sides. As every lamp is tested before being sent out, it is perfectly certain that every novice can obtain the best results, providing, of course, that the instructions are properly carried out. Use only fresh and good oil and wicks that have been well dried; and RE CUT EVERY TIME before using in a perfectly straight line thus, with the corners cut off; and by no means cut thus. If, perchance, the oil or wicks should be bad, or other occasions arise, the little rack and pinion shown at the side of the lamp will raise the hood and admit more air, which will cause the flame to run up and heat the chimney, when this is brought about the hood may again be lowered; this should only be used when absolutely necessary.

If a lamp has been standing by, some time, or even a few days is sufficient, in a damp atmosphere, the moisture is sure to have been absorbed by the wick.

If on lighting, the flames have any tendency to lag, do not waste any time, but cut off half an inch of the wicks from the top, or take them out and introduce fresh ones well dried. Never soak wicks in vinegar, as is at times advised, this method is employed in ship lamps to keep the moisture out, but they are well dried before use, it has a hardening tendency, which prevents the oil rising as it should do. Pieces of charred wick falling between the tubes, should be looked after as they clog up the perforations between the wick tubes, preventing the proper air supply. It is well to keep a small stiff hogs hair brush for this purpose, brushing well around the perforations and between the tubes.

Keep the chimney clean and free from soot, and take care not to run the oil over the lamp, when it becomes warm, this will pass off, in a gaseous state, and often smell very unpleasantly. Do not go to an exhibition with oil in the lamp, if the lantern case should be turned over or on its side, it is rather awkward.

VENTILATION.

All illuminants need oxygen to support their combustion, it is therefore important that a good supply of fresh air finds an entrance into the room or hall, where the lamp is burning. A badly ventilated room with all its oxygen impoverished, and used up by the audience, is fatal to any lamp depending upon atmospheric support. This fact was well born out in the case of a pair of lanterns, which was set up in a hall, but to the owner's surprise they only burnt with a dull sickly yellow flame, refusing to rise with all the coaxing, the end was, he packed up and returned home crest-fallen, and upon lighting up at home they burnt with their wonted vigor. The next night the same hall was tried with no better success, until it dawned upon him, that the room had no means of ventilation. After knocking out a few panes of glass near the lantern, the flames immediately rose and burnt as they would in a pure atmosphere, and the problem was thus solved which had puzzled the operator for hours. This took place in Canada.

LIME LIGHT.

The Limelight can generally be fitted to any pre-existing oil lantern: the oil lamp is taken out, and a lime-tray with rod attached, substituted; a low chimney must be fitted in the space usually occupied by the lamp chimney; one door at least should be made at the side of the lantern to allow the hand to put on a fresh lime, this of course can be done from back of lantern, in that case the operator is very liable to knock his hand against the jet, and move it out of the central focus, especially as he is likely to do it hurriedly.

JETS.

Of jets there are three kinds, and unfortunately their names are not very distinctive: for brevity we will call them the Spirit or Oxy-calcium jet; the Safety or Blow-through jet; the Chamber or mixed gas jet. We will use the above-named titles in future.

OXY-CALCIUM SPIRIT JETS.

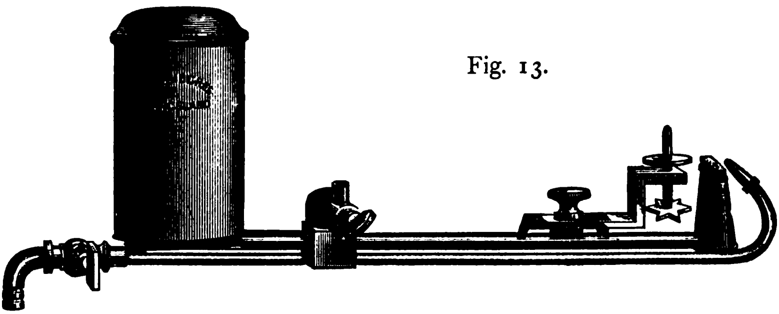
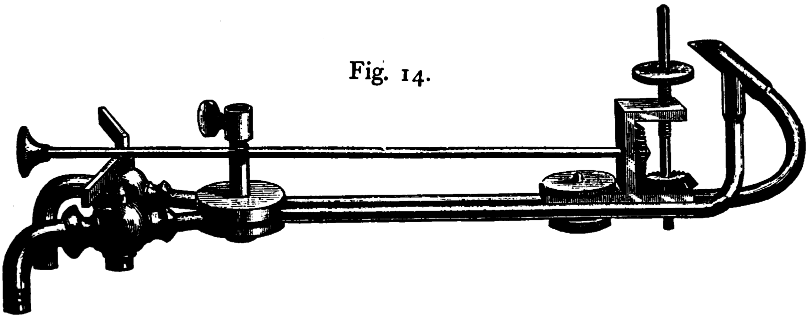


Fig. 13.

Spirit Jet.—With this a fine jet of oxygen is blown through a volatile spirit, usually methylated spirit or alcohol, the former being the cheapest is generally employed, and is mostly used in villages and places abroad where gas is not procurable. The jet is clamped to the rod of the lime-tray in the usual manner, the cistern being outside where it cannot be dangerously heated, lamp-wick of a soft and fluffy nature is introduced into the wick-holder in front of the oxygen nipple and should not protrude too far above the top: experience will give the correct height, usually about a quarter of an inch, and is fed with spirit from the cistern; take out the inner cistern and when inverted, fill with methylated spirit, pull the pin attached to the check-valve up, now invert the cistern to its proper position, and gently lower into the outer holder or cistern, it will thus automatically feed the wick, taking care to tilt the jet sufficiently so that the spirit will flow to the wick. If the lantern is tilted there is a swing attachment fitted to the jet, so that the jet always keeps at the one level,—this is a very important addition, which no spirit jet should be without; a soft or incandescent lime is fixed on the lime-pin, the flame from the spirit is almost non-luminous; the oxygen is now turned on from jet tap, and the lime is watched until the highest state of incandescence is obtained.

Fig. 14.



Safety Jet, is also known as the Oxycalcium or blow-through jet; in this jet the oxygen is used in conjunction with the ordinary meter supply and is constructed on a similar principle to the blow-pipe, only that it is or should be arranged to give the maximum of light and not heat. The hydrogen is the outer and larger tube, controlled by the tap on left hand, the oxygen is driven in a fine stream through it, which is again controlled by tap on right hand side. Much depends upon the point at which the oxygen is introduced into the hydrogen for obtaining the best illuminating point. The reason for calling this a "safety" jet is, that the gases only meet at the orifice, not mixing in a chamber before igniting, thus the merest tyro can handle this jet with impunity, as an accident is impossible: a pop may be made by turning the oxygen sharply into the hydrogen, and nothing more.

When a dissolving tap is used, a small leak of oxygen is left on, this prevents all popping when dissolving: it is a common weakness to allow the hydrogen to flare more than necessary. After adjusting the jet on the lime-tray allow a little hydrogen to warm the lime, giving it a few turns so that it may become equally heated. The hydrogen tap should now be turned to the full, or in the case of a good supply, about three parts on, and the oxygen introduced gradually until the best light is obtained. If a cylinder with a regulator is used, the jet tap is rarely turned on to the full; when a certain point is reached it is possible to continue the supply of oxygen, but the light is not increased; to obtain the best result, the hydrogen tap will be nearly full on, whilst the oxygen tap is little more than half on, this is not to be taken as a set rule, as much depends upon the orifice and bore of the jet, and the pressure from the meter supply. In London the pressure is generally pretty good, in the provinces the main pressure is often very poor, and the illuminating candle power far from the proper standard.

To prevent waste of oxygen by forcing it through without its being consumed, the flow should be adjusted roughly by the tap attached to the regulator, an excess of oxygen really diminishes the light, as it passes through the hydrogen flame and cools the lime; having adjusted the oxygen to a niecty by watching the disc on the screen, the hydrogen tap should be reduced as low as possible, the best light is obtained when this is slightly in excess, a little of the flame playing each side of the lime: careful attention to this will prevent the lantern becoming overheated, and reduce the risk of cracking a condenser.

THE HUGHES' SPECIAL SAFETY JET,

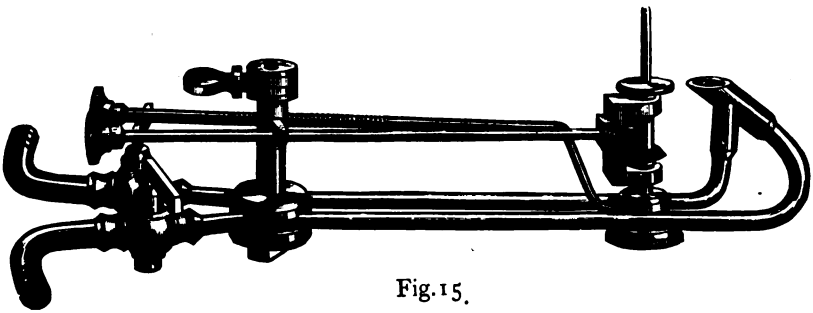


Fig. 15.

As shown in illustration, may be considered the best jet in the market, the illuminating power equalling that of a great many mixed chamber jets. There are two spindles to work the lime adjustment, one raising and revolving the lime in one movement; the second, moving the lime to and from the nipple, which is very convenient, when the inequality of the limes is taken into consideration. For a single lantern a jet with simplex dissolver attached should be used, as it allows the gases when set, to be shut off, leaving only a little hydrogen burning.

CHAMBER OR MIXED GAS JET,

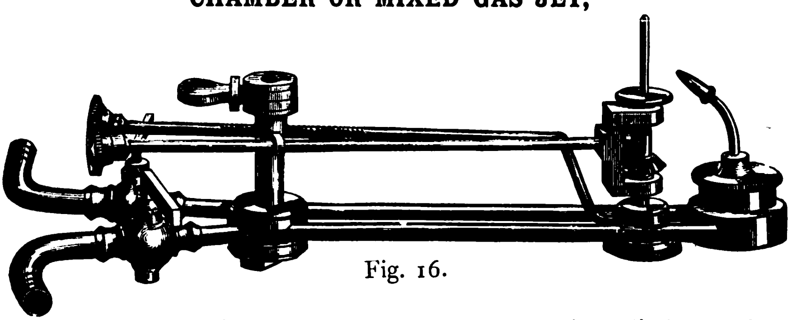


Fig. 16.

For two gases under pressure, either in bags or in cylinders; when cylinders are used (fitted with regulators of course) greater care must be taken in the joints and fitting up as the extra pressure soon finds a vent in any badly made or defective joint.

The connections with rubber tubing are the same as described for safety jets.

These jets are made in various styles and qualities, from 10/6 and upwards, and with the special chamber jet, as shown in illustration, light of intense power can be obtained.

It is not intended to give illustrations and dimensions of mixing chambers, because the novice could not construct them.

It is needless to mention that the above special chamber jet is the outcome of years of unceasing experiment and observation, and the delicacy of its construction necessitates it being somewhat expensive. For working, the hydrogen should be nearly full on and the oxygen a little under, the maximum light is at that point at which the jet has a tendency to flicker, not so that it is observable, because the flickering denotes the want of more hydrogen. If the hydrogen is full on, a mere touch of the oxygen tap one way or the other, is sufficient to obtain that intense whiteness which is the principal characteristic of this jet.

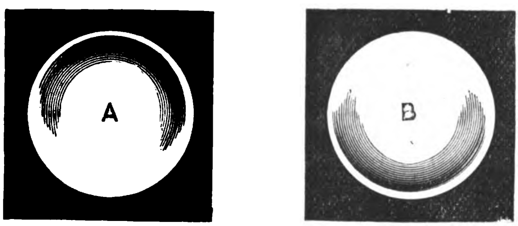
The above mentioned instructions apply particularly to the Hughes' special chamber jet, and are also applicable to most chamber or mixed gas jets. This class of jet requires in general more delicate handling than safety or blow through burners, and to give a good result should have a chamber in which six to eight pieces of gauze may be packed, although it is not necessary to have that number in use. The operator should try for himself if he is a fairly experienced man, and see which gives the best results, as some jets will require only two pieces, others may want four pieces of gauze; on this depends, to a great extent the roaring and spluttering with this style of jet. The chamber should not be too deep, or the gases will burn back and light in the chamber, in that case the oxygen tap should be turned off at once, although no fear need be entertained, another cause of a jet burning back is insufficient supply of hydrogen.

The nipple should not be more than 1 mim. bore, as this also is the cause of the gases burning back in the chamber, it is well to have some spare nipples of various sizes, as the bores vary according to the amount of pressure, and depend upon whether they are being used with cylinders or gas bags.

TO REGISTER OR REGULATE THE LIGHT ON CONDENSER.

The rod on the lime tray, is for holding the jet, the hollow pillar of which is passed over the rod, and held in position by the aid of a thumb screw being clamped to the rod. When the jet has been lighted and the desired light obtained, place a picture in the slide holder, and focus same up sharply; this done, remove the slide, as the condition of the disc has to be observed, and proceed to adjust the jet for the best illumination. The easiest way to hold a jet, when adjusting the light, is to place the first and second fingers of the left hand under the jet by the pillar, and steady with the thumb. With the right hand hold the thumb screw, raising the jet up and down on the rod, watching the screen at the same time, and moving same to the left and right, giving lateral and longitudinal movement, until the jet is in the exact centre of condenser, then clamp same to the rod, by aid of the thumb screw, giving a little extra pressure to ensure it holding firmly. The tray with jet attached should now be moved in or out as the case may require, this movement affects the edges of the disc. The diagram below will help the novice in adjusting the limelight for the first time or two.

Fig. 17.

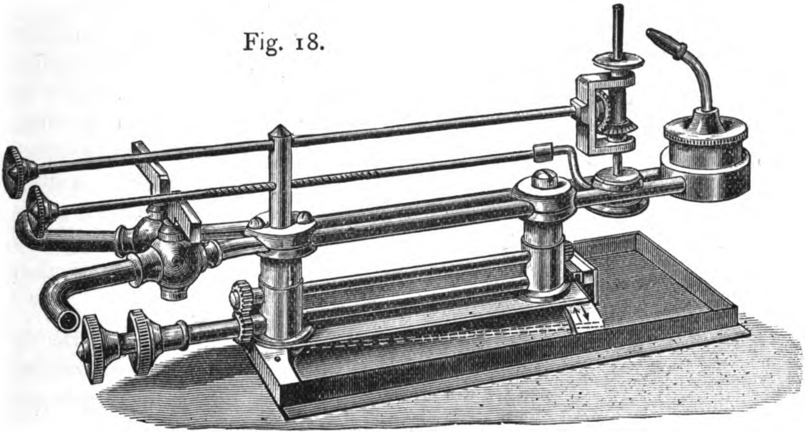


A. Jet not low enough on the rod. *B.* Jet too low down.

C. Jet too close to condenser. *D.* Jet not near enough. *E.* As a disc should appear.

A MECHANICAL STAND FOR HOLDING THE JET.

Fig. 18.



Accurately centreing the jet is often very tedious, and more so if the lantern is raised and out of reach. The idea of a rack adjustment, although by no means new, is considerably modified in the present motion, which is controlled by the two milled heads attached to the spindles, one working inside the other, but a separate spindle for each motion is thought the simplest plan.

The horizontal motion is produced by turning the lower milled head to the left or right. The end of the jet nearest condenser describes a quadrant motion, the back part remaining stationary, as indicated by the dotted lines in illustration. The vertical motion is governed by the upper pinion being held steady by a rack and small telescopic tubes, the former inside the latter, giving up and down play of about two inches.

For microscopic work it is most essential. The slightest movement on the part of the jet will throw the light out of the centre, and to centre the light by the ordinary clamping screw on the rod when using high powers, is well nigh an impossibility.

DISSOLVERS.

Dissolving with oil lighted lanterns is brought about by the alternate opening and closing of the shutters, or the metal fan in front of the lens, this also was the manner of dissolving with the oxy-hydrogen light (when first introduced by Mr. Childe), but is now effected by cutting off one or both gases in the lantern not in use, this not only gives the operator greater control over the gases, but enables one half of the gas to be saved. Several arrangements have been invented to enable the gas or gases to be shut off without disturbing the previously arranged adjustment of the jets; the double plunger, with two supply pipes and four outlets, being the most primitive and still the most effective, especially when used with gas bottles. With this pattern, when the lever handle is in mid way position both jets are being supplied, if moved to right or left one or the other jets are cut off, the gases not being self-igniting, means are made for keeping a leak or bye-pass of hydrogen burning, sometimes it is already made in the plunger, but mostly there is a stop-cock by which this may be regulated, it is not only necessary when using blow-through jets to have a leak of hydrogen, but a leak of oxygen is necessary, or else when the dissolver is turned, the sudden introduction of the oxygen will put the hydrogen out.

Simplex Dissolver.—This, as the name designates, is perfectly simple, in the respect that each gas has a separate supply and outlet, there being no fear of the gases ever becoming contaminated, each gas when turned off is supplied with a leak or bye-pass.

The Malden *(see page 31)* or Star Pattern tap is the favourite, being less complicated and more compact. It was invented many years ago by B. J. Malden, he never took any means to protect it, thinking it too great a boon to be denied to any lanternist, and when well made is certainly the best dissolver yet invented. This form of tap has one plunger only which is grooved out each side to allow of a passage of the gas. when these passages are open for the egress of the gases the jet is supplied, when the plunger is turned this is shut off.

This plunger must be most accurately ground in its socket so as to prevent any possibility of the opposite gases escaping into each other, the groove or channel in the plunger must also be so cut that the hydrogen gas comes up first and is shut off last. Many of these jets that are carelessly made do not perform either of these important points, and now that cylinders are used with their extra pressure the defects are made more conspicuous, a novice using a badly made dissolver would be puzzled to account for the sudden popping out of the jet when dissolving, and would look to everything but the dissolver. We have tested such taps and found them absolutely dangerous, the oxygen coming from the hydrogen side and *vice versa*. To test a star dissolving tap connect a hydrogen cylinder to the *inlet* place the finger over the one *outlet* and apply a light to the opposite outlets and if you find a leak which is denoted by a slight flame, have nothing more to do with it, it is dangerous, and cannot be patched up.

To overcome any possibility of an accident Mr. Colin Docwra improved on the Malden tap by introducing a plunger separately for each gas, although the pattern and compactness of the original tap is retained, there is still the satisfaction of knowing that all chance of a risk is done away with, the principle is "one gas one plunger."

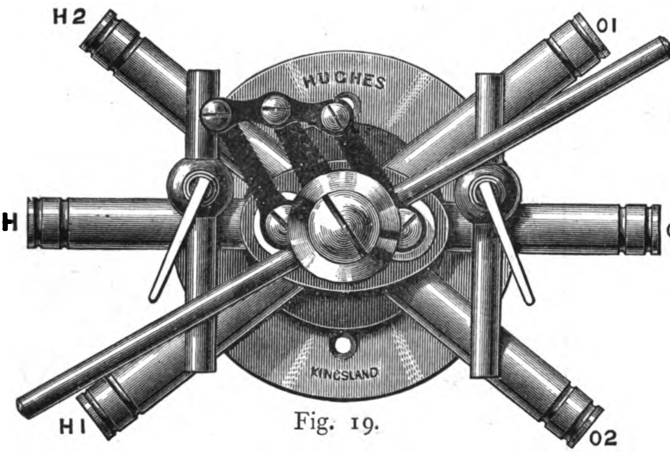


Fig. 19.

The Biunial may be justly named the exhibitors' lantern, as it will suffice for the most general work; and more of this pattern lantern are in use than that of any other, even if ordinary slides are only used, it enables the alternate lantern time to become cooled, and if anything should go wrong with either jet, there is always the second lantern to fall back upon, and again, there is the pretty effect of dissolving, and the rolling curtain illusion, which is a pleasant change and rest to the eye. Generally the two lanterns, so far as the woodwork is concerned, are made in one, the fronts and optical system are separate. There is an advantage in having the body made entirely in one, as greater solidity is given for registering, and the lantern will stand more rough usage, than if divided. Although it is not unusual to make them to divide, especially if oil lamps are intended to be used, and in this case, they must be used side by side, to allow of the tall chimneys for the draught. Biunials are made in japanned iron, or wood, the latter is recommended in preference, for many reasons, hereafter to be mentioned. A japanned iron or tin body becomes uncomfortably warm, and the slide holders do not work with the freedom and nicety of brass, and altogether is a makeshift for a practical lantern, as no solidity or accuracy can be obtained in registering. A mahogany body biunial, with brass fronts, is the lantern advised for lecturing purposes, and even these can be scamped and badly made in their get up. We have never come across a business that admits of such scope for the shoddy and cheap jack style of work as the lantern trade. There is no lack of unscrupulous individuals, who are ever

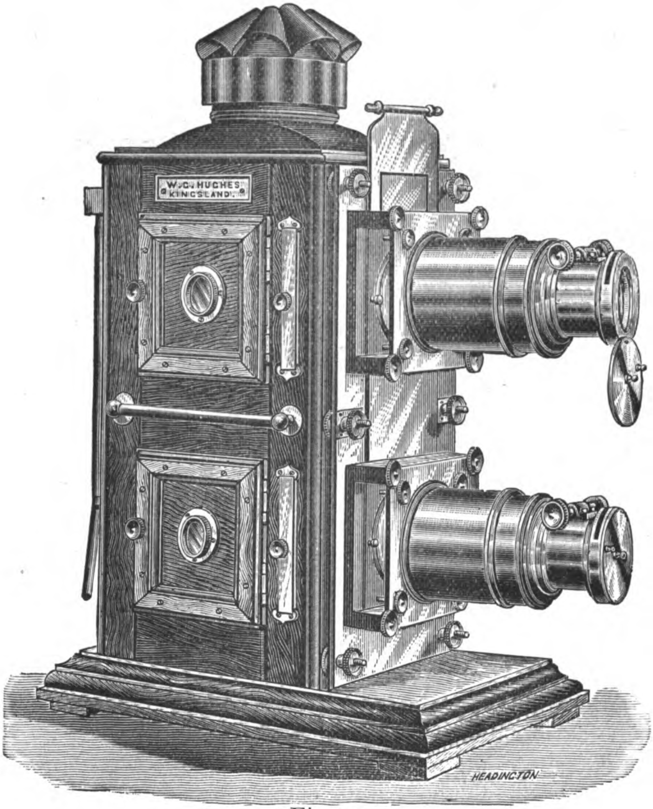


Fig. 20.

ready to take a mean advantage of the uninitiated in every way, either in lanterns, or slides, the latter not being dealt with in this section.

A Biunial is made with solid brass fronts, mahogany body and lined with iron. A lantern is made with a wooden body, to stand heat and travelling, the woodwork should be framed up, morticed and tennoned, and the foot or base likewise framed, panelled, and decorated, and doors framed, panelled and keyed, with moulding put on after, and the wood especially should be well seasoned, in fact, to give a full description, would be altogether too technical.

The following is a fair description of a cheap, shoddy, gingerbread gilded lantern, of which there are not a few at present in the market.—Woodwork of cheapest mahogany or teak, but often deal stained or veneered to represent mahogany, the stiles and rails are tongued and grooved, as this saves a considerable time in making, and the whole is glued together. The doors, often deal veneered with walnut or rosewood, more often stained or painted. The foot is cut out of one piece, worked and painted to represent ebony or rosewood; the whole highly polished with glaze, which is a substitute for french polishing, and when mounted with a brass front, looks well in a shop window, where it should stop. Now a lantern of this description would not last many months in the hands of an exhibitor, who would give it good work, but to look at, appears all that it is intended to represent, namely, a good imitation of a well-made lantern. When selecting a lantern from an optician of repute, do not forget that it is not necessary to have a plain body, to ensure a good instrument, as a lantern may be finished off in walnut and rosewood, and yet only cost a sovereign or so more than the plain body. Lanternists sometimes imagine that, because one lantern is of a higher price than another which looks plainer, that it is the extra wood work and finish they are paying for, this is not necessarily the case. A higher grade lantern with superior lenses, and optical system necessitates accuracy in manufacture, which costs a great deal, finishing and truing the optical system (as it should be,) entails a great deal of labour and time, and certainly is worthy of a well finished body, which perhaps in itself will only cost a guinea or so extra over a plain one. It is as compared with two watches, a time-keeper can be obtained for eight shillings, and yet is not to be despised, a chronometer will cost thirty guineas, but the owner would never think of having such a piece of mechanism placed in a white metal case.

The same thing applies to lanterns, it is the mechanism that costs the money. Many gentlemen keep their lanterns in their dining rooms, they would not do so, unless they had a finished appearance, no lanternist, who has any pride in his instrument, would like a plain unfinished body, the same as supplied to a lantern costing, perhaps, half the price which has not the same lenses, and technical skill spent upcn it.

We have seen it stated that a soap box would act as well as the most elaborate body, it is as untrue as ridiculous, a box could no more be utilized for a lantern body than it could for a jewel case.

It is well to avoid cheapness in this class of lantern, as it cannot be cheap if practical value is required, be content with a single lantern with good lenses, one set of first class objectives is far preferable to a lantern that will give various foci, quality, not quantity, should be borne in mind when making a selection.

Most effects can be used with a double lantern, only there is the objection of the effect being taken off before the next picture can be shown. Take as an instance, the set of the fields of Bethlehem; the scene with shepherds, No. 1, the angels appear, No. 2, and before the next slide can be dissolved, slide No. 2 has to be turned off. If a triple was used slides Nos. 1 and 2 would be dissolved off together, as No. 3 is dissolved on. For simplicity, it is advisable to have two single dissolving taps, one for each jet, as it allows of both lanterns being turned off on the leak, and readjustments at the jets when once set is avoided.

Hydrogen to the left side, oxygen to the right, this is the general mode with most lanterns, and should be with all, as it is simple to remember and easiest in working.

MANNER OF FITTING UP BACK SUPPLY OF BIUNIAL, WITH A DOUBLE TAP.

If a double tap of the Star pattern is used, it is the best plan to have it fixed at the top of the lantern, some lanternists prefer it in other positions, between the two lanterns or screwed on to the tripod. From experience we certainly like it fixed at the top of the

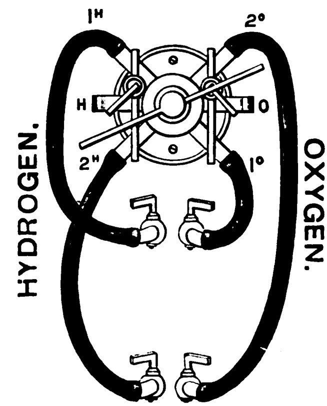


Fig. 21

lantern body, as it is entirely away from the jet taps and lime trays. The two horizontal central pipes are attached to the supply tubes, carrying respectively the oxygen and hydrogen gases, the other four pipes serve to distribute the same to the jets. These pipes are connected as follows —:The top pipe on left hand side of the dissolver (hydrogen) is attached to top jet (same side), and the bottom left hand side of dissolver to bottom jet. The top right hand side of dissolver (oxygen) is now attached to bottom jet, and the bottom pipe is fixed to the top jet, as shown in illustration.

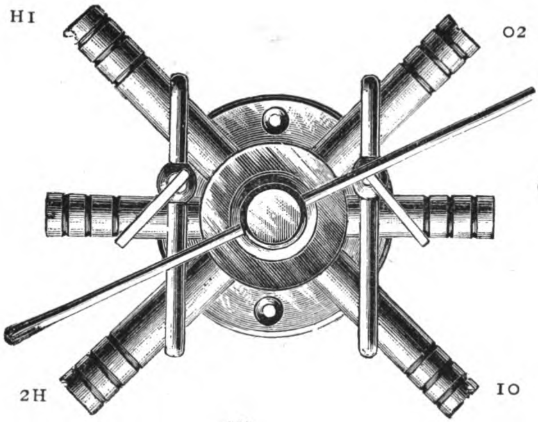


Fig. 22.

When the handle or lever attached to the plug of dissolver is horizontal, gases are being supplied to both jets, but when the handle is moved up or down, only one jet is being served. The small taps each side of the dissolver are the bye-pass or leaks, which serve a small flame to the jet not in use and may be regulated to suit the pressure at the main.

The hydrogen leak should play about one inch up the lime, and if blow through or safety jets are used a little oxygen leak should also be on, but very little, just sufficient to give the appearance of a blue pea in the hydrogen flames. This leak of oxygen prevents the jet popping when it is dissolved on. And the hydrogen leak to keep the shut off jet from going altogether out. The dissolver may thus be turned on and off, and no re-ignition of the jet is necessary.

When using chamber or mixed gas jets, the oxygen bye-pass should not be used, but shut off entirely. If a double dissolving tap is used, one lantern only can be turned off at the time. And after adjusting the jets, or during an interval, when it is necessary to lower both lanterns, one must be necessarily lowered at the jet taps, which means readjustment of the gases at the jet, before it can again be brought into play. Another point in using a double tap, it is not quite clear to the novice at a first glance, whether the top or bottom lantern is on or off.

With frequent use this becomes familiar, but to the casual user it is perplexing; whereas a single tap to each jet makes the working very simple. When using two single dissolvers connections are the same as for a triple, as illustrated below.

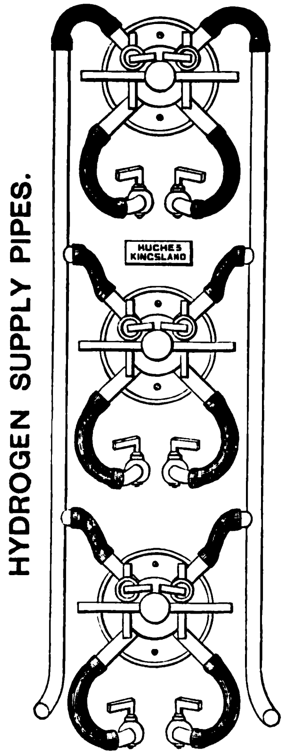
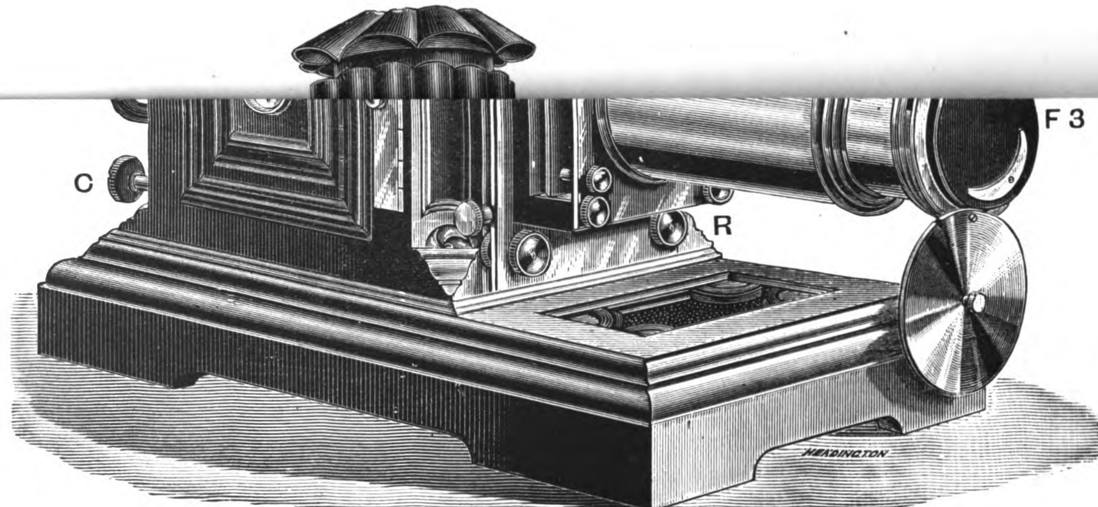


Fig. 23.

Triple.—Several arrangements have been devised for dissolving a triple lantern by the aid of one dissolving tap, and coupling two or more dissolvers together by the aid of rods, such complicated arrangements are a veritable nuisance.

A triplet dissolver not only gives the operator great trouble in having to make a mental calculation. But now that compressed gases are so often used, there is every chance of the plunger leaking and causing pops, the operator has quite sufficient to look after, especially when working effects, without the extra worry of having to look to a dial to see where he should turn his dissolver handle next, or whether the front or back handle has to be turned. To an exhibitor who has made

THE DOCWRA TRIPLE—Front View.



the thing a study, and used such an arrangement for years, it may be as plain as the alphabet, to the average lanternist it must be an incessant source of anxiety.

The sole secret of perfect lantern manipulation is simplicity of working; as all experienced lanternists acknowledge. Several arrangements are devised for enabling the gas or gases to be turned off and on without disturbing the previously adjusted jet. But the best of them is the single Malden dissolver, or star pattern tap, fitted with adjustable bye-pass. With three single dissolving taps on a triple, and two on a biunial, complete control is given over each lantern, with a considerable saving of gas.

In the case of a triple, one double tap is sometimes used for the middle and bottom lanterns, with a single tap for the top. The simplest principle beyond all doubt, is "one lantern, one tap." If one double is used for two bottom lanterns, fit up with tubing and connect same as described for a biunial, the single tap as described later on.

To prevent a complication of tubing, a brass supply pipe with three outlets is arranged up each side of the back of the lantern, hydrogen supply pipe on the left and oxygen on the right. Each oxygen outlet is connected with the *top* pipe of the dissolver, by means of rubber tubing. The hydrogen is connected in the same manner to the dissolver and supply pipe, in other words, the two top pipes of dissolver are the supplies, and the two bottom pipes serve the jets. *(See illustration, page 32.)*

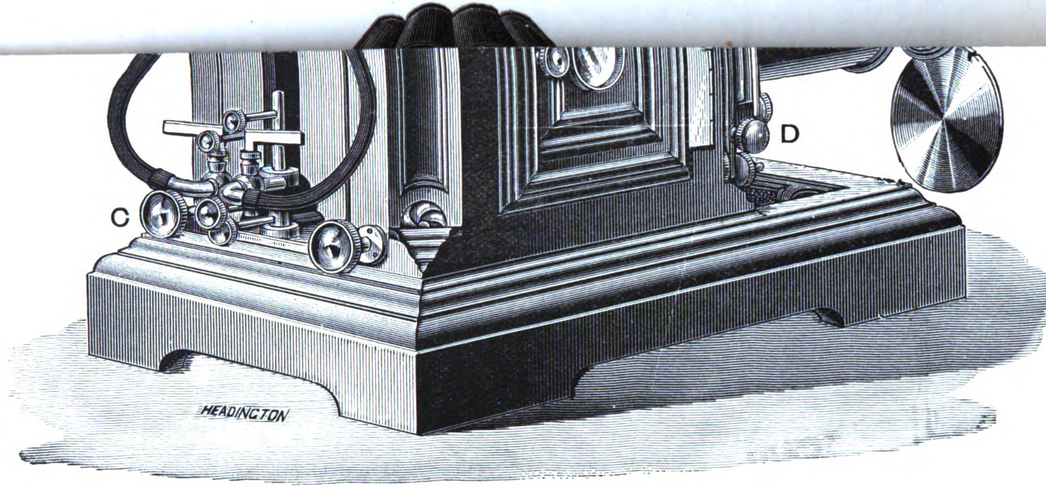
When the handle or bar attached to the plug of dissolver is horizontal, the lantern is on and both gases are supplying the jet, when the bar is turned either up or down the gases are shut off from the jet. To prevent the gases being turned completely out in the lantern when the handle is moved up or down, bye-passes are fitted each side of the dissolver plug which allows a small leak of gas to be kept always burning.

Triple Lanterns are really only the addition of a third lantern to the Biunial, but special care is needed in the construction, to bring about the extra result that is anticipated. Many people imagine that a single lantern placed on a Biunial will give them the same result as a triple made throughout. In the first instance, this is so, up to a certain point, but when it comes to the technical parts, the solidity that is required for crucial registration, it is found lacking those qualities. The stereotyped question of "what is the use of a Triple?" is so often forthcoming that it will prevent some misconception if explained now. Take the set of The Grotto of Calypso, a lake scene, a rising grotto, nymphs sailing through the grotto. Lantern No. 1 showing the lake scene, No. 2 shows the grotto rising out of the water, and with No. 3 we have the nymphs sailing through the grotto, or again, the fields of Bethlehem with shepherds is No. 1, a star appears and sheds its light over the distant city No. 2, angels appear to the shepherds No. 3, it is seen that to use these effects all three lanterns are used at one time, and for ordinary occasions, when simple views are dissolved, two lanterns only are used, in the case of emergency or of one of the lanterns going wrong, there is always the third lantern to fall back upon. We were once using a Biunial in a large hall, and through no fault of our own, the lime split and fell, and in less time than it takes to tell, the mixed gases had melted down the lime pin into a little lump thus preventing the use of a new lime, as it could not be placed on the pin.

If it had been a Triple lantern, there would have been the third lantern to fall back upon, as it was, one lantern only could be used for the remainder of the exhibition. No professional exhibitor would risk his reputation in using only two lanterns, although he may not often use effects. There are many charming little effects to be made by the operator, which can only be done with a Triple, take as an instance the showing of statuary, the orthodox way is to dissolve one over the other, there we think half the charm is lost, how much better it is to roll the curtain up disclosing the statue beneath, and the statue to stand out against a varigated background of tints, and into these tints a second statue dissolved, the manner of bringing this about is as follows, in the bottom lantern is placed a circular carrier, and in the diaphragm slot of the lens is placed a colored glass, say dark blue, as the curtain slide is rolled up disclosing the statue beneath, the bottom lantern is also turned on, the statue thus stands out against a colored background, this glass may be withdrawn, but in so doing follow it up with a dark red or green. Beautiful tints may be made in this manner by overlapping the colours and in some cases three glasses may be held in the hand overlapping each other, and the effect is marvellous The statue dissolved into a dark red background or heliotrope is a change, and if using animated statuary at the same time a very charming illusion is created. In a storm scene the view may be darkened by a blue glass and a red or blue lightning flashed on, whereas perhaps the storm scene would look nothing by itself, the lightning making the effect, these, and a host of other little effects can be best used in a Triple, and all have their particular charm.

THE DOCWRA TRIPLE

derives its name from that eminent lanternist, Mr. Colin Docwra, THE DOCWRA TRIPLE—Back View.



who designed the body of this lantern, and has done much to raise the tone of lantern exhibitions.

It is as its maker designates, a *chef 'd œuvre* in skill and invention. Its mechanical yet simple contrivances are covered by several patents. The necessity for a solid and well finished body to carry the magnificent optical system, and the gas supply being so requisite for a Biunial (see description of Biunial), is of especial importance in a Triple, and here every conceivable plan is used for producing the grandest results ever yet attempted in lantern manipulation. The essential points in a Triple lantern, of whatever type chosen, are solidity, mathematical accuracy in centreing of the optical system, with simplicity in its mechanical parts, and equal distribution of the gas supply to all three lanterns at the same time. *A B C* are the rods for registering the fronts from the back; *D* are the clamps for holding up the supplemental shutters; *F 1*, 2, 3, show a mechanical appliance for covering up the lens when a slide is withdrawn. It is well-known that when the gases are turned off, there is still retained on the lime sufficient incandescence to interfere with the succeeding picture, and this is more especially the case with hard lime than soft; to overcome this difficulty, this mechanical appliance is used. When a slide is dissolved on and the preceding one dissolved off, the frame and slide are withdrawn, at the same time shutter *F2* drops over the lens. When the frame is replaced in the lantern and pressed home to the stop, a cam acting from this imparts the necessary motion to the rod (seen running along the top of the tubes) turning the vulcanite shutter upwards, as *F 2*.

Registering the disc, slides and jets are dealt with under their several headings, but there is an important point in Triple lanterns that is often overlooked, although there are several very vital points in a Triple. We refer to the back gas supply; as a rule, the pipes which carry the gas are not of a sufficiently large bore to supply the gas equally to all three lanterns, generally there is more pressure at the bottom lantern than those above. In practice, the bottom lantern is used least, the top and middle being used for general dissolving, thus the heat has not so far to travel to the outlet. To overcome this unequal supply of gas, the back supply pipes (as shown in Fig. 24) are made with extra wide bore (including the dissolving taps), and joining the inlet to the dissolver is a bulbular fitting, and in this is accumulated a sufficient force of gas to keep up a steady supply, instead of the connection between the dissolving tap and supply pipes being made with indiarubber tubing, it is joined direct to the bulbular fittings by the aid of a screw nut or coupling, there being no fear of kinks to confuse the operator, as occurs in tubing.

THE REGISTERING RODS.

In the usual method of effecting the coincidence of discs, the front is let down at the top by means of a milled nut, this answers the purpose very well, but takes a considerable time to centre accurately. In fact this is the cause why many lanternists do not register their discs to the requisite precision, it is too much trouble; the rods *A B C* overcome this difficulty, the discs are perfectly registered by simply turning

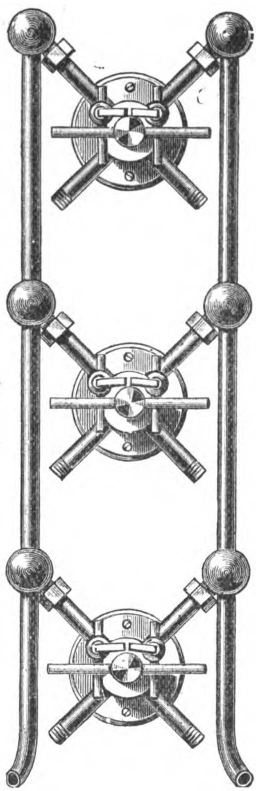


Fig. 24.

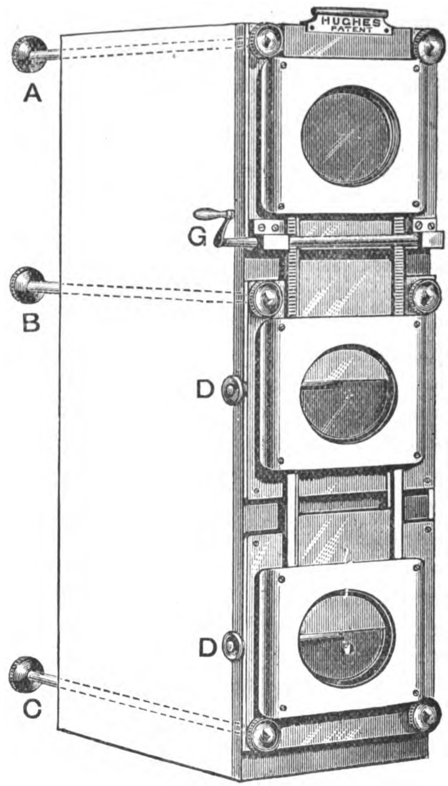


Fig. 25.

the milled heads on the registering rod at the back of the lantern, and it is done in less than a quarter of the time occupied in the old way. It is of great importance before adjusting a triple to see that the central lantern front is on the same plane with the body. The top of the central front controlled by rod *B* should not be tilted downwards or drawn too far back but equally flat to the body. After the lantern is lighted up and the metal work becomes heated, it will expand and throw the discs out, it is then a very simple matter to give the rods a minimum turn to bring the fronts up to the required degree of accuracy, which is no easy matter when it has to be done by the milled nut in front, which is the case when these registering rods are not fitted.

THE ROLLING DIAPHRAGM, OR CURTAIN EFFECT.

This illusion was first invented by Mr. B. J. Malden, and he was enabled to keep the secret for two years before it became known by what means it was brought about. In use it has the effect of one picture rolling upand a second appearing beneath it and on the reverse movement, the picture is rolled down over the preceding view. In a great many lanterns this is defective in the following respect, if in rolling the picture there is a heavy dark band shown, it is because the diaphragm is too long, a little is required to be taken off the bottom of the brass diaphragm, if on the contrary there is a white band, it is because the diaphragm is too short; the former is easily remedied by filing away, but the latter is only to be remedied by piecing, or the making of a new diaphragm.

With the ordinary rolling shutter, in commencing an exhibition, the shutter is pulled or racked up, the curtain slide placed in the middle lantern and the view in the top, and upon the diaphragm being brought down, the illusion is produced of the curtain rolling up, this when used with statuary is very effective, and should be introduced at times during an exhibition in lieu of dissolving, being a nice change. Many improvements have been recently added to the original idea, which was a sheet of vulcanite worked between the two lanterns by means of a brass lever, it was next made of brass and lifted up and down from the top of the lantern, being capable of being drawn out when not required. A rack was next added to facilitate the motion, and a recent patent of Mr. Hughes' enables the rolling diaphragm to be used in all three lanterns, and at no time is the diaphragm required to be withdrawn, which is the case with the ordinary form. When the lantern is on an elevated position, it is not an easy matter to draw the diaphragm out (which runs the length of two lanterns) especially if the lantern is placed underneath a gallery and the top nearly touching the ceiling. This difficulty is overcome by the aid of supplemental shutters, or brass discs, which are made to drop down into position when in use, or to lift up out of the way when dissolving. The first to introduce the idea of supplemental shutters, we believe was Mr. Steward. For working of the diaphragm in the three lanterns according to the illustration:—*G* is the handle which works the rack; *D*, *D*, are the handles of the runners which move from top to bottom, raising or lowering the supplemental shutter, as the case may be. The object of the three diaphragms may thus be described; supposing the operator is ready to start an exhibition. The curtain slide in middle lantern is showing (diaphragm racked up) on to this a title is thrown (bottom lantern diaphragm is also up), then as the shutters are rolled down, the curtain and title have the illusion of being rolled up, disclosing the picture beneath (top lantern).

The middle and bottom lanterns always work exactly alike, so that if the middle lantern is occupied, the diaphragm is worked in the top and bottom lanterns. When it is required to dissolve a picture instead of rolling it, the supplemental shutters are lifted up at the handle *D*, each one being independent of the others. The three lanterns are left free for dissolving effects whenever required without having to withdraw any shutter from the top.

LENGTHENING TUBES AND ADAPTERS.

When using long locus objectives it is necessary to have long lens tubes, or adapters, to bring the lens the length of its focus, from the slide--this may be brought about by a telescopic front, a series of adapters, or lengthening tubes, or else by a solid tube or two tubes sliding into each other.

Telescopic tubes have a tendency to sag, no matter how firm they may be when new, the telescopes become loose through wear, and the weight of the lens will also cause these to drop in proportion—they are altogether unsuited for a biunial or triple, as registration is impossible, the slightest pressure brought to bear on the pinion in focusing is sufficient to move the draw tubes out of their centered position, and the larger the picture the more perceptible this becomes. The original method of constructing these telescopic draw tubes has been considerably improved upon of late years, and more than one patent granted for the protection of the ideas. One form of draw tubes deserves especial attention: each draw tube has a flange attached by which it is screwed or clamped to the next tube,—for instance, if there is one tube with three inner draws, each draw tube is clamped to the next in such a manner as to give them the solidity of a single draw tube. We have not given them a practical trial by using them with a heavy long focus lens at the end, but from a theoretical point of view, they should fulfill all their intentions. Another method is to have three draw tubes severally fitted with a rack and pinion, each successive draw being longer and lighter than the preceding one, therefore giving greater solidity than any of the old telescopic draw tubes; it is easy to handle and very simple to rack out, no leverage being required to focus the tubes out as in the old method. The simplest and most rigid beyond a doubt, is a solid tube with one draw made to slide out several inches; most exhibitors of note use long focus lenses, which are taken off the lantern for travelling, these are packed separately with the solid lengthening tubes, and are made with a coarse thread to screw to the lantern front easily. For perfect registration and firmness this form of lengthening tube commands first attention, as it will do for two or three sets of lenses of various foci, and if ever very short focus lenses are used, a separate small tube can be screwed in the place of the long ones. With properly made tubes of this character no support of any kind is necessary, and such an old enthusiast as Mr. B. J. Malden would not adopt this plan if it were not the best.

PORTABLE TRIPLE.

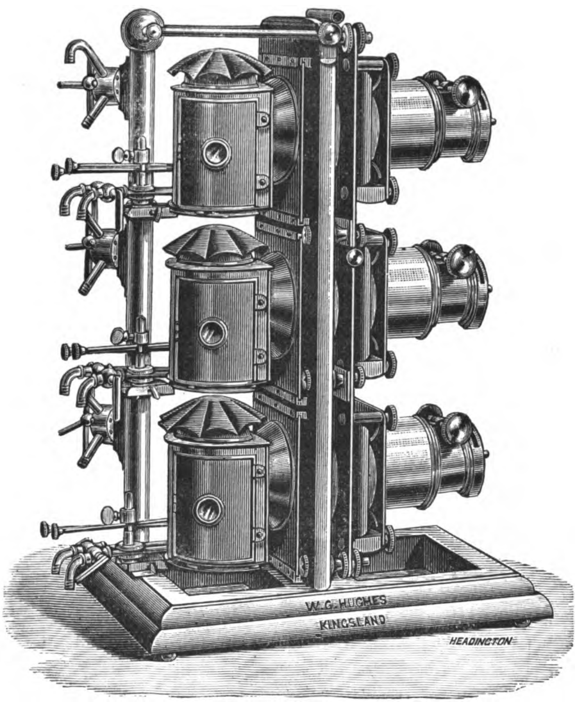


Fig. 26.

The illustration explains the plan of this lantern sufficiently, and is called "The Skeleton" Triple. It is 20 *lbs.* less in weight when compared to a similar lantern of ordinary construction. The height also is some 10 inches less, bringing the lens tubes considerably closer together. Each lantern has a separate hood or cone to cover the light and condenser, with sufficient arrangements for ventilation, and a door is attached for access to the lime; the whole of which is detachable for cleaning.

At the present time there seems to be a demand for portable lanterns, no doubt to a travelling exhibitor a heavy triple is a consideration, but as triples are made in all grades and weights to suit the users' convenience, they can be built accordingly. Often for the sake of portability a biunial only is used, yet a conveyance must be taken to transport it about, this being the case, another 10 or 12lbs. extra cannot make any difference, and allows the third lantern to be used in emergency, also the advantage of the use of the higher class effects, which are the parts most appreciated of an exhibition, when well manipulated, this alone more than compensates for the little extra weight.

ALUMINIUM.

This metal has considerably fallen in price of late years, and when it reaches within a reasonable price of brass, it may be used for lantern work. To substitute aluminium for brass in this lantern would reduce it to nearly half its present weight. Aluminium at present is a third more in cost than brass, also a third less in weight; being such a tough metal it is very hard to work, and costs much more to work up than brass. Therefore to substitute aluminium for brass in a Triple lantern is not practicable at present.

DIORAMIC EFFECTS.

With all the increase in instruments for the furtherance and production of effects, there seems a general disregard on the part of lanternists for that magnificent illusion of dioramic effects. It is a great regret that such an entertaining and beautiful branch of lantern work is so neglected, which has only come about since the decline of the "Royal Polytechnic." Considering the number of triple and biunial lanterns used, it is surprising that the owners do not put them to their intended use. There are a number of lanternists who still appreciate the beauty and interest aroused by this charming branch of lantern work, such workers spare no pains in making an exhibition what it should be. There is no reason why, every owner of a triple, should not produce the same style of effects, as the most popular lanternist, if only he will do the same as they do, in fact it is seldom that the full value is got out of a triple.

Why this neglect and apathy?

We appear to live in a lazy age, with a taste for simplicity. When an audience is tolerably well satisfied with simple photographs, we do not care to spend the necessary time and trouble that is requisite to register effects. With a lanternist who is seldom twice in the same place, and using lenses of different focus, it is very different to the old Polytechnic, where the lanterns were stationary, with the slides and effects registered and marked for each lantern.

This system when worked in modern instruments, proves a failure, as slides registered at a short distance from the screen, will not come true when lenses of long range are adopted. And consequently effects trued and registered at home, in nine cases out of ten, fail to come right at an exhibition. What is more trying, and irritating to an audience, than to see effects bobbing up and down on the screen, as the operator endeavours to get them into their proper positions. This is the class of exhibition which brings lanterns into bad repute, and is it to be wondered at?

WHAT DOES REGISTERING IMPLY?

It means that one and every slide dissolved should appear perfectly coincident to the preceding picture in size and shape. Take two effects for instance, day and night of the same place, when the two are on the screen together, the buildings, etc., must superimpose over each other, with such precision that they have the appearance of one slide, likewise the circles or edges of the picture should superimpose to a minute degree.

Without a system, such registration is impossible. With such a method as Mr. Hughes advocates, the whole course of registering slides is reduced to a rule of thumb. When once the effects are trued, they are true for ever after, whatever focus lens may be used.

MANIPULATING A TRIPLE LANTERN.

After getting the lantern into position on its tripod or box (the latter should be very rigid and fitted with a canting table). Clean the condensers and front lenses with a chamois leather, which should be free from grease, and kept specially for the purpose. In replacing the condensers notice that the holes are at the top, to allow of the escape of moisture, and on a very cold night it may be necessary to warm all lenses by a fire, generally this is not required. Take care that the condensers are well pressed home in their sockets, as this is often the cause of a blurred picture particularly at the edges. Fix limes on the jets and turn lime pin as low as it will go, so that the lime may be gradually turned upwards during the evening. Never oil the lime motion, as it will cause a clog, when lime dust becomes mixed with the oil, brush them clean and if necessary blacklead the cogs. The connections with rubber tubing between jets and dissolving tap may now be made, and let the tubing be of good quality, pure rubber only. The average commercial tubing is of little use for this work, it will soon kink in bending, and thus causes a stoppage to the flow of gas. If the light fails at any time, let the first thing be to look to the tubing for kinks. Red pure rubber, of special thickness, cannot be too strongly recommended for connections, avoid all wired tubing, it will only impede the flow of gas.

Having connected all jets and supply pipes with bags or cylinders, see that all taps are off, except dissolving taps, of which we will suppose there are three, single Malden pattern, place the bars of dissolving taps horizontal, which means both gases can pass through, turn handles of the bye-pass taps of dissolver inwards towards the plug, in this position they are off, and out of the way of being caught by the fingers in dissolving.

Having turned on the gases at the mains O and H, we turn on hydrogen tap of jet (on left hand side) slightly and light the gas, gradually turning it up to the full. The bye-pass at the dissolver on same side should now be turned to its full (placing it perpendicular) and dissolving tap turned down by the lever handle, we now have the gas burning that passes through the bye-pass only, regulate the bye-pass or leak, which will always be alight when the dissolver is turned off, do not have too much leak (about half an inch up the lime) or it will show on the screen. We light the whole three jets on the hydrogen side in like manner, leaving all three lanterns with a leak of hydrogen burning in each with dissolving handles down (off). The following applies to blow through jets only :—

Next turn on oxygen (right hand side) taps at jets about three parts of the way, this done, gradually turn on the oxygen bye-pass tap letting a little gas through into the hydrogen, watch the flame, and when the oxygen makes its presence known by a small blue flame about the $\frac{1}{8}$in. in diameter like a pea, stop turning the bye-pass as that is sufficient. The dissolving tap handle which we left down may now be brought up, bringing both the gases on together.

Proceed now to adjust the oxygen, turning on more from jet-tap if necessary, or reducing it as the case may be, also regulate the hydrogen, reducing same as low as possible. The light should now be adjusted to the central axis of the condenser (see p. 24). When this is done, a slide should be put in the slide stage and focused up sharp, focus all three lanterns in like manner and with the same slide.

When chamber jets are used, no oxygen leak is necessary. Turn hydrogen on to the full, gently turning the oxygen into the flame, stop just short of the point at which the jet roars or screams, and if necessary, gradually lower hydrogen.

A chamber jet requires a much finer adjustment of the jet taps than a safety jet. And if Hughes' special chamber jet is used, exceedingly delicate handling is necessary as the slightest movement will give that intense brilliancy, not otherwise obtainable.

If the lantern is fitted with Hughes' system, directions are as follows—

Directions—for system of registering when fitted with adjustable stages. We presume the lantern set up to be a triple, and that the jets are centred, and each lantern focussed up sharp with the same slide.

Turn on middle and top lanterns, white disc only showing; proceed to make the two discs superimpose by means of the registering rods at back, or the screws at top of front in TOP lantern, lowering the front until you get the discs perfectly coincident. Now turn off the top and proceed to the bottom lantern, and register this disc into the middle in like manner by raising front, by means of the registering rods or screws. When these three discs, *T M B*, are once coincident, the registering rods or screws must never again be touched. It may here be necessary to adjust the jets again on the condenser, as we have moved the axes by dropping and raising the top and bottom lanterns; also note that the centre front is on an equal plane with the body on all four sides.

Now turn on middle and top lanterns, put the + slide into middle lantern, proceed to fix the middle + into the centre of plain disc (thrown by the top lantern) by means of the rising stage screws which are found at each end of the platform; raise or lower as the case may be until you find the centre of the white disc longitudinally —. The lateral movement | is obtained by means of a stop, which is always found on the left hand side of lantern, when this cross slide is in centre of disc. Bring up the set screws of stop and stage screws, so as to clamp them and prevent them from moving. Never alter these screws of middle lantern when once set.

Place + No. 2 in top lantern; raise or lower the platform at each end, until you get the longitudinal — lines exactly over that showing from the middle lantern. The lateral | line is made to cover by means of stop on left of lantern, when these two crosses superimpose and meet in every way bring the set screws well up to prevent any moving of platform screws as before mentioned. Top lantern is now finished.

Now take the same cross slide as used for top lantern, and place in the bottom and proceed to register this bottom + on to the middle lantern with its + using the platform to raise or lower, adjusting the stop for the lateral movement. It is important that the set screws be clamped tightly, and in so doing care must be taken that the platform screws are not moved.

If the above directions are strictly carried out, the registering of all three lanterns will be identical, viz., the two crosses can be placed in any two lanterns, and they will register dead true on the screen, changing them as often as you like.

This exactness can only be obtained with registering platforms and test or cross slides, the latter being identical to a minimum in every way, These "trued" test slides can only be obtained from Mr. Hughes.

The special masked carriers may now be put in and they will be found to be exactly one over the other, if not, a small plane may be used to take off a shaving if required, as a rule this is not necessary. In starting to register up effects, always register the first slide on to a carrier frame.

REGISTERING TRIPLE WITHOUT ADJUSTABLE STAGES.

If the lantern is of ordinary pattern without registering rods or adjusting stages, lower the top disc, and make it superimpose with the centre by means of the registering screws and milled nuts at the two corners of the front, loosen the screws, when the spring at the back will force it forward, it may be necessary to bring one side considerably more forward than the other, as the front is let down it should be backed up with the set screws behind, to prevent it going back.

When registering the discs for the first time they should superimpose exactly, even if it is a little unpleasant and tiring work, all this must be done on the focus, *i.e.* a slide put in and focussed up sharp, in preference, the same slide to each lantern. Presuming the top disc is coincident with the centre, turn off top lantern and register the bottom disc to the middle in the same manner, only here the bottom front must tilt upwards, bringing up the back screws, to hold the front as we loosen the milled head.

With all three discs, as coincident as possible, we proceed to register the carriers. If they are plain square carriers it is an easy matter, turn any two lanterns on, place the carrier in one, move it about until it fits equally in the circle, it may require piecing on the bottom to make it higher, or plaining off to bring it lower. Move the frame from right to left and having obtained exactly the centre of condenser place a screw at bottom of the corner of frame nearest to the operator, to act as a stop in future, to prevent the frame going in too far, the thin edge of the screw is apt to wear a hole in the edge of the slide stage, to prevent this, file the edge down, of course due allowance must be made for the amount to be filed off,—when finished try it two or three times in and out the lantern, to make sure the screw does not move and is in the right position. Carrier No. 1 is thus finished, mark it for the lantern it belongs to, proceed to register carrier No. 2, on to this, in like manner, and mark it for its respective lantern. Register carrier No. 3 mark also; the carriers are then registered and always ready for use. If the carriers have masks, square, or circular, so much the better, only to be of any service, the carrier masks must be of a smaller aperture than the slide mounts, and this means cutting off some of the edge of the picture. When effects have to be registered, start with two plain discs showing, place the first slide of the set in either of the lanterns, move it until it is exactly in the centre of the white disc of the second lantern, block up the frame, or plane off, as the case may be, and put in screw to act as stop, the second slide should be registered on to the first, the third on to the second, and so until the set is completed, marking each slide for the lantern it is registered for. With every fresh slide commence in the same manner again. With a triple lantern, always if possible, arrange effect slide to come in the bottom lantern, the set slide in the top or middle.

Although the above system is good, and from experience found to be the best of any for lanterns, without registered stages, yet it is not a permanent or reliable method.

THE COMPLETE SYSTEM OF REGISTERING.

If a lantern has only one set of fixed lenses, and no others are to be used, the slide stages themselves may be trued, and can be easily accomplished by one familiar with the use of tools.

The distance of the slide stage from the condenser must be mathematically true to a minimum, and mathematically true to the optical system. Any lantern can be trued in a short time.

As before mentioned, a lantern with one fixed set of lenses may be permanently registered, but when it comes to using several codes of lenses, of different foci, this mathematically trued platform will not work out its own theory! Why? Because the optical axis of two lenses when put on a lantern never appear in the same place. In fact the same lens and draw tube cannot be placed twice in the same position, unless it is so marked, that the threads always come to the one position. Let any lanternist focus a picture on the screen, and then turn the front tube that holds the lens round one revolution, and notice the screen in so doing, the picture will be seen to wobble and take an elliptical course, this is just what happens when a fresh tube or lens is screwed on a triple or biunial. Let three discs be registered up in any ordinary triple, give each tube half a turn only, and then notice how the discs are out of centre No two discs superimpose. This alone is a sure proof that a solid platform so far is a failure. It is true that by altering the registering screws top and bottom of the lantern that the discs can be made to drop in their places again, but place a square picture in the stage it will then be found that the corners are all blurred with color.

The only true way for perfectly registering a lantern is to adjust the platform to the axis of the lens, and not the lens to the plat-

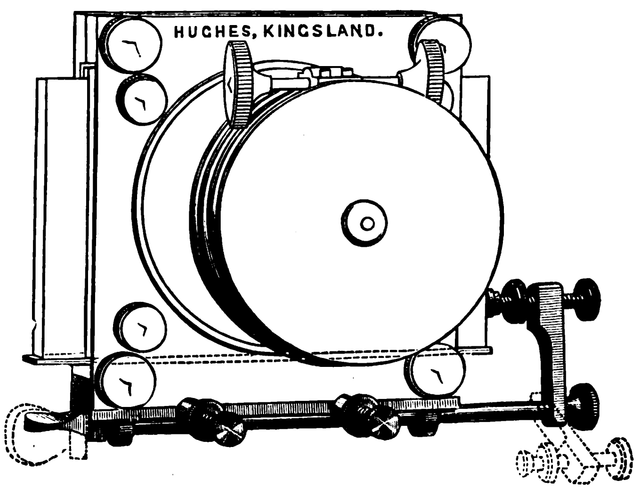


Fig. 27.

form. This is the principle of Hughes' patent system of registering. With this method, the lantern is registered in five minutes, and effects once trued will always register dead true at any time with varying lenses, and the slides may be placed in any lantern and always come exact, it is truly one of the greatest boons to a lanternist to find such a method at his command.

Fig. 27 shows the registering adjustable platforms with stop, which are raised and lowered either by rack and pinion or thumb-screw motion fitted to an ordinary slide stage; the dotted lines show the stop unlocked from its socket, and turned down when a panorama or long slide is used.

REGISTERING EFFECTS AND OTHER FRAMED SLIDES.

Previously to registering effects, all the slides must be blocked in frames and fixed so as to prevent them moving or shaking about, adopt a method and abide by it, not registering them in one way at one time, and differently the next.

The following method as used by the writer will be found as good as any.— The usual wood frames or carriers used for framing slides, vary in size, according to width of the slide, and are known as one line, two line and three line, the medium size is the most useful, and should measure $4\frac{1}{2} + 7$ outside. Take photo block, hold it in the left hand, pulling out the moveable piece with the right, if the slide fits loosely a strip of card of the necessary thickness, should be laid in the rebate, to cause the slide to fit tightly and prevent it shaking about in the frame, glue the strip of card, about $2\frac{1}{2}$ inches long, to the bottom of the rebate or groove, next glue all three sides of frame, strip of card included, this is easily done with a fair size camel hair or any suitable brush, providing it is not too large or the glue will get over the edges of the frame, nor should the glue be too thick. This done, take the slide in the fingers and reverse it in the exact manner, as though it were being put into the lantern, with the paint towards you, or in other words, with cover glass next to condenser, slide same into the rebate of the glued frame, next, glue the loose end of the block, top and bottom including the rebate, and press tightly into its place, this having been done, stand to dry for three or four hours, it will then be seen that the slide is as firmly fixed in the frame as could be wished. When registering in the lantern it will then be seen why the card strip was put in the bottom rebate, and not on the top, or not equally top and bottom, and why the loose part of the frame was put into the wood block from the right hand. As all slides are inverted ready, all that is required is to introduce same into slide holder of the lantern, when all the level ends will come against the stop, making it much easier to work. If the loose end of the frame came against the stop, it would be necessary to glue a thin piece of wood on nine out of every dozen, to bring it up to the level of top and bottom rail of frame.

By putting the piece of card at the bottom the slide is raised, as it is easier to take a shaving off the bottom of frame with a plane, than it is to glue a piece on, which you would find necessary if any other method is used. It may be necessary to cut away the edges of the frame in the centre as they overhang, especially in circular mounted slides, this is easily done with a chisel or pocket-knife. In the case of mechanical frames, when inverted for placing in the lantern, all lever handles and slips should come to the right hand. Endeavour to arrange effects in this manner because it will save a lot of trouble in working, especially if one pair of hands has all the operating to do. If this cannot be done, reverse the framed or set slide, which comes previous, so that its painted side, instead of the cover glass, comes next to the condenser. When registered, glue or gum a piece of white paper, about one inch square, on the frame and mark in good bold black figures, *1 2 3* and so on. This paper should always be in one place, so that it may be a guide in the dark, and prevent slides being placed the wrong end up in the lantern.

Another difficulty in registering is the varying sizes of the masks or mats, these should always be kept one size, and in preference, should be circular for the reason that they are easier to register than cushion or square mats, also because a square picture is optically incorrect; it is not to be expected that a true square picture can be thrown by a circular lens, there is sure to be a slight tendency of the edge of the disc to be thrown out of the perpendicular, more especially with short focus lens, of course, this can be overcome by using long focus lens of a wide diameter, the lens in that case being of a wider diameter than the slide opening. If the mats which are to be used are circular, they should not be smaller than $2\frac{15}{16}$ths. in the opening, if possible keep them all 3 inches. It will frequently happen when registering effects that the painting may be made to register, but the mats will not allow of the edges to superimpose, this being the case, the slide must be unbound and the mat shifted until it is right; it is a tedious task, but must be done if slides are to register properly.

TOOLS FOR REGISTERING EFFECTS.

Before commencing to register and true up effects, the following odd tools are necessary.—Glue pot, *fig 8* (a small copper one is handiest as it is quickly heated); bradawl, *fig. 3;* screwdriver, *fig. 1;* one-inch chisel, *fig. 2;* triangular file, *fig. 4;* a small American iron plane, *fig. 7;* some inch and inch and-a-half screws, *fig. 9 (screw)* it will be noticed has one side filed away—this is screwed into the top or bottom of frame, leaving about an inch projecting, when a long slide or panorama is used, and acts as a stop when coming against the slide stage, greater precision is obtained by filing the side flat. *5* and *10* are arrangements for holding a single or pair of gas bottles; *fig. 6* having been already screwed on the lantern-box into which the frame is dropped and held in position; some strips of mahogany (or an old cigar box is as good as any), and a shooting board (Fig. 29) about sixteen inches long.

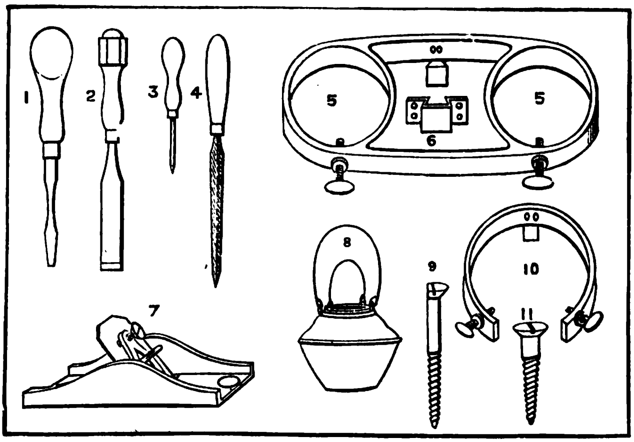
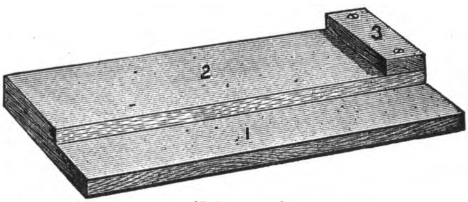


Fig. 28.

In case the latter is not understood, a sketch is given. Any carpenter will knock one up for two shillings.



(Fig. 29.)

Shooting board, for planing the bottom and edges of slide frames truly.

The plane is placed on its side on the lower board (1), the slide frame on the top board with the edge to be planed towards the plane and well pressed against the stop (3), the plane is then brought backwards and forwards, the latter motion, of course, taking the shaving off.

Having the lantern, either a Triple or Biunial, in working order, the discs all centred, and the crosses or carriers exactly trued, and in the exact centre of condenser, by the method previously explained, commence to register the first slide of any fresh series of effects to the trued carrier or cross slide, *i.e.*, either by planing or building up the frames, so that the mats cover exactly the plain disc of the carrier or cross, and after registering slide no. 1, register all succeeding slides to this.

EFFECTS.

Some Complicated Effects, and how they should be worked.

Exeter Theatre Fire.—(1) Exterior of Theatre by night, and lamps illuminated. (2.) Interior. (3.) smoke issuing from auditorium, very finely at first, then increasing in volume until flames burst forth. (4). And the whole auditorium is in one rolling mass of smoke and flame. (5, 6 and 7.) Exterior in flames, the fire burning out leaving only the ruins. To work this effectively a triple is required, as three lanterns are in use at one time.

Firstly, No. 1 exterior, then No. 2 and 3 are put on together, the rack slide No. 3 on which smoke is painted, has a slip glass blacked, and when in its normal position all but obliterates the smoke itself.

As 2 and 3 are dissolved on, gently turn the smoke rack, being careful that the handle is being turned the right way. To see the smoke descending instead of rising, at once makes an otherwise grand effect ludicrous. To guard against such a mistake, cut deeply an arrow on the edge of the frame, so that in the dark the direction of the arrow may be felt. Continue to turn the smoke, at the same time gradually pulling off the slip glass, uncovering more of the smoke. An assistant will be necessary to turn the smoke rack whilst the rack with the fire No. 4 is introduced into the third lantern, dissolve this on gently, turning the handle of the fire and gradually pull out the slip glass, which covers the fire, at the same time gently pushing back in its place the slip glass of the smoke rack, until the fire is on full and the smoke is covered up, dissolve off this smoke rack and introduce the next picture (5.)

No. 5. Exterior in flames, engines, firemen, etc. Dissolve off the interior and its fire rack, introducing No. 6 rack fire for exterior, gradually withdraw the slip glass until the flames cover the building to the full extent. After working the rack a few seconds, introduce the "Ruins," dissolve on with care. At this period we have three lanterns going until we dissolve off No. 5. The rack fire and ruin slide are now showing, gently push back the cover glass of the rack which cuts off the flame, until it is back in its normal position, and lighten up the ruin view to its full extent, hold the open fingers in front of the lens of the lantern containing the rack; flicker the flames by opening and closing the fingers a few times, until you cover up the fire entirely, leaving the ruins alone on the screen. *Note.*—All fire and smoke effects are improved by being slightly out of focus.

Vase of Flowers.—(1) In Bud. (2) Blossom, here butterflies are introduced, in two lanterns, the motion the butterfly takes, is that of an elliptical curve, which is done by a slip glass working on a sliding pivot one in each lantern, moving the fingers in front of the lens, gives a scintillating effect as though the butterflies moved their wings in and out of the light. A second assistant is here necessary, to keep the butterflies at work, while the flowers are turned into decay, the butterflies may be tinted various colours by the aid of light tints of glass or gelatine introduced into the diaphragm slot of the lens.

History of the Emigrant Ship.—The real beauty of this set of dissolving views is enhanced by the song "Ship on Fire," by Henry Russell, being introduced, or appropriate airs being played. "The Girl I left behind me," "To the West," "Bay of Biscay," "Ship on fire," "Rule Britannia," &c., &c.

The vessed is towed out of Harbour, and left at sea with moving waves. The sun is made to sink, and as this is brought about by a separate sunset movement, a pale blue glass should gradually be slipped into the diaphragm of the lens giving a realistic effect of approaching night, when glass fully covers the picture dissolve to storm, and make ready the second and third lanterns for red and blue lightning. Keep the three lanterns on, only be sure to close the flashers on lenses of the two lanterns containing the lightning, flash half the lightning once or twice from one lantern, (by flashing the shutter half way), then flash the shutter fully opened and closed, then flash the second lightning in the same manner. Do not leave the lightning on the screen, simply flash slowly at first, and then once or twice in rapid succession, and finally both lanterns at once, if not overdone, but worked well, the effect is most vivid and startling. If thunder is wanted, hang a sheet of zinc or iron by the corner and shake it.

The fire caused by the lightning now breaks out in the forecastle of the vessel, take out a lightning slide and introduce the rack for fire with the blacked slip glass in its place which only allows a small portion of the flame to be shown, place the hand in front of the lens as dissolver is turned on and allow the light to escape through the fingers, opening and closing same, as described in the Exeter Theatre set, this giving a rising and falling effect to the flames. Mark the edge of the rack with an arrow so as to indicate which way the handle should turn, after a few seconds the hand is taken from the front and the flames allowed to spread by pulling out the slip glass; dissolve to the next which is a similar scene, only the sea calm without an eccentric movement of the waves and tossing of the ship; if the fire effect was put on to the moveable ship, it would be absurd to see the vessel rolling and the flames stationary: dissolve on this stationary view of vessel and gently extend the flames by pulling off the blacked slip glass of rack; when out to its full extent the flames cover the vessel; introduce the picture which is exactly similar to the preceeding one, with the difference that the masts and bulwarks are burnt away, and that a slip glass is attached on which is painted a raft; if these are truly registered and effectively dissolved, the effect can be given of the masts gradually being consumed. When the previous scene is dissolved completely off, the slip glass with raft is withdrawn from under the stern of the vessel; now reduce the amount of fire on vessel by pushing home the slip on rack fire slide, at the same time bringing on the last slide of the Ruins, as the slip rack is pushed home the effect is given of the fire burning itself out until nothing is left but a small flicker of flame, move the open fingers in front of the nozzle carrying fire, two or three times, then cover up completely, which leaves the burnt-out skeleton of the vessel showing, whilst this is on; make clear two lanterns for the two remaining slides which are put on together,—this is imperative,—and they should be registered in such a manner that no dark or light band shows on the horizon, which will occur if the sea and sky do not register perfectly, the sea being painted on one slide, and the sky and wreck on another; a very realistic illusion of the sinking vessel is produced; after sinking the wreck, be careful not to let the lever slip down.

Sunrise on the Matterhorn.—The first slide is placed in the lantern, and in the slot of the front lens of same is placed a dark blue glass, when the picture is on the screen it has the appearance of dawn, with just an outline of the mountain. The effect of the rising sun is brought about by moving the slip glass off,—the second slide, after this has been uncovered about a third of its distance, gently withdraw the coloured glass in front of the lens at the same time as illuminating the remaining portion of the mountain, which gives the illusion of the sun rising and illuminating the peak, at the same time a soft glow is gently thrown around until every part is fully illuminated. It is certainly one of the most charming and artistic effects that can be produced.

The Peter Botte Mountain allows of a better display of this illusion, as there are three slides, the third being a moonlight view. Care must be taken to use the coloured glass of a correct colour, and it must be withdrawn very gradually.

All this class of work must be entirely hand painted, and is necessarily very delicately and finely executed. The aritists who paint them are very few, such intricate work is a life's study, and deserves every appreciation.

SUNDRIES THE OPERATOR SHOULD CARRY WITH HIM.

1.—Gas-pliers with three-sized grips, wire-cutter, handles forming screw driver and rammer. 2—Gimlet. 3—Driver hook or staple. 4—2 and 3-in. nails. 5—Hammer. 6—Gas-nib with bent tube, male thread. 7—ditto, female thread. 8—Screw eyes. 9—Screw hooks. 10—Pulley block for hauling up the screen. 11—Broach for clearing out jet nipples. 12—Tacks. 13 and 14—Elbow joints for gas fittings. 15—Connection for hooking to gas burner to save a kink in tubing. 16 and 17—Y or T pieces for obtaining a supply of gas from two burners when a poor supply of gas is given. 18—Lime tongs.

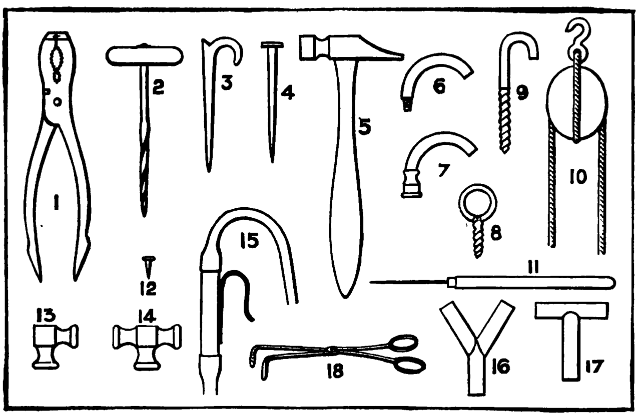


Fig. 30.

Method of obtaining a gas supply from a star burner without closing the nipples up with lead. Connect from burner to burner with pieces of old tubing (shown tinted in drawing) and if a Y piece is not to hand to carry the supply to the lantern from two burners, tie a knot in the odd piece, leaving one open for the supply tube. It is always best to use a T or Y piece, it gives a much better supply. Be sure and remove the burner first before putting on tubing which supplies the lantern.

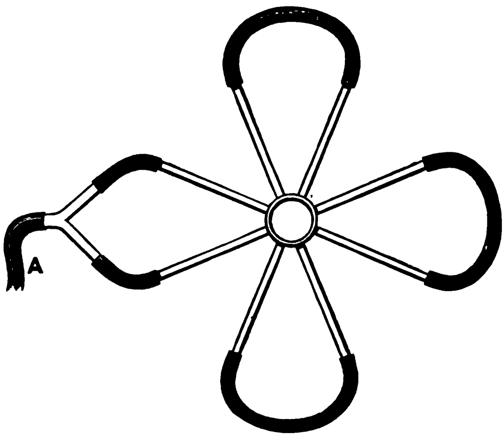


Fig. 31.

CONDENSERS.

The object of a lens which is termed a condenser, is to take up as wide an angle of light as possible from the illuminant, be it oil, or lime-light, and so cone it down in such a manner, as to pass it through the objective, or front lens, which it does by refraction, wider the refractive angle, shorter the focus, and consequently the shorter the focus of condenser, greater the light on the screen. This can be done with a single condenser, only that the lens would require to be of such a thickness, that much light is lost by absorbtion, and the chromatic and spherical aberration would also be very great, the disc appearing uneven with a fringe of colour around the edge. The use of two lenses of moderate thickness accomplishes the desired result, and minimizes the aberration.

Condensers have been made in various forms and curvatures from the single bull's-eye, to the present triplet.

Previous to the introduction of photographs, when slides were entirely painted by hand, it was the rule to have the slides from six to eight inches in diameter, for the obvious reason, that more detail could be painted in an eight inch circle than in a three inch picture. With these large slides it was necessary to have large condensers of eight to ten inches in diameter, which were of very long focus and badly cut.

At the present time we are enabled to use a 3in. picture, and obtain a much finer result.

The standard size slide is now $3\frac{1}{4} \times 3\frac{1}{4}$, and the circle of the said slide 3ins., now if this was always the case, and circular mats were always used in slides, a $3\frac{1}{2}$in. condenser would suffice, as it is, slides are mounted with square and cushion shaped mounts, and it is thus requisite to have a condenser of 4in. diameter, so as to take in the corners of the square slide. With a condenser larger than this there is a great loss of light, unless slides are used of a larger size in proportion, and front objective to match. As little is to be gained by so doing, and the extra expense considerable, it is rarely attempted.

The form of condenser which absorbs the most rays, and is now generally adopted either in conjunction with lime or oil light is a double plano convex, mounted with the convex surfaces inward.

A plano and miniscus mounted together with the miniscus to the light, is a good form for limelight, and admits as much of the rays as any form, and has the advantage of being suitable for long or short focus objectives, being of short focus, it necessitates the illuminant being very close to the miniscus lens, and if the jet is kept burning for any considerable time, is very apt to crack.

For oil light, and for use with a short focus objective, a double plano convex, as already mentioned is the best form and should be of very short focus. The curves of a short focus condenser being very acute, it will take up more of the rays outside its axis than a lens of longer focus, and give considerably more light on the screen than one of longer range. When a lens or objective is used of a longer focus than six inches (we refer to back focus) a condenser must likewise be employed of a longer focus, if square or cushion shaped slides are used. With circular slides it is not necessary.

If a short focus condenser is used with a long focus, a disc with colour and falling away around the edge results. Owing to the extreme outer rays being taken up.

If only 3in. circular pictures are used, with the 4in. condenser, the extreme marginal rays are not used, as half an inch all round the slide is cut off. Whenever a square or cushion shape is used, the chromatic aberration makes itself slightly visible at the four corners.

Lesson.—A condenser of longer focus is necessary when a long focus lens is used, than with a lens of shorter focus.

When it is necessary to cone down the rays of light to a very small area, as in the case of a lantern Microscope, a triplet combination is brought into use, as fig. 32, it has an advantage in this particular case, but for lantern work generally it is not necessary. The more lenses we add, the greater the number of reflections, and consequently there is a falling off of the light.

For experimental purposes, and where a parallel beam is required, a double condenser of 2½in. combined back focus is used. This is also the best focus for use with front lenses above 6ins. equivalent focus, and for single lantern work when using limelight, the back condenser is not so liable to crack, the jet being further from it, than with a shorter focus.

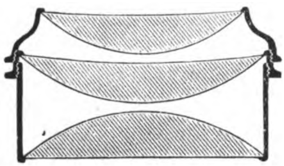


Fig. 32.

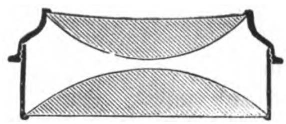


Fig. 33.

Fig. 33 shows a plan of condenser for reducing the risk of cracking this lens, and we also think a slight gain in light; it has a 4in. front with a 3½in. back; there is not the amount of glass to become heated as in a 4 in., this half inch making a considerable difference in the curvature.

As the condensers increase in size so the focus is proportionately augmented for enlarging purposes. To cover a half-plate negative an 8in diameter condenser is necessary. For a whole plate, a 11in. and 10 × 8, a 14in. diameter is required, for this purpose the rectangular condensers were constructed, reducing the size of the condenser considerably, besides reducing the weight. In the future they should play an important part, as a substitute for the large round formula. *(See enlarging lanterns.)*

LENSES.

Here are shown various forms of single lenses used in the component parts of front lenses and condensers.

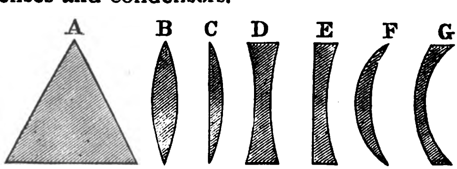


Fig. 34.

A. Is a right angle prism, being really half a lens. *B.* Double convex. *C.* Plano convex, two of these with their convex surfaces mounted inward are at present used as a condenser. *D.* Double concave, mostly of flint, used in the front objective. *E.* Plano concave. *F.* Meniscus, or periscopic. *G.* Is a concavo convex.

Two or more of these lenses are mounted together to form a combination. Generally *B.* and *F.* are cemented together, one of crown and the other of flint. With a single double convex *B.* it is not possible to bring the whole of the rays to one focus, but it is possible to conbine this with a concave such as *E.* which nutralises the defects of the convex *B.*

THE OBJECTIVE.

This is the front lens employed in the mount to focus the picture, formerly a single lens was used, now it is only employed in toy lanterns, the spherical aberration being so great, a stop to cut off the extreme rays was necessary, and even then it was impossible to focus a picture sharply all over. When hand painted slides were used, the extra sharpness that is now wanted for photographs, was not necessary, in fact, it added to the general effect. Distance verily lent enchantment to the view. Next comes the

DOUBLE ACHROMATIC LENS.

Ranging in focus from 4 to 18 inches, the spherical aberration is considerably reduced, when compared with those first mentioned, two or more of such lenses combined, form a combination of short focus and make better lenses than the single achromatics, and give better definition in themselves when combined in this manner, than when used separately. A set of these lenses of 6, 8 and 12in. focus will give six combined foci for different distances. A stop or diaphragm is necessary to cut off the marginal rays, and must be placed in the front of the lens.

After the introduction of the lens next to be mentioned, the former

DOUBLE COMBINATION LENSES.

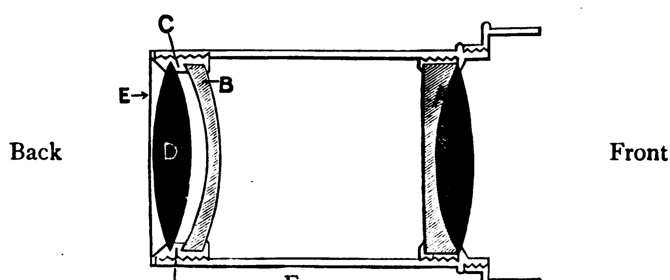


Fig. 35.

class of lens became obsolete, as it would not give the extreme sharp and crucial definition necessary for photographs and enlargements.

The formula now generally recognised and acknowledged, is that known as the Pelzvil form or the usual portrait combination (Fig. 35) consisting of four lenses, the two front combination *A.* being cemented together, consisting of a plano-convex or a meniscus of slight external concave curvature, and a double convex. The posterior lens composed of a bi-convex *D.*, and a concavo-convex *B.*, mounted with a ring *C.* between, so as to prevent them touching each other. Of this class of lens, there are good, middling, and bad, and unfortunately the system of cheapness has brought about a great influx of the latter class.

In taking out the lenses for cleaning, it is most important that they be replaced in their proper order, the diagram will help those taking a combination apart for the first time.

For lenses of short focus, the back combination should be of slightly larger diameter than that of the front. A good long focus lens is made by taking out the back combination and using the front only, a stop is necessary to sharpen up the sides, with this there is a great loss of light. Naturally the same results cannot be obtained with this, as from a complete combination already described. As a rule the shorter the the focus of the objective the greater the light on the screen, the average short focus lens does not require to be of a wider diameter than 2ins. back. When a lens of longer focus than 5ins. back focus is used, the diameter must be increased to 2½ins.. When the focus is 10ins. and upwards, the diameter must be 3ins., nothing is gained by increasing the diameter beyond this. This is a critical point, and one which practical knowledge alone can prove. According to theory there is no more loss of light with a long focus lens than with one of short focus, and this is where many writers on optics fail.

The loss of light is considerable in every inch added beyond 4ins., and the loss of light from a 10in. focus lens of small diameter when compared with a short focus, is 50 per cent., and the fact is simple enough, when demonstrated. If a beam of light is watched coming from the condenser, it will then be seen that at 10 inches away a larger lens must be substituted for the small one, if the whole of the rays are to be taken up.

Compensation for the great loss of light with a long focus lens, is only to be brought about by the use of an objective of large diameter, and the student who can pass as much light through a 10in. focus lens of small diameter as through an objective of 4in. focus, must indeed have discovered a royal road. No, it is all book theory and cannot be done; let the lanternist try for himself.

Unfortunately after the introduction and popularising of these large diameter lenses, by Professor Malden and Mr. Hughes, other lenses of large diameter appeared in the market, many of an inferior character, and the unwary at once conclude that so long as they have a large diameter combination, they will succeed in the best results, this does not follow, as some of these lenses are no better in definition than the 2½in. single achromatic.

THE FOCUS OF THE LENS.

Before the distance can be ascertained at which the lantern should be placed for a given size picture, we must first know the optical or equivalent focus, a term which arises from comparison with a single lens, that produces the same size disc, and thus being equivalent to each other, this can only be properly tested and found by the optician, but may be roughly got at as follows:—Supposing the back focus of a lens is four inches and the tube it is mounted in is four inches also—halve the length of the tube, and add this to the back focus, which would mean an equivalent focus of six inches—in other words, the equivalent focus is measured from midway between the lens tube to the focussed image.

The plan generally adopted for marking the lenses, is that of the solar or back focus. A view is focussed up sharp by the lens on a white wall or paper, and the distance between the wall and the back lens measured, this is called the back focus, and measures from 3½ins. upwards. This is of little service for determining the disc it will throw, and is a frequent source of trouble. As two combination lenses may be taken, with their solar foci identical, when used on the screen they are considerably out, even to the extent of 2ft. on a twelve foot disc. The diameter of lens and length of tube it is mounted in, has to be considered, practically the back focus of a lens is no guide whatever, therefore no scale can be made to help the operator.

Having ascertained the equivalent focus of lens, the following scale will be found very convenient, being copied by permission, from the *Optical Lantern Journal*, *October*, 1890:—

"When one is called upon to give a lantern entertainment in a hall or room, the following questions will be uppermost in the mind of the operator:—(1) What size of disc can be obtained with a lens of a certain focus? (2) How far distant from the screen must the lantern be placed in order to get a disc of a certain size with a given lens of ascertained focus? Doubtless many more questions will arise, but these mentioned will be of the most importance. It is a "rule of thumb" practice for an operator to wheel his apparatus up and down a room in order to find the desired position from which to operate; and the minds of any spectators will not be confirmed in the idea that the exhibitor thoroughly understands his business. How very much more simple and satisfactory is it to reason thus before starting for the place of entertainment. A screen of —ft. diameter is required, so if I bring a lens of — focus the lantern must be —ft. from the screen, the length of the room being of course taken into consideration in order to ascertain that it is possible to erect the lantern at the desired distance. This having been ascertained beforehand, all that is required is to take an objective of the desired focus and measure off the necessary space between the screen and the place where the lantern should be set.

Supposing we are called upon to operate the lantern in a hall 25ft. in length, we first ascertain the size of disc required, which we will suppose to be 10ft. With an objective having a focus of 6in., how far from the screen must the lantern be placed in order to produce a 10ft. disc?

Here is the rule by which it can be ascertained :- –

Let A = focus of objective.
,, B = diameter of slide.
,, C = ,, ,, disc.
,, D = distance between the lantern and screen.

Multiply the diameter of the circle round (C) by the focus of the lens (A), and divide by the diameter of the slide (B).

$$\frac{C \times A}{B} - D = \frac{10 \times 6}{3} = 20\text{ft.}$$

It is thus seen that in order to produce a 10ft. disc with a 6in. objective, the lantern must be placed 20ft. from the screen. On the other hand, we may possess several lenses of different foci, and it is necessary that the screen and the lantern must occupy certain positions which we will suppose to be just 20ft. apart, and that the diameter of the disc must be 10ft. How are we to ascertain whether we must use a lens of 4, 5, 6, 7, or other number of inches in focus?

Multiply the distance between the lantern and the screen (D) by the opening of slide (B) and divide by the size of disc.

$$\frac{D \times B}{C} - \text{A focus of lens} = \frac{20 \times 3}{10} = 6\text{in. focus.}$$

Again: We have a lens of 6in. focus, and intend that 20ft. shall intervene between the lantern and the screen, and wish to know what size of disc can be produced. In order to calculate this it is necessary that we multiply the distance between the lantern and the screen (D) by the size of slide opening (B) and divide by the focus of the lens used (A), which gives us—

$$\frac{D \times B}{A} = C \text{ size of disc} = \frac{20 \times 3}{6} = 10\text{ft. diam. of disc.}$$

The following Ready Reference Table has been computed by the foregoing rule, and by a glance it will show the relations between lantern and disc with object-glasses of every focus from 4in. to 15in.

READY REFERENCE TABLE.

Distance between Lantern and Screen.	FOCUS OF LENS.											
	4in.		5in		6in.		7in.		8in.		9in.	
	DIAMETER OF DISC.											
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10 feet.	7	6	6	0	5	0	4	3	3	9	3	4
11 „	8	3	6	7	5	6	4	9	4	2	3	8
12 „	9	0	7	2	6	0	5	2	4	6	4	0
13 „	9	9	7	10	6	6	5	7	4	11	4	4
14 „	10	6	8	5	7	0	6	0	5	3	4	8
15 „	11	3	9	0	7	6	6	5	5	8	5	0
20 „	15	0	12	0	10	0	8	7	7	6	6	8
25 „	18	9	15	0	12	6	10	9	9	4	8	4
30 „	22	6	18	0	15	0	12	10	11	3	10	0
35 „	26	3	21	0	17	6	15	0	13	1	11	8
40 „	30	0	24	0	20	0	17	2	15	0	13	4
45 „	33	9	27	0	22	6	19	3	16	10	15	0
50 „	37	6	30	0	25	0	21	5	19	8	16	8

Distance between Lantern and Screen.	FOCUS OF LENS.											
	10in.		11in.		12in.		13in.		14in.		15in.	
	DIAMETER OF DISC.											
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10 feet.	3	0	2	9	2	6	2	4	2	2	2	0
11 „	3	4	3	0	2	9	2	6	2	4	2	2
12 „	3	7	3	3	3	0	2	9	2	7	2	5
13 „	3	11	3	7	3	3	3	0	2	9	2	7
14 „	4	2	3	10	3	7	3	3	3	0	2	9
15 „	4	6	4	1	3	9	3	6	3	3	3	0
20 „	6	0	5	6	5	0	4	7	4	3	4	0
25 „	7	6	6	10	6	3	5	9	5	4	5	0
30 „	9	0	8	2	7	6	6	11	6	5	6	0
35 „	10	6	9	6	8	9	8	1	7	6	7	0
40 „	12	0	10	10	10	0	9	2	8	6	8	0
45 „	13	6	12	3	11	3	10	4	9	8	9	0
50 „	15	0	13	8	12	6	11	6	10	9	10	0

Examples.—An 8in. focus lens at a distance of 35ft will give a disc of 13ft. 1in. To produce a disc of 12ft. with a lens of 10in. focus, the lantern and screen must be separated by 40ft. To produce a disc of 15ft. at a distance of 45ft. will require a lens of 9in. focus.

THE OBJECTIVE MOUNT.

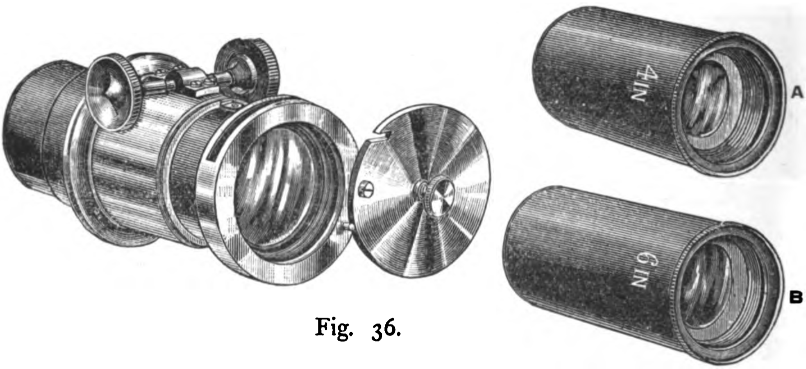


Fig. 36.

The lenses themselves are always mounted in tubes as Fig. *A.* and *B.*, but these again must be mounted or placed in a jacket with a pinion working on a rack which is screwed on to lens tubes *A. B.*, being racked in or out by the milled heads, when the lens tube is so mounted it becomes a fixture in the jacket or mount, and is the best arrangement for solidity.

To save weight and slightly reduce the expense, another plan is very servicable, when lenses of various foci are intended to be used, that is, to have the jacket or mount so constructed that each combination in its tube will slide into the mount, usually from the front, or screwed in from the back. The sliding plan seems to commend itself more generally, the tubes should fit into the mount somewhat tightly, especially for two or more lanterns.

The lens mount Fig. 36., is fitted with a double pinion, enabling focussing to be worked from either side, and is fitted with a diaphragm slot in the front to enable coloured glasses to be introduced. The cap or flashing shutter is shown in the illustration on the wrong side, it should open over to the right, otherwise the hand will be in front of the lens when uncovering. When setting up a lantern, rack the lens out half-way (as shown in engraving) focus roughly with the front tube into which it is screwed, and give the final definition with the pinion, never rack the pinion out to its full extent, it is sure to cause a downward tendency, although only very slight.

COMPRESSED GASES.

Compressed gases in cylinders are more general now than hitherto. Although compressed gas is not new, the cost years ago was very heavy, being 7d. and 8d. per foot (whereas it is now 3d.) which prohibited it being used much for lanterns.

Low pressure cylinders have been used in America for years past, where it is used direct from the cylinder without any intermediate regulator. The following method is also a mode of compressing gas, but let us hope, has not always the same ending. A travelling exhibitor in the United States, not wishing to carry bags, used a wrought iron cylinder into which from a large aperture at the top, he placed his oxygen mixture (potasse chlorate and black oxide of manganese) after making the top fast, the cylinder was placed upon the fire, with a considerable heat, the gas generated, and in so doing compressed itself. After the cylinder had cooled down (which took a considerable time) it was ready for use. It was certainly the ideal of simplicity for obtaining compressed gas, without the aid of pumping machinery. On one occasion, the chemist who was entrusted with making up the gas mixture, used instead of the black oxide of manganese some foreign substance as charcoal or antimony, it is needless to say the whole place was wrecked, pieces of the cylinder being blown through the wall, in fact the explosive acted in every way, like a bomb.

It is a rule, now by Brin's Oxygen Company (London), to test every cylinder sent them to fill for the first time. Every cylinder must be marked for its specific gas. Red for hydrogen, black denoting oxygen. No oxygen will ever be put into a hydrogen cylinder or *vice versa*, and this rule is like the laws of the Medes and Persians.

It is general now in England to fill cylinders up to a pressure of 120 atmospheres or 1,800 lbs. pressure on the square inch.

Whether the cylinder is made for six feet or a hundred, the pressure, when full is the same. If a pressure gauge is put on a full cylinder it should indicate 120 atmospheres or 1,800 lbs. Presuming that a cylinder contains 40 ft. it would indicate on the gauge 1,800 lbs., if only half full (20 ft.) the hand would stop at 900 lbs., if a quarter full (10 ft.) 450 lbs., so on in proportion.

A simple method to know the contents of a cylinder is as follows :—

The dial of a gauge is usually marked in lbs. or atmospheres. The *red* figures indicating atmospheres, and the *black*, lbs.

To tell the contents of a cylinder, divide the red figures (atmospheres) by the numbers here given, and when full, works out as follows :—

For 40-ft. cylinder,	divide	÷	120 atmospheres	by	3,	= 40
„ 20 ft.	„	„	120	„	× 6,	= 20
„ 15 ft.	„	„	120	„	× 8,	= 15
„ 10 ft.	„	„	120	„	× 12,	= 10

This may appear perhaps confusing at first, when once grasped it is very simple. Example:—A 40 feet cylinder is taken, the contents of which are not known, the indicator gauge stops at 80 atmospheres.

80 ÷ 3 = 26, (26 feet).

The contents of a cylinder may be roughly estimated, by weighing the cylinder when empty and again when filled, and keep a record of the difference. As a rule 10 feet go to the pound.

A few precautions may be necessary to the novice: do not under any consideration oil any connection with the cylinder especially the valve pin, or use soap, or white lead if there should be a leakage. Wipe out the seat of the coupling before connecting the regulator. This is most important especially with the inside thread valves, as the dust often collects here in no small quantities If the valve is thought to leak at the orifice, place a little soap suds or saliva across the top, and if there is an escape of gas it will make itself known by the bubbles it will force up. Should the valve pin be too hard to turn, have a key with a long arm, it will give a good leverage. It is not necessary to turn the key more than once round to open cylinder, nothing is gained by continuing this motion as more gas cannot be forced through the valve, should the cylinder be full and the key turned many times, it will force the pin out, and as it will come out with force, the consequences would be very unpleasant.

Should the valve be one as supplied by Brin's Company, it will be sure to want a little tightening up as it becomes worn round the seat of the pin, to do this turn the key on slightly, at the same time turn the nut which holds same the reverse way, with a pair of gas plyers or a spanner, a good leverage is wanted for this.

This form of valve generally has the thread inside the collar which protects it from injury in travelling. The valve of a cylinder should be used carefully, its structure being very delicate and easily damaged.

It is now customary to make the hydrogen thread on cylinders and regulators left-handed, so that it is compulsory to use only the proper regulator and fitting for each gas, it was rather confusing at first, but is an excellent plan, as there can be no possible mistaking the gases.

NO DANGER WITH GAS CYLINDERS, OR BAGS.

The few accidents that we hear of are very far between, when it is considered fairly, with the thousands of lanterns in use at all times, in all places, and under various conditions.

When practically considered, an accident has never yet occurred in which gross carelessness could not be traced. Many simple things in daily use are dangerous, when perverted from their intended use, and the same applies to lantern apparatus. As all students of chemistry are aware, when oxygen and hydrogen gases are mixed, in the proportion of three parts to one, and a light applied, an explosion results.

Supposing the gases were so mixed together in a single cylinder, no explosion would take place unless a light was applied, and even then under certain conditions, the gases will burn without an explosion, the ignition inside only takes place when the cylinder is nearly empty or the pressure reduced, then the light passes back.

Example.—If a bladder filled with a mixture of these two gases in their most explosive form, has a small hole pricked in it and a light applied from the end of a stick, the result is the gases burn steadily with a bright flame, until the bladder is all but empty, and at that point when there is no pressure to force the remaining gas out, the light appears to be drawn back, then the report.

Now, supposing by misadventure (which we do not admit possible), the two gasses have been mixed in one cylinder. What happens? The operator lights up his jets, if mixed in the hydrogen cylinder, a bright light appears at once, as though the oxygen tap was also on, and if the operator is wise, he shuts off the jet at once, and tests the hydrogen, not by applying a light—that would be worse than the evil,—allow a little of the gas to escape into a tin can (the lime tin is the handiest), allowing sufficient to force the air out, cover the top, apply a light if you like, at a distance from you, if the gases are mixed a slight report will take place, if pure hydrogen, or coal gas, it will burn with a small flame around the top of the tin.

Now, presuming the hydrogen this time has become mixed with the oxygen. What happens? The gas from the hydrogen cylinder or bag is alight in the lantern, the oxygen tap is turned on, and if mixed, the usual brilliancy of light is not obtained, as is usual when the oxygen is turned into the hydrogen, in that case the oxygen tap should be turned off at once, do not wait or continue to try again, but test the oxygen in a tin in the same manner, filling the tin by allowing the gas to run in, and oxygen being considerably heavier than the atmosphere, it will soon force the air out, apply a match, of course holding the tin away from the body. If mixed the gas goes off with a small report, if the oxygen is pure nothing will happen, nor will it light, if the match is dropped into the tin it will only burn with increased brilliancy, until all the oxygen is exhausted.

Oxygen and hydrogen gases by themselves are as safe as the word safety implies. Fill a jar or bottle with hydrogen and drop a lighted match in—*result*, the match is immediately extinguished: hydrogen will not burn of itself, it must have oxygen to support it, but allow the hydrogen to escape in a stream, and on reaching the air it will light and burn, as our common house gas lighted at its burner illustrates, because the oxygen in the air supports it, causing combustion, without the aid of oxygen, hydrogen is as harmless an illuminant as is possible to imagine.

For oxygen, take a jar or vessel filled with this gas in the same manner, plunge the match or taper into the vessel, and the match will burn with increased brilliancy, the gas itself will not light, that is impossible. Oxygen alone is a supporter of combustion, and if allowed to escape into a room in any quantity is perfectly harmless, in fact in a crowded room its results are beneficial. The reader may say, if these gases are harmless, how is it that gas bags and even cylinders have exploded. If the true facts could only be traced, it would be proved in every individual case that the accident was caused by the gases oxygen and hydrogen being mixed, and a light applied,—no accident or explosion can possibly occur unless this is done, even if the gases are so mixed it is perfectly safe until a light is applied. We were once in a theatre, when a gas bag exploded on the stage, causing nothing more than a loud report, the manager appeared and explained to the audience, that a gas bag had been filled too full and consequently burst, this the audience from their applause, evidently thought was a sufficient explanation. The real fact which we learnt afterwards was this: the man who was paid 1s. 6d. to 2s. a night to work the limelight was *non compus mentus*, and had filled up a half-full oxygen bag with hydrogen, and, in attempting to light the jet, he was thrown several feet away. The time may come when every accident of this kind will be investigated by a qualified board, and the culprit punished, the sooner the better for all.

If gas bags are used, each bag should be marked with a large H or O both sides, and under no consideration should they be used for any gas but those marked.

Safety Valves.—Valves fitted with pumice and back pressure valves are of little use as a means of safety, and are an encumbrance, checking the flow of gas.

OXYGEN (Brin's Patent),

now generally used in cylinders is the pure gas. The common air is purified and dried by passing through lime and caustic soda, and pumped into retorts, charged with barium oxide, which under a heat of 1,400 Fah., has the chemical properties, for absorbing the oxygen from the air, the nitrogen and other products being conveyed away. The air is pumped into the retorts at 10 lbs. pressure, the pumps are then automatically reversed and the oxygen is then sucked from the barium oxide, the process thus using no chemicals whatever, and becomes simply mechanical. Oxygen manufactured under this process has the advantage of being free from chlorine, which is not the case with oxygen manufactured from potasse chlorate, it is the chlorine that destroys the rubber in gas bags, and causes the green deposit in the tubes and taps of jets. Brin's oxygen when first introduced six years ago differed materially, the quantity of nitrogen being left in, being considerable, and thus made a great difference in the illuminating power, these difficulties have now long been overcome and the average quality of oxygen is 93 per cent.

TESTING AND FILLING CYLINDERS.

We cannot give a better description than an account of our interview with the able manager of Brin's oxygen works, Mr. Keith S. Murray, which took place at their factory, and goes to prove that the bursting of a cylinder, or mixing of the gases, is an impossibility, and that the public stand at no risk whatever, and considering that the makers of the cylinders have previously tested them to two tons pressure on the square inch, there is not much fear of a cylinder coming to grief in the hands of the public.

"Do you test every cylinder sent you, Mr. Murray?"

"Yes, cylinders are tested by us to double their working pressure, viz. 1½ tons. Our test is of course an hydraulic one."

"Have you ever had a cylinder burst after it has left your factory?"

"Not that I have ever heard of, and we are supplying now over a million and a half feet annually, compressed into cylinders, which means that many thousands of bottles pass through our hands."

"Do you ever burst cylinders in testing?"

"All cylinders are filled by us to one standard pressure, viz. 120 atmospheres, and as I have already said they are first tested by us with water to double that pressure. Some years ago there were many cylinders of inferior quality in circulation and bursting such cylinders in testing was by no means an uncommon experience, now however, such experience is very exceptional, as the type and construction of cylinders have so much improved."

"How does a cylinder act when it bursts, does it go off like a bomb?"

"No. When a cylinder bursts in testing, it simply rips open, water being an inelastic substance, and if care is taken to remove all air before applying the test pressure to a cylinder, there is no element of danger in such a burst. If a cylinder charged with a gas were to explode, of course it would be a much more serious matter."

"Have you ever had an accident in testing cylinders?"

"No."

"I believe you keep a list of every cylinder sent you to test and fill?"

"Every cylinder sent us for the first time by a customer is tested, and if sound, stamped with our registered test mark. If not already numbered, a number is given to it. Its number is then recorded with other particulars including date of test in our books. In this way we establish a life record of every cylinder, and know when it ought to be retested. We always reserve a right to retest all cylinders annually."

"Have you no fear from a strange cylinder. Supposing a cylinder containing, or had contained hydrogen was sent to be filled with oxygen?"

"The great risk in our business and the only matter in which we are in the hands of our customers is in the possibility of a cylinder which has been used for coal gas being sent to us with instructions to fill with oxygen or *vice versa*. By hedging ourselves with safe guards against this risk we have been in conflict many times with our customers. As you know of course red is the distinctive mark for hydrogen or coal gas, and black for oxygen, but until recently the risk involved in the compression of mixed gases was so little understood by a certain class of customer, that it was no uncommon experience with us to have cylinders sent in without a word of caution, painted black, to be filled with oxygen, and yet reeking with the smell of coal gas, and an inquiry has elicited the fact that the cylinders had been repainted for the different gas by the customer in all ignorance of the fact of course that by so doing he was exposing us to grave danger. All cylinders are emptied of any gas they may contain by us before they are admitted to our Factory, and they also pass through three different hands for examination, so that it is difficult for such a cylinder as I have just mentioned to reach our compressors without detection, such however has happened more than once and although I am glad to say no serious injury has ever occurred through ignition of gases and consequent explosion in a cylinder, we have had alarming experiences, and narrow escapes from serious accidents. I may point out that these are accidents which could only occur during compression, and are consequently risks to which we and not the customer are exposed. Such experience is now very rare indeed, as the danger is more generally known, and I may add that as an absolute safe-guard in addition to colour we now make all connections for oxygen and coal gas different and consequently non-interchangeable, and when this is universally adopted, the real and I may say only element of danger in our business will be practically done away with."

"How do you account for such explosions of coal gas and oxygen?"

"That is a difficult question to answer, they are undoubtedly due to sufficient heat being generated in some portion of the cylinder to cause ignition of the two gases."

"It may be due to a variety of causes. The actual compression of the gases causes a certain amount of heat, but this alone is not sufficient to explain the occurrence. It can only be that (owing to, in part, the compression, but to a much larger extent—the friction caused in the valve passages which may be full of oil or hydro-carbon deposit, and the sudden impact of the gas rushing into the cylinder) sufficient heat is caused locally to ignite an explosive re-action of gases, and of course the moment ignition takes place enormous heat and pressure is created inside the cylinders. A cylinder which has been long used for coal gas lends itself most to such accidents, as it would be coated inside with a lining of hydro-carbon deposit."

"When oxygen escapes from a cylinder in any quantity, it is noticed that the flow is very uneven. How do you account for this?"

"This should only occur when oxygen is allowed to escape very rapidly from the cylinder and then the explanation is very simple. It is just the reverse of what takes place when the gas is compressed. The highly compressed gas in the cylinder has by the time it is used cooled down to the temperature of the surrounding atmosphere. This large volume of gas when expanded out of the cylinder, abstracts the heat from the surrounding atmosphere, with the result that such an intense cold is generated immediately round the cylinder as to create ice from the moisture present and this ice getting into the valve passages causes obstruction and consequent unevenness of flow. You can easily verify this by holding your hand on the mouth of cylinder valve."

STRENGTH OF CYLINDERS FOR COMPRESSED GAS.

By Keith S. Murray.

(Extract from *Engineering Review.*)

"There are two kinds of steel bottles generally in use for the transport of gases at high pressure. They are known in the trade as lapwelded and solid drawn. Both are made of mild wrought steel, with the difference that the lapwelded bottles are rolled and welded up like ordinary tubes, whilst the solid drawn bottles are formed from a circular slab, or a circular block of steel, which by repeated heating and pressing in suitable dies is moulded into a tube with a spherically closed end. The process of solid drawing acts beneficially on the strength and rigidity of the metal, it has been found from tests made that the ultimate tensile strength of this metal is about 66,000 lbs. per square inch, as compared with about 54,000 per square inch in the case of welded bottles.

The solid drawn bottles are consequently lighter, neater, and perhaps more reliable than the lapwelded, and although rather more expensive, are slowly but surely superseding the older lapwelded type, more especially in the smaller sizes. All bottles, or at any rate all these employed for non-liquified gases, are made to contain a certain easily measurable quantity of gas at a pressure of 120 atmospheres, which is the recognised standard pressure.

Both classes of bottles are now made of three common external diameters, viz., 4in., $5\frac{1}{2}$in. and 7in. and they vary in length according to the quantity of gas they are required to contain at the standard pressure. The thickness of these bottles is as follows:—

External diameter,	4	inch,	...	solid drawn,	$\frac{5}{32}$ in.
" "	4	"	...	lapwelded,	$\frac{3}{16}$ "
" "	$5\frac{1}{2}$	"	...	solid drawn,	$\frac{7}{32}$ "
" "	$5\frac{1}{2}$	"	...	lapwelded,	$\frac{1}{4}$ "
" "	7	"	...	solid drawn,	$\frac{9}{32}$ "
" "	7	"	...	lapwelded	...

(No lapwelded bottles are now made beyond $5\frac{1}{2}$in. external diameter.)

Bottles of various other sizes and thicknesses are in use but they are gradually being superseded by these standard sizes, and in the course of a very short time they will probably have become extinct. As regards the ultimate strength of bottles, many tests have been made in order to ascertain their bursting point and elastic limit, and as all the above sizes (which are the standards adopted by the Brin's Oxygen Company, and the various Companies working under their patent rights) are constructed of nearly proportionate strength, the results may be generally summarized as followed :—

Pressure per square in., at which bottle bursts	lapwelded ...	2½ tons.
	solid drawn ..	2½ ,,
Limit of elasticity per squre in. of metal	lapwelded	35,000 lbs.
	solid drawn	45,000 ,,
Ultimate tensile strength per square in. of metal ...	lapwelded	54,000 ,,
	solid drawn	66,000 ,,

The results of tests go to prove that lapwelded bottles are almost as strong in the weld as in the solid plate. Solid drawn bottles gain their ultimate tensile strength rather at the expense of their elastic limit; but both are largely in excess of the test pressure applied to the bottles. The actual hydraulic test pressure applied to each bottle is 1½ tons, just double the pressure to which it is charged with gas, and it will be seen that this test is well within the elastic limit of the metal, in the case of lapwelded, as well as the solid drawn bottles, and that no permanent injury to the metal can be occasioned by it. It is the custom to select one out of each delivery of new bottles, and either test it to destruction, or have it sawn up in order that a thorough examination of the metal can be made.

For testing the elastic limit of bottles, a good arrangement has been devised by Mr. H. Brier, Manager of the Scotch and Irish Oxygen Company. It is briefly as follows :—

The bottle to be tested is filled with water and placed vertically in an iron envelope, the envelope is also filled with water to the exclusion of all air, and a perfect joint is made round the neck of the bottle by means of a flexible rubber ring. A small glass tube taken from this envelope or outer chamber serves as an indicator. When the bottle is subjected to hydraulic pressure, any distortion of the metal can be seen by the raising of the water in indicator. If no permanent stretch is given to the metal, the water will return to its original position in the indicator when the pressure is released. If any permanent stretch has been caused this will not be the case, and should such a thing occur in the testing of a bottle it would be immediately rejected.

I think users of oxygen compressed in these high pressure bottles may rest satisfied, that every reasonable precaution is taken to ensure safety.

In conclusion, in order to prove how safely gas may be transported in these high-pressure bottles, I cannot do better than quote some experiments, which were made by the Scotch and Irish Oxygen Company, in March, 1890. These experiments were made with a view to ascertaining the amount of rough treatment, which a bottle would stand without bursting. Three bottles were all subjected to very severe treatment; they were all of a standard type, viz., 5½in. external diameter by ¼in. thick and lapwelded. Nos 1 and 2 were charged with 120 atmospheres oxygen; No. 3 was filled with liquefied carbonic acid. No. 1 bottle was twice raised to a height of 35 ft. and dropped horizontally upon a solid iron block 12 ins. square, each blow bending it to the extent of about ¾ in. It was then dropped vertically on its round end having a clear fall of 31 ft. when it was found that the impact had only flattened a part of about the size of a penny piece. It was crushed with a 15 ton blow received whilst it lay across an iron block, and it was finally bent with the same blow whilst it was supported on two anvils set 4 ft. apart. No. 2 bottle was dropped horizontally five times from a height of 35 ft. across an anvil, receiving the blow each time on the same spot. No. 3 was dropped twice 35 ft. and then crushed by a 15 ton blow. On these bottles being subsequently tested they were found to contain the full quantity of gas and to be perfectly sound.

It it inconceivable that bottles during transit could undergo anything like the severe treatment to which these were subjected; although their valves often bear testimony to the rough treatment received at the hands of railway porters.

Any latent weakness in a bottle is more likely to make itself known in the gas compressing factory whilst it is being recharged than afterwards in the hands of a customer, and yet I am glad to say that although thousands of these bottles now pass through our hands every week, we have never had an accident through the bursting of one of them in our works. The only two recorded accidents due to the bursting of high-pressure bottles, one in Dublin, 1889, and the other in Glasgow, 1890, were proved beyond any question to be due to the spontaneous combustion of mixtures of oxygen and coal gas, and the consequent creation of a pressure inside the bottle which vastly exceeded what it was calculated to withstand. It is in this possible mixture of gases that an element of danger has hitherto existed in the use of high pressure bottles. It has been due mainly to the fact that insufficient precautions were taken to avoid the possibility of bottles used for one gas being charged with another. The recognised rule in the trade was to paint oxygen bottles black, and hydrogen (or coal gas) bottles red. This, however, was no absolute safeguard, and the system now adopted (in addition to the different colours of bottles) is to make all valve and other connections for oxygen and hydrogen non-interchangeable. This absolutely precludes the possibility of mixing gases in bottles, and when it becomes universal (as it must in a very few years), I feel convinced that the only real element of danger in the use of high-pressure gas bottles will be removed."

OXYGEN MAKING.

Oxygen is a colourless invisible gas possessing neither taste nor smell, and is made for our particular use from potassium chlorate (commonly called chlorate of potash). If a small quantity of manganese dioxide (black oxide of manganese) be mixed with the potassium chlorate, the oxygen is given off from the chlorate at a much lower temperature and in a more regular manner, and thus the evolution of the gas is facilitated, but the manganese undergoes no change whatever. Although oxygen may be obtained by heating manganese dioxide to red heat in an iron bottle, but this is out of the question for the average lanternist.

The best proportions, which are the outcome of a great many years' practice are,—4 parts potassium chlorate,—1 part manganese oxide, well mixed and incorporated together. The chlorate may be obtained in powder or crystals, the latter is prefered, it is easier to mix with the manganese, 3 lbs. of this mixture should produce 8 ft. of gas.

The retort should be made of sheet iron with a double bottom, so that the iron work or a new bottom may be renewed by any smith, when charged place on a fire, ordinary heat from a fire or bunsen is sufficient to generate the gas, with a retort of this description, a cork or safety plug of at least three quarters of an inch in diameter is fixed at the top, in the event of any stoppage in the tube, this will force itself out and the gas pass harmlessly away.

On no account should cast iron or mercury bottles be used as retorts, an enormous heat is required to make them hot, and then the gas rushes off at a terrific speed and there is no means of stopping it, and should the retort cool down before all the gas is given off, it is the hardest matter possible to get it to start again. This is not the case with a sheet iron retort, which being thin is acted upon at once by the heat, an amateur may make gas for the first time in this form of retort, with the greatest comfort and ease. The gas when given off by the retort is passed through a—

PURIFIER OR WASHBOTTLE.

It is a great mistake with the majority of purifiers made, that they are too shallow. A washbottle to be of any service should be filled with water to a depth, say eight or ten inches, and the gas from the retort taken to the bottom and allowed to pass through the whole ten inches. To cleanse and wash the gas properly, two purifiers should be used, the gas after passing through the first is made to go through the same routine with the second, even after the gas has passed through the purifier it will be noticed that there is a strong disagreeable smell with it, and as there is no smell from pure oxygen some other product must be present, in proof it is found to be chlorine, given off from the potash, of which it is one of the component parts, it is this gas that destroys the gas bags, and corrodes the brass taps of our jets, and the more washing we give the gas the greater the chance of throwing this down. A handful of common washing soda or the old limes and dust should be thrown into the purifier; after the chlorine has been taken up by this, we have a residue of chloride of lime.

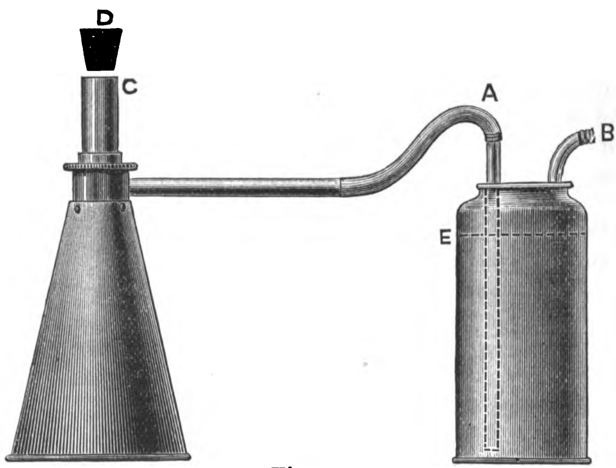


Fig. 37.

The illustration shows the method of making the connection with the retort and purifier. *C* is the brass top to retort, which unscrews for washing out; *D* is the cork which acts as a safety valve in the case of any stoppage, and should not fit too tightly; *A* is the rubber tubing connecting retort to purifier, and should be of a wide bore; *B* is the outlet tube, which is connected by rubber tubing to the bag. *E* is the average height to which the purifier should be filled with water.

Having blown through every tube to make sure of no obstruction, place the mixture in the retort and see that the cork in the retort is fitted tight and yet easy, take the purifier (three parts filled with water, in which some soda or lime has been placed) and connect by means of rubber tubing with retort, use only best pure rubber for this purpose, wire tubing is useless, soon clogging up with the manganese, previous to connecting, blow through the purifier with the breath and note if any water is splashed out, if so, it is too full and a little must be emptied out. Having connections according to illustration, place retort on a fire not too fierce, and, before making the connection to the bag, allow a little of the gas to escape through the purifier; in the purifier the first few bubbles heard is only air, after a short time a rapid generation of the gas continues and the tubing may now be connected with the bag. Notice that the tap of the latter is left open. Should the gas come off with violence through the fire being too fierce, the retort should be lifted off without disarranging the apparatus, and after a few minutes, replaced; do not wait for it to stop before doing this, or there will be a little difficulty in getting the heat to penetrate through the already spent chlorate. When the gas has entirely come off, which is known by the cessation of the bubbles in the purifier, detach the tubing from retort and allow it to cool, the purifier may be used as it is again and again, of course washing out the tubing connecting same with retort. The retort having cooled, unscrew the top and invert same over a sheet of paper, and if there is any mixture not used it will fall out, the used up chlorate remaining solid at the bottom. This and the delivery tube should all be washed out with several successions of water, the whole dried on a fire and put away ready for use next time.

MANUFACTURING HYDROGEN GAS.

This gas we are perfectly familiar with in the form of coal gas, this is not pure hydrogen, but carburetted hydrogen, and is as equally suited for limelight as pure hydrogen, without doubt the illuminosity is equal, and as it is the chief illuminant in all large towns the bag can be filled by attaching with rubber tubing to the ordinary gas-branch, the bag will naturally fill quicker if the burner is first unscrewed. In the Colonies and places abroad, this is not always possible, as many towns are not illuminated with gas, and there is a certain amount of uneasiness in travelling with a bag filled with hydrogen although there is no need for any apprehension, as it is constantly done, especially in cases where the lanternist knows the gas in the town or village he is destined for, is of a poor illuminating power. When necessary to make hydrogen gas, a hydrogen generator, and purifier, are necessary. The generator must be made of lead, this metal being non-affected by the acid. It is necessary to use a purifier as for oxygen gas-making but do not use the same for both purposes. Keep them separate by a distinctive mark, connect with rubber tubing in like manner as for oxygen, the generator bent tube to the perpendicular tube of the wash-bottle.

The top is unscrewed of the leaden generator, and granulated zinc introduced, covering the generator bottom to the depth of about two inches the top containing the tubes should be screwed into its place, the leaden funnel placed into the long perpendicular tube, and sufficient water introduced to cover the zinc to the depth of about three inches, or in fluid measure, about two pints, Sulphuric acid (commercial oil of vitriol) should next be introduced in small quantities through the same pipe, about a gill at the time, when a rapid evolution of gas takes place. Now, the substances which have been put into the generator will act upon one another, and the hydrogen is set free, and escapes. If water were not used, hydrogen gas would not be given off freely. When sufficient of the gas has passed over to expel the air in the generator and purifier, the connection should be made to the bag, this precaution must not be overlooked in making hydrogen gas. It is better to waste a little gas than allow common air to mix with this gas, as the two mixed together form an explosive mixture. After a time the evolution of the gas declines, when fresh vitriol should be poured through the funnel. There is a point at which the acid will not restore the action, then the top containing the tubes is unscrewed, the fluid only thrown away, as the hydrogen properties of the water are used up, introduce fresh water into the generator, as before, then the vitriol. When sufficient gas is obtained, wash out leaden vessel, throwing away the liquid, as it is of no further use, the zinc may be preserved for future operations.

Granulated zinc, if not obtainable is made in the following manner. First melt some zinc, when it is melted, pour it into cold water, it is then granulated, or strips of sheet zinc cut small may be employed.

Sulphuric acid, or commercial oil of vitriol, is obtainable very cheaply, care should be taken to keep it off the clothes and hands, it being of a very destructive nature.

REGULATORS.

In using a triple or biunial lantern these are necessary adjuncts for controlling the flow of compressed gas to the jets. With a single lantern it is possible to use the gas direct from the cylinder by regulating the amount of gas at the valve of the cylinder itself, this will need some little experience at first, but after a time it becomes much simpler, care must be taken not to emit more gas than the jet consumes, or the rubber tubes will be blown off. A novice should use a regulator, even for a single jet, as it obviates all risk of this happening. The reason for not using the gas direct from the cylinder for two or more lanterns, is that when the valve of the cylinder is adjusted for the supply to one lantern, it is inadequate for two. If on the other hand, the gas be adjusted for two or more jets, and one jet alone is burning, the supply is so greatly in excess of the consumption, that the tubes are blown off, or the light itself is blown out, if the oxygen is in excess. To prevent these difficulties, a regulator is used to control the pressure, the general principle being that, when the flow of gas is in excess of the requirements, a small rubber bag, situated inside the regulator is filled with the gas, which thereby automatically closes the orifice from wherever the gas issues.

There are several Regulators at present on the market:—Beards' Regulator, the Rubber Wedge shape, the Duplex and Reliable, and recently a regulator on the principle of the first-mentioned, with the difference that the bag, instead of being rubber, is of spun metal.

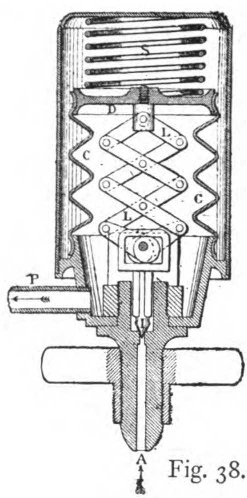
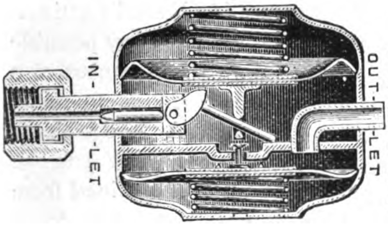


Fig. 38.

Beard's Regulator consists of a small rubber bag of cylindrical shape, fig. 38, corrugated as a bellows or camera body, *C*, the top of which is of metal, *D*, to which is attached inside a lazy tongs arrangement, *L*, which lays comparatively flat when the rubber bag is empty, when this is inflated, the lazy tongs arrangement is drawn up, this in turn closing the pinhole orifice by means of a small plunger, *I*, which admits the gas from the cylinder. To control the supply of gas to the jet and to keep it at an even pressure, a spring or weight *S*, forces the rubber bag downwards, thereby preventing the supply being completely shut off. After a time the dust and particles of grit blown out of the cylinder, congregate at the bottom of the plunger, *I*, causing a leak, and wearing it out of the round. When this takes place, the gas escapes into the rubber bag, and when sufficiently full, forces it away from its fastening. When this happens, it should be sent back to the optician, to have the plunger re-ground.

Considering the immense number made, and the great pressure that is brought to bear on such a delicate piece of mechanism, it is surprising that so few are put out of gear in this manner. We have had some dozens through our hands, and have only had this happen once, still it is well to mention these points, to put the users on their guard. A most necessary adjunct to all regulators is a small tap, fitted to the outlet, *P*, by this means the full pressure may be turned on at the cylinder, and the supply regulated from the tap at the regulator, preventing any tendency of roaring at the jets, this may be done to a great nicety, whereas if no tap is fitted to the regulator, the adjusting has to be done at each jet itself, aud when sufficient gas is adjusted for one lantern, there is not sufficient for two or more and *vice versa*; although no single regulator will regulate to the nicety of gas bags.

It is well not to turn on the gas too suddenly at the cylinder, the gas rushes into the regulator, filling the small bag to excess, which forces the spring up close against the top, where it will stick, not having sufficient room to regain its elastic power, this spring works exactly in the same manner on the bellows, as the weights do on gas bags. Should the bag become too full, thus closing the inlet, give the regulator a knock with the hand to shake it down, taking care that the outlet tap is open when so doing. As a preventive of this, when turning on the gas from the cylinder valve, allow a little of the gas to escape from the regulator tap or at the jet. When turning off the oxygen for any length of time, (if not leaving a leak), take care to turn the oxygen tap off at the jet, or the hydrogen will creep down the tube mixing with the oxygen, and when the jet is turned up, will cause a report, possibly blowing off the tubing.

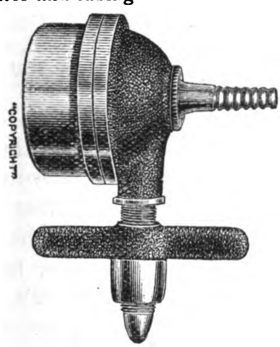


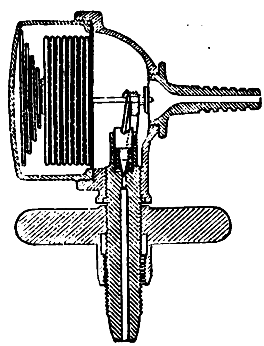
The Duplex.—The chief feature consists in the combination of two regulators, in order that any defect in the action of the first shall be corrected by having to pass a second. This insures efficient action over a much wider range of pressures, as the full supply is maintained until the pressure at the inlet has decreased to one-third of an atmosphere.

The Metallic Regulator is constructed somewhat on the style of Beard's, with this difference, that the bellows instead of being of rubber, is of spun metal, it is very well made, and certainly has the advantage of lasting a long while; as this bag rises and falls, so it opens and closes the valve inlet by means of a lever and other mechanical adjustments inside the metallic bellows.

DIRECTIONS.—Attach by the winged union to the cylinder, first taking care to clean thoroughly the joint surfaces, and connect by a stout rubber tube to the apparatus requiring the supply of gas.

When not in use, close the cylinder valve to prevent pressure accumulating in the regulator and tubing.





As before mentioned, a single regulator to reduce the pressure from 180olbs. on the square inch, to something like 8 inches on a column of water is more than can reasonably be expected, especially to regulate the pressure evenly for one or three lanterns. There is no single regulator that will give the uniform pressure of a gas bag. When tested on a **U** shape water gauge, it will be found that the pressure shut off from a regulator will never be twice alike, and as a rule it will blow the water completely out of the tube, and we know in trying to work three chamber jets in a triple, when there is sufficient pressure for one jet, there is insufficient for three, and when the pressure is adjusted for three lights, and two are shut off, the one will scream beyond any possible means of being used. The true principle on which to construct a regulator and the pressure at which it should work, led us to make numerous experiments with gas bags and jets. A wedge-shape gas bag ($36 + 24 \times 24$), with 1½cwt. pressure, will serve three jets, or one, with that degree of nicety and evenness that alone is obtained from a gas bag, and having found the pressure, we at once knew that for a regulator to be a worthy substitute for gas bags, it must work at the same pressure. Below is a scale showing the varying pressures in the two gases and their pressure under various weights and conditions :—

HYDROGEN.—Gas Bag, $36 \times 24 \times 24$.

Number of inches raised on 24″ column of water.		Weight of Bag.	Condition of Gas Bag.	Number of inches raised on 24″ column of water.		Weight of Bag.	Condition of Gas Bag.
5″	...	56lbs.	Full	8¾″	...	168lbs.	Half full
6″	...	112lbs.	ditto	9¼″	...	168lbs.	Quarter full
7¾	...	168lbs.	ditto				

OXYGEN.—Gas Bag, $36 \times 24 \times 24$.

5″	...	56lbs.	Full	5″	...	112lbs.	Half full
6″	...	112lbs.	ditto	8″	..	168lbs.	ditto
7″	...	168lbs.	ditto	8¼″	...	168lbs.	Quarter full

But no single cylinder will do this, nor is it possible with the great pressure behind it.

Now, the only way to compensate for this is to have a second automaton to act on the first, and shut off the supply when it becomes beyond the given pressure, or in other words, when the flow of gas exceeds that which is given from a large gas bag; and the only way this is to be brought about is by means of a small gas bag, which is weighted in the same manner as a large bag, Fig. 39, and is kept nearly full, as this empties itself it opens the first regulator by the aid of a lever, and allows itself to be replenished, and being weighted it always keeps the same pressure, and practically it is found to work even better than large bags, the pressure being always equal, no extra weights being necessary towards the end, which is the case with ordinary gas bags. The small bag is placed between a small pressure board, which is weighted with lead weights to 20lbs. To the top flap of the board, is attached a rod, which is again fixed at the top to a long arm or lever on the tap of the regulator, as the gas bag drops it carries with it the lever which opens the regulator tap, and to this is attached a length of flexible tubing, which carries the gas to the orifice at the back of the wedge end of the small bag, as the bag fills so it rises, carrying with it the levers, and in so rising gradually closes the regulator outlet.

This is how it acts on the water gauge :—

OXYGEN.

Small Wedge Bag ... ... 13 × 9 × 8.

Number of inches on water column.		Weight.		State of Bag.
8″	...	24lbs.	...	Three parts.
5¾″	...	18lbs.	...	ditto

HYDROGEN.

Number of inches on water gauge.		Weight.		State of Bag.
11″	...	28lbs.	...	Three parts.
10″	...	28lbs.	...	Half full.
9″	...	24lbs.	...	Three parts.
8″	...	24lbs.	...	Half full.

When these figures are compared with the table for gas bags, it is found that it is between the two extreme pressures of the gas bag, being really 8in., which is a continuous even pressure, not fluctuating as a large gas bag is found to do.

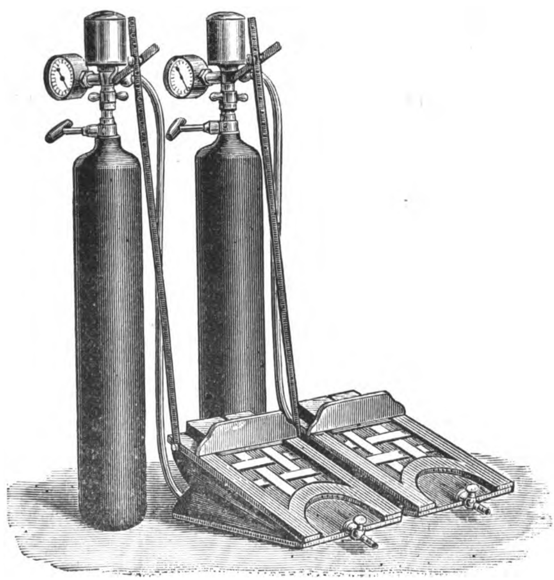


Fig. 39.

When two of these automatic arrangements are in use for a chamber jet, it will be necessary to put about 5lbs. extra on the hydrogen, to prevent a flickering of light. In adjusting these in position, press all air out of the bag, and place between the boards, connect with flexible tubing the regulator on cylinder to the inlet pipe of gas bag (at back of bag), then attach the long lever rod to side of pressure boards, place the hole in the rod over the pin, fixing the nut in position to prevent rod falling off. not too tight or it will prevent the lever moving easily. The top end of the lever rod has a series of holes, to which the lever on regulator tap is attached in a similar manner, but not until the gas has been turned on at regulator tap, filling the bag just over three parts ; this done, shut the gas off at the regulator lever, when in that position connect to the nearest hole in the long rod.

Fig. 40.

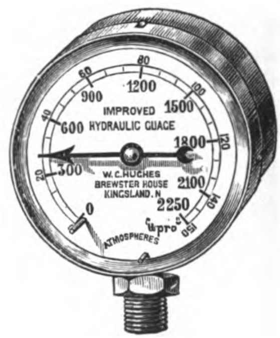


Fig. 41.

PRESSURE GAUGE.

The occurence in the past of some more or less violent explosions in pressure gauges have given rise to no little uneasiness to those who have no particular desire to attempt anything that has the appearance of risk, and before urging the discontinuance of their use, careful enquiries have been made to ascertain the precise cause of their bursting, so far this has been successful, and the means found for preventing their re-currence in the future, and we wish to place, so far as our experience goes, the cause of these failures on the part of the pressure gauge. The explanation is simple enough; they are, in fact, the result of gross carelessness or ignorance on the part of the maker and possibly of the operator. Before going further in the matter, a cursory description and mode of manufacture would be the most practical.—A Bourdon's gauge, the essential part of which is a steel tube of elliptical section, bent to form a semi-circle, one end of which is screwed to a boss, through which the gas is admitted to the above-mentioned tube, whilst the other end of this steel tube is free to move, being simply closed by a cap, usually of brass. When a steel tube of the shape here described is subjected to a greater pressure on the inside than the outer, it tends to become straighter, or in other words the curvature is lessened, and it is this movement of the tube that indicates the amount of pressure brought to bear upon it, this is again magnified by means of a toothed quadrant, controlled from the free end, which is coupled with the pointer or hand, thus any movement on the part of the free end of the tube causes the axle carrying the index finger to turn, and the index then moves along the graduated scale; any backlash that may occur by the too free working of the pinion and quadrant is governed by a fine spiral hair spring. Fig. 40 shows the dial removed, exposing the elliptical tube and mechanical portions.

The most important part in the gauge is the tube, and everything depends upon this, they are tested to the pressure of some 27,000 lbs. before and after bending, and should the tube not return to zero, it is rejected; the bursting pressure of these tubes is stated as being between seven and eight tons per square inch; each dial is then temporarily placed in the case and marked by comparison, consequently, each dial is written severally by hand. A guage of this description will indicate accurately at all times, and may be left under pressure without liability to deterioration.

Having now become acquainted with the construction and working, it will be easy to trace out the cause of accidents. When the valve of a gas bottle which is fully charged to 120 atmospheres is suddenly opened, the whole of the contents of the connections to the steel tube are instantly compressed to 120th part of the natural size, and in this manner will raise sufficient heat to ignite any inflammable matter that may be in the tube or elsewhere; supposing traces of oil have been left in the tube, or oil used as a lubricant for the valve of the cylinder or other purpose have been blown into the gauge tube, and the valve at the cylinder is turned on suddenly, what is the consequence? If sufficient heat is generated with air to fire a foreign substance, how much more readily will the substance burn in oxygen, and if the gauge has been used previously for hydrogen, the result is supplemented. Result.—The oil is fired by the heat generated in tube, and this mixing with the hydrogen forms an explosive of no mean order, the tube bursts and blows out the front of gauge with considerable force, and should this be protected by a glass cover, adds considerably to the damage that it is likely to ensue. Our knowledge of the chemical action of gases under great pressure has been considerably augmented since the introduction, or we should say of the more general use of cylinders of high pressure. It was the custom of the makers of pressure gauges, for steam and hydraulic purposes, to test them with oil, and it was almost impossible to dry them out, the result was the bursting or exploding of the gauges as previously mentioned in the forepart of this chapter. We have had the experience and we now know the cause, and we may venture to say that we shall not hear any more of gauges bursting through this cause, as every possible care is taken to avoid contamination of the gauge tube and connection with oil. Water being the sole mode for testing, and it entirely remains with us to carry out the principles already laid down, and under no consideration ever allow oil or any lubricant to be applied to any portion of the connections or gas cylinders, and always to dust the seatings of connections, to reduce the risk of any foreign substance being blown into the gauge or regulator, and especially to turn the gas on from the cylinder valve slowly. We have left, till last, an important item, viz. :—To remove the glass face from the gauge before using, a moveable glass front is, we think, most essential, as it is the glass that does the damage if it should burst; it is as well not to stand over the guage when turning on the gas, it is just as easy to hold it away from the body, and as much leverage may be put on the key. With a view to minimising the risk of the gas rushing in too suddenly, a plug between the valve and the tube in gauge is introduced in some gauges now being made, no matter how suddenly the gas is turned on, the plug valve relieves the pressure from the gauge tube, allowing only a minimum quantity of gas to pass, from the time the valve is opened until the indicator is at rest, is about 30 seconds; too much faith should not be put in these arrangements, as it is so easy to regulate the flow from the valve of the cylinder. In our initial experience of gauges, the same gauge did duty for both oxygen and hydrogen gases, and the force with which the gas rushed into the gauge was never considered, and there are, no doubt, hundreds of other lanternists who have done the same, and yet have never had an accident. "Forewarned, forearmed," use only a distinctly marked gauge for each gas, marking each gauge back and front with a good sized **H** or **O** as most gauges (when not marked for feet for a given size bottle) indicate lbs. pressure (*black* figures) and atmospheres (*red* figures) with the aid of the red figures and the following table, the quantity of gas in a cylinder is accurately ascertained.

Table for Ascertaining the Quantity of Gas in Cylinders from Gauges showing Atmospheres.

RED FIGURES. Atmospheres Indicated on Guage.	CAPACITY OF CYLINDER WHEN FULL. 6 Feet.	10 Feet.	12 Feet.
20	1 Cubic Foot	1½ Cubic Feet	2 Cubic Feet
40	2 Cubic Feet	3¼ " "	4 " "
60	3 " "	5 " "	6 " "
80	4 " "	6½ " "	8 " "
100	5 " "	8½ " "	10 " "
120	6 " "	10 " "	12 " "
	15 Feet.	**20 Feet.**	**40 Feet.**
20	2½ Cubic Feet	3 Cubic Feet	6¼ Cubic Feet
40	5 " "	6¼ " "	12½ " "
60	7½ " "	10 " "	20 " "
80	10 " "	12½ " "	25 " "
100	12½ " "	16¾ " "	33⅓ " "
120	15 " "	20 " "	40 " "

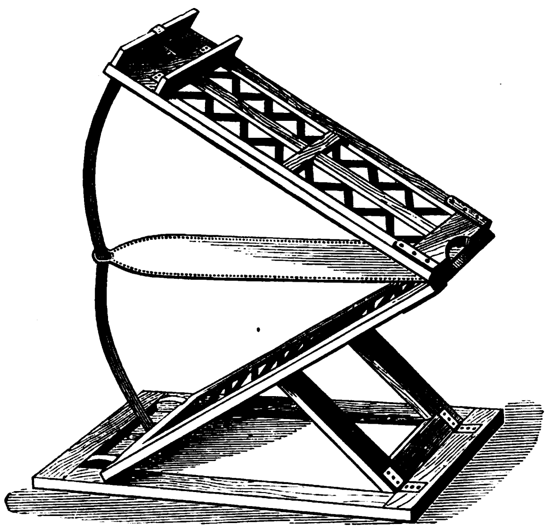


Fig. 42.

PRESSURE BOARDS

When required for a single bag are very simple, consisting of two boards an inch or two each way larger than the bag, they are hinged together at one end, and a hole cut away to allow the tap of the bag to protrude, a flap is hinged about six inches from the top end to hold the weights and prevent them slipping, the boards are readily put together by anyone possessing the slightest idea of joinery.

When Two Bags are used.—Boards slightly different are used, and are known as "double pressure boards," although practically one, but arrangement must be made to compensate for the second bag being introduced, if two bags were placed under the ordinary boards intended for one, the space they would occupy would bring the top board upright, at right angles to the bottom, consequently it would not work or hold the weights, to compensate for this, the front part of the boards must be raised about a foot (Fig. 42). A bottom case or frame is made to which the regular board is hinged at the back, each side of this there is a number of sliplike racks or slots, in which the raising struts fix, allowing the bags to be tilted angle to angle; supposing this front was raised too high when the bags were nearly empty, the back of the boards would be very much lower than the front, and the weights would fall off; to secure them, two flaps are made, both folding inwards, the weights are placed between these and are thus secured in position, when bags are full and when empty. Double boards to be free of all risk should on no account ever have a flap between each bag, although it has been advised on former occasions in manuals on the lantern; reasons why this should not be done is dealt with later on. But a canvas should be placed between the top and bottom bags, with a hole at the end for the strap to pass through.

When the bags are full with weights adjusted they have a peculiar knack of slipping away out towards the back, to prevent this a good wide strap with a buckle should be screwed to the boards, fastened round the back of the bags and through the hole in the canvas lining, thus strapping them into position and so preventing any slipping back. If the opening in front of the boards is not sufficiently large in the boards for the taps to come through it is very annoying, as the taps get out of reach as the bags go down, often causing a kink in the tubing. This hole should be cut away at least 8 inches deep on top and bottom boards.

Directions for Use.—Put the hydrogen bag at the bottom, and oxygen at the top, pull the centre sail cloth tight between them by the loop, while the lower board is flat on the frame; then strap them up and raise the boards into the position shown in the drawing by raising the hinged end, and the lower board will drop to its place of its own accord.

On no account use two separate boards, although safe enough when used privately; a public audience, we consider, should never be exposed to the slightest risk; avoid ever using a double board with flaps between the bags, it is most risky, and after all has no practical issue, as the gas is consumed so the bags and flap gradually go down, and it is the easiest thing possible in the dark for any one of the audience to push a form or chair, in their ignorance, against the bags, and if the flap should rest on any obstacle of this kind the pressure is taken off the bottom bag, as it was once to the writer's knowledge.

If this should happen the experienced operator would soon know that something was wrong as the light would go down, and to keep it up to any degree of brightness he would have to continually reduce his oxygen, and knowing that the bags contained plenty of gas, would at once come to the conclusion that something was amiss, and shut off the lantern for an interval. If this was allowed to continue the gas from the top bag would pass into the bottom by way of the jet.

Mr. Malden's new boards have been made to his own idea for obtaining a greater pressure near the close of the lecture, without the addition of an extra weight, this is brought about by making the top flap of the boards considerably longer than the other portions.

WEIGHTS.

The weight required to be used for a single bag of 8 feet capacity is not less than 56 lbs. to 112 lbs. When two bags are used under pressure start with 112 lbs., adding a 56 lb. and possibly a second 56 lb. towards the end. If a triple is in use it will require more weight than would a single jet. The easiest form of weight for lifting and fixing steady on the boards are the square or oblong pattern, they can be bought at a price a little above that of old iron.

LIMES

which appear insignificant in importance, practically, are a source of trouble in consequence of the variations in quality, size, and boring. On the quality to a great extent depends the light, and if the sizes are unequal when placed on the lime pin, the lime turner requires adjusting, and to replace and adjust a lime of this nature in the middle of an exhibition, when the jet is hot, is well nigh a feat of dexterity.

The lime motion adjuster, mentioned on page 22 (figs. 15 and 16), overcomes this difficulty. The boring of a lime is not to be relied upon always for its trueness, and is often too small, a watch-maker's broach passed through the hole and worked round will soon enlarge it to the desired size. It is as well to have a couple of limes so drilled and cleaned always ready in the bottom of the lantern tray, in the case of more than one lantern being used the heat from the jet below will keep the lime warm ; when putting limes on the jets for first time, a little hydrogen should be allowed to play, and so gradually warm them, and to make the heating equal, the lime turner should be gently turned once or twice.

We can never see the object of putting limes up in boxes with the lime dust, such packing to the general idea is to keep them from bursting. Now we have very strong proof that it has a tendency to act just the reverse; a box of limes filled up with powder will burst much sooner than one packed without. Lime powder absorbs the moisture much quicker than wiil a piece of solid lime, the lime powder is often very old before it is put in with the limes and boxed up, saying nothing of the mess of lime dust every time a lime has to be used from the box.

The class of lime to give the best result is found by proof, to be of the nature known as soft lime, yet it is not soft, but brittle, like a biscuit, we believe it to be very rare as it is the picked lime from a quantity, and causes much waste in turning. The ordinary soft lime is suitably adapted for safety jets, and may even be used with chamber jets, only it is very necessary to keep a constant watch by frequently turning, as holes are soon bored by the gases which causes the flame to rebound at an equal angle and crack the condenser.

A soft lime gives a light superior to the hard stone limes, known as Nottingham, Excelsiors, etc., some of which are not pure limes, but a composition ; another advantage of the soft lime is that it becomes incandescent as soon as the gases are turned on to it, and dies off as readily when turned down, which is not the case with hard limes, as they take some time to become incandescent, which is very inconvenient when quick dissolving is required.

Hard stone limes have their advantages over soft in certain circumstances, although there is a loss of light where a jet is required to be constantly burning, or when it is not possible to give the necessary attention to the jet, as in the case of light boxes for theatrical work.

The form of lime which for want of a better title is known as "Incandescent" may be depended upon for uniform quality, it is made from a lime obtained in France, and possesses the advantage of not being too hard or yet soft, when first acted upon by the gases the edges will turn slightly red, which goes off as soon as that part becomes heated ; after having been used once, say for two hours, it appears to lose some of its virtue, and if required to be used again it should only be for an experiment or registering.

Substitutes for Limes.—Zirconium has been introduced into this country as a substitute for lime, and if we could obtain a substitute it would be a boon, as Zirconium will not give so much light as half that of a good lime—it cannot claim success. Forms of carbon have been tried with no better result. Marble has been used under extreme circumstances as a substitute for lime, but even at its best is very poor.

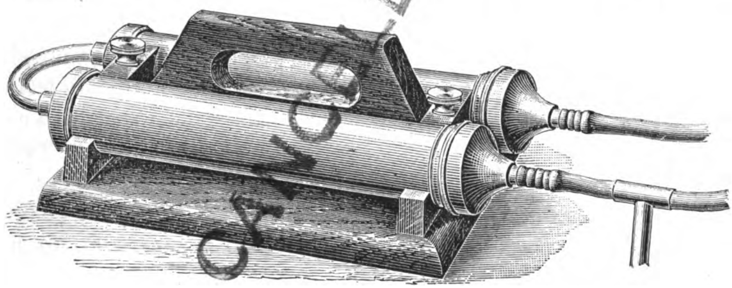


Fig. 43.

ETHER SATURATORS.

Saturators, of which there are several forms and patterns, are used as a substitute for hydrogen or coal gas, and are a great saving in weight when compared to an hydrogen cylinder or bag and can only be safely used under certain conditions.

We enter upon a subject that is uppermost in the minds of many lanternists, who hesitate before introducing such a means of illumination to their lantern in a public audience, and perhaps it is as well, because it is not in the way of every lanternist to experimentalize. After various trials, under different conditions, we can only advise its use in conjunction with Mr. Hughes' best chamber jet, with a medium sized nipple. The packing and construction of this jet seems most suitable for the ether light, dissolving from one to the other, may be worked without any fear of pops. This alone marks it distinctly from any other jet. The following are personal experiences with the ether light:—a pair of chamber jets with shallow chambers, small bore nipples, were used, which give a good light, and are most suitable for gases under pressure. They were used in a biunial fitted with supply pipes and dissolver. The first half hour they burnt well. On attempting to dissolve there was a slight pop, but nothing to be alarmed at, after filling one of the chambers with three layers of gauze it was found unsatisfactory, as the gases had a tendency to burn back in the chambers, having taken the gauze out again, we attempted to dissolve, when the tubing was blown violently off, still leaving one jet burning At this point the lacquer of the ether saturator was becoming darker at the end nearest lantern, (which was connected by 10 feet of tubing to the dissolver), a proof that the saturator was alight inside, after turning the oxygen off at the cylinder, and making an examination of the saturator, it was found that about 3 inches of the woollen packing had been on fire, and melted the piece of metal that runs through the centre.

The same saturator has been used since with suitable jets, and given satisfaction. It will be seen from the above trial, that ordinary jets will not do for use with ether. A well-known lanternist once suggested using a blow through or safety jet In less than 10 minutes the orifice had become red hot, and shortly after had melted the top completely.

Methylated ether 720° costs wholesale 1s. 6d. a lb. by the quantity. Any chemist will procure it at about 2s. 6d. It takes 1lb. to fill a saturator properly.

To prepare the Saturator for use.—Unscrew the cap from one cylinder, without removing from the stand, hold with open end up, and pour in about 1 lb. of light methylated ether, until both cylinders are full, then replace the cap and allow to stand in this position for a few minutes. Remove the nozzles (the small screw caps,) and pour back the surplus Ether into bottle through a small funnel which will receive the ether from both cylinders at once, drain a few seconds, and screw on tightly small caps to nozzles to prevent leakage. It is now ready for use.

To connect to the Jet or Dissolver of the Lantern.—Procure a **T** of brass, connect the long end with the tubeing leading from the oxygen bag, then connect one of the ends of the **T** with one of the nozzles of the saturator, and the other end of **T** being connected with the oxygen side of dissolver, connect the ether tube to hydrogen side of dissolver in the same manner, and the whole is ready for use.

Precautions.—Be *sure* that the saturator is *well supplied with ether* before starting the Lanterns.

Turn on the ether side of jet first, and as soon as you smell the ether light up. Then turn on the oxygen side gently and adjust the amount of gases until the best effect is obtained, which should be a most brilliant and steady illumination.

Keep a moderate pressure on the bag.

In finishing up, turn out the light gently at the jet, and then turn off the gas at the bag, *and not vice versa.*

Put soap on all the screws to prevent leakage of the ether, and *always* use a "mixed gas" jet or burner.

At intervals take out flannels in saturator and dry them.

The filled saturator should always stand on a nearly level surface to prevent the ether from draining to one end.

BENZOLINE AND NAPHTHA SATURATORS.

Any more than an experiment, we do not advise the use of benzoline saturators in their present form, in the hands of the most practical lanternists they have been known to catch fire or blow up, fortunately in most cases the audiences have not been present. We know that an act of parliament prohibits the sale of benzoline after sunset, or its storage in a building, in consequence of its volatile nature, and yet in the face of this we have from time to time ideas and suggestions for increasing the volatility of this fluid by the application of heat; the idea of making benzoline or naphtha hot with a naked light, to the ordinary observer, is a sufficient warning of the risk attached.

To work quietly at home with any of these substitutes for hydrogen is very different to a public entertainment, where all is hurry and excitement. Audiences should never be exposed to the slightest risk whatever.

A REVIEW ON SATURATORS.

Considering at all times, even under the best conditions, the amount of uneasiness that is felt in using saturators, saying nothing of the smell of the volatile spirits, which percolate through the tubing (which it soon destroys) making it unpleasant in a small room, is it not best to use a second cylinder of hydrogen?

Ether is a dangerous substance for anyone to handle in large quantities, the vapour is very heavy, and it will sink and travel along the floor; Sir Henry Roscoe's warning also is not very comforting.

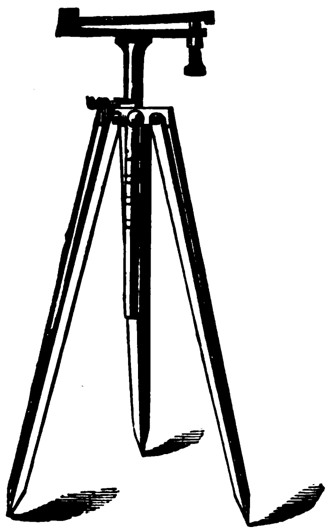
A single jet will work with greater satisfaction than with two or more going at the same time; a thorough practical knowledge of the lantern is most necessary: for a novice who has not had the previous training in its manipulation, to use ether would be the greatest folly. Without a doubt, when the jet is properly regulated, the light is most intense, and saturators certainly are very portable.

The majority of lanternists use blow through jets; with saturators, chamber jets must be used, and to be safe, jets of special construction are necessary. After taking into consideration the cost of these, with saturator and ether, there will not be much of a saving.

Supposing a building is not fitted with gas, then two cylinders of compressed gas, oxygen or hydrogen, would be used. It is not always necessary to use mixed or high pressure jets, under these circumstances, providing you have a good supply of hydrogen, say 3 or 4 feet more than oxygen, the blow through jets can still be used, it is requisite to keep the hydrogen taps well down, as very little pressure is required, or a gas bag filled from the nearest gas supply, with a board or coat laid on the bag is quite sufficient pressure for the hydrogen.

If a brighter picture is required, then of course, chamber or high pressure jets should be used.

TRIPODS.



Many an otherwise good exhibition is oftentimes spoilt by the miserable apologies made to do duty as a support for the lantern. Boxes, desks, trestles, even chairs, and often a pile of books,—a pile of bibles may be a good support in one sense—but is anything but solid for a lantern to rest upon. In this manner four times as much space is occupied as a proper Tripod would take up, and often adds much to the discomfort of the audience who are behind the lantern endeavouring to obtain a sight of the screen from each side of the obstacle. At each movement of the lantern in changing the slides, the picture oscillates and becomes very trying to the eyes. We advise all amateurs to invest in a tripod, it is worth the outlay.

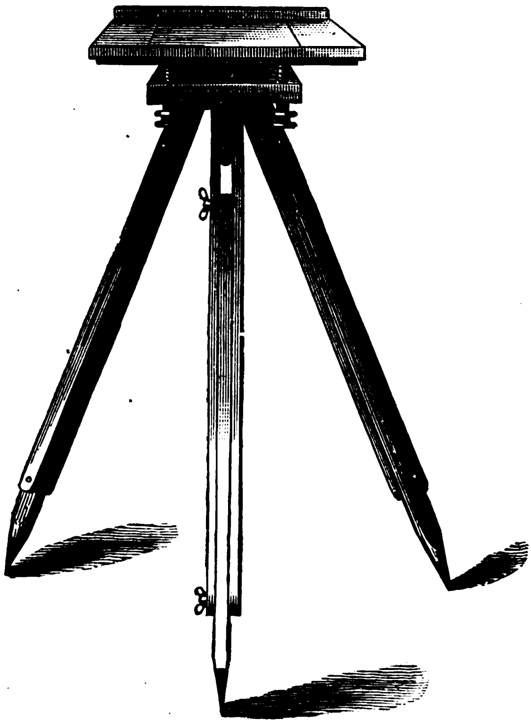


Fig. 46.

Tripod, as shown in the illustration, is most suitable for a biunial or triple, the legs are made telescopic, thus raising the tripod to twice its original length, each leg being independent of the other, makes it very convenient when it is placed over two pews, where two legs only are required to be extended and the third retained in its normal position; the top is also capable of being tilted to an acute angle, a ledge running along the back keeps the lantern in position. The illustration shows the two side flaps held in position level with the principal base, the side flaps are very handy for holding slides, lime tongs and carriers, and are made to fall down for travelling and portability.

In the case of a triple, the travelling case should be fitted with a canting board, the top flap being generally used for this purpose, two coarse threaded **T** shaped screws fitting in screw plates at each corner, tilting the flap up to the required angle, and this if necessary placed on a box or firm table, forms the best of tripods.

Avoid all elaborate arrangements of screws and angle pieces, and so-called canting tables, they are unnecessary, simplicity is of the most vital importance, when travelling the screws become loose and lost, and the metal side plates get bent.

When a single lantern only is used it is not necessary to have a tripod of so solid a structure as Fig. 46. A very light ash and deal tripod is made, and can be raised to the height of six feet or more, and with the top that may be tilted, is all that can be desired for one lantern, rigidity should not be sacrificed for portability, as nothing is more irritating to an audience than to see the picture oscillating on the screen.

CARRIERS.

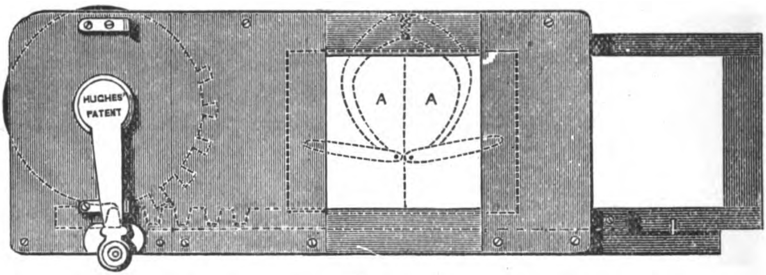


Fig. 47.

It is necessary for all slides that are unframed to use a carrier of some description, of these there are many kinds, we will take those for use with a single lantern first.

Dissolving with a single lantern is no new ideal, only that we are as far off from the actual accomplishment of this illusion as we were ten years ago. Dissolving with a single lantern, to obtain the same effect as is achieved with a biunial is an impossibility, and those carriers and lanterns with this title are misleading and untrue in their interpretation.

A carrier may be so constructed that the change from one view to another is almost imperceptible, as the one slide disappears from view, another takes its place without any perceptible movement. The only carrier that can do this effectively is the "Presto Carrier," from the general plans of this carrier all the so called "instantaneous carriers" are made, and has the advantage of being moved with any degree of rapidity entirely at the will of the operator. The method of its working is as follows: **A A** are two vulcanite wings, which are always out of focus, when a picture is required to be changed the handle is turned from top to bottom (halfrevolution), this closes the shutters and then moves the slide, and when the slide No. 2 is in its place opens the shutters; no movement of the slide whatever is seen on the screen, if the handle is turned rapidly the movement may be said to be instantaneous, although the screen is in darkness for the fraction of a second, yet it is not perceptible, as the impression is still on the retina of the eye, and the appearance is given of slides being flashed consecutively; if the motion is slower, the illusion is that of one slide being closed in from the side, and the second slide opens from the centre. When a single lantern is used for devotional purposes no carrier could be better, as the picture is not seen sliding off the screen, everything is so smooth and simple.

Such a carrier must be delicately handled and not dropped and tumbled about as a plain wooden frame, as the working portions are very finely made, although not to the extent to make it complicated or likely to get out of order. With this carrier or any other double form, it is a good plan to fix a strip of wood each side of the opening, so that the spring slide holder of the lantern may rest in between same and prevent it moving when a slide is changed, to do this, take off the front tube of lantern with flange and front lens, place the carrier in the slide stage, and place it in such a position until the condenser appears exactly in the centre of the carrier opening, to do this, it is necessary to look down the open tube, this done, mark on the frame the position it should occupy in the lantern to be central, take the carrier out, and screw two strips of wood about half an inch wide each side of the mark; the carrier is slid in from the top of the stage and held firmly in position by the wood strips.

Eclipse Dissolving Carrier.—Fig. 48.

By an ingenious contrivance, one slide is pushed over the other to give the so-called dissolving effect, the second slide being out of focus, the runner that pushes the second slide in over the first is pulled back again bringing slide No. 1 with it, the same movement acting upon *C* (Fig. 48), pushes the second slide to the front of frame, thus putting it in focus. This carrier is supplied from one side of the lantern only.

BEARD'S DISSOLVING CARRIER.

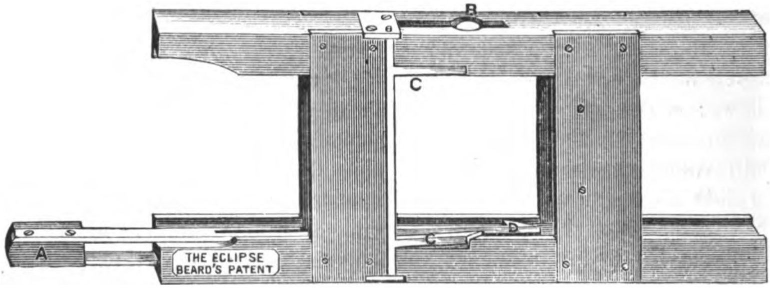


Fig. 48.

Instant or Sliding Carrrier.—This is actually the wood-work of the " Presto, " in fact, all sliding carriers are an imitation of the " Presto " more or less. This carrier is flipped quickly from side to side, the inclined brass base raising the slide above the level of the top of carrier,

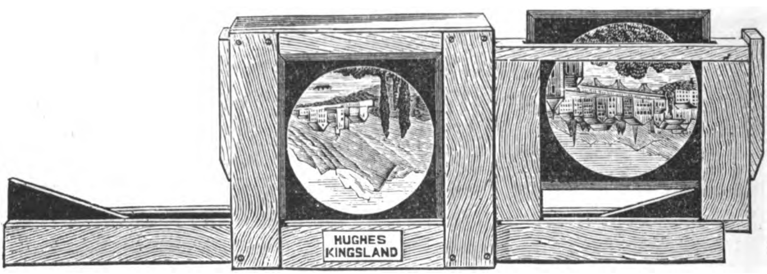


Fig. 49.

making it very easy to take out, preventing the hand from steaming the slide in putting in, or shaking the carrier in taking a slide out ; for a cheap and good carrier for a single or double lantern, it certainly has no equal.

Double Panoramic Carrier.—Consisting of a frame for two slides, each slide is dropped in from the top and the whole moved from right to left ; the previously mentioned frame has superseded this.

Panoramic Carrier.—For passing long panoramic slides through the lantern, also $3\frac{1}{4}$ slides, of which it holds three, so that when filled the middle slide is exactly in the centre of condenser, the slides being pushed through give somewhat a panoramic effect, its only draw back is that the lanternist is very liable to forget to take the slide out on the opposite side to that which he is putting them in, until he is reminded by hearing it smash on the floor.

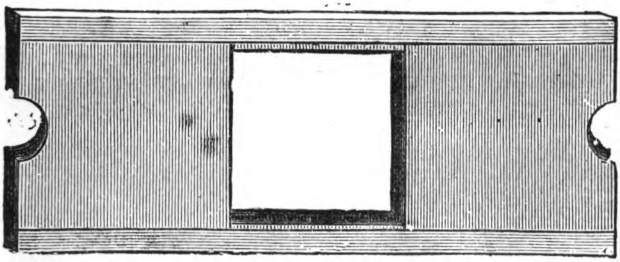


Fig. 50.

Carriers for two or more Lanterns.—The simplest is a solid frame with an opening in the top into which the slide drops (Fig. 51). This is a good carrier in its way, but has the drawback of having to be withdrawn completely from the lantern when the slide is changed, the slide is lifted out, or the frame inverted and the slide then drops out, a fresh one reinserted; many superior carriers are now made to this.

(Fig. 51) is now made with an outer frame of very thin wood. This frame remains in the lantern whilst the inner carrier is pulled out, the slide withdrawn, another is inserted and the carrier pushed back in its frame which ensures the slide occupying the same position on the screen each time.

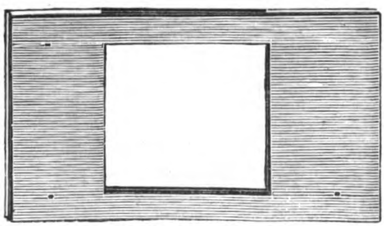


Fig. 51.

Self-Centreing Carrier (Fig. 52) has the advantage of being stationary in the lantern, and when once placed so that it occupies centre of condenser need not again be moved, a slide of any reasonable size, from English $3\frac{1}{4}$ to American $3\frac{3}{4}$, can be placed on the brass runner, and is pushed home against a lever which centres it exactly in the frame, whatever be the size of the slide, it will occupy the centre of condenser and thus ensure registration. Its working is wonderfully simple, and it has no levers or catches to get out of order.

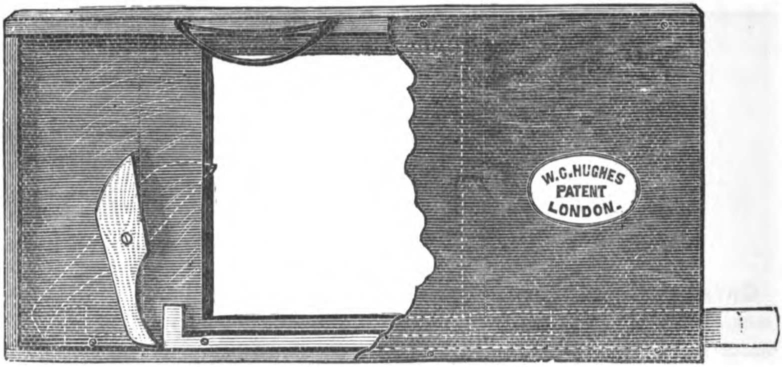


Fig 52.

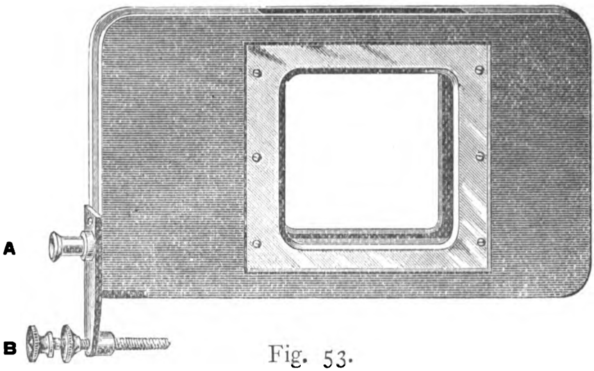


Fig. 53.

Docwra Carrier.—The best has been left until last, although the order of previously mentioned carriers are not according to their respective merits. Slides to receive the full benefit of this carrier should be mounted without mats or masks, if it is necessary to use these, let them be very narrow, not more than $\frac{1}{16}$ wide, to prevent the painting or film touching the cover glass.

The front of this carrier has a brass plate let into the wood-work, out of which is cut the cushion or circle in the said plate; a special tool has been made to cut each and everyone exactly true to a minimum and without doubt, this is the only true method by which a series of photographs may be made to register dead true, only those who have tried can comprehend the almost hopeless task of trying to make slides with cushion mats to superimpose, the slightest strain on any one side of the mat being sufficient to throw it out of the square; with circular mats there is not quite so much trouble, even then, if exactness is required each slide must be blocked, a difficulty which these carriers overcome.

The Docwra carrier is so constructed that either square or circular pictures can be placed on the screen with such dead accuracy that no critical observer will see where the one begins and the other leaves the screen. The mechanical parts are so arranged, that by compressing a projecting button the slides are gripped automatically and held firmly against the front of the carrier, to ensure each picture being in focus, and are so geometrically true that perfection is attained which cannot be accomplished by any other means.

A is the thumb press that presses the clips back which hold the slide in position, to place a slide in the carrier hold it at a slight angle, with the brass face undermost, drop the slide into its place, pressing the spring at the same time, by this means the slide is held firmly in position and pressed to the front of the frame; to make sure of the slide being down on to the bed of the frame, always press the spring once or twice in succession.

B is the regulating stop, for adjusting the distance the frame shall go into lantern, as it presses against the lantern stage.

SCREENS.

A great deal of the result is dependent upon the screen, it should hang perfectly flat, and be of snowy whiteness. Many an exhibitor will sacrifice his light by using a screen of a yellowish or dirty nature, in fact before now, a domestic sheet from the bed room has done duty as a screen. The best screen for general purposes, especially for travelling, is of a linen texture, scrupulously white and above all very thick and strong, especially for the larger sizes, the thickness gives it opacity, and the strength prevents the risk of splitting, the corners should be strengthened with an extra layer of strong linen. In the large sheets there is a very great strain on these corners, some are made with eyelet holes along the top and sides, others with rings along the top and tapes along the other three sides. We prefer the latter, it is entirely a question of use, as many exhibitors prefer the eyelet holes. A public exhibitor usually has three screens, 12, 16, 20 feet, as it is not always possible to use the larger screens, even in large halls. Some school rooms have roofs with a very low pitch, the acute angle of the roof preventing the use of a large sheet. The screen should always hang at a sufficient height to clear the heads of the audience. When the lantern is tilted at an angle, the screen should also be placed at an equal angle, or the picture will appear egg shape, being out of focus top and bottom. When tilting the screen in this manner, care must be taken to pull it very tight else it will sag, with a convex surface like a sail. Great care must be taken in the seams, that the join is not strained or puckered, as nothing looks so bad as to see every portion flat and even with theexception of the seams. The widest material for screens without a join is 9 feet, above that size a screen must be joined. When the join is at the bottom it is not seen, appearing as it does in the foreground of the picture. When requiring to show through the medium, it should be wetted by the aid of a garden syringe. Never do this unless it is absolutely necessary, as it takes all the whiteness out of the material, which is not recovered again in ordinary washing. Where possible, a screen should be retained, specially for this purpose. If in time the dirt makes itself visible, send the sheet to a laundry in the provinces, and have it bleached, the smoke and smuts of our big towns do not admit of this being done properly.

Always show on where possible. It may appear superfluous to add, that it is not necessary to wet the screen for this purpose.

Opaque.—Opaque screens are a luxury, but very effective and clean. When a lantern is frequently used in one place, as an institute or school, the screen can be made a fixture, and rolled up out of the way, it has the advantage of being clean and ready for use. There is a slight gain in light over an ordinary sheet, but nothing like the amount often estimated. For travelling about they are out of the question the roller and keeper top and bottom making them very unwieldy. They are made exactly in the same manner as maps, the canvas being covered with paper, when this becomes dirty it must be re-papered. It would not do to whitewash it, as it would flake off, when rolled up. With the larger sizes there is a great falling off of flatness at the sides, this can always be remedied with an ordinary, but not with an opaque screen.

The best form of opaque screen is a white-washed wall, nothing is better. If it is rough, it may be papered, and a coat of wash will always bring it up, do not put any blue in the wash, a little black is preferable.

For microscopic work and where a small picture is required, tracing paper stretched on a frame forms an excellent medium, and it may now be obtained 60 inches wide.

Fig. 54

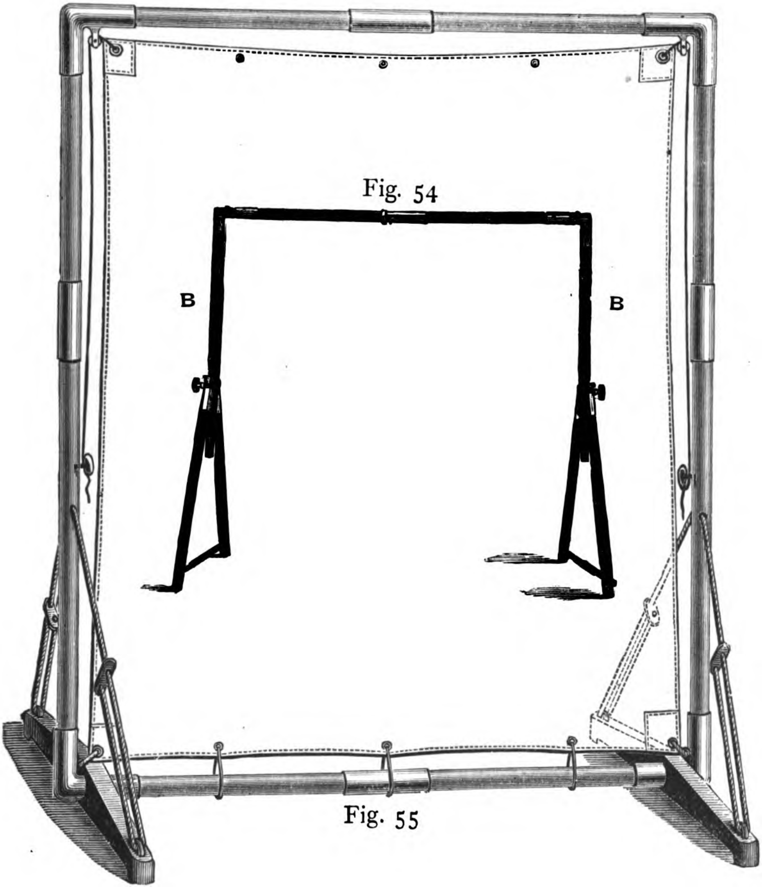


Fig. 55

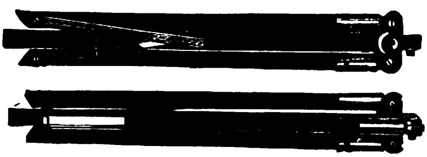


Fig 56.

SCREEN FRAMES.

Considerable discretion is wanted in the selection of screen frames, especially in those of larger sizes, the old-fashioned frame that is put together like a sweep's machine, being a succession of poles joined together is a dreadful affair, if one of the poles is left behind, the lanternist is *hors de-combat*, and even when it is up has no solidity.

The only recommendable frame up to 12 feet is the "Articulosus" (Fig. 54) it has no pieces to join together or parts to be left behind, brass knuckle joints hold the whole frame complete in two halves as Fig. 56. After setting out each half of the frame, and placing the brass pin through the holes in the top knuckle joints, to hold the top rails stiff, run the whole of the rings of the screen over one side of the top rail, this done, join the two halves together by means of the bayonet catch, and distribute the rings equally over the pole or rod, slipping the ring of each end over the end of the brass work of the frame. If not sufficiently wide for this purpose, fasten a piece of string to the last ring of each end, and tie over the corner of the brass work, in a similar manner, raise the frame with screen attached a little at the time, by means of the central pole, and as the rod is raised fasten the tapes of the side of the screen to same. When the screen is at its full height, the bottom corners of the screen are tied to the stays, going across the Λ shape sides in the cross bar of the A as it were, if this is not sufficient to draw the screen tight, fasten a cord from the eye attached to the bottom of the upright rod, passing it down underneath the cross bar or stay to the other side, under the stay or cross bar, and up to the other rod, fastening off at the screw eye. The screen may then be fastened at the bottom and sides to this cord, and may be made as tight as a drum.

When dealing with a large frame from 16 to 20 feet, an entirely different principle is necessary. That which will stand firm and rigid at 12 feet, when lengthened to 16 or 20, becomes quite flimsy and inadequate, to hold the extra strain, a resource must be made to guy ropes and a firmer basis. This necessisates stronger poles and heavier castings for the angle pieces. With these larger sizes, it is a complete frame in itself, with all four sides, Fig. 56. When this is firmly placed, and guyed to the extending feet or base, the screen is pulled up by a cord running on wheels at the top corner, the tapes of the screen are fastened to the woodwork of the frame at all sides including bottom. All this cannot be done without weight, for a 20 feet frame, the woodwork must be solid and firm with brass castings of a substantial quality. Bamboo is very portable, but lacks the solidity necessary for large frames, for smaller sizes there is a slight gain in weight, over ordinary deal rods.

In most large halls, a nail can be found on which can be hung a pulley block, such as is used in tent and awning work. A strong cord, (blind cord is the best,) is passed through the ring at top of the screen, and fastened off tightly at each end, this cord is then passed through the pulley block and hauled up. The pulley blocks are always handy. If the screen has to be placed in a hall where even a nail cannot be driven, two long planks must be procured, and these guyed up with ropes, the cord passed over the top and secured to a screw eye driven into the floor, or failing this, two ladders may be secured upright in a similar manner.

LANTERN SERVICES FOR THE MISSION ROOM AND CHURCH.

(Pictorially illustrated.)

It is now fully recognised and acknowledged that by the means of pictures, the eye and mind are more easily impressed than they would be otherwise, and coloured pictures appeal to the imagination more especially of the uncouth, than any address or sermon. This is substantiated beyond a doubt, by the manner in which these exhibitions are attended during holy week. At first the clergy were prejudiced in introducing the lantern into their churches, thinking that some of the solemnity due on such an occasion would be lost. This is found not to be the case, if proper precaution is taken, as will be hereafter mentioned, such services as held by Canon Barker at Marylebone, Westminster slums, Holy Trinity, Dalston, Canon Scott, Salford, and a host of others, are sufficient testimony to this assertion. In some churches, it is the rule to give a lecture or pictorial service, after evensong on Sundays, the ordinary congregation leaving, making room for others, who could not be got into church by other means. Such subjects being used as "The Angels," as mentioned in the old and new Testament, "Church History," "The Passion of our Lord," "The Passion Play," "Seven Sacraments," "Lecture on the Creed," "The Tabernacle," "The Holy Land," &c., &c., and showing such effects as the "Rock of Ages," during the singing of the hymns by the choir, "Sunrise on Mount Carmel," "Fields of Bethlehem," "Jacob's Dream." Illustrating the hymns, as "Lead, Kindly Light," "Sun of My Soul," and others equally as beautiful.

If every prejudiced person could be present at one of these evenings, he would see what really can be done with a secular and rough congregation. No books are needed, the hymns and prayers being thrown on the screen where every one must look, and are thereby almost compelled to sing, and the singing is indeed most hearty.

Good Friday.—No one would think of displacing or attempting to rival the three hours' service. Nothing is a more suitable devotion for that day, but the three hours' service cannot be held in some parishes, and there are many who cannot attend, and many also who are too ignorant and untrained to appreciate and understand it. For such is the pictorially illustrated evening devotion. Illustration of scenes in our Lord's Life and His Passion. The Stations of the Cross.

Scrupulous care should be taken that there be no possible chance of a hitch in any manner; the priest or missioner, with the choir (if any) should be close together near the screen. It is essential that the lantern and slides be of the highest class. In a church nothing that suggests the least unworthy remark should be seen or heard. Slides that are not of the highest order should in no case be used, it is one of the great dangers of such a devotion. Some slides are unintentionally grotesque and shockingly painted. All must be carefully planned, down to the smallest detail, and if needs be well rehearsed. If the lanternist is not a professional, let him at least be a good amatuer, and if necessary, let him have an assistant to hand him the slides.

Label all the slides with a white circle of paper on the top right hand corner as he faces the screen, the slides being already inverted, as it would never do for a slide to appear upside down. All the operator has to do is to place them in the carrier.

The position of the lantern and screen depends much upon circumstances. If in a church, the screen should cover the chancel, and the lantern be low down, or at the bottom of the nave. If there are many windows in the east end, the opaque screen should be large enough to obstruct the moon's rays, otherwise, the moonlight nights may be rather an objection in this respect. The best form of lantern is a triple, with long focus objectives, so that there is always a spare lantern if anything goes wrong. All this may be done with a single lantern, and we would suggest a Presto Carrier, as with this each slide is changed so smoothly, gradually closing in from the sides, and opening again with a fresh slide from the centre, no movement being perceptible in the change.

Where only a single lantern is used, it can well be placed behind the screen in the chancel, and the pictures thrown through, and if the screen is not large enough, the sides filled in with curtains, to prevent any movement being seen. The choir may also be behind in this case, to answer the responses. If it is a service for adults, under no circumstance admit children. For these a special service should be held, with moral pictures, and a more suitable address. Take special care that the rays from the lantern escape the head gear of the feminine portion of the congregation and under no plea allow persons to pass in front of the screen. Nothing mars the solemnity more than to see a silhouette of a person's head on the bottom of a picture.

PRACTICAL HINTS TO INTENDING LECTURERS.

Many persons who are unpractised find themselves called upon to lecture upon a given subject, and a great many, unfortunately, essay the task, who are physically and mentally unfit for it, although it is prompted by a good motive; few untrained persons would presume to preach a sermon, freely acknowledging that they are perfectly incapable for such a position, yet they imagine they are capable of "reading a lecture" as it is termed; a lecturer is not an adjunct to a lantern entertainment, but the principle feature, upon him rests the responsibility of making or marring, which is in every other respects a good exhibition. Even the clergy, as a rule, lack the style and humour of a practised lecturer, to compile or write a good sermon comes easy to them, or even a lecture, which may be a compilation of well written matter, but to deliver it in a terse and humourous manner is quite a different thing, whether it is that they are strange to their audience, or having to talk in the dark, or that the matter is not congenial to them, we are unable to say. We have often heard a most learned divine, who in the pulpit is a great source of edification, utterly spoil an exhibition by the hum-drum manner in which he will read off his manuscript, as no emphasis or elocution whatever appears to be thought necessary. The class of audience is not taken into consideration, but the usual sixpenny stereotyped lecture is considered sufficient for all, and the lecturer takes it for granted that the audience understand his description of a building, or a particular portion of the slide on the screen, without the trouble of using a pointer.

Inexperienced lecturers commence by apologising and making excuses, that they have not had sufficient time to prepare, or that the slides are not quite to their ideas of the subject, that the operator is fresh at his work, and to make allowances for his or the lanternist's shortcomings; putting a damp blanket on everybody, operator included, for the remainder of the evening. Fancy a clergyman commencing a sermon with a preliminary of this kind. Let the lecturer remember he has undertaken to give the lecture and be responsible for everything; and if the audience who have paid their money (whether for a charity or not) are not appreciative, the lecturer is generally to blame.

Lantern lectures are often brought into bad repute by incompetent persons, and the very name of a lantern lecture is enough to bias the minds of a most indulgent audience, as the anticipation of a "Willy-Nilly" description will very frequently drive them away.

We will now take the manner in which a lantern exhibition *should* be managed, with a few hints on lecturing. Chairmen are often a source of anxiety to a lecturer if they commence a lengthy introduction, as they frequently do as soon as the curtain or title slide is thrown on the screen, the gas is going and the slide exposed to the risk of being broken with the heat. If the chairman must have his say, let it be before the lights are lowered. If the lecture is the usual printed one, it should have been well rehearsed in private, and each slide gone over, to become familiar with the subject described; every lecturer knows the difference when talking of a place he is familiar with. When describing any particular feature in the view, it should be pointed out by the lecturer either with a pointer, or if the screen is very large, by the aid of a fishing rod, as this is portable for travelling. Do not tell the audience what they are to expect in the succeeding picture, for instance—when an effect is introduced, we have heard it said: "The next picture will be by moonlight, and after that the windows will light up." It spoils the whole charm of the change, if attention must be drawn, let it be after the change has taken place, do not stop the reading and turn and watch the screen, practised lecturers never do this, it causes an unpleasant gap in the lecture.

The most effective lectures are those spoken and not read. Those who feel it necessary to read their MS. should practice reading it aloud several times before it is to be publicly delivered, that they may be familiar with the subject.

When writing and arranging the material for a lecture, let the wording be simple and the sentences short and concise. A sentence consisting of several lines without a stop becomes wearisome, make the lecture to the slides, and not what is generally done, the slides to the lecture. Avoid statistics and lugubrious wording, a terse and racey description, with a well told anecdote here and there will be found most appreciated by the listeners, as they want to be amused as well as instructed, plenty of pictures with a compact description is all that is needed. Lecturers sometimes will talk on one picture for 15 minutes, going into technical details that are most wearisome to the majority of their audience.

A slide should not remain on longer than two minutes, and many not even so long as this. In lectures of a popular and entertaining character, it is desirable to introduce a little music, and if the lecturer is a musician, the introduction of a few songs of an appropriate character, after the style of Corney Grain, and Grossmith, are a pleasant change; sentimental songs, as a rule, are quite out of place in a lantern exhibition unless they are exceedingly appropriate. If a musician is to be employed as well as the lecturer, a system of cues and signals should be arranged between them, a few bars played now and again during dissolving, or an appropriate air during the showing of effects and statuary.

There should be some well understood code of signals between the lecturer and the lantern operator, a verbal signal such as "the next picture, please," or the concluding words, "as our next picture will show," are irritating to anyone who has the least idea what an exhibition should be. Reading lamps are now made with a colored glass, which is uncovered by a touch of the finger on the lever, a small bell is also attached, but this is nearly as bad as the spoken signal.

We once manipulated a lantern for a lecturer who used neither reading lamp nor bell, but carried a pointer in his hand, and being strange to his delivery, was asked what signal he should give us, as he always held the pointer in his right hand, we suggested that he should change it to his left hand when he required the picture changed, and if we failed to observe this to gently tap it once on the floor, as though it was brought down in the usual manner, this worked perfectly satisfactory, and the tap not resorted to more than once or twice at the most. The best system of any for signaling is a small electric battery and bell, the bell covered with wash leather or removed entirely, the bell is fitted inside the box containing the battery. We believe now that the battery is entirely superseded, a small magnetic arrangement taking its place. The wires are carried between the operator and lecturer, who has a small bell push fixed to his desk or held in his hand, no sound is audible except to the operator, who is conscious of a sharp tapping or rattling sound in the box, *one* tap for next picture, *two* taps for focus, *three* taps look to the lights or picture, and so on; by this means a code of communication is made.

The whole affair is put up in a few minutes, the wires running along the ground underneath the matting, or if there is a gallery, the wires laid along any projection, there is really no difficulty in fixing it anywhere, and the little extra trouble is repaid in the working, for nothing is so bad and irritating to the lanternist as to be told to focus up, and if he is 60 feet away it is no easy task to distinguish between a good focus and bad, especially if he has been looking at the naked light.

[SPECIMEN OF WORDING FOR A PROGRAMME OR POSTER.]

"THE SEA IS ENGLAND'S GLORY."

"STIRRING NAVAL YARNS,"

With Magnificent Limelight Scenery,

BY

CAPTAIN CHARLES READE, R.N., F.R.G.S.

Nephew of the Author of "It is never too late to mend."

Personal Reminiscences of Fiji,

With many instances of the extraordinary and amusing habits and customs of the Fijians,

Illustrated by beautifully-coloured Limelight Views by Miss GORDON CUMMING (Author of "At Home in Fiji" and other original sketches.)

SYLLABUS : How I went out to Fiji—The girls at Savage Island—Thakambau crowned—The Annexation, my messmate hoists the British Flag—The epidemic of Measles—The extraordinary way the natives dress their hair—How a wrecked Englishman was nearly made a meal of.

My adventures en route to the Cannibal country—I am considered to be "no good" for the fleshpot—Native Etiquette—Their clever dances—How a native caricatured the bad points of the white man — Their Marriage ceremonies, Feasts and Cannibalism.

How the Missionaries' wives saved some women from being eaten at the risk of their own lives — Pagan belief of the Natives — The Sago Palm and Pandanus tree — The different uses of the wonderful Cocoa-nut tree — A horribly amusing account of the way in which a young man caused himself to be buried alive - Fijian pottery.

The King of the Cannibal Islands visits my ship — His characteristic speech — The wondrous change brought about through the efforts of the Missionaries.

A REAL CANNIBAL FORK WILL BE EXHIBITED.

RULE BRITANNIA.

It is well to have an interval in the middle of the lecture, for the introduction of effects, statuary, etc., it is a change to the audience, and admits of conversation, besides being a relief to the lecturer.

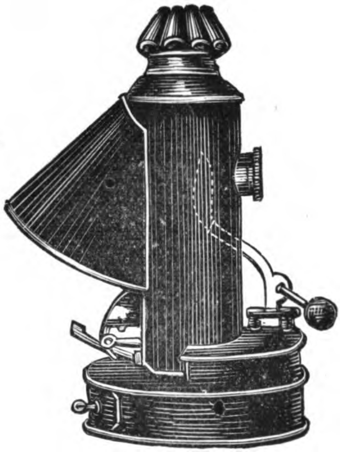


Fig. 57.

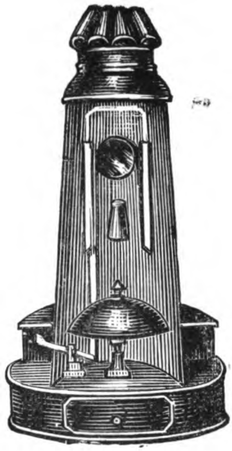


Fig. 58.

READING LAMP.

A Lamp that will give a fair amount of light, and not go out in the middle of an effective description !

Candle lamps, after burning some time, become heated, and melt the candle, which topples over, and the lecturer is *hors-de-combat.*

Oil lamps, where colza or sperm oil are used, are very messy and dirty, and thread-like cottons must be used, and with these a pinion cannot be fitted, the consequence is that the wick, which is perfectly firm when starting (the oil being cold), but after it has become heated, it has a peculiar knack of slipping down, and when attempting to prick it up, acts in a similar manner. The only remedy against these embarrassing objections, is to have a lamp with a woven wick, and a rack and pinion to raise and lower it at will, burning benzoline or paraffin. If a candle lamp is used, the candle itself must not be inside the lamp, but rather below, on the principle of a carriage lamp, the bottom being pressed up with a spring, so that the candle, or the lighted portion, is always on the same level.

Figures 57 and 58 represent the benzoline reading lamp. The cistern is outside the lamp and reduces all fear of being over heated. If benzoline is used it is only necessary to saturate the wool in the cistern, and if it is over-filled, or run over, it immediately evaporates without leaving any mess or smell behind. There are two means by which the cue may be given to the operator, by the coloured glass, or the bell. The former is without doubt the best, being silent, but should the operator go to sleep, there is always the bell to fall back upon, which is inside the lamp.

Figure 58 is a sectional inside view, showing bell and aperture through which the wick tube projects, also the small drawer at the bottom for matches.

Directions for use.—Unscrew the metal cap of cistern situated at the back of lamp and saturate in the ordinary way the absorbing material inside the reservoir, the residue to be poured out, taking the precaution if spirit is used not to be near a light, if kerosene or other mineral

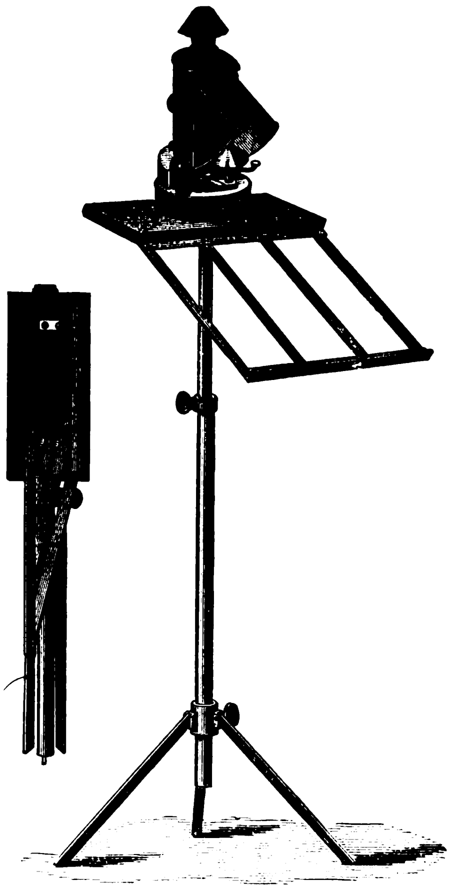


Fig. 59.

oils have to be substituted simply fill the cistern; but benzoline gives the best results.

When paraffin has once been used always keep to it.

READING DESKS.

Of these there are a variety, and it would have been better if some had never been made at all. We never forget trying to hear a lecturer who was placed not six feet away. He was not possessed with an over penetrating voice, and to add to the discomfort of his audience, he had his head inside a box-shaped so called reading desk, into which his voice went, and there it appeared to stay, for very little was heard by the audience.

A desk should be open and clear, as a lectern with no side pieces or flaps to impede the acoustics, giving the lecturer freedom to move at will. If a stand is made with desk attached complete, the stand should be solid yet sufficiently portable to carry for travelling, and be so adjustable as to suit the height of any lecturer.

Portable Reading Desk. (Fig. 59.)—This reading stand and desk is portable and folds up in a small compass. The three projecting legs forming the basis, fold flat against the side of the main rod, the socket holding these, slides up the main rod carrying the collapsable legs with it. When fitting up for use, care should be taken to place the socket at the extreme end of the rod, before fastening with the thumb screw, if the thumb screw is fastened on any other part of the rod, it will cause a dent, and as this is telescopic, there is a trouble to withdraw the inner rod. The other portions seem simplicity itself.

SCIENTIFIC DEMONSTRATING LANTERNS FOR INSTITUTE AND COLLEGE WORK.

This form of projecting lantern (Fig. 60) is certainly preferable to any other for scientific and technical lectures, as any small piece of apparatus or mechanism can be thrown on the screen with distinctness, slides and diagrams being shown in the usual manner. The late Mr. Lant Carpenter, was the first to make this class of lantern popular. The original lantern of this type being of German manufacture, and a very flimsy and gingerbread piece of work, compared to the present form, which is much used for the popular Science lectures, at the old Victoria Theatre, in the Waterloo Road, London. It was also used by Mr. Preece, to illustrate his lectures on "Electricity" to juveniles at the Society of Arts, and by Professor Forbes at Manchester before The British Association, when visiting that city.

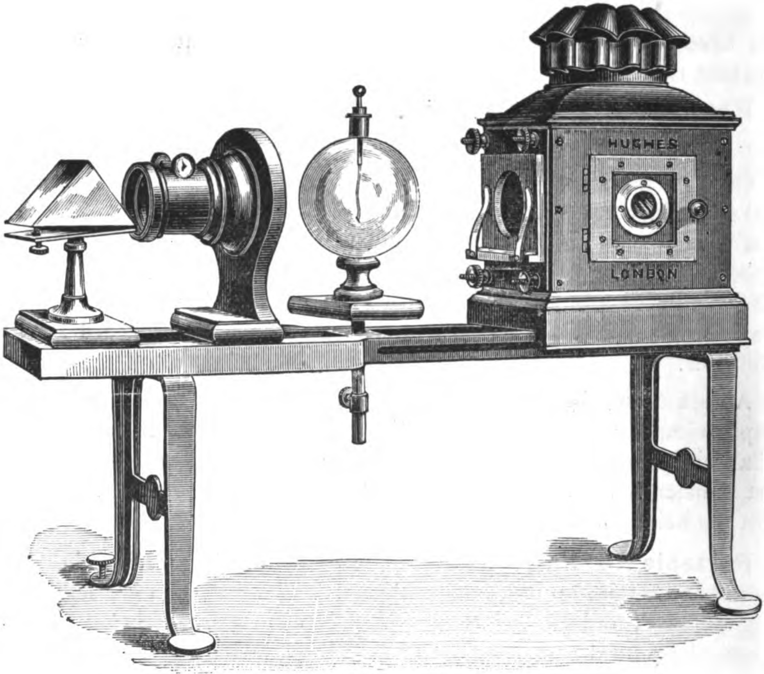


Fig. 60.

The condenser will throw a parallel beam for experiments on "Light" or " Acoustics " and for use with the Polariscope. The front lens must necessarily be of long focus, and to pass the full modicum of rays, of wide diameter, no diaphragm or space for colored glasses should be fitted on the front of the lens, as in the case of a prism being used in connection with experiments to erect the illustration, the prism requires to be as close as possible to the lens. The erecting prism will require careful adjusting for the correct position and should have some means of being lowered or raised, the bottom edge of the prism will reach nearly a third up the lens, before it catches the emerging rays. It is considered necessary to use a prism when showing experiments, as some of the audience often imagine the experiments work upside down, as there are two reflections in a prism, there must necessarily be a considerable loss of light, and all this must be compensated for as much as possible by an exceedingly powerful illuminant. When using pieces of apparatus, that vary in their distance from the condenser, it will be necessary to adjust the jet slightly by pushing it in or drawing it out, as the case may require.

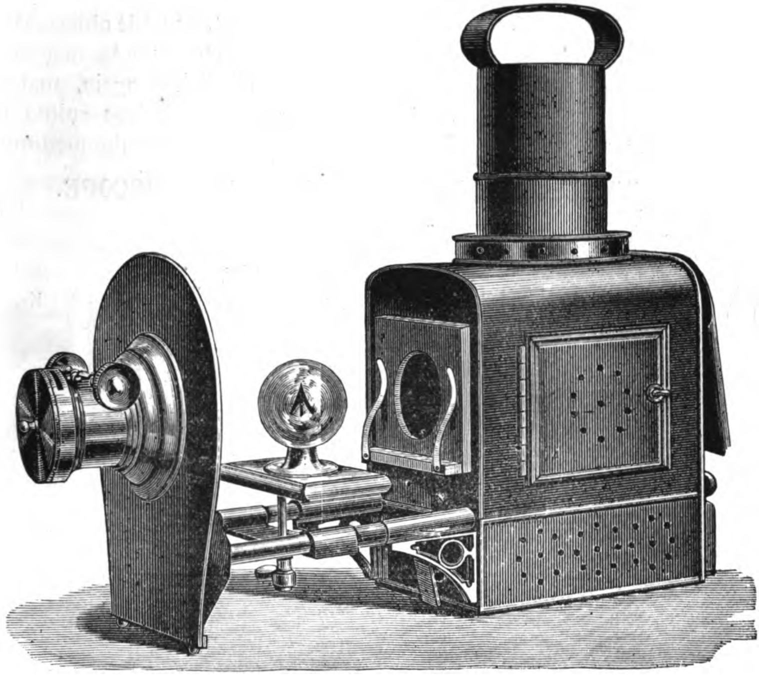


Fig. 54.

A cheap but none the less efficient form of demonstrating lantern for class work and small audiences, is shown and entitled "The Teachers' Aid." The space between the condenser and front lens is entirely open, for the introduction of tank and other experiments, an elevating table capable of being raised and lowered is held in position by a thumb screw, it also slides along the two rails to suit the object being shown. The distance between the condenser and front objective may be extended or reduced at will, the rods holding the front and body together are telescopic.

In demonstrating experiments, it is important they should be placed as near the condenser as possible, especially when oil lights are used the closer the object is so placed the brighter the disc; a short focus objective is preferable to a long one when oil is used for the same reason. When using oxyhydrogen we can afford to sacrifice a little light, but not so with oil. A microscopic attachment is well adapted to this form of lantern as it enables the microscope to be brought much closer to the condenser, and with this there is a gain in light. When using the

Pamphengos lamp with the microscope attachment, suitable objects such as sheeptick, proboscis of fly, head of a silkworm, etc., may be magnified up to two, and some three feet and amplified to half this again, making an image of four to five feet. A tracing paper screen is best suited for this purpose, and of course the class must be very close to the medium.

LANTERN PROJECTING MICRO POLARISCOPE.

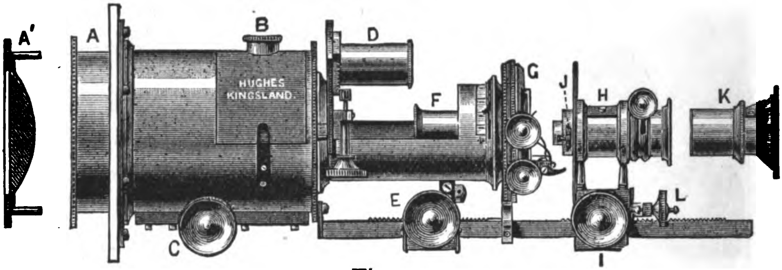


Fig. 55.

Fig. 55 illustrates this instrument which has all the latest improvements made up to the present time and has the polarizing prisms fitted, so that nearly all the experiments both in polarized light and projection can be shown to the class without in any way altering the instrument, a very great advantage to the demonstrator.

Reference to Fig. 55, shows--(*A*) cells containing condensers, one of which is fitted in cell upon a moveable rack work.—(*C*) by which means the amount of divergence of rays can be altered, this arrangement is for use with electric light, when the oxyhydrogen is used, the third lens (*A*') marked for "lime light only" must be added.—(*B*) Alum trough.—(*D*) polarizing prism made to rotate by means of milled head, this is shown in drawing thrown out of position, and is so placed when the ordinary projection microscope is in use, the aperture of body being covered by a moveable lid.—(*E*) rack work adjustment for substage condensers and all apparatus used behind the object.—(*F*) substage condenser. (*G*) mechanical rotating stage having ¾'' motion in rectangular directions and is divided to 360 for use in crystalography.—(*H*) object glass holder on rack work which admits of focussing the different objectives.—(*L*) fine adjustment by means of $\frac{1}{100}$ thread screw, this admits of the most delicate manipulation and is indispensable when high power objectives are in use.—(*K*) analyzing prism rotating mount also divided to 360°.—(*J*) dovetail slot in object glass holder to carry the quarter wave plate and Kleins quartz immediately behind the objective.

Directions.—Having thoroughly cleansed the condensers by means of an old silk handkerchief which is far preferable to wash-leather, proceed to light the oxy hydro jet (of course see that the third lens marked "lime light" is fixed in its place) great care must be exercised in perfectly centreing the light and obtaining the greatest possible amount of light, for every ray will be needed to properly illuminate the substage condensers and so light up the object. We find it preferable in practice when commencing to first try the illuminating power by removing all obstacles, and throwing the plain light disc upon the screen in the same manner as with the ordinary lantern. Before passing the light through any object upon the stage be sure and see that the alum trough is filled with clean water, or better still a saturated solution of alum (this is made by pouring boiling water upon the alum and allowing to stand, continually adding alum till the water will not take up any more of the crystals, draw off the clear solution and use cold). This piece or part of the apparatus is of great utility, as it absorbes the heat rays and prevents them to a very great extent from passing through the substage condenser, and so to the object, and as they are there brought to a focus they act as a sort of burning glass, and as most objects for the microscope are mounted in balsam or some such medium, and are particularly subject to the effects of heat, it would be very annoying to the demonstrator to see some pet slide gradually vanishing from the eyes of the audience.

It is at all times advisable when the instrument is in use to remove the screw cap of trough and leave open so that the heat can escape.

Be careful to see that there are no bubbles upon the glasses of trough as they show upon the screen, a camel-hair brush will remove these. The next operation after choosing the object we wish to show upon the screen, and here it is advised that unless some definite subject is taken for class demonstration, to manage all the slides in a series, so as to admit of the same power objective being used, it will save much time to the operator in changing both the object glass and substage condenser. The substage condensers are engraved Nos. 1, 2, 3, 4 and 5, and the knowledge of the best one to use will easily be found if this rule is carefully attended to. No. 1 is the shallowest and gives a greater covering or illuminating power through the rays collected from the condensers crossing at a point further away from the object, of course the rack will have to be moved back so that it is brought nearer the condensers, and focussed till the best effect is obtained, and the object properly illuminated.

The No. 1 and 2 condensers are used with the object glasses of $1\frac{1}{2}$ inch, $_{10}$ inch magnifying power, upon objects say of $\frac{1}{2}$ inch surface.

No. 3 with $\frac{8}{10}$ inch and $_{10}$ inch object glasses and objects of $\frac{1}{4}$ to $\frac{3}{8}$ inch surface.

No. 4 with $\frac{4}{10}$ inch object glass and objects of $\frac{1}{8}$ inch or less surface.

No. 5 the extra front placed upon the No. 4 must be used with all high power objectives, this now leads us to consider the

OBJECT GLASSES.

The goodness of any object glasses depends mainly upon their freedom from chromatic and spherical aberration and upon the magnitude of their angle of aperture. The freedom from the former (chromatic or colour correction) renders them good in defining power, which means exhibiting clearly and crisply all the markings of the object under observation.

The object glasses, which we strongly advise are specially corrected for use in projecting work, as by using a slight excess of the red rays of the spectrum, the lines of the object are shown upon the screen perfectly black and the edges of the object are not fringed with colour. This is the exact opposite to the corrections used for objectives supplied for micro-photography, when the blue or actinic ray has to be utilized. This will perhaps better explain why object glasses specially adapted for this work should be used.

The second or angle of aperture which if large gives power of penetration, or of rendering markings upon the surface of the object visible or distinct.

Of course, if you have a table microscope with a battery of objectives, these may be used, but it will be found that many of the objectives that perform well upon the ordinary microscope body will not yield good results upon the screen, owing (as above explained) to the different corrections, also to the mounting, or to explain more clearly, the distance between the posterior combination of the lenses and the screw fitting into body of microscope or object glass holder of projecting microscope. The microscope body being about one inch in diameter only, forms as it were a stop cutting off the marginal rays, and leaving only the centre of lens (always the best definition), while upon the lantern the image is projected direct upon the screen, and it is disappointing, to say the least of it, to find the centre of object beautifully sharp and distinct while the edges are almost invisible through their blurred state.

We advise the operator to obtain the best results from low power objectives which will not give such large images upon the screen, but may be enlarged by means of amplifiers and are far easier to use and illuminate, and will be found more useful to the ordinary demonstrator.

Upon the mechanical stage *G* will be found a diaphragm which is used for cutting off any excess of marginal light, and giving a sharp edge to the illuminated disc upon the screen, this is moved by means of a small head behind the divided ring and is made to contract or enlarge as the nature of the object may require.

AMPLIFIERS.

These consist of a series of concave lenses of various foci mounted in cells fitting into object glass holder behind the objective and are marked Nos. 0, 1, 2 and 3.

No. 0, being the shallowest, therefore amplifying the image to a smaller size than No. 3, which being of a greater curvature, projects the image at a wider angle, and the enlargement is in proportion.

This conveys the idea of the working, and it will be as well to try each object under different amplifications and make note of the power of object glass and the number giving best effect, it must be distinctly understood it is not the matter of how large you can show anything, but under what circumstances the markings and general details of the object are best illustrated upon the screen. Be sure and see that the cell carrying the amplifying lens is placed right home in the object glass holder, otherwise the rays will not be taken up in a proper manner and the image will be cut off by tube of cell.

Having thus described the main parts of the instrument our next thought will be the apparatus which can be used with the same, they consist of spot ens, lieberkuhn, live cage, revolving selenite stage, frog plate, etc.

SPOT LENS.

This consists of hemispherical lens of great convexity having a centre spot ground into the plano or flat side, this cutting off the central rays, the marginal ones are so diverted that they cross above at a very oblique angle and passing over centre black spot yield a beautiful dark ground illumination, this piece of apparatus is sometimes called the black ground illuminator, and is invaluable for showing diatoms and opaque objects that are mounted transparently, it is placed in the same fitting as the sub-stage condensers, and focussed by means of the rack-work till the proper effect is obtained upon the screen. Of course a great deal of light is absorbed or lost by this piece of apparatus but the result is very beautiful, and the object is shown in its true form, which often does not happen when the pencil of light is passed directly through it.

The markings upon many of the diatomacæ can only be made out or properly determined when examined by oblique light, as procured by intercepting the central rays, which effect is produced by the spot lens. Objects, such as rocks, metals, etc., mounted upon the slide opaquely, or for the determination of pigment-granules, cells, etc., will need a

LIEBERKUHN

which consists of a silver cup of such a curvature suited to the object glass upon which it is to be used, and is fitted by sliding on to the body or cell of object glass. The interior or front combination of same passing through the centre of cup (except in the case of very deep lieberkuhns which are very rarely used). The light passing through the substage condenser and round the black disc upon which the object is mounted, is collected by this cup or curve and reflected back upon the object from which it is taken up by the object glass and projected upon the screen, giving back a brilliantly illuminated object upon a black ground.

LIVE BOX.

This piece of apparatus consists of metal base-piece upon which a cell is fitted having a glass bottom, into which slides another cell or tube also having a glass fitted, this cell is provided with a moveable cap so that the glass can be changed for varying substances suitable for the object under investigation from $\frac{1}{50}$ to $\frac{1}{200}$ of an inch.

The live box is made to contain portions of liquid containing infusoria and other small animals or plants can be confined so as to prevent evaporation and allow of their being watched in a living state. Another piece or apparatus specially useful for class work is the

GROWING SLIDE

the manner in which the slide is used is this; supposing it is wished to follow the changes undergone by some minute algæ or infusorium which has been detected in a drop of liquid, it is placed upon the slide, distilled water, mixed with a small proportion of the water in which the organism was living is next placed in the cup at side, and a few threads of lamp wick cotton, thoroughly moistened with distilled water, are then so placed that one end is immersed in the cup whilst the other is brought into contact with the edge of the liquid in which the object is immersed, then as the water evaporates from beneath the thin glass, the threads will afford a continous supply, and the threads will not become dry until the whole of the liquid in the cup has become absorbed by them and evaporated. In this way we obtain the requisite conditions for continued growth of aquatic organisms. Care must be taken that the thin glass presses but slightly upon the object, another piece of apparatus used for showing live objects is the

FROG PLATE,

which is a plate of stout brass about 6″ long, fitting by means of a dovetail piece into a female-fitting upon the stage, it is furnished with a glass disc let into one end flush, which is brought central to the opening of stage. To exhibit the circulation of blodd in the foot of a frog, one of the most beautiful and wonderful objects that is possible to be shown upon the screen; take a full grown frog gently cleanse the animal from any slime that may be about him and insert him in a small bag leaving one leg out, which secure by means of tying the mouth of bag, have ready a number of pieces of soft silk which fix securely to each toe of frog and pass the other ends through the holes which will be found round the glass disc, this will leave the foot extended over the disc, now fix the body of frog in bag which has been previously damped (let us make the thing as comfortable as possible in its by no means enviable position) by means of a good long piece of tape carefully wound round the body, the end fixed by slipping under the spring on under side of plate, it is now ready to fix upon stage and show to the audience. It will be found a great advantage to gently smear the foot under observation with some glycerine, this prevents evaporation and a stoppage of the circulation, if so treated it can be shown any length of time.

THE POLARIZING APPARATUS

Consists of two large Nicol's prisms and are composed each of two half-rhombs of calcareous spar, cemented together so as to transmit only one image.

The polarizing apparatus is useful in bringing to light certain peculiarities of structure which cannot be detected in any other way.

The revolving selenite stage used in conjunction with the polarizing apparatus, consists of two selenites revolving by means of rack work which give by super-position the different waves of colour.

The Klein's quartz and ¼ wave are used in the same subject and will be found fully described under the heading of polarized light.

POLARIZED LIGHT.

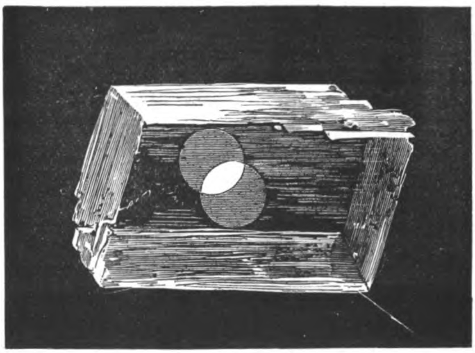
Before attempting to explain the nature of polarised light, it may be necessary that we should define the title, and so answer the oft repeated question: "What is polarised light?"—It is light reflected from or transmitted through glass at an angle of incidence of 56° 45'; according to the *undulatory theory*, light is propagated in *two* planes at least, at right angles to each other, whereas polarised light is propagated by only *one* plane separating as it were these rectangular planes, and in so doing acquires certain properties which were supposed to bear some relation to the opposite poles of a magnet, unfortunately the term "polarised" affords no indication of the phenomena it professes to describe.

Some two centuries since, a traveller brought from Roërford some crystals which eventually came into the hands of a Doctor Bartholinus, a man of great learning, who upon examination made the discovery that all objects when viewed through the crystal appeared double, this occasioned no little surprise to the students of the theory of refraction which at the introduction of Iceland spar required some modification.

Iceland spar, is also called calc spar, arising from its chemical composition, carbonate of lime, and is sometimes termed rhombohedral spar, from the shape of its crystals.

The four principal processes by which light may be polarized, are reflection, ordinary refraction, double refraction and scattering by small particles, that alone which can be adapted to the use, and in connection with the lantern will be dealt with. If a piece of spar be taken, (which

Fig. 56.



A BLOCK OF ICELAND SPAR, SHOWING DOUBLE REFRACTIONS.
(*By kind permission of* Messrs. GEO. ROUTLEDGE & SONS, LTD., "*Inventions of 19th Century.*")

readily splits up by cleavage) a sheet of paper with a small hole made with a needle, placed behind the spar, then viewed against the light, it will be found that instead of one light we shall see apparently two, and if the hole is sufficiently small, the holes appear entirely detached from each other, and upon revolving the spar one of the images will be seen to revolve around the other which remains stationary, the latter is called the ordinary ray and the moving spot the extraordinary image. The separation of the two images depends upon the angle through which the crystal has been turned, when this amounts to a right angle, the separation is at its greatest, and if the crystal be still further turned, the images begin to come together again until another right angle is completed, when they superimpose.

On this principal polarizing and analyzing instruments have been constructed by various combinations of wedges and prisms of Iceland spar.

Before going further it is as well to state that the price of Iceland spar, has gone up in bounds, as there is no means of supplementing the stock already in the market, as the mine from which it was obtained is filled up by volcanic coal, and all the later specimens that have been placed upon the market, show, owing to the internal workings of nature, that the crystals are nearly all imperfect, this having being effected by the violent convulsions, it is now nearly impossible to obtain a piece of spar that will enable the optician to cut a prism of much over 1" face, a comparatively small size.

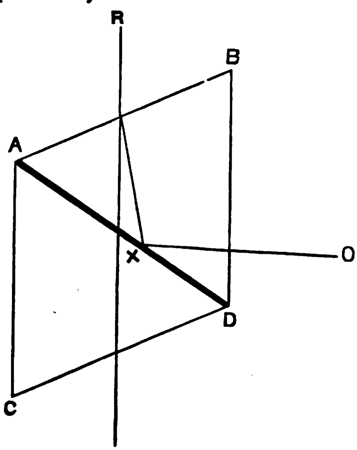


Fig. 57.

Let A. B. C. D. represent the section of a rhomb of Iceland spar, let this be cut through the plane A. to D. and the two severed surfaces polished. and united with a layer of Canada balsam and we have the prism invented by Nicol.

A ray entering R. is divided into two, R.O. the *ordinary*, R.X. the *extraordinary*. The ordinary ray passes and undergoes total reflection at the surface of the balsam, now the refracture index of Iceland spar is for the extraordinary ray, less, and for the ordinary, greater, than for Canada balsam. Thus in passing from the Iceland spar to the balsam the extraordinary ray passes from a less refraction to a more refractive medium, where total refraction cannot occur, while the ordinary ray passes from a more refractory to a less refractive medium, where total refraction does occur. It is thus seen that the extraordinary ray R.X. passes through the balsam and emerges parallel to the incident ray R. which passes through the adjacent lenses to the screen.

A similar prism is necessary as an analyser, but for optical projection it is not requisite to have this of as large a diameter. Owing to the scarcity, and fabulous prices asked for the few large prisms of spar, it became necessary to use other methods, than that of a direct Nicol prism. In 1808 a French scientist, Malus by name was looking through a crystal of Iceland spar, and seeing reflected on the windows of the Luxambourg Palace, the image of the setting sun, turned his crystal towards the windows, and instead of the two bright images he expected to see he observed only one, and on turning the crystal a quarter of a revolution this one vanished as the other appeared, this accidental observation led to the discovery that when a ray of ordinary light, falls obliquely on a mirror (not metal) glass, wood, marble, etc., it acquires by reflection at its surface the same properties as it would acquire if the ray was passed through a Nicol prism, or in other words if a ray of light strikes a pile of several sheets of glass with a black one at the bottom at the proper angle which is 56° 45' for glass, it becomes polarized, and it is this law we make use of in lieu of a Nicol prism. Any process which will serve for polarizing will always serve for analysing, as every reflection means a loss of light, it is much better for demonstrating work to employ a Nicol prism.

To fully describe the effect and phenomena of polarized objects alone would occupy a volume. The polariscope is of great service in revealing structures in bodies, which with ordinary light would not be visible, such as quill, horn, whalebone, etc., etc., except liquids and annealed glass, in fact there are few objects which do not show us their particular kind of structure under the polariscope. Annealed glass under various degrees of pressure is a very charming object.

Colour and beauty are seen in : crystalization of salcine, benzoic acid, calcete, leolite, selecite and sugar, nitre, etc. etc. All of which are particularly good objects, giving the prismatic tints in combination.

DIRECT REFLECTING POLARISCOPE.

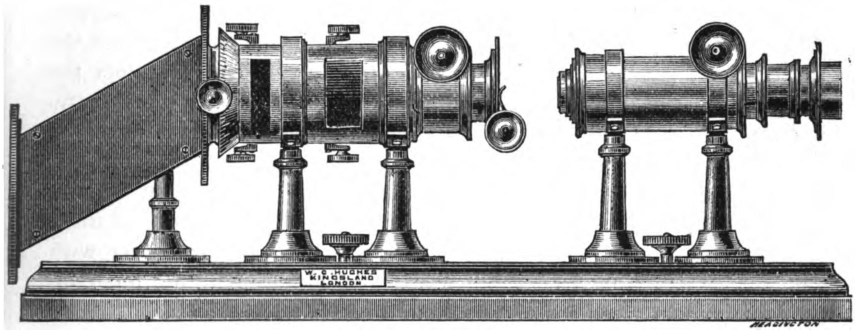


Fig. 58.

In lieu of the calc spar prisms polariser, a bundle of plates are used : the light strikes the plain glass mirror in the direction of the arrow (Fig. 59), and is then turned off and strikes the glass bundle at the proper angle and becomes polarised and passes through the various crystals and objects under observation to the analyser, which is a special flat ended Nicol prism with a rotating motion, divided to 135°; there is also a double converging system for exhibiting the rings in biaxinal crystals.

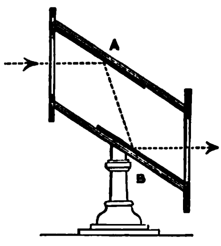


Fig. 59.

When the analyser is turned to that position which gives extinction, (i.e.) when the prisms are crossed, take a thin slice of selenite or mica and introduce between the prisms, light immediately flashes on the screen, not light alone, but colour of the most gorgeous description, which we may safely defy the artist to reproduce.

Bodies possessing the property of double refraction, though not to the extent of Iceland spar, as crystals, salts, crystalized minerals, animal and vegetable substances of a uniform structure, goose quill, and other substances, divide the polarised ray into two parts, splitting them up into the ordinary and extraordinary rays. We take a piece of selenite about a quarter of an inch thick, and place it in the stage between the polariser and analyser, the ray passing from the polariser enters the selenite and is again split up, as we have seen, into ordinary and extra-ordinary rays, and becomes *dipolarised* and forms two planes of polarised light, vibrating at right angles to each other and, on reaching the analyser, do so with different velocities as the two rays from the selenite have traversed it in different directions, and on emerging, one of these sets of waves will be retarded; half the ordinary wave interfering with half the extraordinary ray and, when passed through the analyser, produce colours green and blue, red and orange.

When the principal sections of the film are parallel and perpendicular to the plane of the prism, when the analyser is at 0° or 90°, no colours are seen.

Selenite.—The thickness of the film of selenite (crystalised sul-phate of lime) determines the particular colour produced, if of one uniform thickness, one colour only is produced, when a common piece is taken and split with a penknife it is generally irregular in thickness, and when placed on the stage between the prisms, shows the most beautiful variations. Slides are prepared in selenite by taking ad-vantage of the various thicknesses for different colours, and represent birds, flowers, stars, chameleons, etc. A film increasing in thickness from one edge to the other will show at a glance the phenomena due to films of various thicknesses.

We have seen that colour is produced by "interference" as it is called: that minute differences in the distances through which such rays are transmitted are necessary to cause such interference. If then a double refracting medium is placed on the stage between the prisms, colour will be produced by interference and the colour will change to its complementary tint at every quarter of a revolution of the analyser.

Any two colours which together contain red, yellow, or blue, are said to be complementary, together they produce white light, for example, the complementary colour to red would be green, because of the last containing yellow and blue.

Combining three selenites of various thickness, each being a pure tint, a succession of thirteen different tones are obtained.

If, instead of selenite, we interpose calc spar, quartz, nitre, topaz, or tourmaline and other crystals with their axes cut in certain directions, instead of lines we have colored rings, which change at every quarter of a revolution of the analyser to their complementary tints.

Some of the chromatic effects of irregular crystalization are beautiful in the extreme. A film of horn, sections of a shell, common glass under strain and pressure produce the most wonderful phenomena, apparatus for producing which are sold by the opticians.

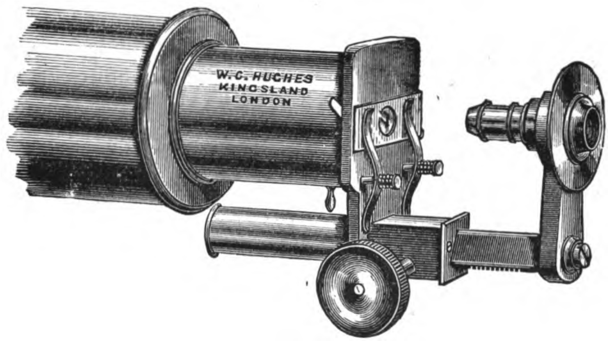


Fig. 60.

A Microscopic Attachment for adapting to the ordinary lantern in place of the front lens; it may be used with oil light, and with the Pamphengos yields very fine results compared with the old form of micro attachments, with the large objects and objectives with this attachment ordinary compound microscopic objects may be used. It is fitted with a substage or secondary condenser for bringing the light down to the required spot, and should be adjustable to suit the various objectives and with a suitable amplifier the object is considerably enlarged. With the oil light the probosis of a blow-fly may be brought up some 3ft. in diameter and amplified up to 5ft., and when limelight is used with an ½in. objective and amplifier the spiral formation of a blow-fly's tongue and sheep tick, 6ft. long, can be shown exceedingly sharp and well defined, sections of wood, spiders, flies, scorpions, and each hair on a flea, or other small insect is brought out with great distinctness. Pond life is easily demonstrated, volvox globator, showing young inside, and hydra, 6ft. to 7ft. long.

When adjusting the jet, greater care must be used than when centreing for lantern work, the slightest movement either way making all the difference with the microscope. The rack and bar motion must be constructed in such a manner that there is not the slightest movement or back lash; the motion generally supplied to lenses is not sufficient for this purpose, not being true or steady enough.

The diaphragm or stop for reducing the size of the aperture is either a plate revolving on a centre with holes of varying sizes, or an iris diaphragm.

The Objective. The object glasses of the compound microscope may be used for this attachment, but these will not be found generally to give such fine definition as those corrected for projection work, the formula too is somewhat different.

Alum Trough is placed in the slide stage of the lantern, and when not used for this purpose, may be utilized for holding beetles, small insects, and chemical experiments, if for the latter purpose, the cells should be of rubber; a trough is now made of two pieces of glass with a strip of rubber between, and is held firmly by a woodwork frame, this trough allows of it being cleaned much better than any other form.

ELECTRIC LIGHT LANTERNS.

A current being available, electric light may then be introduced, as the illuminant in the lantern. Electric lanterns have already been used in colleges and institutes, but till laterly with little success. The original electric lanterns, were constructed with a view to spectrum work, thus confining their work to a very limited area. The Duboscq lantern was the first used in this country, and others have been constructed on the same principle, with this form of lantern the old fashioned arc lamps were used with perpendicular carbons, this form is only suited for a fixed position in a lecture theatre, and for anything more than its original purpose, is practically of little use, as a clear disc is rarely obtained, the Duboscq pattern lantern underwent some modification in this country, but until a perfectly steady lamp was constructed with the arc remaining in a perfectly central position it was out of all possibility to substitute the arc lamp for oxy-hydrogen light, and even now its use is confined principally to microscopic work, when it will magnify with distinctness 500 diameters. A lantern of this description is shown in the illustration. The body is necessarily large on account of the heat and needs to be constructed of very dry wood, and very firmly secured with brass angle pieces. The first combination lantern for college and theatre work constructed in this country was the triplet combination consisting of a combined microscope and polariscope, a demonstrating lantern for experiments and spectrum work, and an ordinary projecting lantern, these three optical systems are attached to a rotary body of hexagon shape, the lamp remains stationary whilst each successive lantern is brought into play, revolving on bearings which give it great steadiness, and not disturbing any pre-arranged experiment on the lanterns being not in use. When the arc lamp is not required the lime light may be made to take its place, and for ordinary purposes this is sufficient except in the case of high power microscopical work. When this form of lantern was first shown at South Kensington, by the late Mr. W. Lant Carpenter, it met with the unanimous approval of the authorities, as being the most approved instrument for science work, and was fitted with the Brockie Pell lamp at Mr. Carpenter's suggestion.

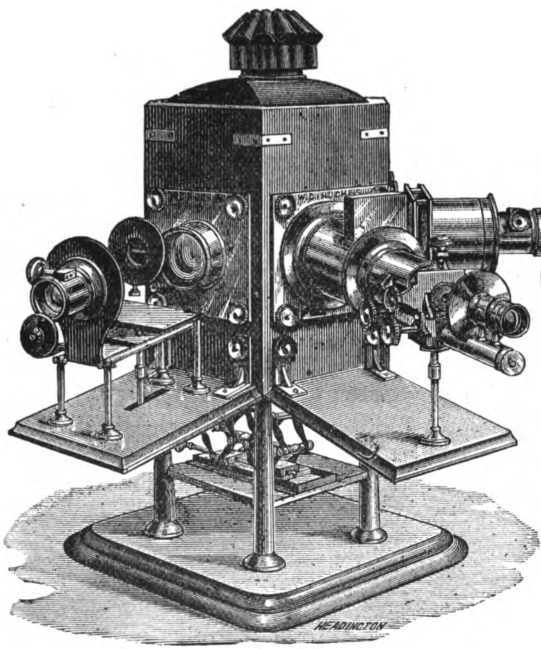


Fig. 60.

ARC LAMP FOR PROJECTION PURPOSES.

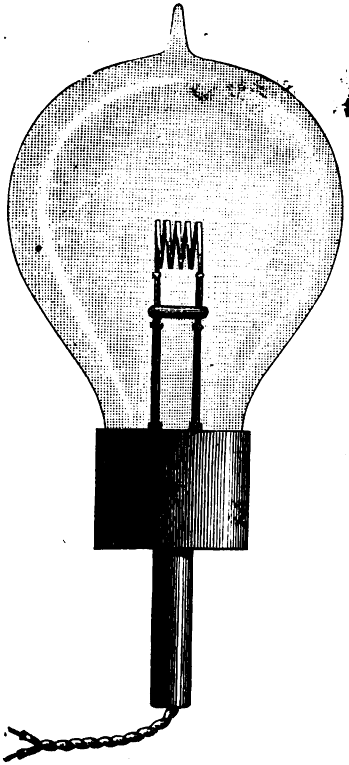
The old Duboscq lamp needs no description, being incapable of giving a really steady light, and being more fitted for battery use with 40 or more Grove or Bunsen cells, it will work fairly well for ordinary lantern purposes.

For dynamo currents as used at the present time there are several lamps made, and known as "projectors" and are comparatively small in size, certainly the best is the Brockie Pell, costing fifteen guineas, it is a focus keeping lamp, with the carbons at an angle of 40° it is very simply constructed and made adjustable from 7 to 15, or 10 to 20 ampéres of current, this must be stated at the time of ordering, a little experience is needed on the part of the assistant to become familiar with it for optical projection, as it is not the usual Brockie Pell lamp.

Stand.—Means must be provided for focussing and adjusting the arc on the condenser and for microscopic work this is required to the greatest nicety, the most minute movement is sufficient to throw the illuminant out of the plane of light.

For bringing about the three necessary movements a mechanical stand is constructed in a most solid and substantial manner, no back lash or loose parts being permitted as the least unsteadiness on the part of the lamp is fatal for microscopic purposes. The bottom pinion gives a quadrant movement for centreing the lamp in a horizontal position, on the central rod is cut a coarse thread which on being turned raises or lowers the rectangular levers, giving the perpendicular movement, and the top pinion moves the lamp to and fro to the condenser, each and every motion is thus fitted to the lamp and enables the centreing of the arc to be brought about in the most perfect and easy manner, which is not obtainable under any other condition.

When will electric light be used in the lantern for general use?—This is a frequent question, and no very easy one to answer, when electricity takes the place of house gas, and a current is available, in as simple a form as gas now is. An arc or incandescent lamp, cannot be attached to a current and switched on as we connect rubber tubing to the gas burner. The lamp must be made to suit the current, or the current to suit the lamp, and this is not done without expense and adjustment, and often with a great loss of power. But in the case of the lantern being a fixture it is not a very difficult arrangement; even then the results are not comparable with a high grade mixed gas jet. The exhibition at the Crystal Palace recently, fully bore this out, and a great deal of faith was necessary to bring the mind to believe that the light was so many times more powerful than the best chamber jet. For anything but microscopic demonstrations the light is very trying and uncertain, a flat and clear disc as with lime light, is not to be depended upon, and in some of our institutes where an electric lantern is fixed it is quite an infliction when the lamp blinks, to expect carbon to burn without this defect is well nigh an impossibility. In this respect the Incandescent lamp has the advantage, only the light is less powerful.



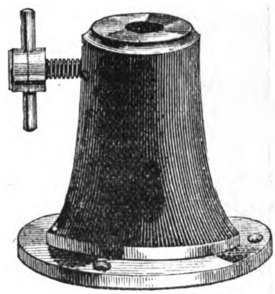


Fig. 62.

Fig. 61.

LAMP and STAND.

Focus lamps are now made for lantern purposes and designed to overcome the difficulty experienced hitherto in glow lamps. Fig. 61 is particularly suited for low voltage of 50 C.P. 80 to 105 volts, price 10/- which does not include the mount or stand (Fig. 62) which rests on the bottom of the lime tray in the ordinary manner, the lamp can be adjusted to any height by means of the screw clamp. The lamp is illustrated half actual size.

In establishments, and on board a ship, where the lantern is used the current being available, these incandescent focus lamps are very convenient; it is needless to say that the oxy-hydrogen jet will give considerably more light than these lamps.

For small discs the "Focus incandescent lamp" fig. 63, shown actual size, is very useful, as a disc of 8 to 12 feet can be obtained with the 100 candle power pattern. The great advantage of this for home use and

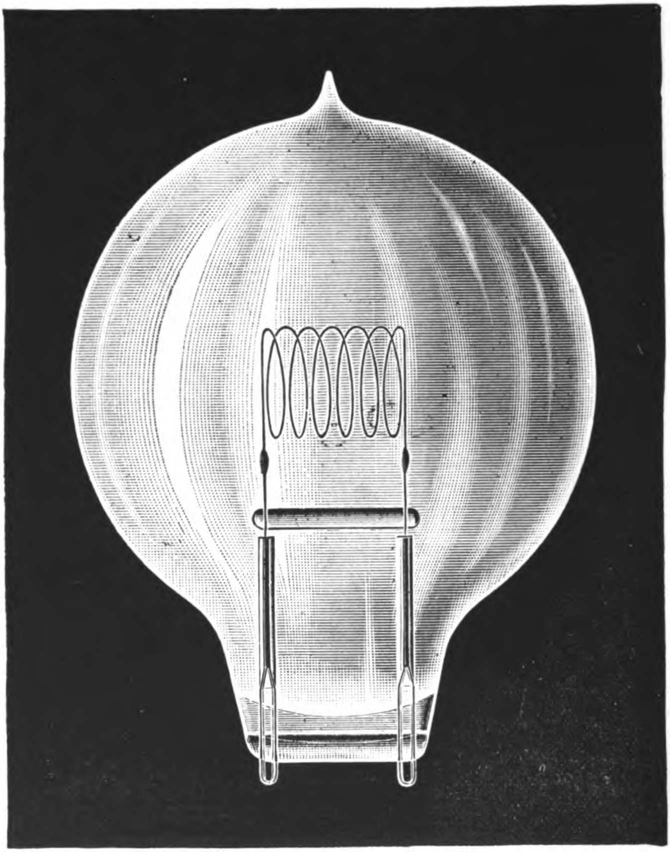


Fig. 63.

experimental work, is that once in position and adjusted for the centre of optical system of lantern, it is only a question of making the connection with the electric supply, or switching on the current, to get the apparatus ready for use, and project pictures, &c., on the screen.

THE APHENGESCOPE OR OPAQUE LANTERN.

An instrument for exhibiting opaque objects and photographs, the size photograph that it will take up or cover depends entirely upon the lens, diameter, and focus, the general arrangements are shown in the illustration; the capabilities of this instrument are seriously over estimated. A single aphengescope, even with limelight is nothing more than a toy, and even with a double limelight is very little better. Some years ago an opaque lantern was constructed by Messrs. Chadburn, of Liverpool, in which the condensers and jets were all made together in the one instrument, enabling a disc of four feet to be shown from a cabinet picture, but even then very indistinct.

Mr. Hughes constructed a mammoth aphengescope for Prince Town College, New York, with which it was possible to show a human head some 12-ft. in diameter, this had eight chamber jets, and four condensing lenses to concentrate the light on to the object, and was necessarily a costly affair, when it is considered that there is a loss of eighty per cent. of the light by reflection, it must indeed be very feeble by the time it reaches the screen.

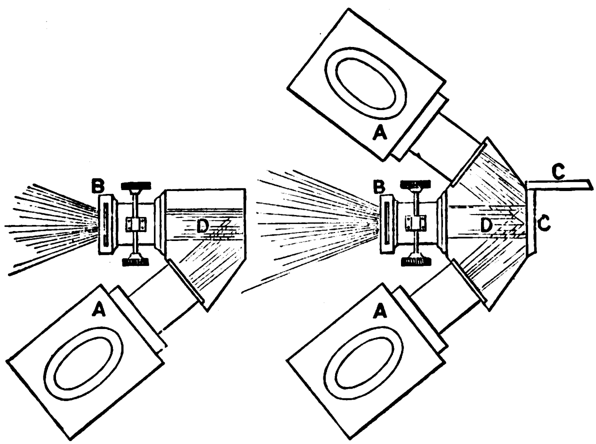


Fig. 64.

Directions.—The front lens of the ordinary lantern is taken off and screwed on to the aphengescope, the front tube with flange is then withdrawn, and the inner front tube of lantern directed into the collar of the opaque lantern, at such an angle that the light is directed on to the object, two limelights being much better than one, any attempt with an oil light must end in a complete failure, for anything above an experiment, there is no comparison between transmitted light and reflected light. It is almost needless to say, that all objects are inverted on the screen, and this effect, say of the dial of a watch when viewed for the first time is very curious. *C C* are the doors on which the photograph is fixed, being double they allow of one picture being adjusted while the other is being projected.

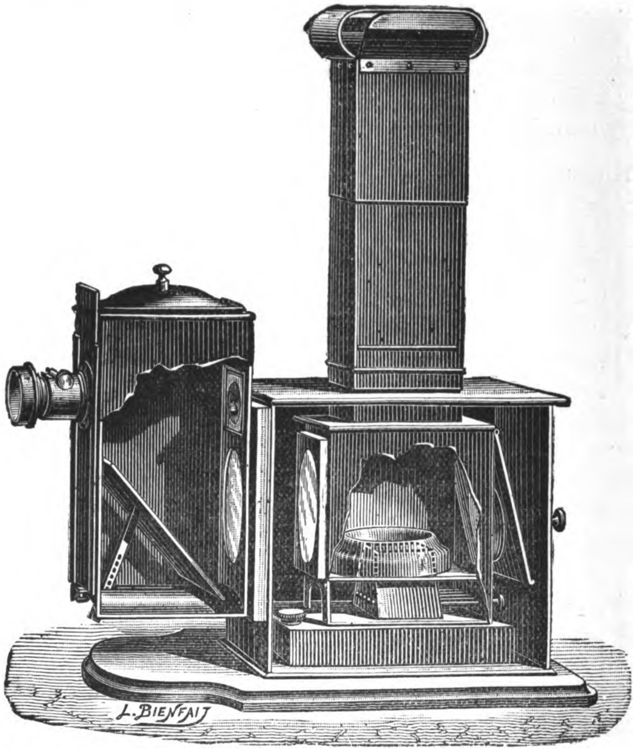


Fig. 65.

LANTERN FOR SHOWING TRANSPARENT AND OPAQUE OBJECTS.

This lantern is of French origin and fitted with a 5 wick lamp 1½ wide. The illustration shows the mirror placed in position for reflecting the rays on the opaque object, such as a carte-de-visite, watch or any small illustration, from thence the image is taken up by the lens and transmitted to the screen. Of course there is a great loss of light when compared to the direct rays from a slide. When slides are to be used in the usual manner, the mirror is laid flat at the bottom of the attached box or aphengescope, the lens is also unscrewed from the position at the top and screwed in its flange level with the condenser.

The loss of light is not so great with this form of lantern as with the ordinary aphengescope, although this form of lantern was at one time brought very prominent, it failed to be much used.

ENLARGING WITH THE OPTICAL LANTERN.

The most important argument in favour of enlarging by artificial light is that it is more reliable than day-light, the results are uniform, with a little experience in judging of the density of the negative.

Apparatus.—An instrument specially constructed for enlarging has to be procured, the cost of a complete outfit for a quarter plate is not very large, to take the whole of a negative in, this size, a 5½ inch condenser is necessary, if an ordinary lantern with 4-inch condensers is already to hand, it may be made to do good service with the exception that the corners of the negative will not be taken in, in numerous cases this is of small moment especially with portraits where the central portion of the negative alone is required. If the cost is the obstacle, the purchase of a condenser the required size, and camera lens utilized, will go a long way towards completing the apparatus. First ascertain the focus of the condenser which we presume is 6 inches; this means that the illuminant will be placed about this distance from it, allowing 9 or 10 inches beyond for the lamp or jet, making the body about 16 inches in all, the extemporising of the body we leave to the reader; it may be either of tin or wood, or a wired skeleton covered with a black material or asbestos cloth, with an opening at the back for the egress of the illuminant. This plan is not advised, but mentioned to show that an enlarging apparatus is to be made with little cost, there are many details, such as registering the light in the correct position on the condenser, solidity of the negative holder, and centreing of the lens so that it will take up the whole of the rays, saying nothing of the advantage of the perfect solidity to the whole structure; as the best camera facilitates the production of good negatives, so is the best enlarging apparatus necessary for good enlargements.

In the majority of cases storage room is an item of no little importance and when a large bulky lantern body has to be placed out of sight each time after use and set up again before commencing, it is necessarily of some consideration. We show in the illustration a form of lantern termed "The Bijou" which is certainly the smallest and most compact form of apparatus that is made, especially on account of the condensers being the exact size of the negative, which is not the case with the enlarging lantern where circular condensers are used, this really being the cause of the unavoidable bulkiness.

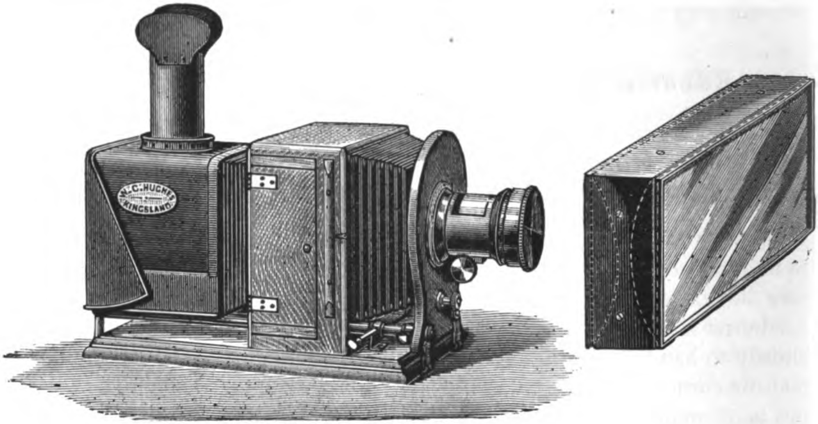


Fig. 66.

Condensers.—These collect the rays from the illuminant, afterwards convert them into a system of convergent rays, the more concentrated the illuminant the greater the evenness of the disc. The focus of the condenser should not be too long, a long focus condenser necessitates a long body, and a loss of light is also the result, or if too short, an equally illuminated field is not obtained, especially if a very long focus lens is used, as the size of the condenser increases, so the focus is proportionately lengthened.

For a quarter plate negative 5½ inch condenser is necessary, half plate 8 inches, whole plate 10½ inches, 8 by 10 13½ inches.

It is suggested in manuals on the subject, that when a large condenser is used that a third lens should be introduced between the illuminant and condenser, making it really a triplet condenser, in practice nothing is gained by this.

To overcome the difficulty of the size of the condenser and the bulkiness of the body, the rectangular condensers were constructed; by this means the light is more equally dispersed, not mentioning the gain in illumination that usnally escapes over top, bottom and sides of the negative, when using a circular condenser there is generally a falling away at the corners, unless a very large condenser is used and the centre alone utilized; owing to the great trouble of casting and grinding of the glass for these rectangular condensers, they cannot be produced quite so cheap as circular pattern, but the little extra cost is made up for in the result.

The illuminant.—For this particular purpose the light must be of intense whiteness. The most perfect illuminant being lime light. A blow through jet being superior to a mixed gas jet for this purpose, for the reason that it does not require the attention, for dense negatives it is "just the thing" and the exposure is very rapid. The only drawback is that it is expensive compared to other modes of illumination and that it is necessary to keep the lime turned, or it will fracture the condenser and if the door has to be opened often it is inconvenient as it floods the room with light. For flatness of field and evenness of disc it has no equal. A concentrated point of light like this or an electric arc lamp produce a picture of sharper definition than a dispersed flame; where a current is available an incandescent lamp described on page 130 is most convenient.

An oil lamp with triple or quadruple wicks constructed on the right principle may be used and does not require the attention necessary with lime-light besides being considerably cheaper, three wicks require less attention than four, besides being more central.

The reflector should be so inclined towards the light that it does not cast a shadow, this is the real objection to the use of most oil lamps, they cast a shadow or else a bright streak down the centre of the disc which is fatal to all enlargements, this of course is not the case with every lamp. It is sometimes advised to place a diaphragm between the lamp and condenser to cut off the marginal ray of light with the object of giving sharper definition, this has no effect whatever and only reduces the light. An argand lamp may be used as the source of light, but is very poor. The Welsbach and other forms of gas lamps are well suited, as the light is particularly central, especially the new form of mantle lamp, in which benzoline (being highly charged with carbon,) and atmospheric air form a very brilliant illuminant when burnt on the perforated mantle, the air is pumped into a reservoir by means of a foot bellows, this being the only drawback to its use.

If a common flat wick parafin lamp is used the flame must be placed edge ways to the condenser and not flat, the difference caused by so placing the flame is surprising. The lamp must be perfectly central and moved to and from the condenser until the field is perfectly evenly illuminated, this is best done with the plain disc alone, when using a large condenser the illuminant needs to be a considerable distance off, often 12 to 20 inches.

The Lens.—This should be of the very best quality only; an inferior lens is of little service. A portrait lens that will cover the plate well from corner to corner is without a doubt the best combination, passing more light than any other; it is somewhat surprising to find that any amount of stopping down, with a good lens has little or no effect on sharpening the picture, an open aperture gives as good a result as a lens stopped, if properly corrected.

Rectilinear lenses give a very sharp definition, only that the loss of light on passing through such a small aperture is very great, quite 75 per cent. is cut off. For registering the light and focussing, a specially sharp negative should be kept. The further the lens is racked out the closer the illuminant to the condenser and *vice versa.*

A wide angle lens is unsuitable, it produces an unequal illumination.

A cap of ruby glass fitting over the lens is a great convenience, allowing the picture to be centred on the bromide paper to a nicety, if the lens has a slot in front or as it is called by the optician a diaphragm mount, the non-actinic glass may be slipped into this. An ordinary cap with the bottom knocked out to allow a piece of orange or ruby glass to be bound on by the leather is the best form.

Exposure.—The length of time required varies considerably and no fixed rule can be given, a thin negative with a good oil illuminant requiring from one to two minutes, while a dense negative may require from 20 to 30 minutes exposure, the colour and density being the governors, a dense negative with a poor illuminant will not give the same result, as when a more brilliant light is used, no matter how long the exposure; at the same time, if a very thin negative is used a less brilliant illuminant yields the best results. Perfect negatives alone should be used, every defect being multiplied and enlarged. Supposing the negative to be dense in one portion and very thin in the other, this may be made quite as effective as an equally dense negative by shading the thin portion with a piece of cardboard, holding it some distance away from the paper taking care it does not cast a hard line which is avoided by keeping it continually moving. Extra exposure to certain portions of the picture greatly enhance the result, extreme white drapery or a white-washed cottage require more exposure than the distant objects. After giving the normal exposure, cap the lens, cut a hole about the size of the object that requires the extra exposure out of a sheet of paper or card and allow the light to pass through this, thus shading all except the extreme white object, keep the card moving and away from the enlarging paper.

A variety of subjects may be treated in this manner shading the weaker and giving extra exposure to the extreme whites and dark portions of the negatives, thin skies, distance and figures are all improved, clouds may be printed in from another negative, by shading the already exposed landscape, in this case a slight outline must be traced and the shading paper cut accordingly, a little of the clouds run into the landscape is not perceptable when the enlargement is developed.

Under Exposure gives extreme black and white adding a snow like appearance, all the intermediate tones being lost. A very dense negative when used with a bad light will sometimes give the same effect.

Over Exposure is preferable to the former, as in all photographic work, it may be somewhat modified in development. A thin negative should not have a strong light behind or the print will lack contrast, the same as an over exposed picture, the light may always be reduced by placing a card-board stop between the illuminant and condenser or in the front lens.

Testing the Exposure.—To start, cut three strips of bromide paper from the margin of a sheet, or keep a sheet to cut up for this purpose, in lengths of say 6-in. 4-in. and 3-in. placing them on the wall or easel by means of pins (we find ladies' long hat pins with a beaded end preferable to drawing pins) so that each receives a fair portion of the contrasts in the negative, of course this must all be done with the non-actinic cap covering the lens, then give the various exposures: to the longest strip the greatest exposure, the shortest strip the shortest exposure, for instance, the large strip 3 minutes, the medium slip 2 minutes and the smallest 1 minute, develop together and note the contrasts.

TO ENLARGE WITHOUT AN APPARATUS OR CONDENSER.

Some time since, in making some experiments with a view to enlarge from a large negative with an ordinary lantern with a 4-in. condenser, we discovered that this is to be done, but the loss of light is very great, and is not to be compared to a proper apparatus.

Fig. 67 shows how this may be arranged,—a sheet of ground glass the size of the negative to defuse the light is fixed upright, *G*, on to this a beam of light is thrown from the ordinary lantern, either oil or limelight.

It is most necessary that the lens be attached to the lantern, otherwise an image of the illuminant is thrown on the ground glass, this is taken up by the lens and transmitted to the screen. Flat to the ground glass *G*.

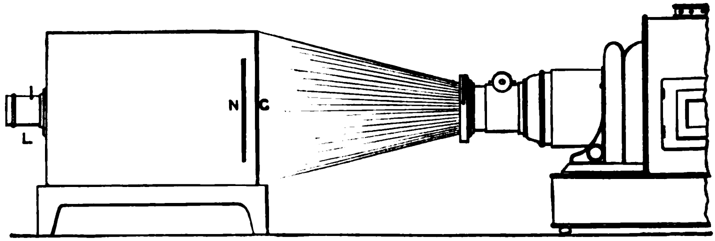


Fig. 67.

is placed the negative *N.* the image of which is caught up by the lens *L.* (which should be of wide diameter or portrait combination) and transmitted to the bromide paper. The ordinary camera with its back placed to the front of the lantern will answer the same purpose, providing the lens is of a portrait combination, the negative being placed in frame, usually holding the focussing glass, the ground glass being behind. The ingenuity of the worker can make up a rough box to hold the ground glass and lens, and if the lantern is not procurable possibly a magnesium lamp would answer as well, not having tried this we cannot say.

Development.—Formulæ are generally given with the enlarging paper, ferrous oxalate is the favourite. Eikonogen gives very good tones with most papers.

SLIDE MAKING.

To dispel the error so often nursed by amateurs, we at once state that the slides produced by the large photographic publishers are not made on any commercial plate, that they are produced on plates of a certain process, as collodion, albumen, &c., is a well known fact, but the methods and formulæ of working are kept *sub rosa*, and for an amateur to expect to produce the same results from commercial plates or plates he may have made himself is perhaps to expect too much; the constant use of a certain process in making thousands of slides, opens up many a field of discovery impossible to the average amateur. We do not imply that amateurs do not produce equal results, and in particular cases superior pictures have been produced in comparison; it is the rule to take the average, and we do the same, the art is seen in taking any negative, be it good, bad, or indifferent, and producing slides uniform in result; this is just what the professional slide maker has to do. The introduction of commercial plates has been a boon to the lanternist there is no doubt, but taken as a whole it has deteriorated the quality of a lantern exhibition, those who have stood by the wet collodion process obtain on an average far superior results than those who use the general lantern plate, take the thousands of slides produced on these plates, how many will come up to the equal of G. W. W's views, or a good albumen picture? yet, out of goodness of heart any amateur will offer to make slides for a public exhibition. We were rather struck with the remark made recently by a friend when complaining to him of the mistake in showing such poor results to a public audience. Why, they must be the best, they were made on so and so (mentioning the plate-maker's name) plates, when informed that the best results were obtained by photographers, whose methods of working are only known to themselves, he appeared quite surprised; all this is stated with good intent, not from any motive to place professional slide makers against amateurs, because as before mentioned, some of the best pictures in competition have been made by amateurs, these are artists and men who make it their sole hobby and study, and spare no expense; to the average amateur this would not apply.

A Perfect Slide should be as soft and distinct as a proof engraving, with gradations and shadows, no part opaque or shadowless, when on the screen it should stand out as a steel engraving, not black and white like so much soot and whitewash, but with gradation in the shadows, which are perfectly transparent, with the white portions perfectly clear, the tone, something between a blue violet and a black.

Choose a good brand of plates, and keep to them, remembering a rolling stone gathers no moss, as a rule there is more in a plate than is generally got out of it by the average amateur, each make of plate has some principal characteristic, it may be in the developer or elsewhere, of course, slides cannot be tried or tested without a lantern at hand, it is difficult to tell at first whether the correct density or detail have been obtained without putting them through the lantern; the density must be regulated to suit the luminosity of the light—be it oil or limelight, and under no conditions aim at getting a black and white picture, so that when the slide is on the screen, it gives the idea of snow on account of the high lights being too transparent. Nothing is more monotonous than to have a series of slides pass through a lantern with every one black and white, as the uninitiated often exclaim: it looks all winter; there should be gradations and degrees of tone, a slide should never be toned red or brown.

Slides are made by two methods:—

By Contact, that is by placing the lantern plate in contact with the negative, the films of the latter and the lantern plate touching, this all being done in a printing frame, similar to paper printing, of course, if the whole of the picture is required to be brought into the slide, the negative must be a ¼-plate, but if the negative be of a larger size, a portion only of it may be used by this method, but the whole may be taken in.

By Reducing in a Camera.—By this means, the whole or portion of a negative may be reproduced as a slide, when the whole of a large negative is reduced on to a plate $3\frac{1}{4} + 3\frac{1}{4}$, it makes a very awkward picture, being neither a circle or a square, and it is often advisable to sacrifice the sides or use only the most effective portion of the negative, thus obtaining a cushion or circular picture. Those who can give the time to making of lantern slides by reduction, obtain many advantages over those produced by contact, the former can only be done effectually with day-light.

Gelatine Bromide Plates.—Whatever are the qualities, advantages, and disadvantages, it is pretty certain that this is the process mostly used by others than those who make a business of slide making; it is by no means easy to secure a thoroughly clear gelatine film with this class of plates, the pictures taking unsightly colours under various circumstances—as a brick red to a dirty green, but the facility of production compensates for the lack of quality.

Each brand will be found to have its especial particularities, and yield different results under various developers—some more than others—yielding warm tones, others a greenish grey; in some, the development is required to be pushed much beyond the limit as it were, the image should commence to make its appearance some 20 to 30 seconds from the application of the developer, the same length of time will require to bring the slide up to its proper density, when the details should be visible, at this point development seems to be at a stand still, thus, if the slide has had the correct exposure, it may well be reckoned to turn out a good one. If on the contrary the picture seems to lag, and when it does appear, high lights and shadows follow each other in rapid succession, it is pretty certain to be foggy and stained. Some plates when they have reached the culminating point in development, have still to be forced until the detail is gone, when this is fixed in the soda it will be found all right.

If warm or redish tones are required, it is easily obtained by a pyro developer and ammonia, shorten the exposure and lengthen the development, immerse in the fixing bath into which has been placed a few drops of ammonia. It is as well at all times to immerse the plate after fixing in a bath of saturated solution of alum and citric acid, it hardens and clears the film of the yellow stains, well wash the plates in plenty of running water, and before putting aside to dry, rub the film side under running water with a piece of cotton wool.

The methods of development are numerous, and the formula generally recommended by the maker of the plates is most to be relied upon, that is our experience, with most brands of plates, for clear highlights with black tones in the shadows the following hydroquinone developer has been found to answer admirably with all plates :—

No. 1.	Hydroquinone - - - - -	160 grains.
,,	Bromide Potassium - - - -	30 ,,
,,	Sulphite Soda - - - - -	2 oz. avdps.
,,	Water to - - - - - -	20 oz.
No. 2.	Soda Hydrate - - - - -	100 grains.
,,	Water to - - - - - -	20 oz.

For use take equal parts of each.

A long exposure and a weak developer (one used several times) reduces the sooty and whitewash appearance in a slide made from a hard negative.

DEVELOPERS.

Both with quinol, hydroquinone, and eikonogen, we have a latitude for a variety of tones, with a normal exposure a black or grey tone is obtained, with under exposure and prolonged development, warmer qualities are obtained; we cannot say we are admirers of this tone. Greater scope is given in this direction by using a pyro developer.

Amidol is put up in cartridge shape tubes ready for use, it is very clean and convenient; like eikonogen, we have found it lacking the contrasts of other developers, a plate may be started with this, then wash and finish with hydroquinone.

Quinol, with a carbonate, will give good grey and black tones, but not purple or brown; it acts very similar to ferrous oxalate, but is far superior in many respects.

Eikonogen will render greyish tones, and when used in cartridges with the alkali already prepared is very handy, but does not commend itself as others in our hands.

Pyro and Ammonia or Soda with a prolonged exposure give the warmest tones, and for admirers of this colour in a lantern slide is *par excellence.*

DEVELOPMENT.

For BLACK TONES any of the following formulæ are suitable :—

Pyro-Ammonia.

Solution 1.		*Solution* 2.	
Pyrogallic acid - -	1 oz.	Liquor Ammonia, ·880 -	1 oz.
Sodium sulphite - -	1½ „	Ammonium bromide -	1 „
Citric acid - - -	¼ „	Distilled water to - -	10 „
Distilled water to - -	10 „		

For use, take 45 minims of each solution and make up with water to 2 oz.

Ferrous Oxalate Developer.

Solution 1.		*Solution* 2.	
Neutral oxalate of Potash	16 oz.	Proto-sulphate of iron -	4 oz.
Citric acid - - -	60 grs.	Citric acid - - -	15 grs.
Hot water - - -	50 oz.	Hot water - - -	8 oz.

Solution 3.

Bromide of potassium - - - - - -	¼ oz.
Water - - - - - - - -	10 „

For development, take 6 oz. of No. 1, and add 1 oz. of No. 2, and 24 drops of No. 3. Gives cold-black tones.

Eikonogen Developer.

Solution 1.		*Solution* 2.	
Eikonogen - - -	½ oz.	Potassium carbonate -	1 oz.
Sodium sulphite - -	1½ „	Distilled water to - -	10 „
Potassium bromide -	8 grs.		
Distilled water to - -	30 oz.		

Take 3 parts of No. 1 to 1 part of No. 2 solution.

Rodinal Developer.

Rodinal concentrated solution - - - -	1 part.
Water - - - - - - - -	30 parts.

This is a very clean developer, and gives a rich black colour.

Hydrokinone.

Solution 1.			*Solution* 2.	
Hydrokinone - -	½ oz.		Caustic soda - - -	½ oz.
Sulphurous acid - -	¼ "		Sodium sulphite - -	2½ "
Potassium bromide -	60 grs.		Water to - -	20 "
Water to - - -	20 oz.			

For use, take ½ oz. of each to 1 oz. of water.

WARM TONES.

Developer.

Solution 1.			*Solution* 2.	
Hydroquinone - -	½ oz.		Caustic soda - - -	½ oz.
Sulphurous acid - -	¼ "		Sodium sulphite - -	2½ "
Potassium bromide - -	60 grs.		Water to - - -	20 "
Water to - - -	20 oz.			

Solution 3.

Bromide of ammonium - - - - -	1 oz.
Carbonate of ammonium - - - - -	1 "
Water to - - - - - - - -	20 "

Brown.

Exposure.—Short, say 50 seconds, 1 foot from gas-flame. Developer, solution 1, ½ oz.; solution 2, ½ oz.; solution 3, 100 minims; water to 2 oz.

Purple Brown.

Exposure.—Half as long again as above, 1 foot from gas-flame, or 3 inches of magnesium wire burnt at a distance of 3 feet. Developer, solution 1, ½ oz.; solution 2, ½ oz.; solution 3, 200 minims; water to 2 oz. Taking longer to develop.

Purple.

Exposure.—Three times the above, or 3 minutes 1 foot from gas-flame. Developer, solution 1, ½ oz; solution 2, ½ oz.; solution 3, 250 minims; water to 2 oz. Time required in development, about 12 minutes.

Red.

Exposure.—Above, 5 minutes 1 foot from gas-flame. Developer, solution 1, ½ oz.; solution 2, ½ oz.; solution 3, 300 minims; water to 2 oz. Time of development, about 15 minutes.

CHLORIDE PLATES.

Exposure.—From experience, we have no hesitation in recommending rapid chloride plate with the developer here given. In the hands of those who have little time to give to the various working of the different plates, they prove very satisfactory; any required density is obtained by the length of the exposure and development, if sufficiently rapid, about 20 to 30 times as quick as ordinary chloride, the exposure may be made with an ordinary lamp in a dark room, or a gas burner is better still, they can be developed very comfortably, as plenty of yellow light may be used without the slightest fear of fogging, after development they should be rinsed and put in the fixing bath. When fixed, which is generally very quickly, put them into the clearing bath; when finished, after a good washing, the high lights and white parts will be almost clear glass.

For contact printing the exposure required with ordinary negatives, using a fishtail burner (burning about 5-ft. per hour) at 1 ft. distance, is about 30 seconds.

For Camera work, with average negatives, pointing to the sky, and using $\frac{f}{24}$ stop, the exposure required would vary from 2 to 5 minutes.

Development.—The following developer gives very fine results with these plates.

Hydrokinone Developer.

Hydrokinone - -	150 grains.	Carbonate of Soda -	2 ounces.
Sulphite of Soda -	1 ounce.	Carbonate of Potash -	2 „
Bromide Potash -	20 grains.	Water to - - -	20 „
Water to - - -	20 ounces.		

To develop, take equal parts of each. The developer can be used several times in succession.

The plate may also be developed with the

Ferrous-Oxalate Developer.

Solution 1.		*Solution* 2.	
Oxalate of Potass, neut,	13 ounces.	Sulphate of iron - -	5 ounces.
Distilled water -	50 „	Distilled water - -	15 „
		Sulphuric Acid - -	15 drops.

For use, pour one part of No. 2 into four parts of No. 1. Do not pour the oxalate into the iron solution, as a precipitate of ferrous-oxalate will be formed.

Add 1 drop of solution of Bromide of Potassium (80 grains to 1 oz. of water) for dark tones, increasing the exposure and amount of bromide for warmer tones.

Fixing.—After developing, wash well, and immerse in a clean fixing bath:—

Hyposulphite of Soda	3 ounces.
Water	16 "

The plates will be fixed very quickly, and should be left in till a minute or two after they seem quite fixed.

Clearing.—The transparencies after fixing and washing may be immersed for 2 or 3 minutes in an acid solution. This is very necessary with plates developed with ferrous-oxalate.

Saturated solution of alum	10 ounces.
Hydrochloric acid	½ ounce.

This will considerably improve the clearness.

It is advisable to give the full exposure according to which developer you use. For making transparencies for the re-production of negatives, chloride plates are particularly suitable, owing to the absence of grain, as the chloride of silver is so finely divided in the film.

Special care must be taken that no trace of hyposulphite soda comes in contact with the plates before or after exposure, as it is certain to cause stains. Separate dishes must be used for each operation, and should be kept alone for the purpose.

COLOURED SLIDES.

Slide painting is an art entirely by itself and is not to be acquired by a few weeks' practice, or even years'. A true artist to paint to nature truly and perfectly is born. The high class artist, on glass is as high in his profession as a brother academician is in his, but unfortunately because it is a lantern slide he paints, instead of a canvas, it is not appreciated by the generality of people to the same extent, and sad to say the financial remuneration is not what it should be by a long way, in consequence of the miserable substitutes for paintings that are put on glass and sold as coloured slides. Cheap coloured photographs are done by girls, who are miserably paid, and who have no idea of real art and harmony of colours. The manner in which these girls are brought into the way of earning their livelihood is a study for a labour commission, sweating is not a word strong enough to describe the system under which cheap slides are painted—we should have said daubed. Three colours will often constitute a coloured slide, blue sky, green trees and a brown foreground, and these sell complete including the photograph from 1/- to 1/6 each.

To colour and make up a slide, as it should be, will sometimes take an artist a day, others of course only a few hours, where a photograph is weak, or wanting detail, the artist will strengthen it up in painting, and in the case of figures, they will be so painted up as to stand out in relief, and rotundity, strengthening the shadows, and often merely using the photograph as a basis whereon to work up his picture.

Figure subjects require very special working up, to give them a life-like appearance, otherwise they appear flat, the more indistinct a photograph the harder it is to colour and greater the skill required to make it effective. A great deal is said pro and con, about hand paintings, our opinion is that an entirely hand painted slide for some subjects is most essential, in fact has no equal, in the case of effects, especially when transparency is taken into consideration. Landscapes and views should have a photographic basis, as detail to the same extent cannot be obtained by an entire hand painting, and again the cost is considerably lessened by this course, a good photograph well painted, is a picture and a pleasure, but a photograph daubed is an eyesore and cannot be appreciated.

The day for glaring red, blue and yellow is fast waning, art tints and soft neutrals are steadily advancing in favour and appreciation by those with an artistic mind, and we hope that the time will come when the cheap and nasty will not be tolerated at any price.

THE ART OF SLIDE PAINTING.

We do not wish to damp the ardour of those who have a taste and possibly the ability for tinting photographs, some amateur pictures are fairly passable but never come up to the standard of those done by professional hands, singular though this may appear it is nevertheless true, (that genial and graphic contributor to the *English Mechanic*, alone excepted) he was an artist only as a hobby, and under the *nom de plume* 'Sable' was ever ready to give aspirants the benefit of his experience. The amateur commencing will have his patience often called into requisition and sorely tried, but constant practice on old photographs is required, and if not liked when finished, wash off, and go over the whole again; no half measures or royal roads are attached to slide painting. Have ready to hand the following:—A bottle of pure mastic varnish, a little oil of almonds, some good turpentine and a little crystal varnish, some red sable brushes assorted 0 to 6, some pieces of clean rag free from lint, half flat camel hair brush for dusting; keep a small gallipot near you containing turpentine, in which cleanse the brushes frequently or they become stiff and gummy, not working with the ease they should, have a slab of glass and a white pallete or two. The student will foresee that it is intended to use oil colours, as without doubt oil colours have a great advantage in many directions over water colours, especially when the colour is laid on a film, when it expands with the heat of the lantern the water tints crack, which is not the case with oil; water is wholly unadapted to glass painting by the amateur. Brush dabbers or softeners for dabbing on the sky are also false friends. The best and cleanest dabber is the finger (the little finger is the handiest), the nail should be kept short, and then either the broad part or the extreme tip will be available, as occasion may require, to prevent the grain of the finger showing on the sky, keep it very smooth by rubbing down with pumice.

Colours.—The following transparent colours may be had in tubes in a concentrated form, one tube being sufficient for a hundred slides or more:—Ivory black, Prussian blue, burnt umber, burnt sienna (orange), vandyke brown, crimson lake, Italian pink, scarlet, and purple, the latter with yellows and carmine are difficult tints to make transparent. The reds, rose madder, and madder lake are not good drying colours, but with a medium of crystal varnish and a little oil of almonds, they may be made workable, mixed colours and neutrals are made by mixing two or more colours, the latter mostly by the addition of a third.

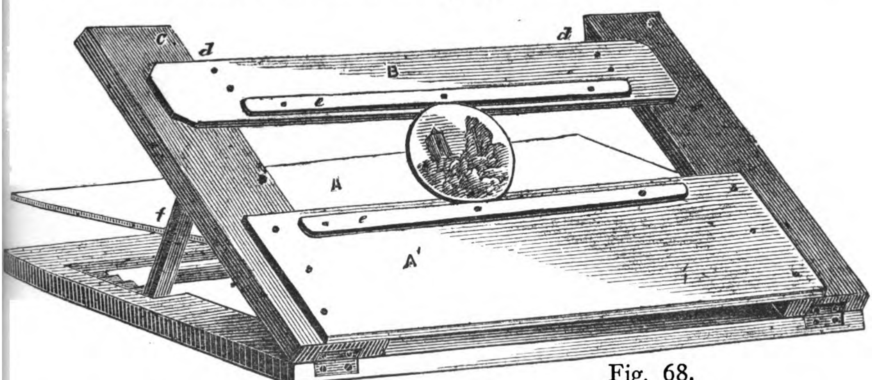


Fig. 68.

Easel.—The painting desk shown in the illustration is as good a form as any in use, it can be made by the student if he is of a mechanical turn of mind, or may be purchased complete, it has the advantage of holding several slides at one time, and when painting a set, in which the same colours have to be identical throughout, it is necessary to have the preceeding pictures on the desk for reference; a circular slide can also be held in any position by pressing down the sliding bar *B*. *A* is a fixture and forms a firm support for the hand when at work. *A* is a flat piece of board as thin as possible with stays at the back to prevent warping. It is attached to the under side of the foot-board by two hinges of leather, and is covered with white paper forming a backing which enables the artist to see the faintest tint he lays on his picture. Always get a good light (not sun light) on this reflecting surface.

Colouring of views is a comparatively easy study when compared to figure painting, and is easier and quickly acquired. The medium for mixing with the colours is three parts mastic varnish, one part turpentine, and where the colour is of a bad drying nature add a very little oil of

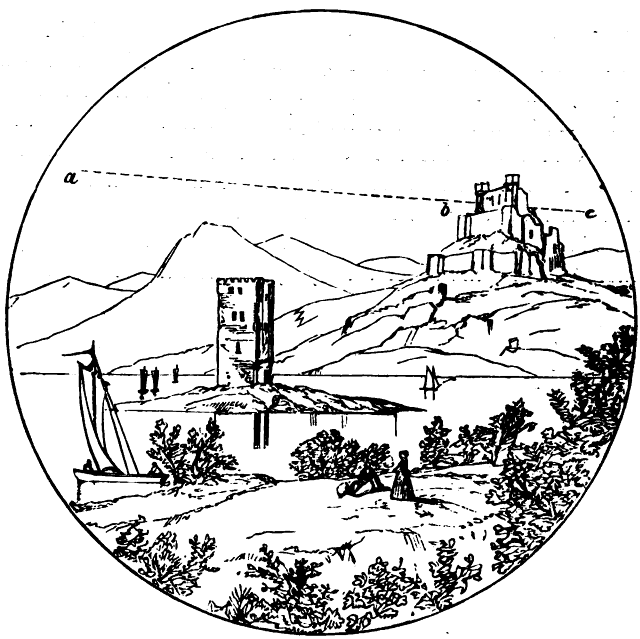


Fig. 69.

almonds and crystal varnish, this is the best drying varnish; in some cases where it is necessary for the colour to remain unset add a little boiled oil to the medium. Perfect freedom from dust, and perfect stillness in the painting room is of the greatest importance. Particles of dust not observable to the artist's eye show upon the screen very coarse, this will be found one of the greatest trials, to keep the grit and dust out of the colours.

For view-painting a magnifying glass is often necessary. Fig. 69 is the "scant" outline of a view, the tower on the Rhine, called Máusethurm, better known as "Bishop Hatto's Tower."

Insure the absence of all particles of dust by the use of your soft brush, and carefully wipe your palette. This is a sky of two tints: mix a little crimson and a little burnt sienna to produce a salmon-coloured pink, dip your brush in the medium and work up your mixed tint thoroughly, and having determined the shade on a piece of trial glass, lay the colour as evenly as possible, commencing at (a); carry your brush obliquely to the point (b); get a broad point and work downwards, going carefully round the outline: when this is completed fill up the portion on the right of the castle, and finish as before: work the tint as dry as you can, it must *not run* on the glass; do not lower the tone too much,—remember "dabbing" will somewhat impoverish it. Now press the point of the brush moderately broad and "stroke" the tint all round the outline of the castle and mountains, drawing the brush at short angles towards the zenith: to do this you will have to turn the view half round; which the easel will readily permit you to do: take care to secure the picture by pressing down the bar. When you have made all as even as possible with the brush, leave the work for a few minutes. As the state of atmosphere and temperature influence these operations experience only can teach the precise time. Commence dabbing with the colour on the finger at the upper part of the tint; as the finger approaches the outline, a very *light* and *rapid* touch must be given, and the finger must be dabbed on a *clean* part of the palette to cleanse it when working round an outline. Should any parts appear weak, press the finger in the colour on the palette, and dab gently until uniformity is obtained. When any part of an object in the foreground or middle distance shoots up into a blue sky, the brush must do its utmost, as dabbing takes the colour more or less on the objects; however, the colour can be removed with the paper stump. White clouds are often introduced near such objects as around the spire of a church to lessen the difficulty. Having rendered your pink tint perfectly soft and even, clean your palette; place on it a little Prussian blue (when a sky of great depth is required, use this colour *pure* and dab it on with the finger). In thinning the colour use the medium; commence at the zenith and let the tone be moderately deep; in going downwards the colour must be gradually paler, but it must not be fluid enough to run, do not carry it *quite* into the pink tint. Be careful in going round the outline of the castle; repeat the stroking, and always let the brush do *all it can* near objects where dabbing must do mischief by taking the blue into an improper spot—much skill and practice are required before the finger can be freely and adroitly used in small places. Commence dabbing at the zenith, working gradually downwards, but not *quite* into the pink: press very gently during the operation, and cultivate a slight rolling motion of the finger. Having reduced the blue to perfect evenness, growing gradually lighter as it approaches the pink (this may be accomplished by dabbing the finger occasionally on a clean part of the palette), next melt the two tints into each other blending them softly together; while doing this clean the tip of the finger frequently to avoid vitiating the colour. It is a crucial bit of painting, but once get the knack and the chief difficulty is vanquished. One ocular demonstration would do more than many written directions; but the latter can do all that is necessary; your sky is now finished. It is advisable to practice laying and dabbing skies on plain glass.

The tops of the mountain to the left must now be laid in a warm salmon colour (crimson and sienna) shading gradually into a darker neutral blue (for this add yellow lake and blue in the requisite proportions)—in colouring the mountains, lay your tints as in the sky, but you may stroke them *into each other:* dab but sparingly and lightly here.

NOTE.—The tops of these mountains are of a darker hue than the pink of the sky; they must not be ragged, but well defined without being *hard.*

Now proceed to the ruin on the hill, colour this a warm brown (crimson and burnt umber); this tint must not be laid too heavily, the same shade may be carried over the right hand part of the little mound on which the building immediately stands. The walls and the stones on the hill may be coloured with the mixture; if a *dash* of Prussian blue is added to it it will make it more suitable for masonry, and it may be used for the mounds about the ship on the *right* hand, and carried up over that part of the hill in shade on the *right* of the view: the little piece of distant mountain immediately under (c) must be tinted a soft purple blue. In colouring those parts where the sails of the boats encroach, the brush should be carried right *over them.* Next colour the hill, and the part of the little mound beneath the castle a light brownish green; (a very little blue, yellow lake in excess, and sufficient burnt sienna to impart warmth without causing the colour to look dull); as you go into the shade on the right a little more blue will be needed to darken the tone. You must *not* dab here; stroking is all that is needed; you do not want to obtain a perfectly *flat* surface like a sky.

We now come to the water, which is found tiresome painting in every branch of the art. Mix with the blue a little crimson and yellow lake, to give it depth and take off its rawness: having determined the strength (not intense), commence to colour, drawing the brush horizontally from right to left, getting the shade lighter just over the bank where the two figures are: it will not signify covering the boats with the colour, it can be removed after. All necessary stroking must be performed with a moderately broad point *in a horizontal direction*, and on no account must the *finger* touch the water; be careful not to smear the tower. When you have finished the water, take out the colour which has been carried over the sail of the boat on the *left* hand with some paper rolled up to a point; also remove any colour which may have been smeared on the tower. The tower itself, and the bank on which it stands may be coloured a warm brown (burnt umber, crimson, and sienna, or sienna or Italian pink); be careful to keep to the outline, that you do not smear the mountains at the back: the shady parts of the building and that of the bank to the right, should be touched with a darker colour, the addition of a very little blue will make the same tint available for this purpose. The end of the bank on which the tower stands at the extreme left should be touched with a bright yellow green.

Those portions of the foreground in the light, should be painted in with a brownish green in which yellow must predominate, and for the bushes and trees, a tint composed of yellow and burnt sienna in the lights (the former to predominate), and in the shades add more blue and sienna; shade also the foreground with a darker green (not too violent), or blue in which also there must not be too much brown. Stroke all these surfaces carefully but not to an absolute *flatness*. If possible do not paint over the figures; if any colour has been carried on them it should be removed; a crimson cloak and white dress will answer well for the standing figure, and a blue dress and white bodice for the one seated. Remember *light* is supposed to come from the left side of the view. Dry your work in the oven.

Shading. Use the same tints, making them darker by varying the quantities of their constituents, being careful to preserve a warmth of tone. Use a brown-black for the hulls of the boats; shade the sail of that nearest the shore with a light tint of umber and yellow; add some blue to this, and touch with it the shady part of the trees in the foreground—it should be a dark brown yellowish green; also shade the light parts of this foliage with a yellow-brown, and draw irregularly light streaks of this over the lights in the foreground bank. In shading the water, a darker tint of blue must be used, with which shade the water at the foot of the distant shore, and also at the foot of the bank in the middle of the river: draw also light horizontal strokes of the same at intervals on the water. When you have completed this stage to your satisfaction, dry your work and proceed to the—

Finishing.—This either makes or mars a picture. An eminent master said to one of his pupils, "He is the cleverest at finishing who knows *when* to let his picture alone."

In this stage, all the near objects in the foreground must be well brought out and the shading strengthened. This will cause the distance to *recede.* By judicious handling of the Bishop's tower and the bank, the objects on the other side of the river may be thrown back some distance. The windows of this tower should now be well defined, with a mixture of umber and black (only a little of the latter); the addition of crimson to this will make it available for shading the extreme end of the tower bank to the right, and for bringing out the prominent parts of the tower which are in shade. With Vandyke brown give the reflection of the building in the water, as shown in the wood cut.

NOTE.—The colour of the water is usually that of the sky; and reflected objects of a similar tint to the objects themselves.

When your work is dry for the third time, you can put in a mark or a deep shade here and there as judgment directs, if it be needful. The etching point, or needle point placed in a cedar stick and a small penknife, are often useful. With the former, you may now mark the high lights in the water by drawing horizontal lines; it will be well to notice how the high lights are disposed of in good coloured engravings: form a minute ripple at right hand point of the bank in the water, as if it were running against it; a thread of white may be drawn round the bulwarks of the boat nearest the foreground, and the sails of the distant ones scraped out with the knife; also, a little touch should be given to water immediately beneath these boats to give the white reflection of the sails. The magnifying glass will be found useful in finishing the minute details of the views. When it has received the final touch, clean a blank glass of the same dimensions, and fix a minute bit of black card-board at the extreme edges, at equal distances from each other, this will prevent the front glass injuring the painting; when dry, place the black mat or mask between. A strip of black paper gummed round the outer edge hold the glasses together, thus securing the picture from injury.

Addenda.—In the distance, dark objects appear lighter; and light objects darker.

Keep the middle distance free from violent colours; they give the appearance of nearness.

Distant objects may be generally covered with the tint in laying a sky; also the parts of trees in the foreground which could not be "left" without trouble and inconvenience. When the tint is dry it will be necessary to touch up the latter with appropriate yellow and brown greens.

Hills, houses and trees in the distance are not injured by carrying a sky tint over them; because when painted after in the proper colours the under tint gives them a bluish hue so characteristic of the atmospheric distance.

Broad lights, clouds, &c., are best taken out while the view is wet; for this purpose, a paper stump is very convenient. In those portions of cloud where softness is required, the finger must be used as a dabber. The edges of clouds must sometimes be left hard. If dark decided clouds are to be represented, the sky tint must be well dried before these are painted in.

MECHANICAL SLIDES.

For amusement and teaching purposes this class of slide most readily draws attention, in fact any slide in which something is done, will create more impression than any ordinary slide, no matter how beautiful; and the amount of skill displayed in the construction of some of the mechanical slides is most surprising.

Moving Wave Movements, or eccentric motions, consist of two glasses moving in an elliptic, and a third glass stationary, sometimes a panorama is made to cross whilst the wave motion is continuous and even a fourth glass is added (which revolves), on which is painted the paddle of the steamer, of course it is impossible with a depth of four glasses to focus them all sharply. It is usual to focus the central or most prominent feature of the slide. This is the only objection to mechanical slides with three or four thicknesses of glass; then there is the

Double Rackwork Slide, with a third glass as a set or cover glass; on these are painted beehives, aquariums, chromatropes, and fireworks. Then comes a class of mechanical slides that are not dependent upon movable glasses for their action, and these overcome the trouble of focussing.

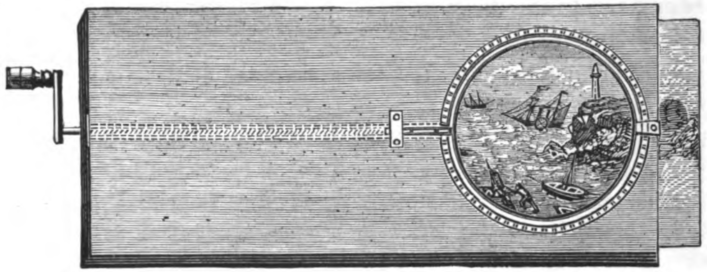


Fig. 71.

Newton's Disc.—This well-known experiment when made as a slide for the lantern is very instructive, the revolving glass is painted in sections with the principal colours of the spectrum in their due proportions, as a rule in four sets, upon being rapidly revolved, the disc appears white, or as near white as possible, of course, a great deal depends upon the manner in which the disc is painted for this effect, if the proper portions and density of colour is not obtained, the illusion is far from satisfactory. If we cover up portions of the disc with **V** shape strips of black paper we get colour, by experimenting we find out which is the most effective colours to suppress for the best effects.

The Wheel of Life, chameleon and chromatic top, all work, more

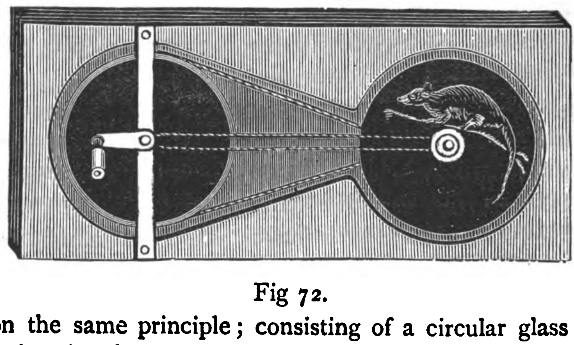


Fig 72.

or less, on the same principle; consisting of a circular glass on which the design is painted, a second disc, usually of zinc, on which a **V** shape opening is cut, and upon the two discs being revolved, by turning the

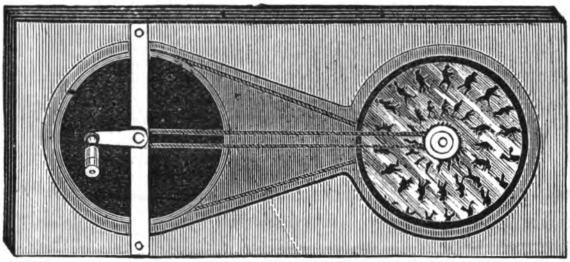


Fig 73.

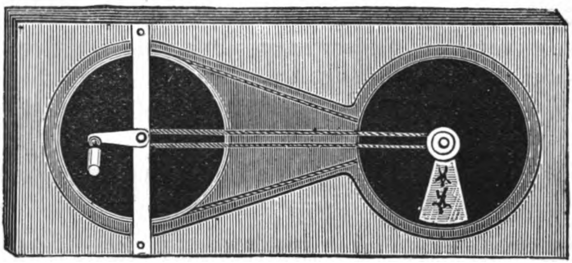


Fig 74.

handle to which they are connected by silk bands, they move with different velocities, and owe their effect to the illusion known as the persistence of vision, owing to the eye failing to perceive the rapid revolution of the opening in the metal disc, the result on the screen, so far as luminosity is concerned, does not come up to that which would be given with an ordinary photograph—as is well understood. Some years ago a slide was shown at the Royal Polytechnic that has puzzled many how it was conceived, we believe there was only three made, and the inventor was Mr. Pickler. One of these slides is in the possession of Mr. Malden, and is termed the Astrometerscope, a series of some twenty white dots are seen on the screen, which upon being set in motion twist and twirl about forming the most fantastic, and geometrical designs imaginable. Now this slide must necessarily be very costly, owing to its mechanical contrivance. In our boyhood days we were very fond of burning the end of a stick until the tip became charred into charcoal and whilst it was still red, wave and flourish the stick until the most varied and curious curves were discernible in red lines. On this principle the Astrometerscope is constructed.

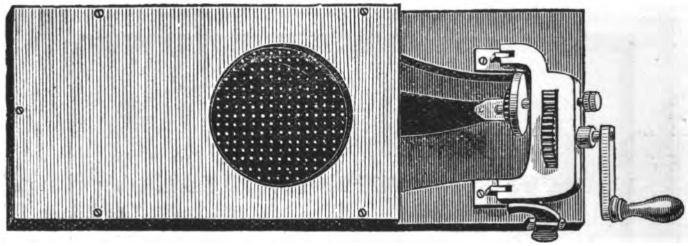


Fig 75

Fig. 75 represents a similar slide, only of course on a much more modified scale, by altering the length of the stroke and the speed of the revolutions varied designs are made.

The Cycloidotrope is another very taking slide, as the designs seem to grow in front of the audience. It is an exact reproduction of what is known as engine turning, tracing designs as on the back of a watch, only that the designs are traced on a smoked glass, as the needle

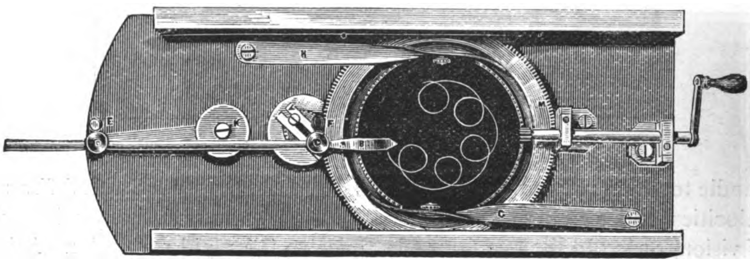


Fig 76.

point passes over the blacked glass it leaves the design in white; the number of designs is not limited to one for each slide, but several may be worked on one glass. The glasses are smoked beforehand over a burning candle, or what is better still a piece of camphor, the carbon in this is richer and blacks the glass more evenly, and in a very short time. A little practice in working the designs on the glass is necessary before using it in the lantern.

The Pandiscope, or sketcher, is a similar instrument to the pentagraph and reproduces on the screen whatever is traced by the index point. The glass is previously smoked in the same manner as for the Cycloidotrope, and the image sketched in white on a black ground. Some practice is requisite to make anything of a result on the screen. Portraits of celebrities, and comic sketches, may be rapidly drawn, as follows:—one end of the frame is occupied with a movable ground glass, the opposite end carries the smoked glasses, on the ground glass end place the design, or sketch, either in distinct black and white or outline;

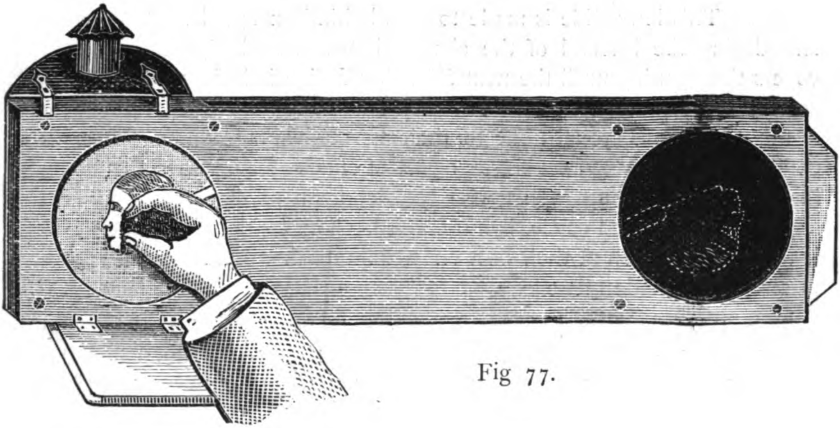


Fig 77.

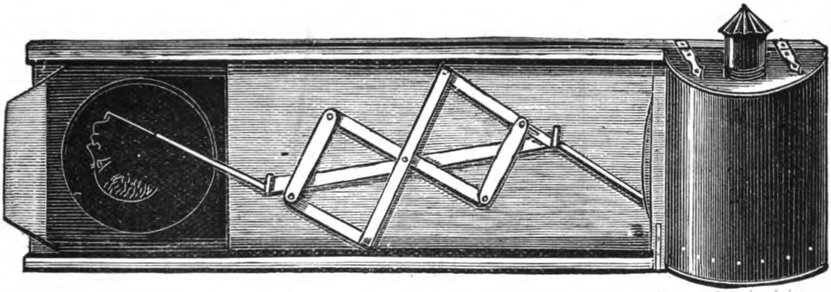


Fig 78.

to facilitate the speed and working of the design, these may be previously made on pieces of glass with hydro fluoric acid, the glass placed over the design and the design traced with the acid, the glass is then allowed to stand and the acid will eat itself into the glass, leaving a concavity or groove; a number of designs may be so prepared. When complete they are placed in the outside end of the frame and the point of the sketcher placed in the grove left by the acid, and so trace at a very fast rate, and when the design traced in white on the black ground is enlarged some twelve to sixteen feet on the screen, it quite astonishes an audience.

The Choreutoscope is another mechanical slide depending upon the failing of the eye to retain the rapid succession of changes. The idea originated from a Mr. Beale, in the days of the old Polytechnic, both mechanism and designs have been very much improved. There is some six to eight designs of figures, in various attitudes, on each slide, which is about ten inches long, but in the Giant Choreutoscope is twenty inches. This long slide is made to pass behind an opening in the frame and during the interval of the change between each figure a shutter covers the opening until the next following design is in its place, when it again opens; the interval between each change is worked *ad lib.* Some of the designs are brought out to their best advantage when shown in conjunction with some set scene, or set of effects, for instance the dancing skeleton indulging in his wild terpsichorean revel in the bedroom scene of the haunted castle, is most weird. The Harlequin and Columbine dance are seen at their best on a dark back-ground, or an appropriate harlequinade scene.

The Performing Monkeys are very interesting slides, and to the juvenile portion of an audience especially, as they tumble about into the most grotesque attitudes, as each monkey is jointed in some six places

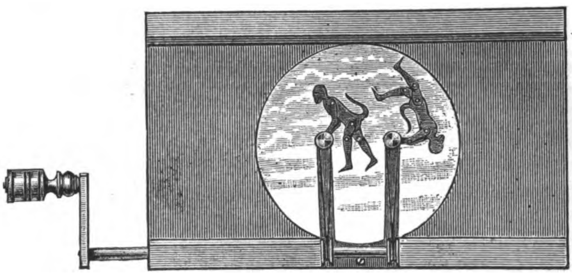


Fig 79.

of his body. A very pretty effect is made by tinting up the back-ground with different tints of colour by the aid of gelatine or coloured glass held in front of the lantern.

The Snow Storm.—The original snow effect was produced by picking out minute specks upon a length of glass painted black, drawn through the lantern upwards from the bottom, the snow represented by the light passing through the pricked out specks appears to fall. At the present time the slide consists of two rollers at top and bottom, a length of black material pricked with a hot needle is made to roll from one roller to the other, in commencing all the material is on the bottom roller and is wound off to produce the falling of snow on to the top (being inverted), care must be taken not to have the holes too large, or the snow flakes will appear very much exaggerated, it is also as well in working to have the holes slightly out of focus. This effect may be used on any slide providing it is dark enough, failing that, the light should be lowered.

The Pluviatrope or Rain Slide.—This is on a similar principle to the "Snow Storm," the set glass is blacked, streaks being cut out with a point diagonally to represent rain, over this a gauge works, giving a scintillating appearance when moving. Altogether, it is not such a successful slide as the snow.

The Chromatrope. An illusion produced by two glasses on which designs are painted, revolving in different directions. There appears at the present time a falling away from the use of this class of slides. We presume it to be a reaction to the over-usage of them a few years back, when no lantern show was thought complete without its display of Chromatropes; there is a great variety of patterns, some especially are most unique in their design, representing church windows, shamrock, ferns, &c. When a biunial or triple is used some very pretty changes are produced by working two or more chromatropes together, only the designs should harmonise somewhat: for instance, into a small pattern dark colour, dissolve a large pattern bright tinted design, not always turning the handles in the same direction, but often opposite to each other. To reflect a chromatrope on to the ceiling is done by holding a mirror at an angle in front of the lens of lantern.

ELECTRICAL EXPERIMENTS.

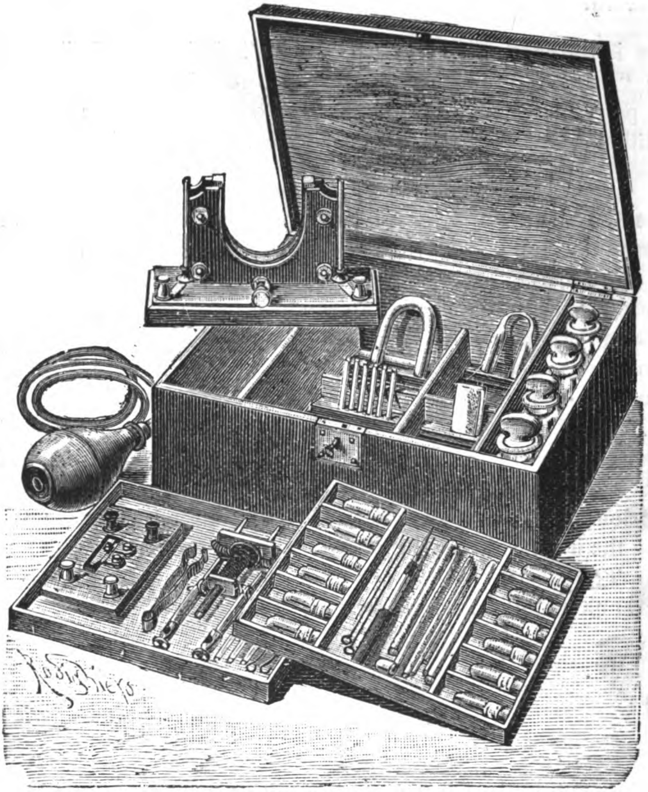


Fig. 80.

It is far more instructive, and easier to demonstrate the actual experiments than to explain by diagrams. With the aid of the lantern the phenomena themselves may be brought before the audience where the ordinary laboratorial experiments would fail on account of the smallness and delicacy of the apparatus; the great amplification that is obtainable by means of a science lantern with an open front, as the "Gilchrist" lantern, allows of every class of experiment being shown to an unlimited audience; with the aid of the chemical tank and a case of apparatus, as fig. 80, a wide range of experiments in chemistry, etc., may be demonstrated, of course, any one piece of apparatus may be made or purchased, but for the sake of compactness it has been thought best to group them together, the case is put up complete.

Trough, which consists of two glass plates with a layer of India-rubber of half-an-inch in thickness, cut U shape, and laid between the glasses, which are held firmly against the rubber by a screw-clamping arrangement in three different positions of the trough. The mounting and dismantling for cleaning are most complete and simple. When fitting up the trough, the sides of the rubber pressing against the glass should be smeared with glycerine; so as to make a perfect connection, the screws should be fastened equally moderately tight; when not in use these screws should be loosened, allowing the glass plates to expand or contract according to the temperature, otherwise they are liable to fracture.

To each side of the trough is attached a metal rod provided with pliers and connections for a bicromate battery of two or more cells.

The trough is placed on the table in front of the condenser, and the connections made with the communicator which allows the current to be reversed or broken, this being in connection with a "Grove's" battery or pile of 3 or 4 volts.

The experiments which can be made with the aid of this instrument are so numerous, that it is impossible to enumerate them all, but we give a few of each group that are very simple.

ELECTROLYSIS.

Faraday has given the name of "*electrolysation*" to the decomposition of a substance which is composed in its element, by the passage of an electric current, this phenomena can be easily demonstrated with the laboratorial trough.

Decomposition of Water. We know that water is the result of the combination of two parts of hydrogen and one of oxygen. To demonstrate this, fill the trough with water which has been made slightly sour with sulphuric acid (to increase its conducting properties), attach two perfectly straight threads of platinum to the two pliers: after having placed the first perfectly upright in the water, place the second wire upright in the same manner, upon passing the current through, a number of fine globules issue from one side (oxygen), and from the other the evolution is much more rapid and the bubbles much largér (hydrogen.)

This is a very old experiment and dates from the beginning of this century, being discovered by Carlisle and Nicholson.

Collection of Hydrogen by Palladium. In the case will be found a strip of white metal which terminates in a spiral form, and is polished on one side of its surface, this is *palladium,* a metal which Wollaston obtained from platinum, about the year 1803. This metal has the peculiar property of absorbing 376 its own volume of hydrogen. This phenomenon was discovered and studied by Graham and called by him "occulsion." Now replace one of the threads of platinum with the plate of palladium, and upon passing the current so that the negative pole is on the palladium, the platinum pole will be covered with bubbles of oxygen, no evolution taking place on the palladium pole, but this plate which absorbs the hydrogen (in proportion as it is produced) gradually swells out until having absorbed the full amount, and in its turn discharged the gas; at that moment let us reverse the poles: the platinum will disengage the hydrogen and the oxygen will rapidly make the palladium disgorge as it were, and resume its original shape.

The experiment may be repeated any number of times.

Electrolysis of Salts. Fill the trough with a solution of chloride of tin, and put into it the two copper rods which terminate at their ends in a bundle of platinum wire, placing them so that the platinum ends may be brought together, on making the current circuit, from the positive pole we see a thin liquid current flow, the negative pole being gradually covered with a rich metallic vegetation, this is because in the electrolysis of salts, the acid is drawn to the positive, and the metal to the negative pole; on reversing the current, the metallic-like vegetation will gradually be dissolved, the opposite bundle in turn being covered with the metallic scales: here we have the principle of galvanoplastry,—if we replace the salt of tin for a solution of acetate of lead, the experiment becomes more beautiful and we have what is called the "tree of Saturn."

The law of the electrolysis of salts. We have said that on the electrolysis of salts the acid goes to the + position and the oxide to the — negative pole, which we will endeavour to prove. Let us fill the trough with pure water, into which place the **U** shaped tube (which is found in the case). This tube is first filled with a solution of neutral sulphate of potash, which has been tinged blue with syrup of violets, a platinum wire is introduced into each of the tubes, and the connection made, the branch of the + positive pole assumes, by degrees, a rose colour tint, whilst the negative side becomes green, and the lower portion of the **U** tube retains it blue colour. Now, syrup of violets has the property of becoming red under the influence of acids, and of becoming green under the influence of oxides, when the current is reversed, the phenomena are reproduced inversely as nearly as possible.

It is advisable to fill the trough with water, by this means the shadows on the tubes are avoided.

Decomposition of a Salt. With tank prepared as above the U shaped tube is filled with a solution of iodide of starch, containing a small quantity of bromine, this solution is colourless, when the current is passed the positive branch assumes an orange colour, whilst the negative is blue.

These are a few of the many changes that may be brought about by *electrolysis.*

I.—CHEMICAL RE-ACTIONS.

The greater number of the usual chemical re-actions can be effected in the trough. If the coloured solutions are too dark, they should be diluted. The small glass funnel or pipètte will serve for introducing the re agents, but its end must not be plunged into the salt contained in the trough, so as to stop up the capillary tube by what is precipitated; the re agents must be put in drop by drop, or in a minute stream, then the effect is more striking. The re-agent may also be introduced by means of the spoon, which must be gently shaken in order to mix the liquids by degrees. Here are some of these re-actions as examples:—

1st. Put into the trough a solution of sulphate of peroxide of iron, add, drop by drop, a solution of ferro cyanide of potash, the result will be Prussian blue.

2nd. Fill the trough with a solution of sulphate of copper—liquid blue—add a little ferro-cyanide, the colour resulting will be reddish brown.

3rd. Fill the trough with the same solution of sulphate of copper, add some ammonia, changing to a green tint, precipitating a cloudy grey, add some more ammonia when the precipitate will dissolve and the water will assume a magnificent blue colour—sky blue.

4th. Fill the trough with sulphate of zinc, add ammonia, drop by drop, there will be a coagulated precipitate of a steel grey colour of quite a peculiar shape.

5th. Fill the trough with a very diluted solution of nitrate of silver, add a solution of sea-salt or chloride of sodium, and the precipitate will be chloride of silver, not unlike snow in appearance.

6. Fill the trough with a solution of chlorate of barium, add, little by little, diluted sulphuric acid, the precipitate will be in the form of fine granules of sulphate of baryta.

7th. Fill the trough with a solution of nitrate of lead (4 parts of water, 1 part of salt), put into it a tolerably large crystal of sal ammoniac, (bromide of ammonium), when very curious floriations of choride of lead will be formed, &c., &c.

II.—PHENOMENA OF COLOURING.

1st. *Turnsol, or Dutch Orchal.* Fill the trough with a tincture of blue turnsol, and pour in thin jets of diluted sulphuric acid ; the turnsol will change to red. Pour in ammonia, the turnsol will change to blue.

2nd. *Aniline.* The colours of aniline are completely decoloured by bases, and revived by acids. Put a solution of rosaniline into the trough, and add ammonia drop by drop, decolouration will ensue ; put in some sulphuric acid, or, better still, vinegar by degrees, and the colour will return.

III.—MIXTURE AND DIFFUSION OF LIQUIDS.

The study of the mixture of liquids discloses a series of phenomena which are very striking. Liquids mingle by *penetration* or by *diffusion* : in the one case the molecules amalgamate by degrees by being worked and agitated about, or by other causes; in the other the molecules mingle together spontaneously, but in both cases without giving rise to any chemical action.

1st. *Mixture of two liquids of different density.* Fill the trough with pure water, and the funnel with a capillary opening, with some coloured liquid—ink, for example By pressing the india-rubber ball we send a minute drop of it into the water. This drop undergoes friction in the liquid into which it penetrates, it turns into spirals which break and in turn cause other spirals to form, and the coloured fluid advances and forms ramifications in rings or convolutions, which are always the same and of the most curious effect.

We cannot here enter into the details of the experiment which, of itself, will show the observer all the advantages which can be gained from it.

2nd. If the trough is filled with alum water, and it is impregnated with a solution of alcohol of an aniline colour, an inversion of density will take place and new forms will be produced, the lighter penetrating into the heavier liquid ; in this the end of the funnel must be placed at the bottom of the trough.

3rd. The experiment can be varied by placing a crystal of colouring matter on the surface of the pure water contained in the trough, *e.g.*, aniline violet. The solution of violet will fall in fine threads from the crystal into the water and fresh spirals will be formed.

4th. *Diffusion of liquids.* Let us fill the trough with pure water and put in it a spoonful of coloured alcohol—or merely of wine; gently put the spoon to the bottom of the trough, and we shall see the alcohol become diffused in the water by degrees.

5th. Let us put into the trough lukewarm water (from 15° to 20°) and put a small piece of ice on the surface, and we shall see some curious undulations due to the mingling of two liquids of different density, and the forms and figures arising from the diffusion will be visible, owing to the difference in the density.

IV.—EXPERIMENTS IN CHEMISTRY.

1st. Put into the water trough a concentrated solution of hydrochlorate of ammonia, and then amalgamate separately a little sodium with mercury. Put a little of the mixture into a spoon and gently lower the whole into the trough. By degrees, amidst an afflux of ammoniacal gas the mixture will be seen to swell and fill the spoon, forming ammonia.

2nd. Fill the trough with water, put some chlorate of potash into the glass spoon, and, on the top of that, one or two little pieces of phosphorous; immerse the spoon with its contents below the water, introducing into the spoon by means of the small glass funnel, some pure sulphuric acid. The phosphorous will take fire in the midst of the water and shoot out brilliant sparks.

Experiments of this sort are numerous and are explained at length in lectures and treatises on chemistry.

V.—PHYSICAL PHENOMENA.

A. *Effects due to capillarity (capillary attraction) in tubes.* Put into the trough the series of tubes of different diameters, which are contained in the case Put at the bottom of the trough some coloured liquid, by means of the india-rubber ball, but stop when the liquid is at a depth of two or three millimetres. The smaller the tubes are in diameter, the higher the liquid will rise in them. Withdraw the water gently by means of the india-rubber ball and each tube will retain a column of liquid the height of which will be in an inverse ratio to its diameter.

B. *Capillarity (capillary attraction) in the inclined plates.* Let us repeat the experiment with the glass plates placed angle ways; the height to which the liquid will rise in them will be so much the greater in proportion as the plates approach each other more, and a clearly characterised parabolic curve will form.

It must be noticed that to make sure of success in these two experiments, the glasses must be washed in alcohol and water in order to remove every trace of grease which would prevent the effect from being produced with perfect clearness.

(C.) *Attraction and repulsion due to capillarity* (*capillary attraction*).

When two floating bodies are both moistened by the liquid which surrounds them, or if neither is moistened by that liquid, a strong attraction between them takes place: if one is moistened and the other not, there is repulsion. If we place two balls of cork or of wax on the surface of the water with which the trough is half filled, we shall observe the phenomena of attraction, if one of the balls is brought near to the other by degrees. If, on the other hand, we put one ball of cork and one of wax on the water, there is repulsion.

(D.) *Equilibrium of liquids.* Put the **U**-shaped tube into the trough full of water and pour some coloured liquid into it, and it will then be shown that the level in the two branches is on the same horizontal plane as the angle at which the tube may be inclined.

2nd. Put the **U**-shaped tube with arms of unequal length in the vessel and pour into it first a few drops of mercury and then a strong solution of sea-salt: the liquids will equalise each other in the two arms in the inverse ratio to their density.

3rd. Put into the trough full of water a tube closed at one end, into which first mercury, then pure water, and then olive oil have been passed,—the liquids will be superposed according to their respective density, then stir them about with an agitator in order to show that the former equilibrium can be restored gradually.

(E.) *Pressure of liquids.* Put on the water in the trough a small disc cut out in a card, press on it with a tube open at both ends; the tube will remain closed by the card which is held against it by the pressure of the surrounding liquid: admit gradually water into the tube, when the disc will fall to the bottom of the vessel, and the respective levels will be restored.

VI.—VARIOUS EXPERIMENTS.

It is not possible here to give a complete list of all the experiments for which the water trough is suited. In the foregoing methodical explanation we have indicated its principal applications to chemistry and physics. We mention a few more experiments, as follows :—

A. *Magnetic Spectrum.* If we put glycerine in the trough, and if we strew iron filings on the surface of the liquid, the particles or scales of the metal will slowly descend into the centre. Let us introduce into the trough the ends of an electro magnet, and send the current through it immediately the descent of the filings ceases, and by degrees they place themselves so as to assume that special appearance to which the name of *spectrum magneticum* has been given. The successive interruptions and assumptions of the current cause the dissolution and the re-constitution of the spectrum.

B. *Formation of cells.* It is known that the cells of vegetable tissue have a hexagonal form, and their process of formation which depends on the contact of the cells with each other (their first shape being spherical), is thus demonstrated.

Make a solution of some common soap in very pure water (1 part of soap to 40 of water), filter it and double its volume with glycerine. Put a thin layer of that liquid in the trough, and produce soap bubbles by blowing through a glass tube with a taper end. The external cells will have a rounded form, the interior cells a hexagonal shape. As the light becomes decomposed whilst travelling these minute liquid layers, the cells become coloured with all the hues and shades of the prism.

C. *Carbonic acid in the breath.* The vessel being full of a well filtered solution of lime water, on introducing a glass tube and breathing through it, we shall notice that the water gradually gets turbid. and by this formation of carbonate of lime, the presence of carbonic acid in the breath is proved.

D. *Formation of frost.* Dissolve sulphate of soda in warm beer in as large quantities as possible, pour the warm liquid on to one of the glasses of the trough with the *pipette*, spreading it out as much as possible ; in a few moments a series of foliage-like figures will have formed, which may well be compared with those which the frost produces on window panes.

In this short notice we simply wish to point out the resources of the laboratory trough. It may be seen how well it is adapted for a variety of experiments. A few grains of salt, a few drops of a re agent, suffice to produce considerable effects which are clearly perceived by a numerous audience. We have no doubt that it will prove a fruitful source of instruction which will be readily appreciated.

VII.—THE SINGLE TROUGH.

The laboratory trough necessitates the employment of the "scientific lantern." In order to be able to repeat in ordinary lanterns, the greater number of the experiments which have been described above, another model of a trough has been devised, comprising plates of glass, fitted in a wooden mount and separated by a piece of India-rubber. The apparatus is of the ordinary dimensions of a lantern slide frame, and can, consequently, be easily placed in the stage of a lantern. Although less handy and more difficult to clean than the former, this trough will, nevertheless, be able to render real service. It is most frequently used as an alum water bath, in order to stop the warm rays when the projection microscope is used; by its use the rapid destruction of micro organisms by the heat of the focus is avoided.

Again, this trough is often employed for special recreative experiments; it is filled with pure water, and in it are put either bits of cotton or light pieces of blown glass. By means of a funnel with a thin elongated tube and surmounted by a ball of india-rubber, filled with water, the swell is produced which agitates and seems to animate the little figures of glass or cotton. Lastly aquatic insects can be put into this water, such as the dytiscus, water fleas, beetles, &c.

LIGHT BOXES.

For illuminating tableaux vivants and stage work :—A plano convex or bull's-eye lens is mounted in a box which is lined with iron, and has an open or very wide top; the box is so arranged that it will tilt up and down on two screws acting on pivots, which is convenient for following a figure or illuminating any particular spot. The size of the lens governs the size of the disc to be illuminated, those of our large theatres being from 6 to 8 inches.

If the light box is to be placed a distance away or up in the "flies" of a theatre, a short focus lens is used; if very close to the object to be illuminated, or in front of the stage, a lens of long focus is required.

To illuminate a large area, the jet is pushed close to the lens; the illumination of a single figure, is effected by drawing the jet out from the lens. The colours or tints are brought about by coloured glasses, or gelatine being placed in front of the lens. The amount of light from a single light box is very misleading: with a good jet one box may be made to give as much light as is obtained from two boxes in some of the theatres; it is sometimes thought that one light box will give the same illumination as seen in some of our large theatres. In Drury Lane theatre, in some of the spectacular scenes, there are forty boxes going at one time. A tableau cannot be lighted too much, and care must be taken when the lights are at the side to illuminate the front of the figures as much as possible, otherwise there will be heavy shadows. It is important that all other stage lights be lowered, if the full effect of the limelight is to be obtained.

In tinting or colouring a tableau by the aid of coloured glasses or gelatine, light tints only should be used, as a great deal of light is obstructed by this means. When more than one colour is thrown on a single figure, care should be taken that the colours do not obliterate each other and produce white, as is often the case, *i.e.*, a red and blue of the correct tints when superimposed produce *white* light, according to a well known law in optics.

GHOST ILLUSION.

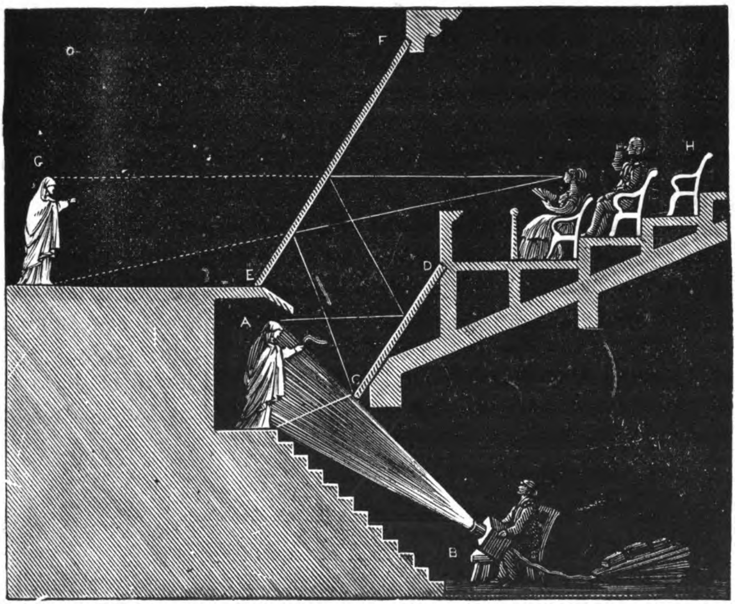


Fig. 70.

No lantern manual would be considered complete without a description of the Ghost Illusion, although it is a too expensive arrangement to demonstrate as an experiment. The recent revival of the illusion at the Christian Institute in Regent-street, which was formerly the Royal Polytechnic, and by the original producers has caused fresh interest to the present generation ; and herewith is a description of the art of ghost producing up to date. The principle of reflection by which this illusion is brought about is very simple, and is seen any time in the window of a railway carriage whilst looking through the window, the interior of the carriage is also reflected on the glass ; or again, at twilight, the interior of room and fire are reflected on the windows, at the same time as the scene outside also is visible to the eye, thus producing a curious illusion, and on this theory the ghost is produced. The real actors are seen through a large sheet of plate-glass, and from the front surface of this glass is reflected a phantom, which is apparently taking part in the scene among the real actors. The illustration shows this arrangement : *E. G.* is the stage separated from the auditorium *H*, by a very large sheet of transparent glass, *E. F.*, placed at an angle, not visible to the audience, the lights being kept low, and the stage itself is comparatively dark ; parallel to the large sheet of glass is a silvered mirror, or looking glass, *C. D.*, placed below and out of the spectators' sight, receiving the reflection of a person at *A*, also out of sight, and is strongly illuminated with a light box at *B*, one or more being used according to the illumination required : the manner of the reflections of the mirror to the plate glass, and to thence to the audience, giving them the appearance of the figure appearing at *G*, which is indicated by the lines drawn on the diagram (fig. 69).

The apparition has an ethereal and transparent appearance, which is increased by the manner in which it may be made to melt away, which is brought about by diminishing the amount of light which falls on the real person. The introduction of the silver mirror was a great improvement, as it allows the phantom figure to stand in his natural attitude, whereas the *ghost* with only the glass *E. F.* could not be made to appear upright unless the glass was placed at an angle of 45° and the actor of the ghost lay horizontally beneath.

(We are indebted to Messrs. Routledge & Son, Ludgate Hill, for the Illustration from "*Inventions of the Nineteenth Century.*")

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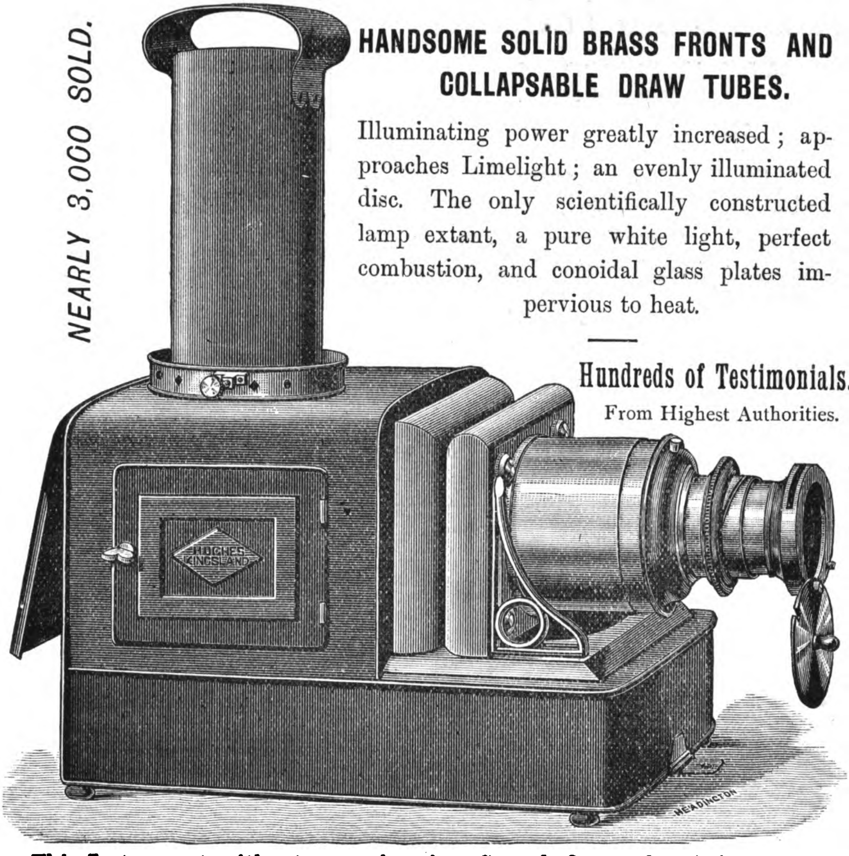

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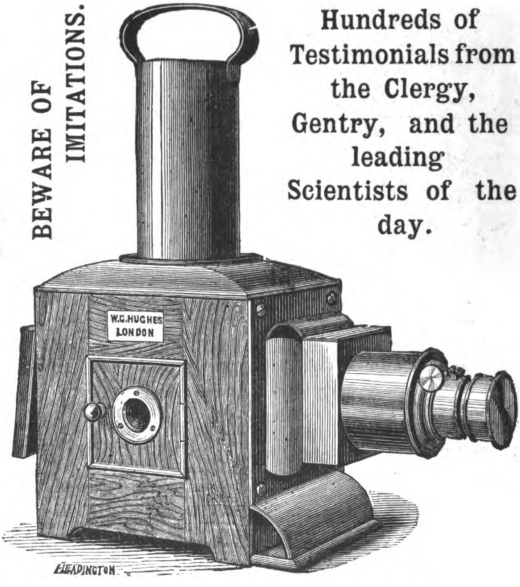

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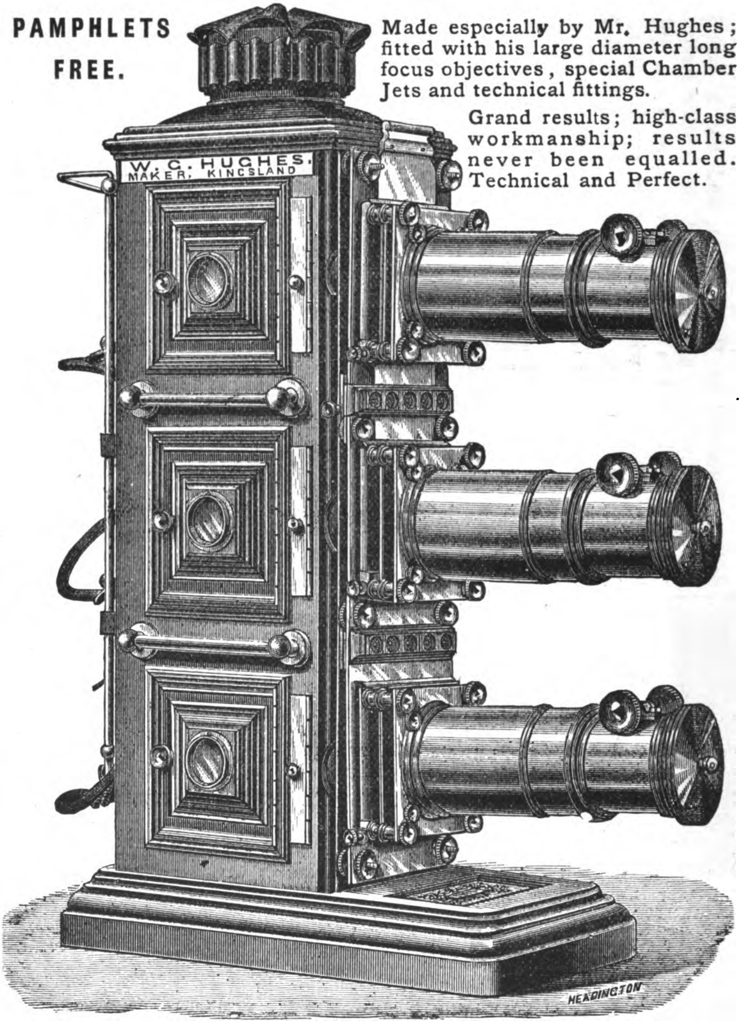

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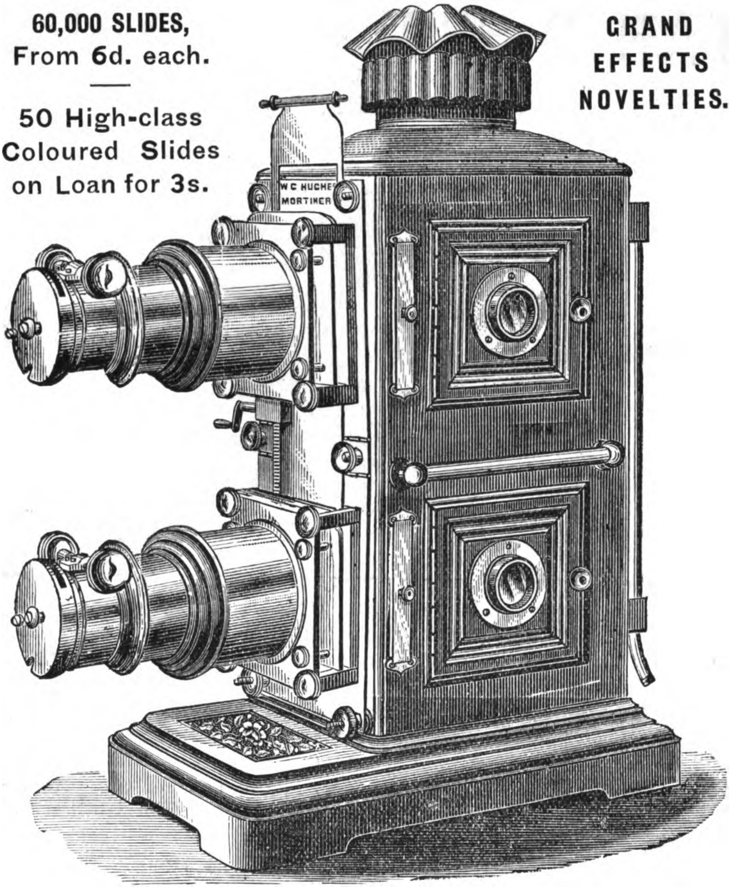

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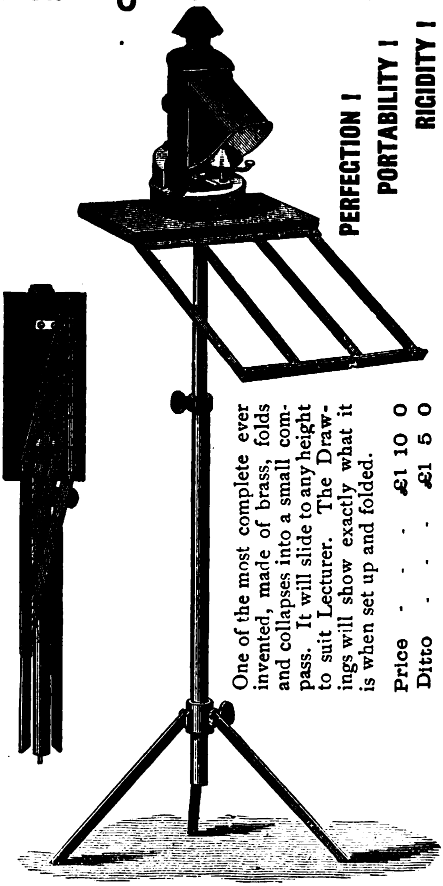

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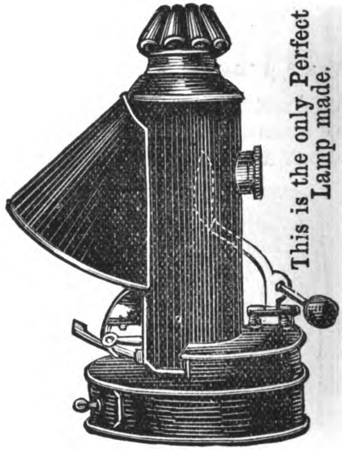

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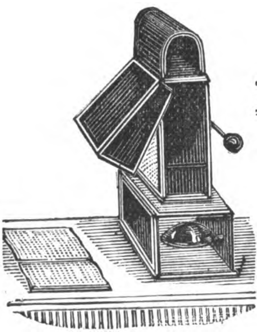

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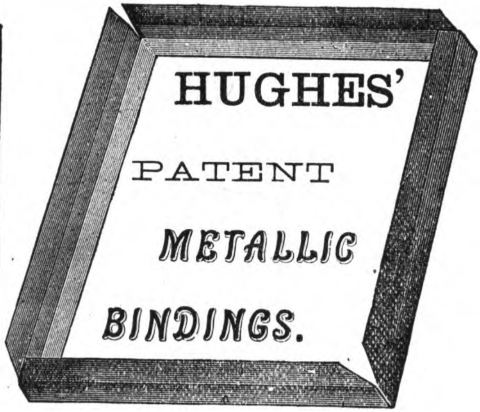

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