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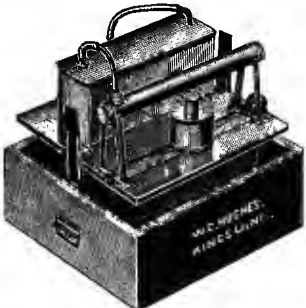

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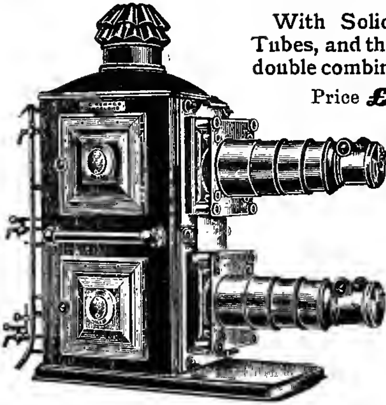

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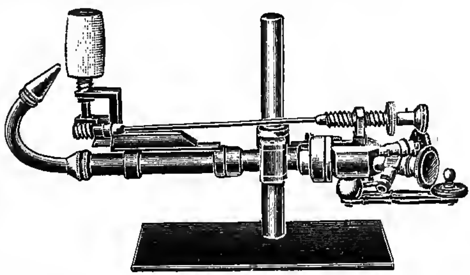

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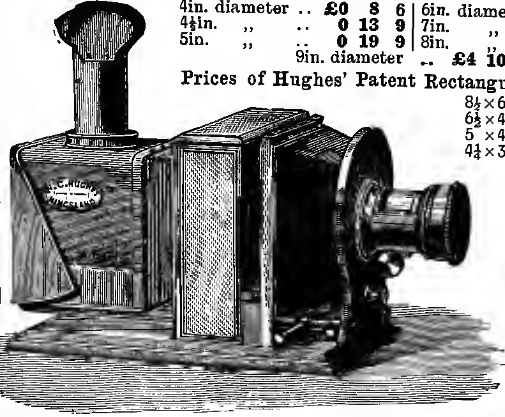

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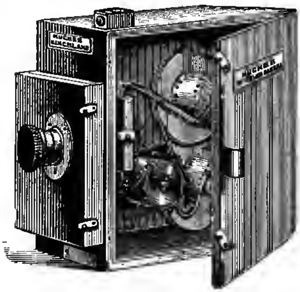

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MODERN MAGIC LANTERNS.

MODERN

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SECOND EDITION.

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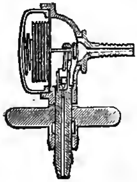

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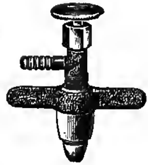

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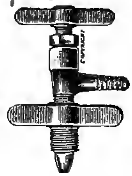

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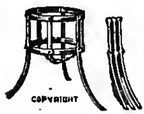

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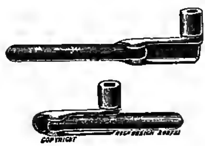

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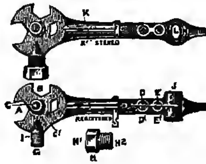

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Preface to the First Edition.

Some few months ago the writer was arranging a limelight apparatus for advertising purposes, and was anxious to get a book at a moderate price to place in the hands of the man, ignorant till then of everything connected with the lantern, who was to work it. None of the existing books fulfilled his requirements, being either too elaborate on the one hand, or on the other, while suitable in most respects, limited to the goods of some one firm of manufacturers. A similar want being felt again a few weeks afterwards, this little book was put in hand, in the hope that it might be of use to others in a similar predicament.

It has been written on the assumption that the reader at the outset knows nothing of the lantern or its technology; terms that he would not otherwise understand have therefore been explained; and the illustrations have been selected to show the principles upon which the various pieces of apparatus work, rather than the mere external appearance of any particular maker's product. It should be hardly necessary to point out that it contains nothing that is not to be most probably found elsewhere, somewhere or other, but care has been taken to point out those cases where the author is unable to speak from his own experience.

It only remains for him to express his thanks to those firms to whom he is indebted for the loan of cuts of special forms of apparatus, and to Mr. R. R. Beard, who has been kind enough to give him the aid of his great practical knowledge of the limelight.

Another Edition having been called for, the opportunity has been taken to bring the various Chapters once more right up to date.

We may mention here that the credit of the experiments upon steel cylinders, referred to on page 26, belongs to the Scotch and Irish Oxygen Co., of Glasgow.

R. C. B.

CONTENTS.

MODERN MAGIC LANTERNS.

CHAPTER I.

Introductory.

THE Optical or Magic Lantern, which has in the last few years come so very largely into use, not only for the purposes of education and amusement, but also for advertising, for photographic enlarging, and has even been

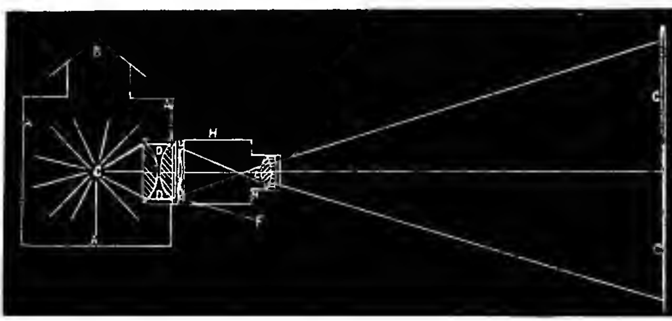

Fig. 1. MAGIC LANTERN AND SCREEN.

pressed into the services of religion at more than one London church, may be diagrammatically represented by Fig. 1. This sketch represents the lantern reduced to its simplest expression, and before proceeding to describe in detail the many modifications of and additions to the instrument which ingenuity during the past few years has effected, the names of the various parts and their functions had best be pointed out.

In Fig. 1, A represents the lantern body, generally provided with a chimney, B. Inside this is placed a light, C, in front of the light is a lens, known as a condenser, D, and in front of the condenser again, and some little distance from it, is another lens, called the objective, E. As close as possible to the condenser and between it and the objective is the slide, which is held between springs, in grooves, or in some similar manner at F. The screen upon which the pictures are thrown is shown at G. Here, then, are the essentials of a magic lantern:—

A light.
A condenser, } These are sometimes spoken of as "the
An objective, }   optical system" of a lantern.
A carrier or slide-holder.
A lantern body, which encloses the light, and which retains the various other parts in their relative positions.

The means of illumination is a point of primary importance, and it is due to the rapid strides in this particular which have been made during recent years especially, that the lantern has increased so largely in popularity. The various lights now in general use are oil lamps, the limelight, and the electric light, the illuminating power of which is in the same ratio as the above order, oil (and incandescent electric lamps under some circumstances) having the least, the electric arc lamp the most, and the modifications of the limelight occupying an intermediate place in this respect.

In buying a lantern the choice of the light is one of the first considerations. If it is intended for use for photographic enlarging and for the exhibition of slides, etc., on only a small scale, there are several forms of the oil lamp burning petroleum which can be employed with advantage in the direction of economy, both of trouble and money; especially if the user is likely to want the lantern where house gas is not available and where there are difficulties in the way of getting compressed gas. Where a considerable size of picture is required, say anything over seven or eight feet in diameter, a more powerful light than that given by a petroleum lamp becomes a necessity if a brilliant effect is wanted, and one of the forms of the limelight must be used, or the still more powerful arc lamp. What form of limelight, again, will depend to some extent on the size of disc and illumination required. The "oxy-calcium" light and the "blow-through" or "safety" jet can be used with success on discs up to twelve or fifteen feet in diameter, but for anything over this size what is known as the mixed jet should be employed. But these sizes are in all cases the author's opinion only. Some workers would be quite satisfied with less illumination than that suggested above, and would consequently use a less powerful light or a bigger disc; others, on the other hand, might wish for more illumination than he regards as sufficient. In the last few years the use of acetylene gas has come into prominence. For photographic enlarging, and for general lantern work, where small discs only are required, acetylene is very convenient. The colour of the light is such that it has a powerful effect upon sensitive papers, and the very small size of the flame renders the optical system very efficient. A *small* illuminant is important, as will be shown further on, and the compact flame of acetylene renders it far more powerful in a lantern than, say, the comparatively large, yet equally bright, light of the Welsbach incandescent gas. At the same time it is as well to mention that acetylene is little or no use for larger discs than about 8ft. It will be gathered from the foregoing remarks that the brilliancy of the picture depends upon the size at which it is shown, and that, given the same light in each case, the smaller the disc of light thrown upon the screen the more brilliant it will be.

These two factors, the light and the size of the image, are by no means, however, the only ones to be taken into consideration. The function of the condenser is to divert all the light that falls upon it, so that it passes through the slide; therefore, the more of the light that the condenser collects the more brilliant will be the image. The objective is employed to bring the light proceeding through the condenser and slide to a focus upon the screen, as will be explained hereafter; and the brightness of the picture depends also upon the proportion of the light passing through the slide which the objective, or front lens as it is often called, allows to pass. This will be best seen by reference to Fig. 2, which represents the optical system of a lantern, and the course taken by the light in its passage to the screen. The letters are the same as in Fig. 1, F being the slide. Photographers will have no difficulty in understanding that if the lens, E, is one which would be described as a "slow" one, it would not allow so great a proportion of the light to pass as a "faster" lens.

All these points have to be taken into consideration in deciding what instrument to employ for any given work.

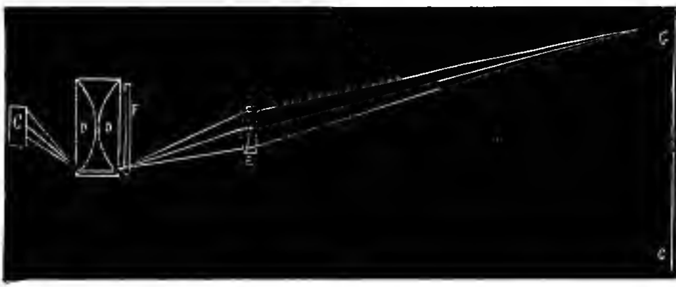

Fig. 2. THE OPTICAL SYSTEM.

With good condenser and objective, probably the following summary will be a sufficient guide:—

For discs not exceeding eight feet in diameter, or for enlarging on bromide paper—a good petroleum lamp, an acetylene burner, or an incandescent (Welsbach) gas light.

For discs not exceeding twelve feet—an oxy-calcium or "blow-through" jet, which is besides preferable to the foregoing for enlarging purposes, when circumstances permit.

For larger discs—the mixed jet or the electric arc light.

A lantern for all-round work, such as an amateur photographer would desire, is best fitted with a blow-through jet, or, if this is impracticable, a three- or four-wick petroleum lamp.

CHAPTER II.

Oil Lamps.

NEARLY all the old-fashioned lanterns in use before the introduction of petroleum as an illuminant depended upon sperm or colza burnt in an Argand lamp, the construction of which can be gathered from Fig 3. The wick in these lamps is cylindrical, with an air passage in the centre as well as outside; the tank for the oil is seen at the back of the figure, carrying in front of it the silvered reflector.

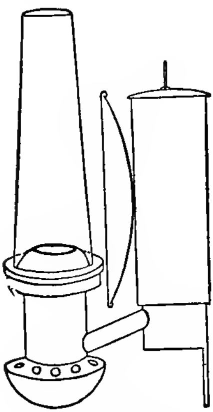

Fig. 3.
OLD TYPE OF SPERM OR COLZA LAMP.

The glass chimney for such lamps should taper towards the top, and the wick must be of loose cotton, the compact wicks employed for petroleum being of no use whatever for sperm or colza. Petroleum cannot be employed in this form of lamp; sperm is preferable to colza, and much longer time must be given for the wick to get saturated with oil than in the case of petroleum. We might add here, that it is not advisable with any lamp to saturate the wick before inserting it, as it is impossible to avoid messing up the outside with oil by so doing, a thing which should always be guarded against.

This type of lamp has long been obsolete in lanterns intended for serious work, but possessing, as it does, many disadvantages, it is nevertheless free from some defects which are inherent in modern forms. It needs a minimum of attention, is simple in construction, but its illuminating power is of the very smallest kind ; still, as it is occasionally met with, and as the precursor of modern patterns, it is worthy of mention.

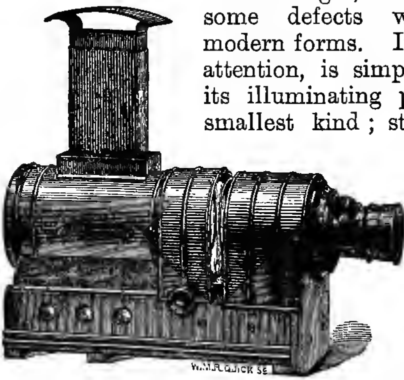

Fig. 4. The Sciopticon.

The introduction of petroleum, and the invention of the Sciopticon lantern by Mr. Marcy, of Philadelphia, improved these old-fashioned illuminants out of existence; modern oil lamps for the lantern dating from what may be called the Sciopticon era.

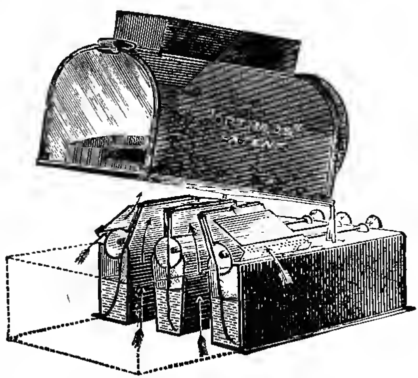

Fig. 5. Three-wick Lamp.

The Sciopticon, Fig. 4, consisted of a reservoir for the oil, out of the top of which proceeded two tubes, each carrying a broad flat wick, the edges of which wicks were presented to the condenser ; the tubes were inclined towards one another at the top. Surrounding the wicks was a semi-cylindrical metal combustion or flame chamber, terminating in a chimney at the top. One end of the combustion chamber was closed by a metal lid carrying a small window for observing the flame ;

the other end, which went next the condenser, was of glass. The lamp and lantern were in this earliest form practically one instrument, the combustion chamber acting as the lantern body ; but the whole arrangement, although a very great advance over anything that had gone before it, possessed certain drawbacks, which have since been overcome. One of these was the presence of a strip down the middle of the disc which was not so brilliantly illuminated as the rest, a defect due to the use of two wicks. This and several minor faults having been removed, we have the modern oil lantern which is upon the market in many patterns, but all of which bear unmistakable signs of their parentage by the Sciopticon, although most of them now have three wicks, and some four or even five, and the lamp generally is distinct from the lantern body, which was not the case with their predecessor. Fig. 5 represents the Optimus three-wick lamp, introduced by Messrs. Perken, Son, and Rayment. In this lamp four distinct currents of air are made to impinge upon the flame, the channels through which they pass being in a direct line with the chimney ; the light given by this form is very satisfactory.

Fig. 6. THE PAMPHENGOS.

Fig. 6 shows one of the very finest of the oil lamps constructed for lantern purposes, "The Pamphengos," by

W. C. Hughes, of Kingsland. It is also based on the Sciopticon, but embodies a number of improvements that place it in the front rank as an illuminant when oil has to be employed.

The following directions for the use of oil lamps may be taken, except where otherwise stated, as applying to all patterns, and should receive careful attention if it is desired to get the best result:—

The selection of the oil should not be left to mere chance, nor half a pint of the cheapest "paraffin" got at the nearest oilshop on the evening when it is required. Many of the oils in the market, although perfectly safe in household lamps in which the reservoir is of porcelain or other material which is a bad conductor of heat, are positively dangerous in the optical lantern, where, from the very nature of the instrument and the exigencies of construction, the receptacle for the oil is bound to get, at any rate, warm. The best crystal oil must be got from a reliable dealer. The addition of a lump of camphor about the size of a walnut to each pint of oil has been recommended as making the light whiter, but we have never been able to detect any improvement in illumination by this means, over that got by the use of the best "crystal" oil. The wicks should not be too long, and of course not too short, a couple of inches longer than necessary to reach to the bottom of the oil reservoir is ample; before use they should be thoroughly dried. When dry, the wicks, if new, must be trimmed with a pair of scissors and replaced in the lantern, the reservoir filled nearly full, whether the lantern is wanted to burn for ten minutes or two hours, and after the lapse of a minute or two for the wicks to soak they should be lit and allowed to burn for a quarter of an hour. A funnel should always be used for filling, and the greatest care taken to avoid spilling any of the oil about the lamp, as it is only by such precautions that the unpleasant smell can be avoided. The chimney is best kept off for the first minute, and put on when the lamp is seen to be fairly alight.

When the new wicks have burnt for a short time, they can be trimmed once more with a sharp pair of scissors, so as to give a perfectly even flame; this trimming can only be roughly done before the edges have been charred by use.

They should be trimmed each time before use, but only that part which is quite burnt need be cut off.

When the lamp is lit, it should be turned up fully at once, and for the first few minutes must be watched, and turned down a little as the lantern warms and the flame begins to smoke, until it is seen to be burning regularly and steadily. To avoid smell as much as possible, the lamp is never to be allowed either to smoke or to burn below its maximum, the greatest height of flame short of actual smoking being always in use; this will entail more or less constant attention, but will obviate annoyance to the noses of the audience.

Another point which must be seen to, is that each of the wicks is doing its fair share of the work. With two-wick lamps this is the case when each is burning so high that any increase in the height of the flame of either will cause a smoke. With lamps possessing three or more wicks, the inner wick or wicks should be in this condition; the outer ones are best a trifle lower.

When the chimney is adjustable in height, the lamp should be removed from the lantern and the height of chimney at which the light is at its best ascertained by experiment; when found, the point should be marked on the chimney once for all. If, now, when the lamp is replaced in the lantern, the height requires altering to get the best result, it indicates that the air inlets are not sufficiently free. This is not often the case; in fact, as a general rule, the inlets for the air receive more attention from the makers than the outlet at the chimney, which is sometimes so contracted as to counteract the advantages gained by improved inlets; still, in good lamps, both matters are the subject of careful study and experiment.

After a display, the lamp should be emptied of oil, the wicks taken out, squeezed up in paper to free them from oil, and put away until wanted again, and the metal parts of the lamp washed with washing soda and warm water and dried.

If a little trouble in this way is taken with a petroleum lamp, it can be used with almost an entire freedom from smell, and the results will astonish those whose experience of the oil lamp is gleaned from the greasy, messy abominations which, with a little inattention, they readily become.

The best petroleum is cheap, and such lamps are the most economical in use; a three-wick lamp does not consume so much oil as a four-wick for the same amount of light, but the difference is immaterial.

It is almost unnecessary to add that the glass at one end of the combustion chamber and the mirror at the other must be kept clean and bright, or much light will be lost. The mirror is sometimes hinged at the top; it is also often provided with a coloured glass window, but this, from its small size, we have not found to be of much use.

The method of adjusting the position of the lamp in the lantern is usually the same as that of the jet tray for lime-light, and will be dealt with under that heading. In the better form of lantern, the lamp slides into the body in grooves, which will also carry a jet, if at any time it is desired to substitute the limelight for the oil lamp.

Owing to the great heat which oil lamps emit, it is necessary for the lantern body to be jacketted; that is to say, for the body to consist of two distinct shells, between which is an air space. Even with this precaution the outer casing, which is sometimes of wood, but more often of Russian iron, is almost sure to get very hot—far hotter, in fact, than should be the case with the limelight or with an arc lamp, but this is unavoidable.

CHAPTER III.

The Limelight.

THE most popular of all lights for lantern purposes is one or other form of what is known as the limelight. This means of illumination was invented by Lieutenant Drummond in 1826, and although it has been employed more or less ever since, it has received its greatest impetus by the sale at a moderate price of oxygen gas compressed into steel cylinders, which are fairly portable.

The use of Limelight as an illuminant, as its name implies, is based on the fact that, by directing a very hot flame against a piece of lime, the latter soon becomes white hot, and emits a very brilliant light of great penetrative power. To achieve this, the flame must be of the most intense character; ordinary house gas, spirit or petroleum lamps are quite useless for heating the lime, and recourse has to be had to flames in which oxygen gas is employed, freed from the nitrogen, argon, or whatever other diluent chemists may eventually decide to be present. By the aid of this oxygen the combustion of most inflammable substances is rendered much more vigorous and complete, and the heat emitted more concentrated and intense.

The instrument by which the flame is obtained and directed against the lime is known as a jet, and some idea of its appearance may be gathered from Figs. 7, 8, and 9, which represent the three types of jet in common use, the oxy-calcium, the blow-through, and the mixed jets. Most lanterns, whether provided with petroleum lamps or not, have a couple of grooves running down their base inside, about 4in. apart, in which slides the lamp when petroleum is employed, or the tray when limelight is being used. This tray

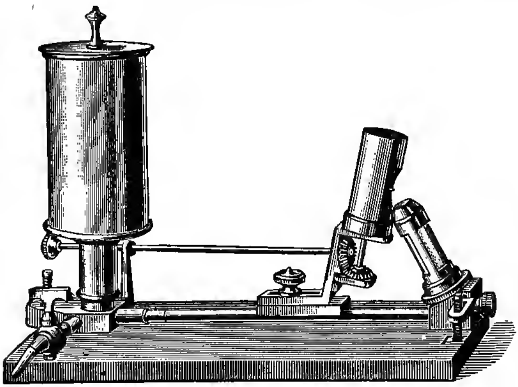

Fig. 7. Oxy-calcium Jet.

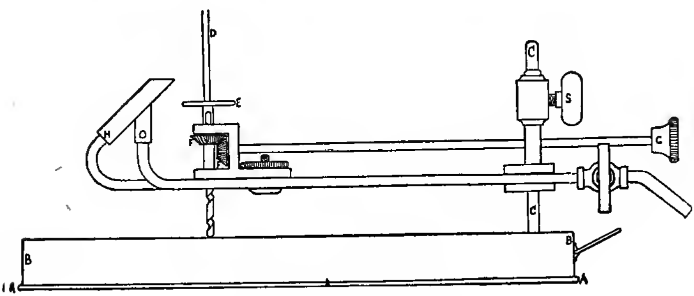

Fig. 8. Blow-through Jet.

is shown in Fig. 8, in which A A are the edges which enter the grooves; B, a narrow, turned-up rim to stiffen the tray and to retain any fragments of lime which may drop from the jet; and C, the pin which carries the jet itself. The tray should slide easily in the grooves provided for it, but should be incapable of being moved or "wobbled" from side to side when in position, and the pin to carry the jet should be rigid and smooth, that the jet may be easily adjusted on it.

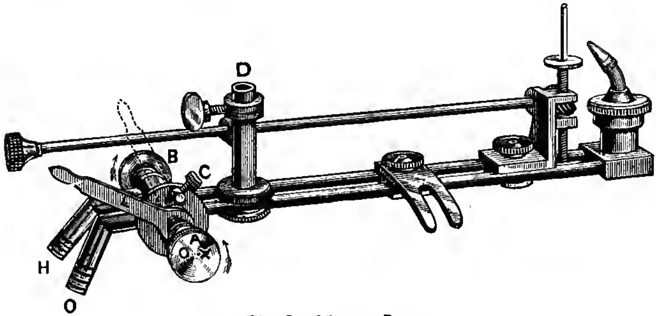

Fig. 9. MIXED JET.

The jet shown in Fig. 10 is one devised by Mr. Gwyer, and is one of the most powerful forms made. It is of the mixed jet type, and can be used either with oxygen and hydrogen, or with oxygen and an ether saturator, as desired. It is claimed for this jet that the smallest

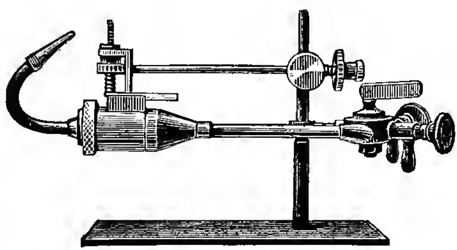

Fig. 10. GWYER'S MIXED JET.

will yield 1500 candle power, and the largest 4000. Unfortunately, there is not at present any satisfactory manner of measuring the candle power of lantern illuminants, but its illuminating properties are enormous.

In the ordinary form of tray the jet is held by being slid up or down on the pin of the tray and clamped by means of the screw, s, Fig. 8. This arrangement, while it allows the jet to be moved very readily and is simple and reliable, has the disadvantages that the jet is supported by a point very much behind its centre of gravity, the pin consequently tending to lean forward, and that the operator who manipulates the jet from behind has hold, as it were, of the short end of a lever, the slightest movement of which displaces the front of the jet very considerably. The arrangement also is very easily disturbed by an accidental touch at the back of the jet; but, in spite of these drawbacks, this form of tray is most often met with, and if substantially made and used with proper care will be found to answer every purpose. Mr. Andrew Pringle, a recognised authority on lantern matters, uses in addition an arrangement of a couple of jaws, which, when the jet has been adjusted in position, grip it in front, and so help to keep it firm.

All jets are provided with a means of holding the lime for the flame to play upon, and as the particular part of the surface soon deteriorates and requires renewal, must have also an arrangement for bringing a fresh portion of the lime under the influence of the flame. This in most cases is effected as shown in Fig. 8, where a vertical spindle, D, carries a little circular table, E, through the base of which the spindle projects, the lime being generally a perforated cylinder in shape, which is slipped over the pin or spindle and rested on the table. This pin is sometimes made long enough to carry two limes, one on the top of the other; this may be useful for long displays, but we ourselves cannot recall a time when it would have been a convenience. The lime pin is connected at its base by means of bevel wheels, F F, with another spindle, which ends in a milled head, G, near the taps at the back of the jet; the pin, however, while turning with the wheels, is free to move up or down; and is indeed compelled to do so when the wheels revolve, on account of a spiral thread which is cut upon it, which engages in pins attached to the bracket carrying the spindle. By this simple contrivance, which is not easily indicated in the diagram, but which can be comprehended in a moment on looking at a jet, by turning the milled head G, Fig. 8, the lime pin, and with it the lime, not only revolves, but at the same time moves up or down, so that a pencil held upon the side of the lime would describe a spiral line around it. The handiest form of screw for doing this is one which raises the lime at least a quarter of an inch for each complete revolution. A defect some forms of jet possess is to be found in the fact that the screw is such a fine one that when the lime has been turned completely round, the jet is playing upon practically the same place on the lime as that at which it started.

In some forms of jet, which now have almost gone out of use, a flat disc of lime was employed instead of a cylinder, as shown in Fig. 11. In this case the lime simply revolved

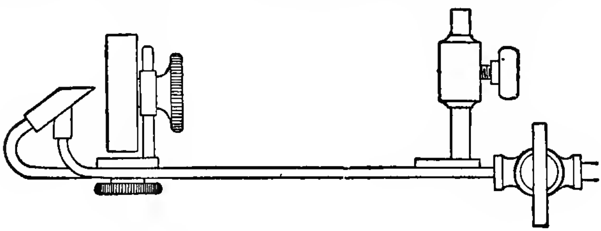

Fig. 11. BLOW-THROUGH JET WITH LIME DISC.

upon a central axis, each portion of a revolution sufficing to bring a fresh part of it before the flame.

The limes for limelight should be turned true, not only as regards their outer surface, but the hole through the centre should be *central* also, since if it is not, the distance between the jet and the lime will vary as it is turned. As this distance is an important factor in getting the most light which a jet is capable of giving, it follows that if one position of such a lime is correct, on turning it, the distance is altered and the light diminished. In this connection, we may observe that what are known as "Excelsior" limes are as a rule better shaped than their rivals, the "Nottingham" limes, although for the mixed jet the latter are preferable when well formed. Limes are often spoken of as *hard* or *soft*, and these two kinds may be considered as most suitable for different forms of jet. The soft limes incandesce at a lower temperature, but are not so lasting as the harder ones; for this reason they should be used for the oxy-alcohol and blow-through types of jet; while the harder limes, of which the Nottingham is an example, are used to best advantage in the intense heat of the mixed jet. The "Newtonian" limes, which are supplied by Messrs. Newton and Co., of 3, Fleet Street, E.C., possesses certain advantages over the above-mentioned, in that they are turned and bored with great accuracy, and are far less affected by exposure to the air.

All limes, except at the time of using, must be carefully protected from moisture, and consequently from the atmosphere. They are generally supplied, packed in powdered lime, in hermetically sealed tins or bottles, and under such conditions will keep for a considerable time. When once the case has been opened, however, they begin to deteriorate unless special care is taken to protect them. Mr. Hepworth recommends that each lime should be dipped in melted paraffin wax or beeswax, half-way, and then allowed to cool. When the wax is firm, the lime should be held by the waxed portion, and its other half immersed; and when the waxen coating is solid, the limes wrapped up separately in paper and stored away until required. This is said to protect them perfectly from the action of air, and the coating is peeled off very readily when the lime is wanted for use, *provided that* the wax in which they were dipped was only just above its melting point and no hotter. Most dealers in lantern requisites supply tubular cases of brass with a screw lid, which are capable of holding six limes, one on the top of another, and these are handy for storing purposes, the contents of a tin being transferred to them as soon as it is first opened. The Newtonian limes just mentioned are sold separately, wrapped in thin paper, and packed in a tin tube with sliding lid: a means of storing which is satisfactory with this particular make of lime, but one which we should not recommend for others. It must be remembered that limes are really *quicklime*, and that with exposure to the air they *slake*—that is, they absorb moisture, swell, and fall to pieces; and that a lime is not used to the best advantage after its surface has lost its initial hardness.

If a lime is taken from its case, put into the lantern, and the jet turned full on it at once, the probabilities are that it will crack and be rendered useless. This is only what might be expected when it is borne in mind how unevenly it is heated, one side being exposed to one of the fiercest flames known, the other to the cold air rushing to supply that flame. For this reason limes before use should be heated by being put in an oven, on the hob, or exposed to the coal gas or hydrogen flame in the lantern, and turned round occasionally, for an hour or two before they are wanted.

When a lime is required for use, the hole through it will most likely be found to be filled with the powdered lime in which it was packed. This should be got out by tapping the lime gently on a hard surface, and no attempt must be made to force it on the lime pin while the hole is clogged up, as by so doing the powder is only rammed more tightly together and the lime for the time being made useless.

Mr. E. G. Wood some years ago introduced what he called a lime shield—a little cylindrical piece of thin metal which surrounded the lime, with an opening where the jet was directed against it; this serves the useful purposes both of protecting the lime from draughts, keeping it warm, and of protecting the condenser from an accidental reflection of the flame upon it from a pitted or otherwise uneven lime. It can be seen in Fig. 7 surrounding the lime and connected with the fixed portion of the jet, the lime being free to revolve within it.

From time to time substitutes for lime have been proposed, but as none of them have ever come into anything like general use—a fact accounted for by all of them possessing one or more disadvantages rendering them inferior to lime itself—anything more than an allusion to them is out of place here.

CHAPTER IV.

Home-made Oxygen, Gas Holders, Etc.

BEFORE the introduction of compressed gases and the use of steel cylinders had rendered the purchase and transmission of forty feet of oxygen from London to John o' Groats as easy and as cheap as the forwarding of, say, a churn of milk for the same distance, lanternists were compelled to use either the delicate, expensive, and rapidly-ruined gas bag, or the anything but portable pneumatic gas holder. As both of these forms are still in use to some extent, and as the latter, at any rate for certain purposes, can still hold its own, a word as to their use will not be out of place. At the same time, we can appropriately bracket with these forms of apparatus the manufacture of oxygen at home.

Gas bags, which are generally wedge-shaped, are made, at least the better qualities are, of a stout fabric bag enclosed in another of a close-textured twill, between which is a third bag of thin sheet india-rubber (Fig. 12). The outlet of the bag, a brass stopcock, is fixed in the middle of the edge formed by the acute angle of the bag. This stopcock, in the case of bags used to retain oxygen made from potassium chlorate, rapidly becomes corroded by chlorine, which is generally present in small quantity in such gas, unless care is taken to get rid of it (see page 23), which

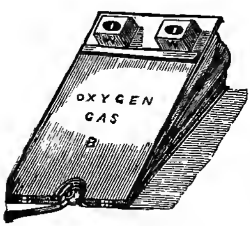

Fig. 12. A GAS BAG.

should always be done. The wedge-shaped bag, when being filled, is allowed to lie freely on the table, but when the gas is being used, is inserted between pressure boards (Fig. 13), the upper one of which is weighted to the requisite degree to expel the gas. Weights are placed at the extremity of the board, against the shelf provided to prevent them slipping down, and may vary in amount from a half-hundredweight to three or even four times that amount. For most purposes, where a moderate size of disc is required, which in these days will probably be the only case in which gas bags are used at all, a single 56 lb. weight will be sufficient to commence with on a full bag, being supplemented with another when the bag is more than half empty. When using oxygen from a bag with house gas there is very little danger of the latter entering the oxygen bag and forming with its contents an explosive mixture, since the pressure in the gas mains is but slight. It must be borne in mind, however, that if at any time the two gases were mixed in a bag, the result would in all probability be an explosion which might endanger life and limb. This is far more likely to occur when a mixed jet is being worked with both gases in bags (this form of jet cannot be used with house gas taken direct from the mains to the lantern, on account of insufficient pressure), and the pressure in the two bags is not equal. To get over the difficulty of maintaining the pressure in two sets of bags and boards equal, double pressure boards were invented, in which the same weights are employed to press down the two bags. When this form is used, the apex of the boards at A, Fig. 13, which when the bags are full is raised, must be lowered by folding in the strut B before the top board has sunk so low as either to overturn the entire frame or to cause the weights to slide off. By the use of pressure boards longer than the bags this can also be prevented.

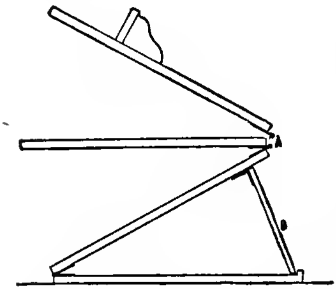

Fig. 13. DOUBLE PRESSURE BOARDS

Gas bags are at the best evils, which in some cases perhaps are still necessary ones. Where portability is not important they yield the palm, or as much of it as is left them, to the pneumatic gas holder, which may take the form either of Figs. 14 or 15. Fig. 14 represents a gas holder which is virtually a model of the huge miscalled "gasometers" which are so striking a feature of the landscape in most towns. The diagram sufficiently indicates its construction: A is a cylinder, the top of which must be perfectly gas-tight, and must carry the stopcock B, which acts as the inlet and outlet for the gas; C is a similar cylinder without a stopcock, a little larger than A, which carries two or more uprights with pullies, over which pass cords from A to the counter weights D. In holders of any size, the space inside the smaller cylinder is filled, to a large extent, by an empty metal drum, as shown in the figure, to avoid the necessity for so large a bulk of water. To charge this gas holder, C is filled to within an inch or two of its top with water, and A, with its open end downwards, immersed until the stopcock, which must be kept open while depressing A, is under water. Before use it should be seen that the counterbalance weights, D, are just sufficient to allow A to move up or down with perfect freedom while the stopcock B is open. As soon as A is completely immersed, the cock may be connected with the oxygen apparatus from which the holder is to be filled. As the oxygen enters it will gradually raise the upper cylinder; the supply must be turned off before the bottom edge of the latter is within an inch or two of the surface of the water.

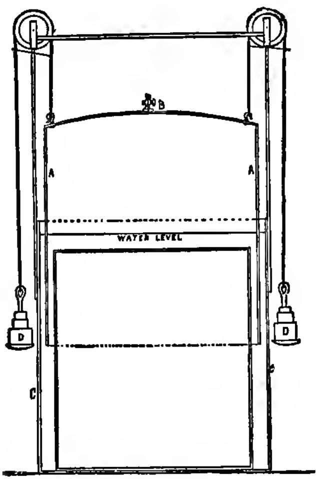

Fig. 14. GAS HOLDER OF THE "GASOMETER" TYPE.

To use the gas, the jet can be connected with B by india-rubber pipe, or a second stopcock can be fitted to the upper cylinder as the gas outlet. Weights must be placed on the flat top of A until the desired pressure is obtained. Small gas holders of this pattern are easily constructed of galvanised iron and will last a lifetime. We have seen a very efficient one made of two of the large cylinders in which paint is supplied. Another form of gas holder is shown at Fig. 15, in which A is the inlet and outlet for the gas; B, a stopcock which is opened during the filling of the holder to allow the displaced water to escape; C, a pipe through which water, under more or less pressure, is supplied to drive out the gas when it is required for use.

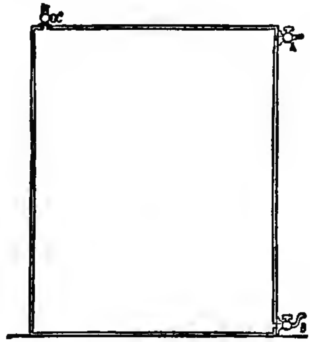

Fig. 15. A Gas Holder.

One or other of these forms of gas holder are still largely used where the limelight is constantly wanted in the same place, as, for instance, in theatres, in photographic enlarging establishments, etc.

Oxygen gas is generally prepared in small quantities by heating together in an iron vessel a mixture of chlorate of potassium and oxide of manganese. Both these compounds should be fairly pure, it being particularly important that the manganese oxide is not adulterated in any way; the presence of, for example, carbon in any form in it being most dangerous. The cheapest (and worst) form of generator takes the form of a conical sheet-iron or copper vessel, which is very difficult to properly clean, and is unprovided with any safety-valve arrangement. Mr. Chadwick, to whom lanternists are indebted for many ingenious and practical improvements, has introduced two forms, either of which are much more suitable. One of these is shown in Fig. 16. In this, the handle at the top being pulled over, the bell-shaped top, which, like the rest of the apparatus, is of cast iron, removes. A prepared cake of manganese oxide and potassium chlorate is introduced, the top put on, the handle replaced, and the gas lit at the Bunsen burner, which is enclosed in the hollow part underneath (only the stopcock is visible in the figure); gas rapidly comes off until, in a quarter of an hour or less, the cake is exhausted, and may be replaced by another. In case of any excess of pressure in the vessel, the springs at the side allow the lid to rise and the gas to escape. The cakes are made by mixing four parts of manganese oxide to one part of the powdered chlorate, enough water being added to just moisten the mass, which is then filled into a mould. The cakes are allowed to dry, when the bottom of each is coated with a thin paste of manganese oxide and water to prevent it sticking to the retort. The use of the cakes entirely prevents the choking up of the retort with the decomposed oxygen mixture, the bye-product coming away in a mass just as the cake was inserted. We recently saw one of these working in conjunction with a large gas holder of the type shown in Fig. 14. It had been in use for many years, making oxygen for enlarging purposes, without the slightest hitch. Another form designed by Mr. Chadwick has a weighted lid at the end, which acts when necessary as a dead-weight safety valve.

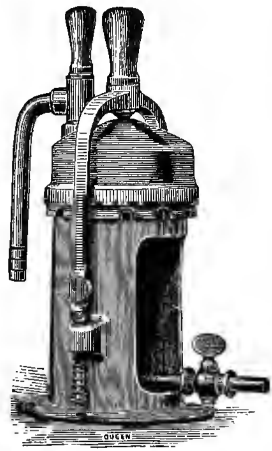

Fig. 16. OXYGEN RETORT.

For oxygen making, as we said before, the manganese oxide should be got from a reliable source. The chlorate is best bought ready powdered if to be made up into cakes as above described; if to be used loose, the crystals should be employed (it is best not to attempt to powder it oneself), and the manganese used should be the granulated form. Both ingredients should be carefully picked over for scraps of cork, straw, etc. When the cakes are not employed, two parts by weight of chlorate to one of manganese are those we used in the days when oxygen was not so readily obtainable. Some workers, however, prefer three, or even four parts of chlorate.

Whatever retort is used, a gas stove is the most convenient way of heating it; the heat should be left on until at least four cubic feet of oxygen have come off per pound of chlorate. This is mentioned because the emission of gas is often irregular, ceasing almost and then coming off with full force again.

When the gas is to be received in a bag, it should be washed by allowing it to bubble up, as shown in Fig. 17, through a Woolff's bottle containing a fairly strong solution of caustic soda, which will last for several operations, and then through an empty flask to remove as much as possible of the water. This washing is not necessary when a pneumatic holder is to be employed. When no more gas is coming off, the stopcock on the bag should be closed and the tube *immediately* disconnected between the retort and the first bottle; if this is not done at once and before the retort is allowed in any degree to cool, the liquid in the flask will be sucked back and an explosion of steam in the retort is sure to ensue. There should be no fear of this in any but the most incompetent hands, which latter had best leave limelight alone altogether. When a gas bag has got hard through cold, it should be warmed a little before filling to soften it. If this is not done the bag will rapidly perish.

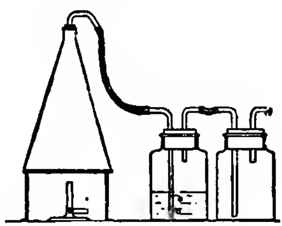

Fig. 17.
APPARATUS FOR MAKING AND WASHING OXYGEN.

In filling a bag with oxygen the sequence of operations should be as follows:—

(1) Having connected the retort and flasks as shown, and having the empty bag with its stopcock open and tube *ready* to connect to the last flask, apply heat to the retort until gas bubbles off freely.

(2) When on applying a glowing match to the open end of the tube it is relit, showing that the air has been driven out of the apparatus by the oxygen, connect the pipe from the bag with the flask.

(3) When gas has finally ceased to come off, close the stopcock, disconnect the retort from the flask at once, and *then* remove or extinguish the source of heat.

It is so unlikely that hydrogen gas will ever require to be made, its place being supplied by alcohol or oxygen and ether, that no apology is necessary for the omission here of any details upon the subject.

CHAPTER V.

Compressed Gases.

Most lanternists nowadays use the compressed oxygen, and in some cases compressed coal gas also. The gas is supplied in steel cylinders, such as shown in Fig. 18, into which it is forced by powerful pumping machinery until it reaches a pressure of 1,800 lb. per square inch, or 120 atmospheres. The extraordinary strength of these cylinders can be best understood when it is pointed out that the

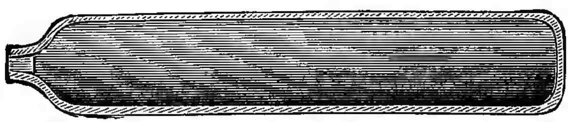

Fig. 18. Gas Cylinder.

weight of one to hold 10 cubic feet of gas is not more than 15 lb., and the outside dimensions for this capacity 4 inches in diameter and 19 or 20 in length.

It might be supposed at first sight that such things must be essentially of a dangerous nature, but when the large number of cylinders in constant use all over the world is taken into consideration, the almost entire immunity from accident should beget confidence in reasonable minds. Still, as there is the potentiality of a great deal of mischief in a charged cylinder, they should not be treated with unnecessary violence.

The amount of knocking about which a charged cylinder can actually stand, if properly made and annealed, is surprising. Mr. Murray, the engineer to the Brin Oxygen Co., in his book on compressed gases, narrates how they have for experimental purposes been dropped vertically from a height of 35 feet two or three times in succession, crushed with a 15-ton blow, and finally bent into a bow form; on testing them after this treatment they were found to contain the full quantity of gas. To secure the degree of safety indicated by this, the cylinders must not only be well made of suitable steel, but inasmuch as the physical structure of the steel becomes gradually altered, they must from time to time be *annealed*, a process which restores them to their original condition as far as strength is concerned. It is therefore advisable, if buying a cylinder, or bottle as it is sometimes called, to get a new one from a reliable maker, and one which has been properly tested. The gas compressing firms themselves let out cylinders on hire, which can be relied upon, for those who do not wish to buy one outright.

Inasmuch as the gas in these cylinders is at a very high pressure, and the pressure required in the lantern is hardly a hundredth part of this, means have to be taken to reduce the pressure of the gas in its passage from the bottle to the jet. The best method of doing this is by employing what is known as a regulator, a little instrument which will deliver the gas uniformly at any pressure desired until the cylinder is empty, although the pressure in the bottle is constantly decreasing as the gas is consumed. There are several forms of regulator on the market; the first to be introduced, and one which is still extremely popular, is that known as Beard's, after its inventor. Brier's and Clarkson's are also well-known patterns. Broadly speaking, the principle upon which these regulators are made is the same, and can be understood best on reference to the Figs. 19 and 20, which illustrate the construction of the Beard regulator. The cylinder has the regulator screwed into its orifice, and the outlet P being closed, the gas is turned on and passes into the bellows C, expanding them and tightening up the spring S. As the top, D, of the bellows rises with the pressure of the gas it gradually closes the valve I, by mean of the system of levers seen at L, and so cuts off the supply of gas. As the gas is used at the jet, the spring forces D down again until the valve reopens and allows the bellows once more to receive a supply from the cylinder, and so on. The pressure at which the regulator delivers the gas, as generally supplied, is about that of 12 inches of water, but it can be varied by varying the strength of the springs. Where both oxygen and hydrogen are used in

Fig. 19. BEARD'S REGULATOR, EXTERIOR.

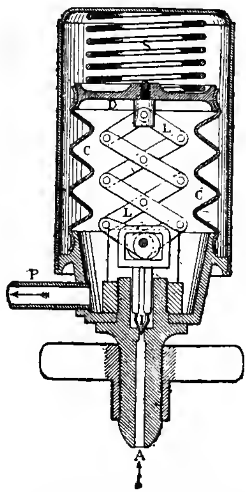

Fig. 20. BEARD'S REGULATOR, INTERIOR.

cylinders, separate regulators should be employed for each, the hydrogen regulator never being attached to the oxygen-bottle, and *vice versâ*. When using the regulator, the gas can be adjusted by the jet taps, and if required they can be turned completely off, which, if no regulator were employed, would result in bursting or blowing off the tube.

In addition to a regulator, those who use cylinders habitually will find a pressure gauge very useful, as showing at a glance the amount of gas the cylinder contains. The pressure gauge is shown at Fig. 21. These gauges are made upon the principle of the "Bourdon" steam gauge, in which a tube closed at one end, and having a somewhat flattened or elliptical cross section, and bent into an almost circular form, is connected with the cylinder of gas. The outer margin of the circle of the tube being of greater area than the inner, a pressure from within tends to straighten the tube, and the extent of this straightening is shown by the index finger, which is connected with the free, that is the closed end. There are other forms of gauge in the market, but the principle in them is the same as in the "Bourdon." When buying a pressure gauge a thoroughly reliable one should be bought or none at all. Messrs. Schaeffer and Budenberg are perhaps the best known and most reliable makers of all forms of pressure gauge, and one of their construction may be relied upon to be both safe and accurate. A dangerous form of accident which has occurred more than once is the bursting of an inferior gauge, and the blowing out of its face. Any danger from such a cause is avoided by getting a first-class gauge from a good maker, and by taking care when using it not to turn the gas on suddenly or with a jerk, so as to put the severe strain of a pressure of perhaps many atmospheres upon the internal mechanism all at once, but to open the valve very slowly and cautiously, watching for the first indication of movement on the index as a sign that the gas is passing into the gauge.

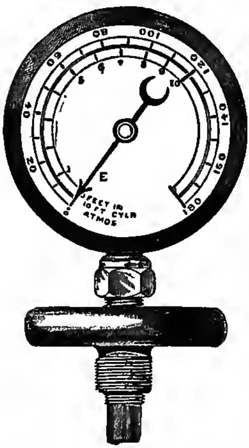

Fig. 21. Pressure Gauge.

Pressure gauges are usually graduated with two scales, one reading from 0 to 140, or thereabouts, and the other from 0 to 10, the 120 of the one scale corresponding with 10 of the other. The smaller divisions are atmospheres (an atmosphere is taken as a pressure of 15 lb. to the square inch) and at a pressure of 120 atmospheres a "10-foot" bottle contains 10 feet of gas, which is read off direct on the other scale. If the cylinder is a 20-foot or 40-foot, the number of cubic feet indicated on the gauge must be multiplied by 2 or 4 respectively; if a 12-foot, by $1\frac{1}{5}$, and so on, multiplying in each case by the number of times 10 feet are contained in the nominal capacity of the charged cylinder. In this way the contents of the cylinder can be gauged. Those who do not care to incur the expense of a gauge can ascertain roughly how much gas the cylinder contains by weighing it. Inasmuch as 12 cubic feet of oxygen gas weigh about a pound avoirdupois, if the weight of the cylinder empty is known, the difference in ounces between that weight and its weight when it contains an unknown amount of oxygen must be multiplied by 3 and divided by 4, the result being the number of cubic feet of oxygen it contains.

For example: A cylinder which when empty weighs 25 lb. 14 oz. is found to contain a certain amount of oxygen making it weigh 27 lb. $8\frac{1}{2}$ oz. It is required to know how much of the gas it contains. On subtracting 25 lb. 14 oz. from 27lb. $8\frac{1}{2}$ ozs., we get $25\frac{1}{2}$ oz. Multiplying $25\frac{1}{2}$ by 3 and dividing by 4, the result is $19\frac{1}{8}$—the number of cubic feet of gas the cylinder contains. This may be taken as a rough guide, but too much dependence should not be placed on information got by means of an operation where a very slight mistake may greatly mislead. In the case of coal gas, no useful indication of the amount of the contents of a cylinder can be got by weighing.

Gauges, like regulators, must not be used indiscriminately for oxygen and hydrogen, and on turning the gas into them it must be done gently as already said, on no account with anything like a jerk. With this end in view, indeed, the general custom now is almost to close the entrance to the gauge, only leaving the minutest hole through which the gas can but gradually force its way, no matter how suddenly it may have been turned on.

With a view to prevent the filling of a bottle which might contain some hydrogen with oxygen, or *vice versâ*, and the interchange of fittings, the screw threads at the mouth of the oxygen cylinders are of a different pitch to those for hydrogen; in consequence, fittings made for an oxygen cylinder cannot be screwed into one made to contain hydrogen, nor is the reverse of this possible. To distinguish the cylinders, those intended for the reception of oxygen are usually painted black, those for hydrogen bright red, and this rule should apply not only to the cylinders themselves, but also to the painted portions of the gauges, regulators, and jet taps. If, in addition to this, black rubber tubing is used for oxygen and red for hydrogen, the connections will become far clearer, and any alterations necessary in them, however complicated the system, will be made with little chance of mistake.

The gas *can* be used direct from the cylinders to the jet without the intervention of any regulator, but this is not advisable, and unless absolutely necessary should not be attempted. If, however, circumstances necessitate such a course, all regulation of the supply of gas *must be done at the valve of the cylinder itself*, the taps at the jets being left full on; on no account must the jet tap be turned off. If this were done the pressure in the cylinder would rapidly accumulate behind the jet, and the tubes would be blown off, or, if tied on, burst. Where the regulation has to be done at the cylinder, a form of screw-down valve in which the adjustment can be regulated to a nicety will be found a convenience, one of these is shown in Fig. 22. Biunial and triple lanterns *necessitate* the use of regulators on the cylinders.

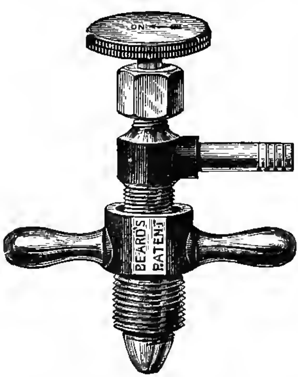

Fig. 22. FINE ADJUSTMENT VALVE.

Cylinder valves are worked by means of a key, which is generally of the form used by piano tuners, Fig. 23, or of a plain lever pattern, Fig 24. The lever key, while handy for turning on and adjusting the flow of the gas, possesses the drawback that its powerful leverage in turning off the gas may cause injury to the valve seating; to obviate this

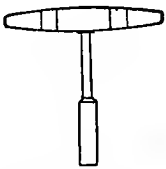

Fig. 23. PIANO KEY.

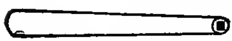

Fig. 24. LEVER KEY.

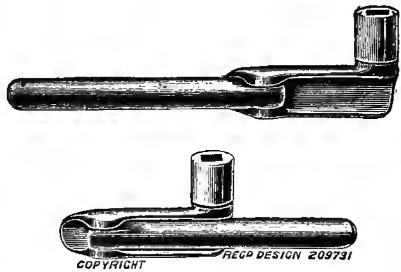

Fig. 25. BRIN'S HINGED LEVER KEY.

Messrs. Brin have introduced a hinged lever key, Fig. 25, which can be used as a lever key for opening the valve, but which when applied to close the valve folds up into the piano key form.

It should be hardly necessary to point out that cylinders in use should be prevented from rolling about, they are most convenient when held erect in a box with firm footing, if simply leaned up against anything they should be tied.

No oil or other lubricant should on any account be allowed to come into contact with the cylinder valves or fittings, and when cylinders are used in the vertical position care must be taken to prevent grit or dirt of any kind falling into the valve opening.

When a cylinder of gas is obtained, unless it is going to be used at once, the valve should be tested for leakage by plunging it under the surface of water, when, if there is a leak, bubbles of gas will manifest themselves. An efficient but not so cleanly method consists of moistening the finger with saliva and making a slight film or bubble over the mouth of the valve. If there is a leakage the bubble will be distended.

Pressure gauges and regulators are often screwed together and used as one fitting, as shown in Fig. 26, a very convenient

Fig. 26. COMBINED REGULATOR AND GAUGE.

method. If no regulator or other fitting is used on the cylinder, a nipple will be required to which to attach the tube (Fig. 27). Rubber tubes are best simply slipped over the metal tubes to connect them, and not tied in any way, but to do this they must be a good fit, that is, not too loose. If tied, and from any cause the pressure becomes excessive, they will burst, whereas if only slipped on they will simply be blown off.

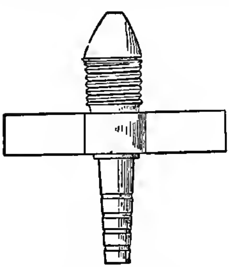

Fig. 27. NIPPLE.

The rubber tubing should be fairly stout, so as not to be likely to form "kinks," and should not be of the cheapest quality. A very good kind can be obtained at about sixpence per foot, red or black. Latterly a piping formed by convolutions of a corrugated iron strip has been put upon the market, which, where the gas has to be led any distance, is excellent. It can be got in any length, with unions fitted to its ends, at very little if anything more than the cost of good rubber tube, and if one or two of the audience chance to stand on it, it does not collapse at once and put the light out, as rubber would. The rubber tube formed on an iron wire spiral is best avoided.

Coal gas if kept in a cylinder any length of time greatly deteriorates, attacking the steel and forming with it a viscous liquid known as iron carbonyl. The presence of this in the gas is manifested by a rapid blackening or reddening of the lime which lessens the illumination, and by a blocking up of the nipple of the jet. The amount of iron taken by this means from the substance of the bottle is not sufficient to materially weaken it, but the compound is annoying in the way above indicated, and clogs up the cylinder valve.

The railway companies having thrown difficulties in the way of the carriage of cylinders of compressed gas, since one or two recent accidents, the stipulations which the Midland Company make for this service are given, as typical of the nature of such regulations generally. The sender has to sign a form stating that he certifies "that the consignment complies with the conditions that the cylinder or cylinders must be of wrought iron, or of mild steel of the best quality, containing not more than 0·25 per cent. of carbon, thoroughly annealed after manufacture, of sufficient strength, and efficiently tested." This should be stipulated when purchasing the cylinder, upon the seller of which should be thrown the responsibility of supplying an article with such a guarantee. The company also require that the cylinder shall be securely protected by being—

(1) Encased in closely plaited hemp or coir; *or*

(2) fixed in ordinary wooden box without lid, but with rope handle; *or*

(3) loose in ordinary wooden box, with lid secured by strap; *or*

(4) efficiently protected by closely-woven wickerwork, the valve of the cylinder not to project beyond the wickerwork.

The company also disclaim all responsibility, risk, liability, and the duties of common carriers as far as this traffic is concerned. Cylinders are carried both by passenger and goods trains, but in both cases have to be paid for, as the companies decline to recognise them as passengers' luggage.

The various forms of protection mentioned above can now be procured from several of the firms supplying lantern requisites.

CHAPTER VI.

Ether, Incandescent Gas, Acetylene, etc.

THE oxy-calcium light is not sufficiently powerful for the largest displays. and a substitute for coal gas enabling the mixed jet, with its intense illuminating powers, to be used, was sought for and to a great extent found in oxygen containing as much as possible of ether vapour. If oxygen gas is passed over a large surface of the volatile fluid, ether, it picks up a quantity of that substance in the form of vapour, and when saturated with it the two form an inflammable but non-explosive gas, which can be burned in place of hydrogen; when the oxygen only contains a fraction of the requisite amount of ether, it forms a powerful explosive mixture.

The apparatus for saturating the gas with ether, or with benzoline vapour, which has been used as a substitute, is known as a saturator, a general idea of the arrangement for the use of which can be gathered from Fig. 28, in which the arrangement is shown very diagrammatically. The actual designs differ from one another very considerably; but in principle they may be regarded as constructed on the lines shown. Only one cylinder, E, and regulator, F, are required in such a case, the oxygen on leaving it being taken in two directions—in one case along the tube A to the oxygen tap of the jet, in the other along B to the saturator C, whence it emerges by D to the hydrogen tap. One of the difficulties earlier inventors met with was due to the rapid cooling of the ether by its evaporation, which, since the lower the temperature the less volatile the fluid, soon led to the oxygen passing over without picking up sufficient vapour. The earlier patterns usually ignored this difficulty, leaving the operator to warm the saturator with hot water, a hot brick, or even a lamp, but later patterns utilise the waste heat from the jet by enclosing the saturator with the jet itself in the lantern. The introduction of one or two forms of saturator which appear to stand the most irrational treatment without exploding, and which possess other advantages, brought this type of apparatus into a considerable

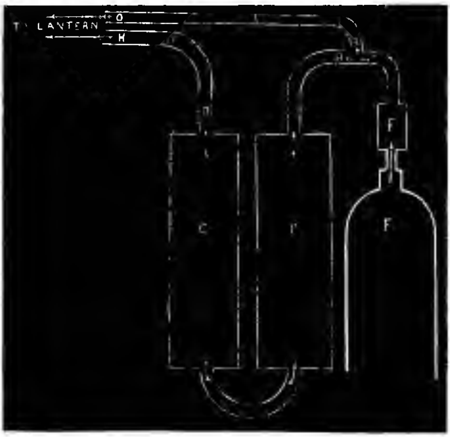

Fig 28. ARRANGEMENT FOR USING ETHER VAPOUR.

degree of favour with skilled operators, in whose hands they give excellent results.

The ether saturator is not, however, a form of illumination which any but skilled lanternists should attempt. Quite apart from the safety or otherwise of the various forms of saturator now readily obtainable, ether, an extremely volatile fluid, the vapour of which forms an explosive mixture with air, in inexperienced hands may be most dangerous, as has been shown at the terrible accidents at the Paris Bazaar and elsewhere, due not to the defects of the saturator, which worked well enough, but to ignorance on the part of the operator as to the dangers of ether, which is best left alone.

In the last few years the incandescent, or Welsbach, light has come into prominence as an illuminant. The nature of this light is too well known to need a description here, but it is as well to point out that it is by no means so efficient as many people would think. The large size of the luminous area causes a very great waste of light, and it is often necessary to have the burner at anything but the best distance from the condenser for

Fig. 28A. ACETYLENE GAS GENERATOR FOR LANTERN WORK.

illuminating purposes, in order to avoid the image of the network of the mantle being seen upon the screen. A simple form of lantern fitting for this light can be got for a few shillings from any lantern dealer. The light answers better for enlarging than for showing slides, for which latter purpose only very small discs can be satisfactorily lit by its means.

Acetylene is another new form of illuminant, also well fitted for small discs and for enlarging. It possesses the great convenience of being available without any other gas supply, the lanternist making the gas as required. For this purpose a piece of apparatus, shown in Fig. 28A, and known as a generator, is required. It is not very costly the pattern shown, which will suffice with one charging for about a couple of hours, being priced at 25s. There are several forms of generator on the market, the Incanto, made by Messrs. Thorn and Hoddle, of No. 1, Tothill Street, Westminster, S.W., being one of the best. Calcium carbide, a greyish substance, which must be kept perfectly dry until wanted, is the material from which the gas is made, it being only necessary to wet the carbide with water to cause it to give off gas. For this purpose a charge of carbide is put in a receptacle in the top of the generator provided for the purpose, and the lid securely fastened. The water in the generator on reaching the

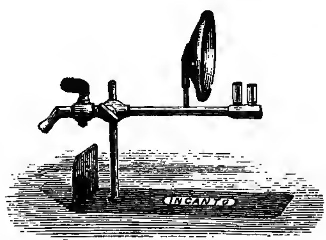

Fig. 28B. BURNER FOR ACETYLENE GAS.

carbide causes the acetylene to be liberated, and the gas is stored up in the apparatus until required for use. As the generator fills the carbide is lifted out of the water, and the evolution of acetylene ceases; as the gas is used the carbide is automatically lowered and again wetted, causing more gas to be given off.

The generator is connected in the usual way with the burner, Fig. 28B. This has to be of a special type, but is simple enough in construction, and cheap. The acetylene burns like ordinary gas, but with a very small intensely white and hot flame. Care must be taken to prevent the escape of acetylene into the room, as its smell is very offensive, and it makes a powerful explosive with air. The latter is not a very positive danger, as its smell acts as a safeguard, giving an unmistakable warning of its presence long before there is any chance of acetylene being present in sufficient quantity to explode.

For those who only want a small display at home, or for enlarging purposes, this new illuminant will be found in every way admirable. It is of little use for discs over six feet in diameter if brilliance is required, but below this it forms a capital, safe, and convenient light, and should prove very popular amongst amateurs.

CHAPTER VII.

Jets.

JETS may be divided into three broad divisions, the oxy-calcium, the blow-through, and the mixed, to which we have already referred (pp. 12 and 13, Figs. 7, 8, and 9). The various features which these jets possess in common have been considered; it only remains to discuss those points in which the types differ. The oxy-calcium, as being the simplest and the one which yields the least amount of light, will be first dealt with.

The oxy-calcium jet, as it is generally styled (Fig. 7), should be called more properly the oxygen-alcohol jet, since all limelight jets would reasonably come under the title oxy-calcium, meaning one employing oxygen and lime. This form of the limelight does not give anything like so much light as the blow-through jet, or still more as the mixed jet, but is nevertheless a simple and convenient illuminant, and one much more brilliant than any oil lamp. It consists of a cylindrical reservoir, from which a pipe leads to the front of the jet and terminates in an upright tube containing a cotton wick. Just behind this is the lime pin. The oxygen is supplied by means of a tube which is fixed under the reservoir, and which passes along close to the other tube and bends round in front of it, terminating in a nozzle. The reservoir is filled with methylated spirit, the wick-holder being filled with straight lengths of the loose cotton wick supplied for the purpose, which should not be packed too closely together, and the ends of which should stand out about a quarter of an inch above the top of the wick holder. A soft lime having been put upon the pin and the lamp lighted, when it is seen that the flame is burning properly, the oxygen can be turned slowly on until the best light is produced. With this, as indeed with all jets, it will be found that on turning on the oxygen there is a point beyond which the light, instead of getting more brilliant, positively decreases with the increase of oxygen. This is due to the rush of cold gas, more than is required for the purposes of combustion, which cools the flame. When, therefore, a jet is burning badly, it should be seen that it is not getting too much oxygen, nor, for the matter of that, too little either.

The form of the oxy-alcohol light, shown in Fig. 7, was designed by Mr. E. G. Wood, and is more elaborate than many oxy-calcium jets, but the principle in all is the same. In this case the lime is provided with a shield, which protects it from the currents of cold air in the lantern, and the wick chamber is annular or ring-shaped, the oxygen passing up the centre and being blown into the middle of the flame. This lime shield can be applied to any other form of limelight, and its use is advocated by some, who maintain that more light is obtained with than without it.

The blow-through jet is often spoken of as the "safety," and sometimes as the "separate," jet, because, as originally designed (shown diagrammatically in Fig. 29), the two gases being kept in separate tubes throughout and only mixed in the flame itself, by no mischance could either tube contain

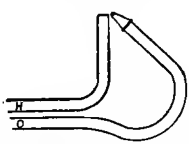

Fig. 29. EARLY FORM OF BLOW-THROUGH JET.

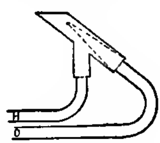

Fig. 30. BLOW-THROUGH JET.

a mixture of the two gases. Blow-through jets at the present time are usually constructed in the manner shown in Fig. 30, where it will be seen that the jet of oxygen is blown right into the middle of the coal-gas flame. Such a jet is as little likely to allow of any mixture in it as Fig. 29, but when the oxygen nozzle is withdrawn further into the jet, or, what comes to the same thing practically, when a nozzle is fitted to the jet, as shown in Fig. 31, the mixture of the gases is effected very much better, and the light emitted from the lime is proportionately increased, but a danger, or rather an inconvenience, is experienced. If in such a jet as Fig. 31 the oxygen be turned completely off, the coal gas will to a certain extent make its way into the oxygen tube, and when that gas is turned on again the mixture in that tube will cause a slight explosion or "pop," putting out the light and startling the audience, although nothing more serious will result. Such an occurrence can be prevented by turning the oxygen not quite but nearly off, so that just a faint blue bead in the flame indicates that it is still passing.

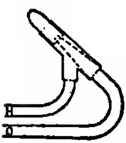

Fig. 31. BLOW-THROUGH JET WITH NOZZLE.

In this form of jet the coal gas or hydrogen is always in large excess of the oxygen, and the area of lime heated is much larger than with the mixed jet. On the other hand, a light powerful enough for everything but the largest displays can be obtained with a blow-through jet, together with an almost complete guarantee against mishap.

To use the blow-through jet, the lime should be adjusted about half an inch from the gas orifice, but not clamped there, and the hydrogen lighted and turned full on. (We might mention here that the hydrogen and oxygen pipes and taps should be distinguished both by colour and by having the words OXYGEN and HYDROGEN engraved on them, or, better still, the handles of the taps should be different in shape, telling the operator by the feel alone of which he has hold.) The oxygen must now be slowly turned on until any increase in its amount ceases to cause the light to increase. When no more light can be obtained by adjustment either of the hydrogen or oxygen, the lime should be moved slightly nearer to or further away from the jet until the position is found where the light is most brilliant. When this is ascertained, the holder should be clamped there once and for all. To turn the jet out, the oxygen should first be cut off, and then the hydrogen lowered.

As the jet plays upon the lime it gradually "pits" it, and the lime must from time to time be turned. Large wings of burning hydrogen should not be allowed to play each side of the lime, as such a course is wasteful, and they may be directed against the condenser and damage it; they also help to heat the lantern unnecessarily.

The mixed jet, which yields the most intense light of any, is shown in Fig. 9. As its name implies, the gases are mixed before being burnt at the nipple, and to this end the two tubes terminate in a chamber below the nipple itself. The nature and form of this chamber have been the subject of many and careful experiments by the Rev. Hardwich, Mr. Lewis Wright, and others, and the outcome of their work has resulted in the form shown in section in Fig. 32. The chamber, which is here shown, is filled up with a series of circular discs, each alternate disc having a central hole, and the others a ring of smaller perforations, the discs being separated by rings. These discs are shown by the side of the chamber in the figure. Such a chamber ensures the gases being most thoroughly mixed, and when burnt in this condition the most intense heat and consequent light is produced. As with the blow-through jet, the hydrogen should first be turned on and lit, then the oxygen added slowly until the best light is obtained. If the jet should roar, the gas should be regulated until it ceases to do so; with some jets this cannot be done. In this case the roaring is a sign that the gas passage in the nipple is not perfectly smooth, and this is best remedied by the maker. To extinguish the jet, the oxygen is first turned off and then the coal gas, the tubes on no account being detached until the light is out. Should

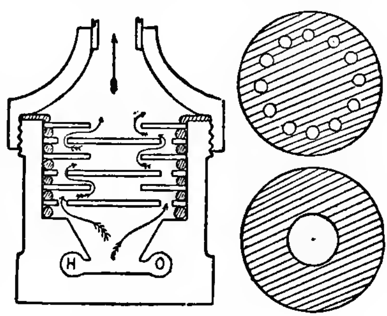

Fig. 32. MIXING CHAMBER.

anything go wrong, the oxygen should at once be turned off. The roaring may also be caused by the lime being at an unsuitable distance from the nozzle, or from it being pitted, in which cases the remedies are obvious.

It will be found that with this form of jet the lime will require turning nearly every minute; with a blow-through this is not so frequently necessary. The correct distance between the lime and the nozzle of a mixed jet is about one-eighth of an inch. It is possible to use a mixed jet with the coal gas supply drawn direct from the main, but it is not at all advisable to attempt this, two cylinders should invariably be used.

Mr. Pringle is the inventor of an attachment to the jet, in which in addition to the usual two taps two more are fitted in the middle of the gas tubes, actuated from the back of the lantern by means of a rod and bevel wheels. These taps being left open, and the jet adjusted in the usual manner, if it is required to turn it out for a little while, it can be done with the knob, which turns the oxygen completely off and leaves a little coal gas passing to keep the jet alight. When the light is wanted again the knob is turned back and the jet is once more burning properly without having to be readjusted, as would be the case had it been extinguished in the usual way by means of the taps used for adjustment. This "cut off," as it is called, is also handy for lowering the light a little when necessary, since both gases are cut off in proportion.

The form of mixing chamber shown in Fig. 32 does not answer when an ether saturator is used in place of coal gas, on account of the danger of a light passing back into the saturator and causing an explosion. For this purpose, therefore, a jet is employed in which the mixing chamber is packed with pumice or other material designed to act on the same principle as the gauze in the miner's Davy lamp, and to prevent any flame passing through it.

The mixed jet yields a much more concentrated spot of light than the blow-through—an advantage optically. This is due to the smallness of the flame, which cannot be increased with advantage. A feature of all jets is that by increasing the bore of the nipple the amount of light is not increased unless the pressure is greater also, and even then only within certain limits, a point being soon reached beyond which such increase becomes both wasteful and noisy.

It will be noticed that the jet plays upon the lime at an angle, and the amount of this angle affects to a great extent the amount of illumination. If the nozzle is at a very slight angle to the lime, that is, if it is nearly vertical, much of its heating power will be lost, if the angle is too great the shadow of the nozzle will be thrown upon the condenser.

CHAPTER VIII.

The Electric Light.

THE electric light has been applied to the lantern both in the form of the incandescent and of the arc lamp. In the former case, with a view to keep down the size of the light-emitting surface, a special type of incandescent lamp has been invented and supplied by the Edison Swan Co., which is shown in Fig. 33. In this it will be seen that the filament, as the little carbon thread which emits the light is termed, is in the form of a closely coiled helix. Such lamps are made usually either of 50 or 100 candle-power, and the light being very concentrated, as much can be got out of a 50 candle-power lamp of this kind as out of a very much more powerful petroleum lamp.

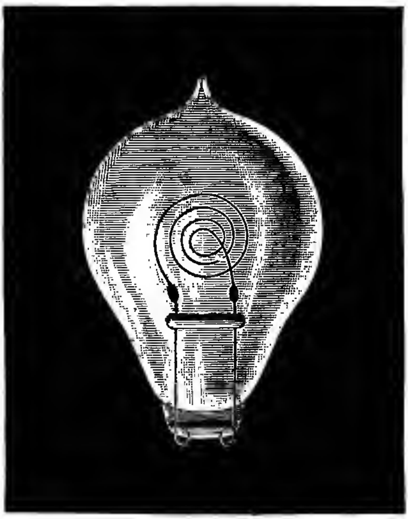

Fig. 33. INCANDESCENT LAMP FOR THE LANTERN.

Where a very intense light is desired, one of these lamps can be "overrun," that is to say, can be put on a circuit of greater pressure than that for which the lamp is intended. The light emitted increases in a very rapid ratio, and soon becomes as bright as any limelight jet, but the life of the lamp is much shortened, a new one being required much sooner than would otherwise be the case. This overrunning is most conveniently done by the use of what is known as a variable resistance, shown in Fig. 34. By moving the handle A to the right, the coils are gradually taken out of the

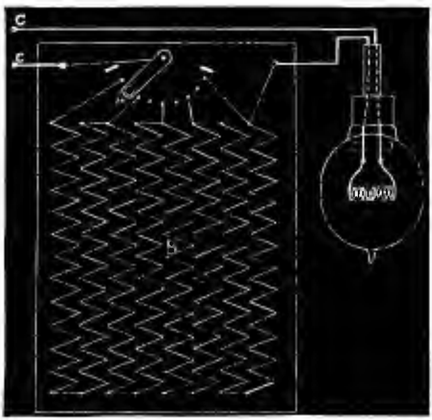

Fig. 34. DIAGRAM OF THE CONNECTIONS FOR INCANDESCENT LAMP AND VARIABLE RESISTANCE.

circuit, and in consequence more current passes through the lamp, with the result that the light emitted increases, becoming at the same time much whiter in colour. Neither this nor the arc light can be run except at a prohibitive cost from batteries, but where the current is laid on they are convenient.

A neat form of holder for these lamps is a plain socket in which slides a brass tube attached to the stem of the lamp, the lamp being held at any elevation, as shown in

Fig. 35, by the screw S. The holder shown in Fig. 35 should be secured by screws to a board cut to slide in the grooves in the lantern, so as to be readily centered. In Fig. 34 (a diagram of the connections for the incandescent lamp), the variable resistance, B, can be dispensed with if the lamp is only to be run at its normal brilliancy, in favour of a fixed resistance, or if the current is supplied at the pressure required by the lamp the resistance can be done away with altogether. The connections with the mains are shown at C C.

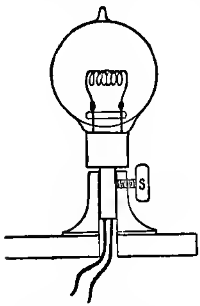

Fig. 35. Holder for Incandescent Lamp.

The arc lamp is, however, the form of electric light which seems peculiarly adapted for projection purposes, since it fulfils two important conditions, a most intense light with the smallest possible area. The arc lamp is so called because the light is caused by the current passing across an air space or arc between two carbon points, which are, by it, heated to a great brilliancy. The arc has first to be "struck," that is, the carbons must touch each other when the current is first switched on, and have then to be separated to the required distance to form the arc. As the light is emitted the carbons gradually burn away, the positive at about twice the rate of the negative; means have, in consequence, to be provided to keep their ends, or poles, at an uniform distance apart, so that the arc may be maintained.

Arc lamps may be divided into two classes, according to the way this uniform distance is maintained—automatic when the current itself actuates or regulates the "feed" of the carbons, and "hand fed" when this is done by the operator. Both kinds are made in a convenient form for the lantern, but as hand-fed lamps do not require much attention from the lanternist, who is, moreover, on the spot to give them that little, and as they are much cheaper and less likely to get out of order, they are to be preferred. Fig. 36 is a simple type of automatic lamp, the "Scissors," by

Borland, of Leeds, it is also made for hand feed ; several other patterns are on the market which space precludes us from describing. Of hand-fed lamps, that made by Messrs. Ross, Limited, of 111, New Bond Street, London, will be

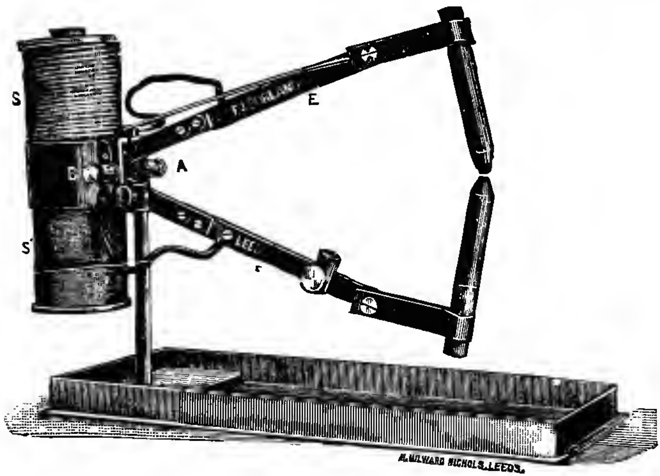

Fig. 36. The "Scissors" Automatic Arc Lamp.

found most satisfactory. It has all the adjustments necessary, and is shown in Fig. 37. The upper is the positive carbon, which is gradually fed down by the large milled nut seen at the back of the lamp, the lower carbon at the same time being brought up to meet it.

To get the best light the end of the negative carbon should be a little nearer the condenser than the other, and the arc should not be too long. If too long, a flame will be seen to play round it; if too short, it will probably "sing." When the carbons have burned for a little time it will be seen that while the negative has come to a rounded point in shape, the positive has a little bowl or crater at its end, and it is from the inside of this crater that the most intense light is emitted. It is for this reason that the arc lamp for lantern purposes generally has its carbons out of the vertical and the negative carbon slightly in front of the other, since by such an arrangement the crater becomes, as it were, tipped on one side, so as to present its interior towards the condenser. This will be best seen from Fig. 38, in which A is the positive, B the negative carbon, C the crater, and D the condenser. When the current supplied is not continuous, but alternating, it will not be found so convenient for lantern purposes —the lamp will sing, and no crater will be formed; it is not, therefore, in such a case necessary to distinguish

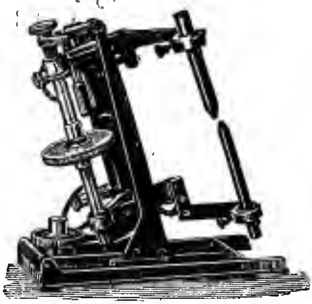

Fig. 37. Ross Electric Arc Lamp.

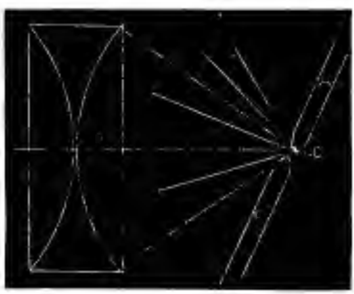

Fig. 38. The Electric Arc.

between positive and negative carbons, the current rapidly alternating from positive to negative and back again.

Carbons are sold in various sizes, known by their diameter in millimetres, and are either solid or cored, the latter containing a core or pith, as it were, of a carbon softer than the outside. The positive carbon should be cored, the negative solid. In getting carbons for lantern purposes, the best quality, not necessarily the highest priced, should be obtained, since they are not an expensive item, and the regular and quiet burning of the lamp and absence of sputtering depend upon their quality. Excentrically cored carbons have been lately introduced for work on alternating current circuits.

With arc lamps, what is called a resistance has to be employed. This is generally a series of coils of *platinoid*

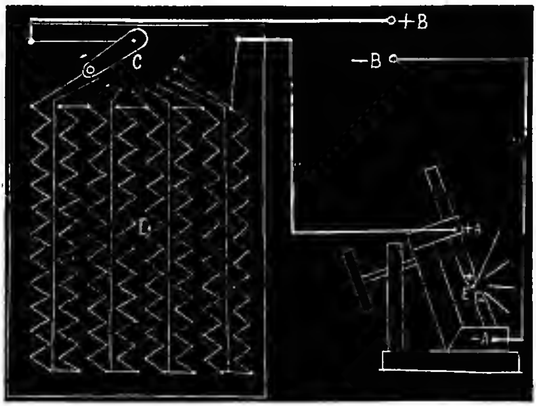

Fig. 39. DIAGRAM OF THE CONNECTIONS FOR AN ARC LAMP.

or *manganin* wire, through which, as well as through the lamp, the current passes. The size of the resistance must depend on the pressure of the current supplied, and for this purpose an electrician should be consulted. Fig. 39 shows the way the switch and resistance should be connected up ; it is immaterial whether the resistance is interposed between the negative or the positive terminal and the lamp. In the figure, the positive and negative terminals of the lamp are marked + A and —A respectively, the current is taken from the two terminals + B and —B ; C is the switch, D the resistance, and E the arc. A variable resistance is shown in the figure, but if a suitable amount of resistance is introduced, the power of varying it is not required, at any rate, under ordinary circumstances.

The most suitable wires for use with the lantern are what are known as twin silk-covered flexible, in which the two are insulated with rubber and silk, and twisted together. Each main wire or lead is made up of a bundle of fine wires to give the whole flexibility; for the lamps usually employed in the lantern, each lead should have a carrying capacity equal to a solid wire of 4 B.W.G.

CHAPTER IX.

The Lantern Body.

THE various illuminants for use in the lantern having been considered, the body of the lantern, which is required to cut off all stray light which would otherwise reach the screen or the eyes of the audience, and which serves to hold the various parts in their relative positions, next demands attention.

In the case of oil lamps, the body is sometimes a part and parcel of the lamp itself, but more often is a metal case in which the lamp slides. The best material for the purpose is Russian iron for the box portion, A B, Fig. 1, and brass for the tubes H H, which carry the lens. In many of the more modern forms of lamp the lamp itself carries its chimney, which emerges through a hole in the top of the lantern, and the body of the lantern is brought down nearer to the lamp and so made more compact. For dissolving views with petroleum lamps, the two lanterns are placed side by side. The better class of instruments in which oil lamps are used, have bodies made of mahogany with brass fronts, and are fitted so that the lamp can be drawn out, and the usual tray and jet substituted when limelight is required. In such a case the lantern should have an inner lining of iron separated from the woodwork by an air space, to prevent the wood from getting hot.

Lanterns for limelight and for the electric arc should always be made in this way. They should be provided with a door on both sides as well as an opening at the back by which to introduce the illuminant, and a curtain should hang loosely round the back of the lantern, and cut off the stray light which would otherwise escape thence into the room. The doors are usually provided with a little window glazed with red or blue glass, so that the working of the lamp can be observed. These windows are not of much use, most operators preferring to look at the naked light itself, but they might be made more suitable by being both larger and glazed with, say, a deep red and blue, or a very dark neutral-tinted glass. This becomes a necessity with the arc lamp, which cannot be watched through the usual windows at all. With the arc lamp care must be used that at no time either carbon holder or other part conveying current is brought into contact with the metal lining of the lantern body.

The base of the lantern is best a perfectly flat board, with an arrangement such as that shown in Fig 40, by which the entire apparatus can be tilted up or down. The base should be stood for use upon an equally flat surface, bearing in mind that the slightest motion of the lantern will be enormously magnified upon the screen.

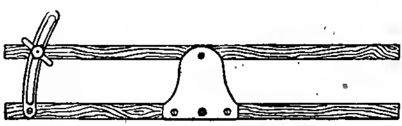

Fig. 40. TILTING STAND FOR THE LANTERN.

The holes by which air is admitted to the lantern are best placed at the bottom of each side, and with oil lamps especially should be of ample size, and must be seen to be perfectly free. Nothing helps so much to keep a lantern cool and in the best working order as a regular and ample current of air passing right up through it, but not a draught or irregular one which may endanger the condenser.

For all ordinary purposes a single lantern is sufficient. It is much the easiest to work, has less to get out of order, and is less expensive both in prime cost and in working. For photographic slides, for enlarging, and for scientific demonstrations it is all that is required. When. however, that gradual melting of one picture into another known as dissolving is desired, two lanterns, which when placed one above the other are known as a biunial (Fig 41), are necessary. The dissolving is effected with limelight by turning one jet down and the other up, with lamps, by moving a notched screen before one of the lanterns and simultaneously remov-

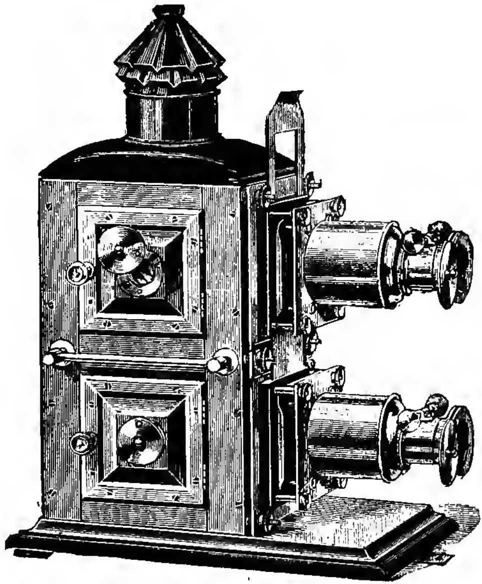

Fig. 41. A BIUNIAL LANTERN.

ing a similar screen from the other; as shown in Fig. 42, A A being the objectives of the two lanterns. For what are called *effects*, in which sunlight fades into moonlight, buildings are illuminated, curtains roll up or down to display or cover up the picture, and similar things, two, and often three lanterns are employed, the latter being known as a triunial. Much work is often lavished on these structures, in the shape of bright brass rods and fittings, rendering them most costly luxuries; but essentially they should consist of three lanterns, each possessing in itself the most desirable features of an efficient single lantern, the only really necessary *extra* being in the case of the limelight, which is invariably employed with them, a dissolver or tap for simultaneously lowering one light and raising the other. They should be so built that one lantern can be separated from the rest and used by itself when necessary. The fronts of these must, moreover, be fitted in such a manner that they can be inclined one to the other, and so adjusted that the picture shown by each lantern falls in exactly the same place upon the screen.

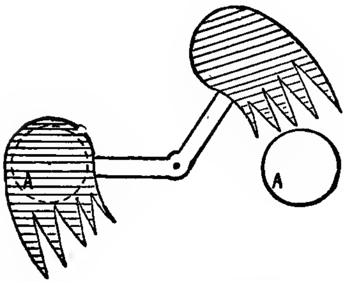

Fig. 42. Dissolver for Oil Lamps.

The lantern front should consist of a stout brass plate securely clamped to the woodwork by its four corners, carrying on one side of itself the condenser and on the other the receptacle for the slides or for the slide-carrier, and a telescopic tube which bears at its end the objective. Immediately in front of the condenser is a gap, open at both sides and sometimes at the top, in which the slide to be shown is inserted. Slides are used in two forms, the slide pure and simple, Fig. 43, composed of two glasses, each $3\frac{1}{4}$ inch by $3\frac{1}{4}$ inch, bound together by their edges, or this slide is mounted in a wooden frame, Fig. 44. In the latter case it is held in the lantern by two springs, one of which is shown in Fig. 1, which press it up against the lantern front. To show dissolving views and effect slides properly, they should always be mounted, and a brass runner with a stop inserted in the gap of the lantern. The mount must then be carefully adjusted, so that when the

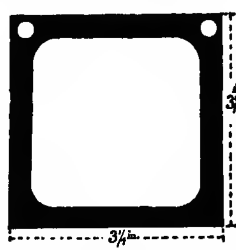

Fig. 43.
An Unframed Slide, Spotted.

mounted slide is inserted and pushed right up to the stop, the picture is exactly in the required position on the screen.

The unmounted slides are held in what is called a carrier, of which there are many patterns. The simplest

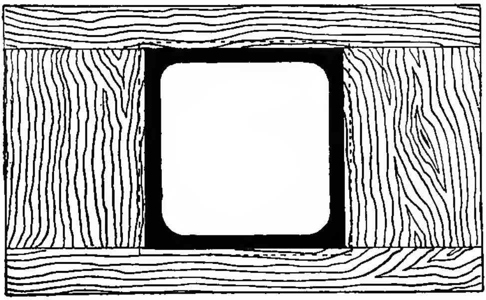

Fig. 44. A Framed Slide.

form of carrier is shown in Fig. 45. This consists of two horizontal strips of wood held apart by two vertical pieces; on the inner sides of the longer pieces are

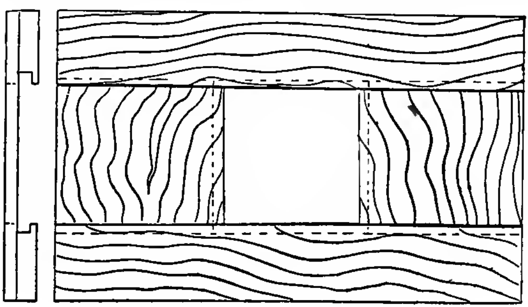

Fig. 45. Simple Form of Carrier.

grooves along which a slide $3\frac{1}{4} \times 3\frac{1}{4}$ will slip. This form has been improved by making the length of it such that on pushing a second slide in until the finger is stopped by the wood of the carrier, the first slide is in the centre of the opening. In some forms the grooves are bigger, and a frame holding two slides can be pushed backwards and forwards as shown in Fig. 46. This has the drawback that the slides are inserted and taken out from alternate sides of the lantern. In the simpler pattern the slides are put in at one side and taken out at the other, a more convenient method, but still not so good as one by which they are manipulated entirely from one side. This is the case with the Eclipse carrier, one of the most ingenious devices of the many which lanternists owe to Mr. R. R. Beard. The Eclipse carrier, which is shown in Fig. 47, consists of a frame with a brass runner carrying the slide. The runner being pulled out, the slide is put on it and pushed into the lantern, after which the runner

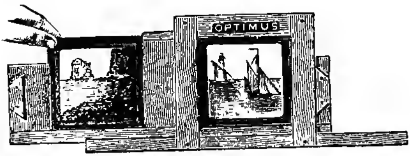

Fig. 46. A SLIDE CARRIER.

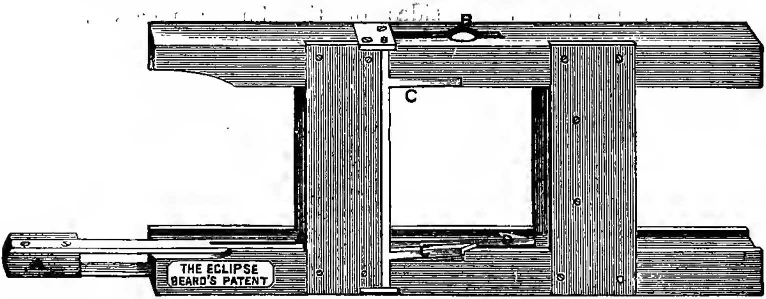

Fig. 47. THE ECLIPSE CARRIER.

is again withdrawn and a second slide inserted. On pushing this into position, it is superimposed on the first, so that the two pictures are seen mixed up on the screen, the first being withdrawn on pulling the runner out once more to put the next slide in, when the second springs up into the exact position occupied by the first, with a little click. The means by which this is effected is extremely simple, and the only drawback the carrier possesses is one in common more or less with all others—that it does not deal well with slides which vary much in thickness. This difficulty has been surmounted in one form of the carrier shown in Fig. 45, by the introduction of two springs which keep the slides pressed up against one side of the groove, and so prevent one slide overlapping the other when pushed through, the grooves being made sufficiently wide to accommodate the thickest glass likely to be met with; this is due to Mr. Chadwick.

Other forms of carrier are those in which the slides are actuated by a tape travelling over pulleys; those having a shutter which cuts off all light while changing a slide; a third variety made by Messrs. Archer, of Liverpool, has a screen of matt celluloid by which the picture is partially obscured during changing, which is done by one movement of a lever.

A carrier, although apparently a simple and unimportant part of the lantern outfit, is, as regards the smoothness and success of an exhibition, one of the most vital spots. A case occurs to us where the regularity of a display was ruined while the operator was engaged in extracting a slide stuck in the carrier in consequence of a piece of its binding having become loosened. In the presence of an audience such a mishap should be impossible, the slides should pass through in an even and unbroken succession. To secure this, nothing is so effectual as the simple push-through carrier, shown in Fig. 45, provided it has springs as mentioned, and provided that the groove at the bottom is just so deep that the centre of a $3\frac{1}{4} \times 3\frac{1}{4}$ slide comes in the centre of the opening, the top groove being fully one-eighth deeper than this. When this is the case, slides of varying thickness and height can be passed through without any overlapping, and without the smaller slides falling backward or forward or the bigger ones jamming.

A point generally neglected, but in the case of a public display a great safeguard against accident, is the provision of some arrangement by which the slide in the carrier, just before it is passed into the lantern, can be seen, so that the operator may be able to tell by a glance whether it is in the proper position. Slides, for a reason to be given hereafter, have to be inserted upside down, and as the most careful lanternists are but mortal, a time is sure to come when a slide gets in the right way up, and the picture on the screen is upside down, a fact which is first conveyed to the attention of the lanternist by the sight of the screen. This could very well be guarded against by some arrangement by which the slide can be seen in position, but before it enters the lantern.

The tube which carries the objective should be provided with at least one telescope joint, so that lenses of different focus can be used. As a rule the tubes are made to suit lenses of about 6-in. focus, but should certainly be able to carry a 9- or even a 12-in. lens. The draw motion should be smooth, but not too easy, the lens being held with sufficient firmness to admit of final focussing with the rack and pinion with which it is provided, without the slightest motion of one tube in the other.

On the design of the lantern body depends to a great extent its portability. The usual form is not a particularly

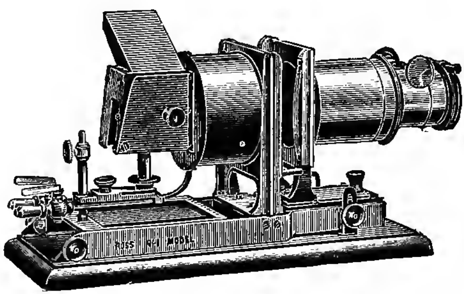

Fig. 48. The Ross Limelight Lantern.

portable one, but with a little modification this desirable feature can be largely introduced; the popularity and convenience of the limelight having led to a very great decrease in the size and cumbersomeness of lanterns. This is seen to its greatest extent in Fig. 48, which represents

Ross' new Limelight Lantern, in which a number of novel features of considerable ingenuity are introduced. The lantern body in this pattern is reduced to the very smallest compass, and the whole apparatus is very rigid. It has the advantage, too, that a biunial can easily be constructed by the very simple plan of putting one lantern on the top of another, nothing further being required beyond a few simple fittings to connect them and the dissolving taps. There are other patterns obtainable also, in which compactness has been carried almost, if not quite, as far as in this, and with no loss of efficiency.

CHAPTER X.

The Optical System.

We have considered the light and the mechanical portions of a lantern, and have intentionally reserved the most important part of all—*i.e.*, the lenses by which the image of the slide is thrown upon the screen, until last. The optical system consists of the condenser, the function of which is not to *condense* the light upon the slide, but to divert the rays from the lamp so that the margins of the slide as well as the centre shall be illuminated by rays which can reach the objective, and the latter itself which is used to secure a sharp and brilliant picture.

That the purpose of the condenser is really what we have said can be seen on reference to Fig. 49, in which are

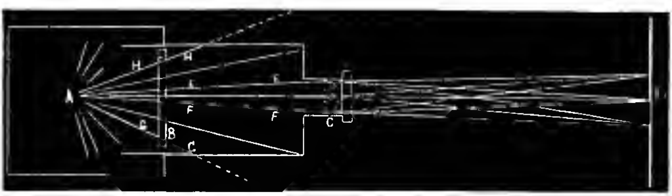

Fig. 49. Diagram showing the Lantern, but without Condensers.

sketched the arrangements of a lantern and screen minus the condenser. It is evident, since light under ordinary conditions travels in straight lines, that the only direct light which can fall on the screen D from the light A, will be that enclosed by the lines EE and FF passing through the centre of the slide B. The rays G G H H which reach the edge of the slide would, if allowed by the tube of the lens, travel as indicated by the dotted lines. In Fig. 50 we have the same

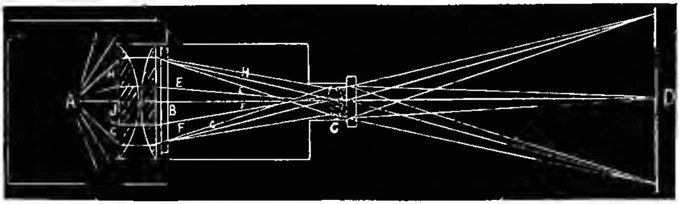

Fig. 50. DIAGRAM SHOWING THE FUNCTION OF THE CONDENSER.

arrangement again, but in this case the condenser, J, has been introduced. The effect is not to condense any greater amount of light upon the centre of the slide, but to bend down, as it were, the rays G G H H, so that they not only pass through the slide but reach the objective. It will also be obvious from this that it is important that the focus of the

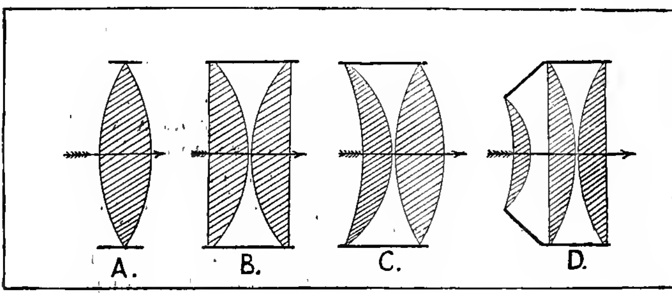

Fig. 51. CONDENSERS.

condenser for the rays from the light shall be somewhere about the position C of the objective.

Condensers in the simplest form are merely double convex lenses, as shown in A (Fig. 51.) These are never to be met with now except in toy lanterns, and have been supplanted by the form shown in B, in which two lenses are employed, both with one convex and one plain surface, the convex sides facing one another, and almost in contact. This is an excellent form of condenser for all ordinary purposes, if well made, and is met with far more often than any other pattern. At C is another very good condenser known as Herschel's, which is also often fitted to lanterns, and answers in practice as well as B; it is often made with the meniscus or concavo-convex lens a little smaller than the other, and the double convex lens has its inner curve flattened, in which form it is known as Gravett's. D is one of the forms suggested for a triple condenser, or one made of three lenses. Of these forms the triple is unquestionably the best, getting nearer to the light, and therefore (see Fig. 52) transmitting more of it through the slide.

It will be seen from Fig. 52 that the amount of light which falls upon a condenser, and which may be roughly considered as the amount available for illuminating the slide, depends upon the diameter of the condenser and the distance at which it must be from the lamp, for it is obvious that a condenser at A would receive more light than one of the same size at B, since in the first case not only will the rays E E F F fall upon it which fell upon B, but it will embrace G G H H. Certain practical considerations, particularly the danger of having the thick glass of a lens too near the light and the consequent heat, prevent the general use of condensers of such a size and focus as to make the angle at C more than about 70 degrees.

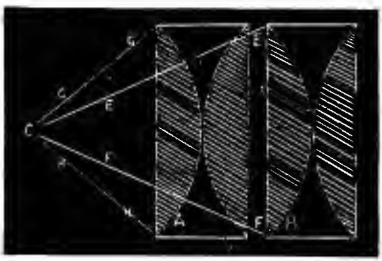

Fig. 52.
DIAGRAM TO SHOW THAT THE NEARER THE CONDENSER IS TO THE SOURCE OF LIGHT, THE MORE LIGHT IT RECEIVES.

For the usual photographic slide with a circular mask a condenser of 4 inches diameter will be found large enough, but if slides with very large masks with square corners are to be shown, such a size will not be found sufficient, and a 4½ inch will be wanted. In getting a condenser, two points should have attention: the glasses should be mounted quite loosely in their brass rings so as to rattle when shaken, if not, when expanded with the heat of the lamp they will most likely break, and the lenses themselves should be as thin as possible at their edges. The slide should be as near to the condenser as the carrier will allow. For photographic enlarging, condensers will be required of a size dependent upon that of the negative from which the enlargement is to be made; for good illumination its diameter should be at least an inch longer than the diagonal of the negative.

The objective for projection purposes is, in the cheapest lanterns, what is called a plano-convex (A, Fig. 53), or a meniscus (B and C), but these are not at all to be desired,

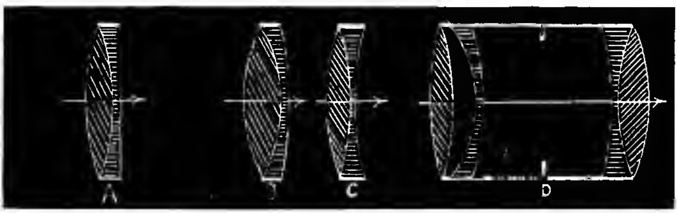

Fig. 53. Lantern Objectives.

especially in those of short focus; for anything over 10 inches they are frequently very satisfactory. With the introduction of the rapid modern dry-plate in photography, however, the necessity for the very "quick" lenses for portraiture has largely disappeared, and portrait lenses as used by photographers answer all the requirements of the average lanternist admirably, and are frequently to be met with at a very low price. This lens, shown diagrammatically in Fig. 53, D, was the invention of Professor Petzval; and it or its modifications in the hands of Dallmeyer are excellent for projection. Several opticians now make special lantern lenses, based more or less upon this pattern, one or two of which we have used at one time or another with satisfaction. This type not only allows a large amount of light to pass, but it also possesses a very flat field, a quality the nature of which must be explained.

The function of the objective can be seen from Fig. 53A, where the paths of three of the rays from the lowest part of the slide only are shown, to avoid confusion, coming to a focus on the screen at G. With many lenses the rays which pass through the centre of the slide would not under such circumstances come to a focus also upon the screen, but at some point further off than it, say at H. The further the rays from the centre, the nearer to the lantern would be the point at which they will come to a focus; in fact, to obtain a perfectly sharp picture with such a lens, the screen itself would have to be concave, like the inside of a saucer. Such a lens would be said to have a curved field, and a lens free from this defect a flat field. In selecting a lens for use in the lantern it should always be tried in the lantern itself, and a

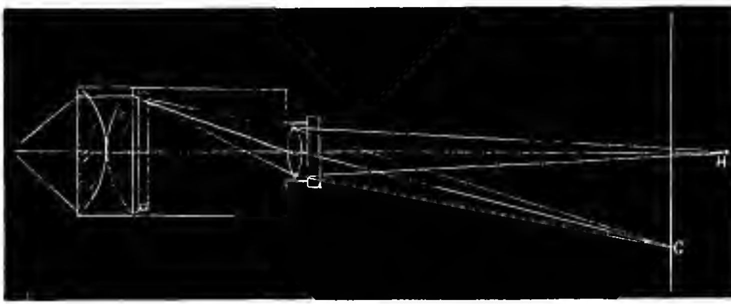

Fig. 53A. DIAGRAM TO ILLUSTRATE THE FUNCTION OF THE OBJECTIVE.

slide should be used of such a kind as to give a good idea of the defining power of the lens or its capability of reproducing on the screen the details of the slide with sharpness. As good a test slide as any for the purpose is made by enclosing a piece of open muslin or fine net between a couple of glasses $3\frac{1}{4}$ by $3\frac{1}{4}$ and binding it up like an ordinary lantern slide. Such a subject put in the carrier and focussed as sharply as possible will give an excellent idea of the powers of the objective.

Another matter of great importance is the focal length of the objective, since upon this depends the position of the lantern and screen for a given size of disc. Perhaps the most useful length is 6 in., which has the advantage of being that of a large number of the portrait lenses which are so suitable for the purpose. The effect of the focal length of the lens on the size of the disc is best expressed by saying that, with the lantern and screen in any one position, the shorter the focus of the objective the bigger the disc, and *vice versâ*, the difference in diameter being in exact proportion to their focus; thus a lens of 12-in. focus gives a disc just half the size of that obtained with a lens of 6-in. focus at the same distance. It follows, of course, from this that to obtain always the same size of disc on the screen, the further the lantern is from the screen the longer the focus of the lens necessary. The 12-in. lens above mentioned would give, with a distance of 24 feet between the lantern and screen, a disc the same size as would be obtained with the 6-in. objective at 12 feet distance.

To ascertain the focus of a lens in inches required to get a given size of disc at a given distance off, the distance in feet must be multiplied by three* and divided by the diameter of the disc in feet. Thus—What lens is required to give a 15-ft. disc at a distance of 40 feet? Multiplying 40 by 3 we get 120, which, divided by 15 gives us 8. The lens, required is therefore one of 8-in. focus.

This rule may be reversed to find out the size of disc which would be obtained—that is to say, by multiplying the distance in feet by 3* and dividing by the focus of the lens in inches. For example: we have a 6-in. lens, how large will the disc be at a distance of 50 feet? Multiplying 50 by 3 we get 150, and dividing by 6 the result tells us the disc will be 25 feet in diameter.

In the same way, to discover the distance at which the lantern must be placed to give a disc of a given size with a given lens, the diameter of the disc in feet is multiplied by the focus of the lens in inches and divided by three.* We need hardly give another example.

* Three is taken as the effective diameter of the ordinary slide. If slides are used of any other size the diameter of their opening in inches must be substituted for "three" in the calculations.

For those who do not care to calculate out for themselves, the following table, abridged from Mr. Lewis Wright's standard work on optical projection, is given. The table is calculated for slides of the usual size.

Diameter of disc in feet.	Focus $4\frac{1}{2}$ inches.	Focus 6 inches.	Focus 8 inches.	Focus 10 inches.	Focus 11 inches.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
9	13 6	18 0	24 0	30 0	36 0
12	18 0	24 0	32 0	40 0	48 0
15	22 6	30 0	40 0	50 0	60 0
18	27 0	36 0	48 0	60 0	72 0
20	30 0	40 0	53 4	66 8	80 0

Before leaving the subject of the lenses, a word on their proper preservation can hardly be out of place. They are best kept out of the lantern itself except when required for use. The condenser should immediately before use be dusted with a clean, soft handkerchief, as also should the objective. In unscrewing the lenses of the latter, care should be used to take only one out at a time, and to make sure it is screwed into its proper place before removing the other. In dusting them, they should be *dusted*, and not breathed on, scrubbed, and polished as if they were the knob of a door. It is a good plan, whenever possible, to get the condensers warmed a little before putting them into the lantern for use.

CHAPTER XI.

The Screen and General Arrangements.

Given a lantern of first-class power, good slides, and plenty of gas, the brilliancy of the display can be made or marred by the nature of the screen itself upon which the pictures are thrown.

One arrangement of lantern screen and audience is that shown in Fig. 54, the dots representing the audience. In this case the screen should be as opaque as possible; since it is wanted to reflect as much as possible of the light falling upon it; in fact, the finest screen imaginable under these circumstances consists of a smooth plaster wall well white-washed. This is not often obtainable, and the lanternist has to put up with a substitute, in the form generally of some kind of sheeting. When this is the case the stouter and whiter the sheet the better, since it will reflect more light. If it must have any seams in it they should run horizontally rather than vertically, and will probably show their presence, and, incidentally, the advantage of an opaque screen, by appearing whiter and more brilliant than the rest. The size of the screen and its position depend largely upon circumstances. It should on no account be hung too high; nothing is more unpleasant than craning back the neck for some time to gaze at a sheet right above one's head; for this reason it should be as far in front of the audience as possible.

Screens are also made of canvas faced with a glossy-white, surfaced paper. These cannot be folded, and consequently are not so portable in large sizes, and are more expensive.

They will roll up into a fairly small compass, however, and give a better result than can be obtained with any sheet; moreover, they do not want stretching, but merely to be hung from their roller with a weighted rod along the bottom. In large sizes, such screens have a tendency to bend, the edges

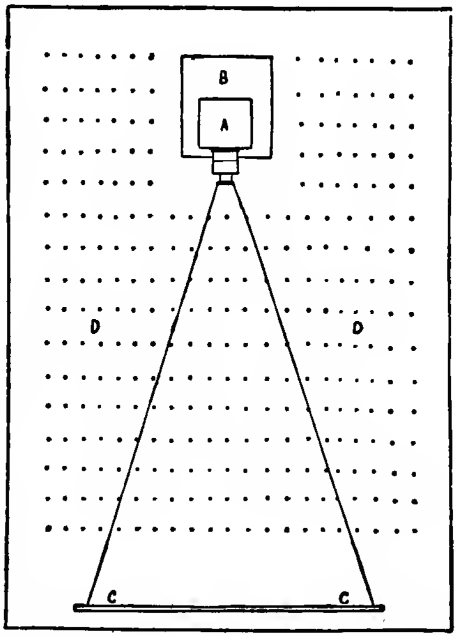

Fig. 54. ARRANGEMENT OF LANTERN, AUDIENCE, AND OPAQUE SCREEN.

stretching more than the centre, which after a time may render them almost useless.

In spite of its many drawbacks, therefore, the sheet remains the sheet anchor of the lanternist, possessing, as it does, portability together with an excellent flat surface and a fair amount of reflecting power. It should be provided with rings or eyelets, which must be securely stitched to its edges every foot apart, by which it is hung and stretched.

A frame is the most generally useful means of stretching a small sheet, say one not exceeding 8 feet square, but above this size the frame, no matter how much it may take to pieces for packing up and carrying, is a bulky affair, and it is better to rely upon ropes. The method of stretching the sheet with ropes is shown in Fig. 55, in which A is the sheet suspended from its two top corners by the rope B B, which passes over two pulleys in the ceiling (which must be further apart than the width of the sheet itself), and thence is fastened to the floor. Stout string is then tied to the top corners and laced backwards and forwards through the holes

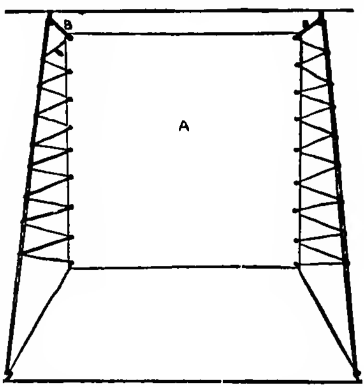

Fig. 55. METHOD OF LACING UP LANTERN SCREEN.

in the sheet and round the rope until the bottom corners are reached, from whence the string must pass to the floor as shown. While it is important to stretch the sheet sufficiently to make its surface quite flat, more tension than is necessary to effect this must not be employed, or, no matter how well the eyelet holes are stitched to the sheet, they will soon become loosened and tear off, bringing, it is most likely, some of the sheet with them. The method of lacing described may also be applied with advantage to the stretching of a sheet on a frame, allowing, as it does, each side of the sheet to be fastened with one piece of string and a single knot.

The arrangement of lantern and screen just described is most suitable for a large audience, where a disc of several feet in diameter is desired; to show slides to twenty or thirty people, a far more convenient plan, and one which will give in general more satisfaction, is that of Fig. 56. Here the screen is between the audience and the lantern, and should be on a much smaller scale to give the best effect. In many private houses are to be found two rooms separated by folding doors (Fig. 56) F F. Such a place is admirably suited for this arrangement, the spectators occupying one room, the lantern the other, and the screen being placed in the opening of the doors. A thin sheet, especially if wetted, makes a good screen for this purpose, but one much better in every way, if its size is not considered a drawback, can be made of tracing paper or cloth. This can be obtained in 5-ft. widths, possibly larger, and is easily stretched and fastened over a light wooden frame with drawing pins. With an oil lantern with a disc of about 4 ft. 6 in. in diameter on such a screen a result of the most brilliant nature is obtained, and the slides are seen to much greater advantage than they would be if shown reflected on an ordinary sheet with twice that amount of enlargement.

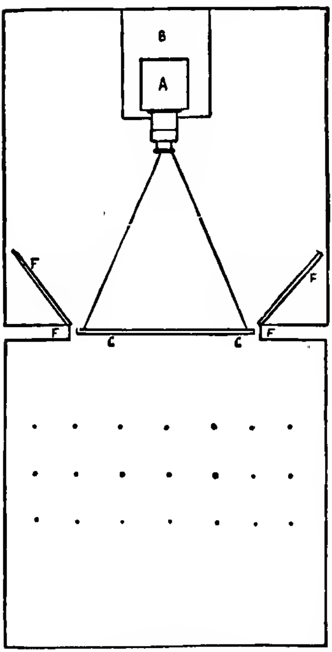

Fig. 56.
ARRANGEMENT OF LANTERN, AUDIENCE, AND TRANSLUCENT SCREEN.

A method of displaying slides for advertising purposes we have seen carried out with great success is shown in Fig. 57. The lantern, A, in this case is inside a room, the window of which, freed from sash frames and bars, is occupied by a blind of tracing cloth, B, which can be drawn down for the occasion, the fittings being those of the ordinary roller blind, C C. The screen is protected by a weather-board, D. The slides are alternately photographs of stage and other beauties, and subjects more immediately connected with the wares of the firm employing the lantern. For such a purpose a blow-through or oxy-calcium jet gives ample illumination; in fact, excellent results can be got with

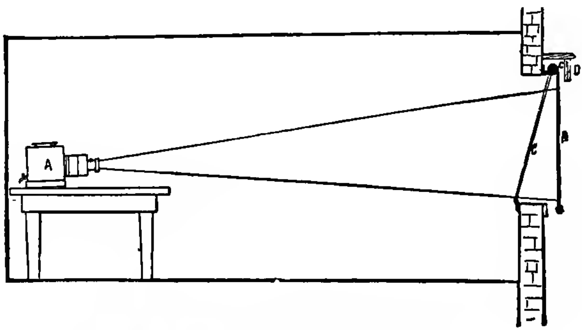

Fig. 57. LANTERN USED FOR ADVERTISING.

the use of a good petroleum lamp. If the window looks out on to a street brightly lit with the electric light, the direct light from the lamp-posts must be cut off, or the light in the lantern considerably increased, if brilliant results are wanted.

For teaching purposes, a large sheet of plain white card-board, or a sheet of drawing paper stretched on a board with drawing pins, makes a convenient screen for a small class. The smaller the screen the brighter the light, and in consequence, the less need there is to darken the class-room. For many purposes it will be found that all that is necessary is to stand the screen where the direct light from the window does not fall upon it, for the diagrams, etc., which would be the class of subject oftenest shown under such conditions, to be easily visible in daylight.

A detail which may be mentioned here is that of the means of communication between the lanternist and lecturer when separated in a large hall. Some people use an electric bell, some a reading lamp with a little red glass window which can be uncovered, others an ordinary bell, or they give a slight tap to indicate when another slide is wanted. Any of these methods can be employed, but it is advisable, when possible, to use one which shall not attract the attention of the audience; for this reason an electric bell, without the bell itself, giving, therefore, a slight buzzing sound instead of a ring, will be found best.

Owing to various accidents, the London County Council turned their attention to the use of the limelight in places of public entertainment, and laid down a number of regulations, the most important of which runs :—"That proper "tanks be provided, placed in ventilated, brick-built cham-"bers, fitted with iron doors and frames; that the hydrogen "and oxygen gases be placed in separate chambers; that "the screws to the holders of each gas be of different "diameters; and that flexible iron tubing with screw con-"nections be used." There are a number of very stringent rules applying to kinematograph exhibitions, which vary considerably with different local authorities. They should always be ascertained beforehand in the case of public shows.

The regulations themselves, in the opinion of most experts, are anything but satisfactory, that which insists upon the use of flexible *iron* tubing in place of india-rubber being positively dangerous if fully acted upon. That clause dealing with the screws of the gas holders is a wise precaution, and is now universally adopted; and it is no doubt an excellent thing to have the gas cylinders outside the place of meeting. On the other hand, insistence upon the storage of oxygen, even when in a pneumatic holder, in "ventilated, brick-built," etc., is vexatious, when it is remembered that the gas in such a form is perfectly harmless. Still, those who use the limelight in public, within the jurisdiction of the London County Council, have got to submit to the regulations until they are amended, and had better, therefore, know exactly what it is they require.

CHAPTER XII.

The Manipulation of the Lantern.

WHEN the screen and lantern have been erected in their proper positions, the adjustment of the one to the other has to be taken in hand.

The first point to receive attention should be that the position of the screen is such that it is exactly at right

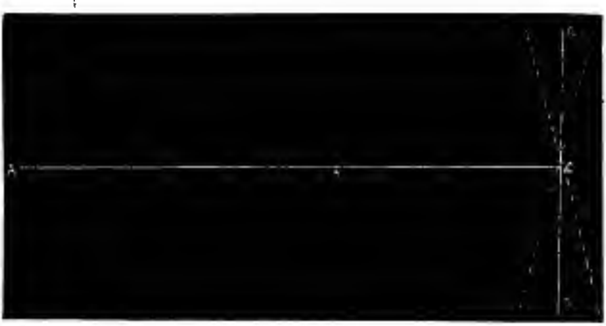

Fig. 58. DIAGRAM SHOWING THE CORRECT POSITION OF THE SCREEN.

angles to the axis of the lantern. This is shown in Fig. 58, in which A C is the axis of the lantern, that is, an imaginary line drawn from the centre of the condenser, through the centre of the objective, meeting the screen B B at the point C; the angles B C A should all be right angles. If they are not—that is, if the screen has the position indicated by one or other of the dotted lines, the pictures thrown upon it will be distorted. It will be seen from this that if the lantern is tipped up or down the screen must not be vertical. The same remarks apply with equal force to the turning of the lantern to one side or the other.

Having seen about this, the lantern can be lit up, when, if limelight is to be used, the light will have to be centred, that is, adjusted until the brightest part of the lime is in the axis of the lantern, and is also at the focus of the condenser. (Oil lamps are not provided with a means of centering the light, as its position is invariable, and is or

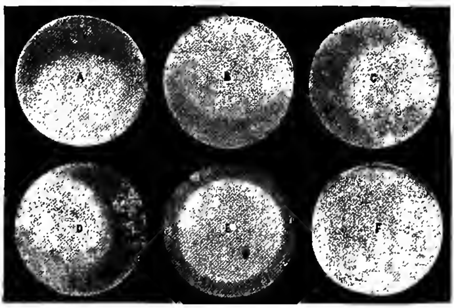

Fig. 59. PHOTOGRAPHS OF THE SCREEN WITH THE JET IN AND OUT OF POSITION.

should be adjusted by the maker.) To do this, the jet having been lit and the oxygen turned on, a slide must be put into the lantern, and disregarding for the moment whether its illumination is even or not, focussed upon the screen, after which it can be taken out without disturbing the focussing. The chances are that the circle of light upon the sheet will now resemble either A, B, C, D, or E, Fig. 59, which indicate respectively that the light is too high (A), too low (B), too much to the right (C), or to the left (D). This must be corrected by slackening the screw which holds the jet in position on the tray pin, and finally clamping it again when the disc presents the appearance denoted by E. When this is the case, the light is *centred*, and must then be adjusted as regards its distance from the condenser. This is done by sliding tray and all in the grooves of the lantern until the disc is evenly and brightly illuminated all over (F); the correct position is easily found. The carrier should then be adjusted so that its opening occupies the centre of this disc, and if it can be clamped in that position when found, so much the better. This being done, it is useful to put a slide once more into the carrier, and with the rack and pinion motion of the lens midway, *i.e.*, neither fully in nor fully out, to focus it with the sliding adjustment only. If this is not done, it may be found that it is impossible to focus each slide sharply with the rack and pinion because it is at the end of its travel.

The slides demand the next attention. If practicable it will be found an excellent plan to tie them up in a paper parcel and put them in a warm oven for a short time. If this cannot be done they may be warmed by being placed in an open grooved box before the fire, or even allowed to remain, separated, in a warm room for a little while. Unless this is done, there will be a great likelihood in the intense heat of the limelight or electric light of the deposition of moisture on the cold slide when put into the lantern. The slides when this is the case are said to "sweat," it is painfully obvious on the screen, and will spoil completely an exhibition which is in all other respects first-class.

The slides must be arranged in the order in which they are required. For this purpose they are often kept in grooved boxes, but this way may lead to mistakes. The most careful lanternist may have his attention distracted for a moment, and in the obscurity may take a slide from any part of the box instead of the next in order, and so get them disarranged and make one of those slight but annoying hitches which mar what should be the regularity which leads to success. For this reason we prefer to have the slides piled up in stacks of about thirty, only one of which shall be within reach at a time, there is then no possibility that any slide but the next in order can be picked up by accident.

Another important detail is the proper marking of the slides. There has been for many years every possible diversity in this respect, but it is now getting customary for slides to be marked on the lines laid down by the Photographic Club a few years ago, this should always be done. The marking consists of indicating the two top corners of the slide by two spots, which are best white on a black background, or black on a white one, as shown in Fig. 43. Not only must they indicate the top of the slide, but they must act as a guide to the face of the slide, which has to go next the condenser. To ascertain this, the slide should be held up in front of a piece of white paper in the position in which it is intended to be seen upon the screen, that is to say, with any inscription it may contain reading the right way round and not backwards. The two spots, which may conveniently be cut out of stamp-paper with a punch or pair of scissors, should then be stuck on the two top corners of that side of the slide facing the observer. In putting slides into the carrier, they must be put in upside down for reasons pointed out before (chapter X.), and when to be seen by reflection on an opaque screen of any kind (Fig. 54) the spotted side must go next the condenser; when shown on a translucent screen (Fig. 56) the spotted side of the slide must be turned away from the condenser. If this is not attended to, the picture as seen will be reversed from left to right, and any lettering, names over shop doors, and the like, will read backwards.

The slides should always be rubbed over with a clean duster before being shown, any dust or finger marks upon them will be enormously magnified on the screen. For this reason they should be held by one corner on putting them into the carrier and not fingered all over.

During an exhibition of slides the room should be kept as dark as possible. This seems so obvious as not to require mention, but the writer has often seen the brilliancy and beauty of a display spoilt by the amount of stray light about the room, proceeding both from the ordinary lights which were only turned down and neither quite nor almost extinguished, as they should have been, and from the back of the lantern itself. Another cause of failure is to be found in a rickety lantern-stand. We have a lively recollection of an exhibition of slides in which the lantern-stand, though firm enough in itself, was mounted on a platform of floor boards insufficiently provided with supporting joists, in consequence the exertions of the lanternist in putting a fresh slide into the carrier were sufficient to make the picture on the screen wobble up and down quite a foot. Minor matters are the following:—

(1) Do not omit to turn the lime, from time to time.

(2) Keep the audience away from the immediate neighbourhood of the screen; they will see better and like it better, although as a rule they will not keep off of their own accord.

(3) Make sure there is ample gas for the display, even if accidentally prolonged a little.

(4) Never allow the audience to see the bare screen illuminated with the full light of the lantern, all slides will look dull and heavy after so doing.

(5) The gas, if in bags, should be kept where it cannot be meddled with; if in cylinders, where they cannot roll or fall.

(6) Be particularly careful never to put a slide in upside down or wrong way round, unless they are those of a friend who is present and who neglects to spot them.

(7) Never leave a lime in the lantern after use. If done with throw it away, do not let it fall to pieces and fill the lantern with dust.

CHAPTER XIII.

Moving Slides and Effects.

UNDER this title fall a large number of more or less elaborate devices intended to enhance the beauty or realism, or both, of projected pictures. Almost all effects require at the least two lanterns, some needing three and even more. There are a few, however, which can be exhibited by means of a single lantern, and these will be considered first.

It is difficult to assign a reason for the decadence of lantern exhibitions which has undoubtedly taken place in the last few years. Signs of it are seen even in displays confined to plain photographic slides, the average of which is in quality markedly inferior to what it was ten, or even five years since. But in "effects," the falling-off has been very much more marked, and of displays such as used to be given at the Polytechnic and elsewhere, there are now none. It is to this change of fashion, or whatever else it may be called, that we must look for the origin of a certain amount of contempt felt by many lanternists for "effects," due doubtless to the substitution for the old displays, of inferior slides with bungling and incompetent exhibitors. The popularity of the photographic slide, which does not lend itself, or rather which has not been adapted to "effects" as much as is possible, has something to do with the matter. Still, as many of these illusions are among the finest things that can be shown with the lantern, are marvels of ingenuity and skill, and are still popular with some audiences, they cannot be altogether ignored.

The panoramic slide, as its name implies, is one which depicts a wide expanse of scenery, the shape of the picture being long and narrow; the slide is gradually pushed through the lantern, only a portion of it being seen at any one time. A modification has been suggested, to get over the liability to breakage inherent in such lengthy slides, in the shape of a roll of transparent film, bearing the picture, which is gradually wound off one roller on to another, as in the photographic roll-holder and the kinematograph.

Lever slides are constructed of two separate glasses, one fixed in the frame, the other capable of being partially revolved while in the lantern by means of a lever. A favourite subject for these is a cow standing in a pool, the cow, minus its head, and the pool being painted on the fixed glass. The cow's head being on the movable glass, on shifting the lever, the cow appears to lower her head to drink. Other subjects for this class of slide, which is best adapted for juvenile audiences, are children see-sawing, cobblers nailing, drummers, etc. In lever slides, as indeed in all slides where more than one glass is employed, the picture must be on the two inner surfaces, which are as close together as practicable, without touching, otherwise it will not be possible to get the two into focus at the same time.

Slipping slides, which also are more suitable for children's entertainments, are likewise constructed of more than one glass. In these, however, one of the glasses slides along in front of the other, and either covers and uncovers some part of the scene in so doing, or removes some portion and substitutes something else.

Tinters consist of coloured glasses which can be slipped over in front of the objective, so as to give any particular slide a general colour. They are most effective with slides of statuary and similar subjects blocked out so as to stand out against a black background, and in using them care should be taken that the tint is not too deep, a frequent error.

Of all types of mechanical slide, however, the chromatrope, as it is called, is the highest. In this, two circular glasses bearing geometrical designs are rotated in opposite directions while in the lantern. One design crossing another in this way can be made most effective, and it will be found difficult to realise what the combined result of any two geometrical designs so revolving will be. Very fine patterns resembling "watered" silk can be got by mounting fabrics such as netting, muslin, etc., with a clear and well-defined thread, in such a revolving arrangement, taking care, to secure the best result, that the two fabrics shown together are similar.

Revolving slides, on the principle of the chromatrope, are made having such things as windmills with revolving sails, acrobats spinning round on a trapeze, fish swimming in a globe, bees round a hive, etc., for their subjects; and can be obtained from most dealers.

The various slides alluded to above can all be shown by means of a single lantern, but those now to be mentioned require at least a biunial for their exhibition. With such an instrument the number of combinations, effects, etc., that can be obtained is almost unlimited. The simplest of these is the curtain slide, in which the picture on the screen is shown with a curtain round it, as if it were on the stage of a theatre. A balcony or verandah slide is sometimes used in place of the curtain; the scene then appears to be viewed from the interior of a room, looking out over the balcony.

In these and similar effects, the curtain or balcony, as the case may be, is projected by means of one of the lanterns, the other being used to throw the usual slides in the blank space left for that purpose in the "curtain" slide. It should be borne in mind that this entails the use of a great deal of gas, as both lanterns have to be kept going all the time.

Some forms of carrier are so made that the screen is dimmed by means of ground glass or celluloid while a slide is being changed, and in another it is entirely darkened by an opaque curtain, which appears to come down and mask one picture, rising afterwards and revealing the fresh slide. Such a carrier, with a curtain or border slide of any kind in the other lantern, would no doubt give a pleasing effect.

Akin to these are snow and rain effects. These are obtained by means of a slide in which a roll of opaque material is gradually unwound through the lantern. For snow, the fabric is pierced with little holes; for rain it is marked with fine lines. In both these cases the effect is improved if the slide is not inserted in the lantern in a perfectly horizontal manner, but is slightly inclined, so as to give the idea of a little wind. It is important, moreover, if the illusion is to be of the best, that the light in the lantern showing the rain or snow slide shall not be too powerful; especially is this the case with the rain. The writer remembers seeing a lantern display in which a poor waif, seated on a doorstep, was exposed to what was intended to be a shower of rain. Owing to the operator having, if anything, a brighter light in the "rain" lantern than the other, the shower suggested nothing so much as one of white hot knitting-needles, and the effect on the audience was anything but what was intended.

Moonlight effects are obtained by means of a biunial lantern and two slides, the subjects upon each being absolutely identical as regards outline, but one can be very much more vigorous than the other. With photographic slides, which are much the best for the purpose, this difference can easily be obtained. The first slide, intended to depict the daylight view, can be made in the usual way, with the usual amount of density and contrast. The second slide, however. should be exposed for a little under the suitable time, and should be developed with a view to getting plenty of contrast, rather than what a photographer would describe as a soft result. This second slide must then be treated with a bath of a deep blue aniline dye, so as to give it that blue tint usually associated with moonlight views. Any lights which it is intended shall appear in it, such as gas-lamps, illumined windows, stars, the moon itself or its reflection on the water, must then be carefully picked out so as to leave the slide bare where it is intended these shall be. The two slides being then most carefully registered, the daylight picture is first shown, and gradually dissolved into the moonlight one.

Such effects can be multiplied almost without limit, by having accurately registered slides and plenty of assistance. The number of lanterns required rarely exceeds three in the most elaborate displays, since in nearly every case the effect at any one time is obtained by the two lanterns, leaving the third free for the introduction of a fresh change or addition to what is already on the screen. Space will not admit of our going more at length into the matter of these effects, which, at one time the only use to which the lantern was put, have now been to no small extent superseded by what some people would regard as less frivolous displays.

CHAPTER XIV.

Lantern Experiments.

THE form of lantern described in the foregoing pages is in itself suitable for many experiments, but, with cer-

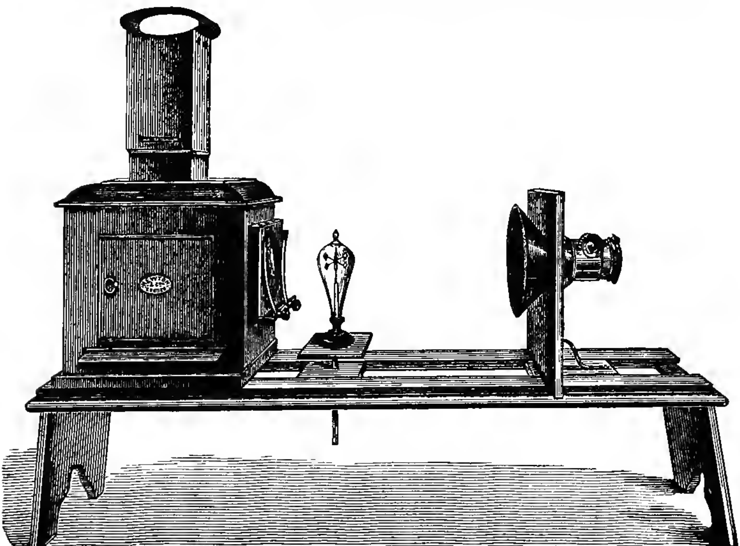

Fig. 60. LANTERN FOR EXPERIMENTAL PURPOSES.

tain modifications, can be employed to render visible to a large audience a far greater number. The chief alteration required is the removal of the tubes carrying the objective, so that objects much thicker than the usual slides can be inserted, and the provision in consequence of some other kind of support for the front lens. A method of effecting this is shown in Fig. 60.

Such a lantern will admit of the insertion of cells of liquid, test tubes, galvanometers, and many other pieces of apparatus. The number of scientific experiments which can be shown in a lantern of this class is legion, but we can only give as examples one or two that can be performed.

The development and fixation of a photographic plate can be shown by the use of a tank, as shown in Fig. 61. A chloride or lantern plate should be employed, both on account of its superior transparency and of its lower sensitiveness to light, the developer being ferrous oxalate. The plate is exposed under a negative in the ordinary way, and is then placed in the tank, care being taken that the image on the plate is upside down. The plate should be protected from actinic light by the insertion of a piece of ruby glass between the condenser and the tank before the experiment commences. When the plate is in position it can be focussed, a strip of wood being inserted so as to hold the back of the plate in contact with that glass of the cell which is furthest from the lantern. Unless the wood is weighted it will probably float up when the developer is poured in, and the success of the experiment will be marred. When the plate is thus held in position and focussed, the developer must be carefully poured in with the help of a funnel, no splashing being allowed to take place. When all the plate is protected by the developer the ruby glass may be removed, the deep orange tint of the solution being a sufficient protection with a slow plate. The image will be seen gradually to grow up on the originally plain opalescent

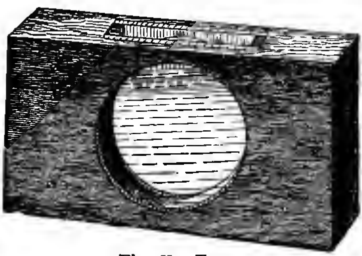

Fig. 61. TANK.

plate. When development is complete, the ruby glass should be again inserted, the tank withdrawn and emptied, the plate rinsed in slightly acidulated water, then in plain water, and restored to the empty tank replaced in the lantern. This is now filled with fixing solution, which will be seen to dissolve gradually the unaltered silver salts in the film, leaving the finished transparency, if all has gone well, in full brilliancy on the screen, when the ruby glass can be finally withdrawn. This experiment is a very striking one, and is not difficult to perform, but it should be rehearsed once or twice before being attempted in public, a remark which applies to all demonstrations of a like nature.

It is often convenient to be able to show upon the screen the presence of currents of electricity set up by one means or another; this is easily done. At any of the shops which supply working jewellers, such as are to be found in the neighbourhood of Clerkenwell, little compasses with glass

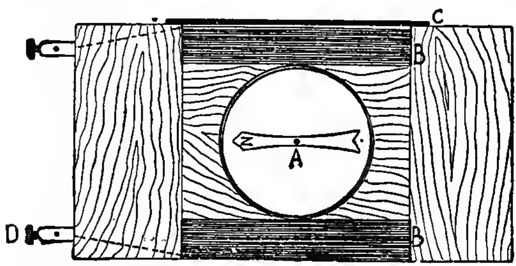

Fig. 62. LANTERN GALVANOMETER.

sides, which when mounted are often worn on watch chains, etc., can be purchased for a few pence. One of these can be easily made into a fairly sensitive galvanometer by mounting it in a wooden block, as shown in Fig. 62. Round the block should be wound some turns of silk-covered copper wire, B B, Fig. 62; twenty or thirty turns of No. 30 B W G wire will answer most requirements, though more can be used if necessary, the two ends of the wire being brought out to two terminals, D D, on the end of the block. A little bar magnet, C, which can be made by magnetising a piece of knitting-needle, should be arranged on the top of the block, so that the needle of the compass is just held horizontal when no current is passing through the wire. The magnet should not be too near or too strong, or the sensitiveness of the galvanometer will be impaired. The block being inserted in the lantern, the binding screws connected with the source of the current by wires, and the compass focussed sharply on the screen, when a current passes the needle will be deflected; owing to the degree of magnification of the image on the screen, such a galvanometer possesses a considerable degree of sensitiveness.

With the help of the tank shown in Fig. 61, such experiments as precipitation, reactions resulting in change of

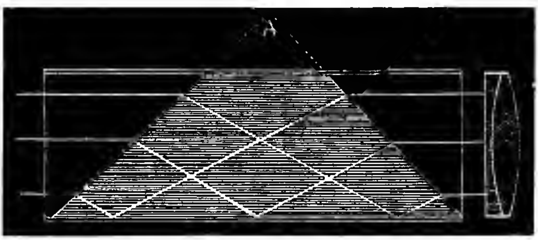

Fig. 63. DIAGRAM SHOWING THE USE OF AN ERECTING PRISM.

colour or appearance in solutions, as well as demonstrations of capillary attraction, pressures of liquids, etc., can be exhibited. In some of these experiments it is highly desirable that the image upon the screen shall be the right way up, while at the same time it is impossible to invert the objects themselves in the lantern. When this is the case an erecting prism has to be employed. This is shown at A, in Fig. 63. They are very convenient in some cases, but always entail a considerable loss of light.

The erecting prism consists of a block of glass, having its sides cut to a suitable angle to one another. It is fitted on close in front of the objective, the course of the rays being then as represented diagrammatically in the figure. One form of erecting prism is shown in Fig. 64; this is known as

Zentmayer's. The principle is the same as in the other, which is the more usual pattern, the modification in shape being made with the idea of using the whole of the prism right up to the apex, which cannot be done when the angle at A is a right angle. Some lecturers prefer the Zentmayer pattern, but Mr. Lewis Wright, an authority to whom we have already referred, recommends the use of a prism midway between the two forms depicted.

Fig. 64. Zentmayer Erecting Prism.

In Fig. 65 is shown diagrammatically the arrangement of the lantern and objective for throwing upon the

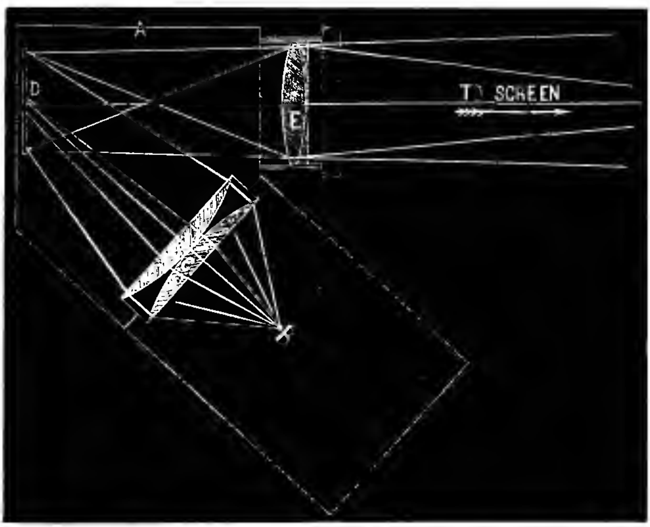

Fig. 65. Arrangement of the Lantern for showing Opaque Objects.

screen images of opaque objects. Lanterns constructed for this purpose, with the tendency to describe everything appertaining to a lantern by some long Greek name, are often called Aphengescopes. It is a useful device occasionally for demonstration purposes, but owing to the very great loss of light, can only be employed with limelight or with the electric arc, and then is never very satisfactory. In Fig. 65 the source of light is shown at B, and the condensers at C C, the object, which is placed at D, having its image focussed upon the screen by means of the objective, E. There is no need to get a special lantern for the purpose, as a box is easily arranged to carry the objective at one end and to receive the nozzle of the lantern in the direction shown. Such a box should have its interior lined with black paper, or better, with black velvet. The back can be arranged to carry the objects it is desired to exhibit, access being obtained by the side A, which is closed with a curtain.

When the Aphengescope is being used, and, indeed, in a large number of other cases, it will be found that, unless steps are taken to prevent it, harm will very frequently occur from delicate instruments or inflammable substances being exposed to the intense heat concentrated upon them by the condenser. To obviate this, what is known as an alum cell is employed. This is an arrangement similar to that shown in Fig. 61; in fact, the same cell can be employed for either purpose, as required. It is filled with a cold saturated solution of alum, which must have been carefully filtered so as to be quite free from dust or other floating particles. The solution will in course of time get fairly hot, but while allowing nearly all the light to pass, it will absorb the heat, which would otherwise be doing harm. In the absence of the alum solution, plain water can be employed. It is not quite so efficient, but is satisfactory enough for most purposes.

Another arrangement of the lantern for demonstration purposes is that shown diagrammatically in Fig. 66, as employed for vertical projections, as they are called. The beam of light from A, as it leaves the condenser, B, falls upon a mirror, F F, placed at an angle of 45 degrees with the horizontal, from which it is reflected vertically upwards. The table, D D, upon which the object to be projected is placed, is immediately over the mirror, while above it is placed the objective, E, bearing above it again a reflector, G, which once more directs the beam in a horizontal direction to the screen. For most purposes such an arrangement can be fixed up at very little expense to answer all requirements except where great brilliancy and crispness of definition is desired. The bottom mirror can be a piece of the usual silvered plate glass, the top one is best of the thinnest silvered glass procurable, as if not, the

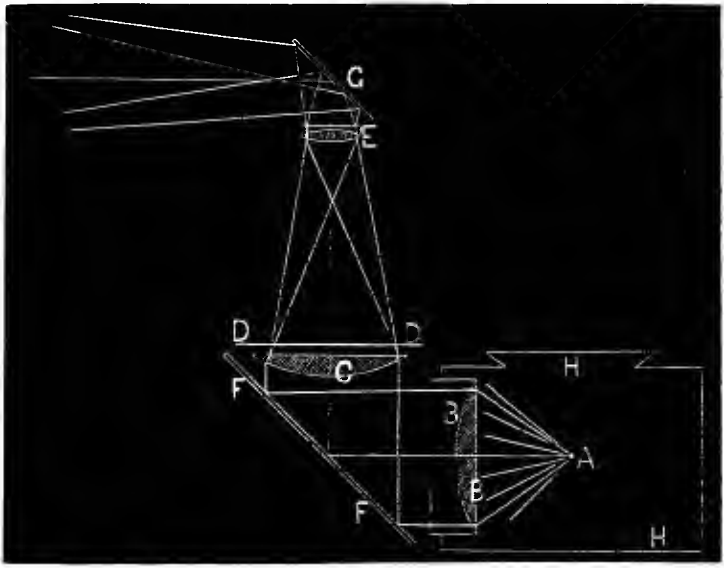

Fig. 66. ARRANGEMENT OF LANTERN FOR VERTICAL PROJECTIONS.

secondary reflection, that from the surface of the glass itself, may become troublesome. It will be seen that the two component lenses of the condenser have to be separated, one remaining in the usual position in front of the illuminant, and the other immediately beneath the table carrying the object to be projected. With this arrangement of the apparatus many experiments, such as those showing crystallisation, etc., can be performed. For this purpose a glass dish with an even flat bottom is required. This is placed upon the table, D, of the apparatus, and contains the solution to be used. One of the best of these is sodium sulphate, a saturated solution of which should be placed in the tray, and a crystal of the salt added, crystallisation at once taking place.

The decomposition which takes place when an electric current passes through certain liquids can also be shown upon the screen without much difficulty. For this purpose an incandescent lamp, the filament of which has broken, and which is therefore of no further use for lighting purposes, makes a very good decomposing cell, a suggestion due to Mr. T. Bolas, to whom I am also indebted for the design of the simple galvanometer just described. The point at which it was sealed off should be carefully scratched with a file and broken off so that air is admitted, or better still, the point of a blowpipe flame should be directed against a spot close to the sealing, until the glass has softened and admitted air. The lamp can then be cut off as shown in Fig. 67, the filament removed, and the two platinum wires left to act as the electrodes. Any of the ordinary forms of lamp holder will answer to mount the cell thus constructed, being fitted for that purpose on a slab of wood with terminals for convenience in connecting up. If a little water slightly acidulated with sulphuric acid be poured into such a cell, and the current from three or four Bunsen batteries passed through it, bubbles of gas will be seen given off from each of the electrodes. The reversing prism should be employed to show this, as otherwise the bubbles will appear to descend on the screen instead of ascending.

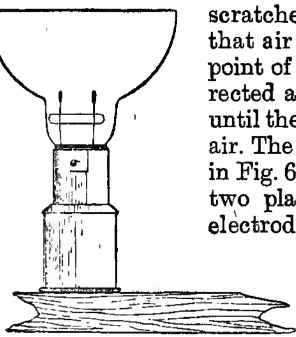

Fig. 67.
DECOMPOSING CELL CONSTRUCTED OF AN INCANDESCENT LAMP.

Space precludes the mention of a number of other experiments which are better shown by means of the magic lantern than in any other way, but many of these will occur to the reader as he gradually learns the power and adaptability of the instrument.

CHAPTER XV.

The Lantern-Spectroscope, -Polariscope, and -Microscope.

ALL of the experiments hitherto mentioned have been concerned only with the projection of apparatus, pictures, etc., in the light of the lantern, without any of the beauty derivable from brilliant colouring. With the lantern polariscope and with the spectroscope, the projected images possess a fresh charm by reason of the beautiful colours they assume, in which colours lie, in fact, their chief interest.

Any detail as to the principles upon which the spectroscope is based would be out of place here, and we must refer the reader in search of information on that head to one of the many books on the subject; merely mentioning that the object of the instrument is to split up and render separately visible the light of various colours which, when blended together, would without its aid be regarded as a single-coloured light, and not as a mixture of many tints. The simplest form of apparatus for projecting the spectrum consists of a slit, which may be a slide made of blackened card, having in its centre a vertical opening 1 inch high and $\frac{1}{16}$ of an inch wide, together with a prism. This arrangement is illustrated diagrammatically in Fig. 68. A glass prism will do, and is, indeed, for ordinary purposes, best, but for certain reasons many prefer a prism-shaped bottle containing carbon bisulphide. In Fig. 68, A is the source of light, B the condenser, C C are lenses used to concentrate and render parallel the rays of light, D is the cardboard with the slit, E the objective, and F the prism, the screen being beyond the latter in the direction indicated by the lines of light. The slit being placed in position, it must be focussed upon the screen in the usual way; too great a degree of enlargement should not be attempted, or the illumination will be feeble. When focussed, the lantern must be turned round bodily until its position with reference to the screen is as it would be if the latter were placed across the right-hand bottom corner in Fig. 68, and the prism placed in front of the objective as shown. A little

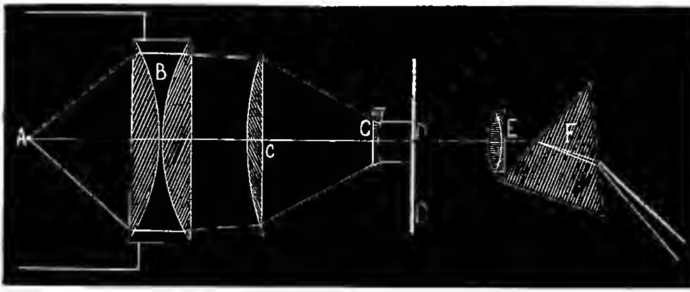

Fig. 68. ARRANGEMENT OF APPARATUS FOR PROJECTING THE SPECTRUM.

adjustment will be necessary to get the best result; for this reason the arrangements should all be made, and the prism put into its place before the audience are present. The best position for the prism to occupy is that in which it bends aside the beam of light the least, and this should be found as nearly as possible by experiment. If all has been properly arranged, the beam of light from the lantern will be found to be split up in its passage through the prism, and to be widened out into a band of coloured light, one end of which is red, and the other violet, with the other colours in between these two extremes. This band is the spectrum.

By inserting in the path of the beam as it emerges from the objective, coloured glasses or stained gelatine films, the absorption of such media can roughly be shown. Solutions of various substances can also be employed, using for the purpose a cell similar to that shown in Fig. 61. Solutions of potassium permanganate, of potassium bichromate, of many of the aniline dyes, etc., give interesting results when shown in this manner. With glass or stained films the absorption is better shown if the coloured material is in contact with the slit itself, covering, say, the lower half of it. A sharp line upon the screen will then be seen to divide the spectrum into two distinct parts, the upper one being the spectrum of the light employed after it has passed through the coloured film, the lower one simply the spectrum of the light itself.

An interesting experiment consists of saturating a sheet of white paper with a solution of quinine sulphate in water rendered slightly acid with sulphuric acid. The paper should be allowed to dry, and then be mounted on a sheet of card side by side with a similar piece of paper which has not undergone the treatment with quinine, in such a way that the two papers are separated by a straight line running right across the card. If now a very bright spectrum be thrown upon such a card, so that the upper half of the band of colours falls on the plain paper, and the other on that treated with quinine, it will be seen that a greater length of spectrum at the violet end is visible on the latter than on the former. It will most likely be necessary, in order to show this distinctly, to cover up all the spectrum between the blue and the red, as otherwise the brilliancy of that portion will drown the darker violet, and the experiment be less striking. This is shown better with the electric arc than with limelight, although with care it can be very plainly demonstrated even with the latter.

The experiment can be elaborated by interposing, in the path of the beam of light, a glass cell containing the solution of quinine. This will at once alter the appearance of the spectrum, which will then appear no longer on the one paper than on the other, but on the other hand the solution itself will exhibit a very beautiful blue fluorescence. Various other substances can be used in place of the quinine with varying results.

A more expensive arrangement for the projection of spectra, but one which possesses the great advantage that the whole of the apparatus is in one straight line with the screen, consists of the employment of a group of prisms, as in a direct vision spectroscope. Such a series of prisms, when interposed in the path of a beam of light, disperse the rays passing through them, without refracting them. The whole

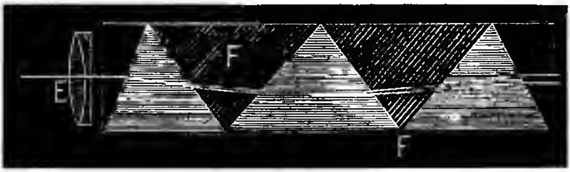

Fig. 69. LENS AND PRISMS FORMING A DIRECT VISION SPECTROSCOPE

apparatus then takes, in plan, the form shown in Fig. 68, but with the lens and prisms E and F, Fig. 69 taking the place of E and F in Fig. 68.

While on the subject of the spectrum, we might mention a form of Newton's disc for use in the lantern, which shows in a very distinct manner how, by the admixture of light of the various colours of the spectrum, we once more get white light. It consists of a circular disc of glass painted as brilliantly as possible with colours resembling those of the spectrum, the different tints being laid on in radiating wedge-shaped sectors; the disc is provided with a pulley and band by which it can be rapidly rotated (Fig. 70). To exhibit it effectively, the disc must be inserted as a slide in the ordinary lantern, and its image projected on the screen and focussed. The room should be perfectly dark, and the illumination of the disc the brightest possible. While stationary the image of the disc on the screen presents, of course, a magnified image of the original disc with all its

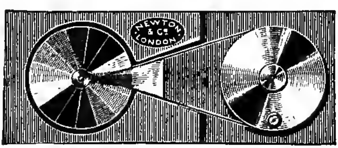

Fig. 70.
NEWTON'S DISC FOR LANTERN USE.

colours brightly shown; but as soon as it is rapidly rotated the colours blend, with the result, if the disc be a good one, that the image on the screen is a simple white circular patch of light. By covering over some one or more of the colours on the disc with black paper, and then rotating it, it can be shown that the absence of any of the colours gives the blended images a colour, the white image only resulting when *all* the tints are mingled.

The lantern polariscope is, as its name implies, an instrument designed to exhibit objects on the screen by means of polarised light. To do this the beam of light, before it falls upon the screen, has to pass through two pieces of

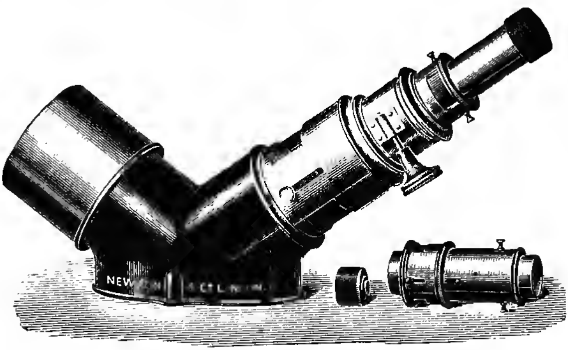

Fig. 71. POLARISCOPE ATTACHMENT (ELBOW FORM).

apparatus known respectively as an analyser and a polariser, Fig. 71. These may be similar in construction, since they could be used the one for the other indiscriminately were it not that, for mechanical reasons, the polariser is generally larger than the analyser; but, as a general rule, in the more expensive instruments the polariser is constructed of glass, and the analyser of Iceland spar, in the form known as a nicol prism. With the aid of this apparatus many experiments can be performed, one or two of which we mention.

Slides made of selenite and other suitable substances, frequently quite colourless in themselves, yield magnificently coloured images when projected by means of the polariscope.

Geometrical designs, butterflies, etc., are built up of pieces of the substance in question, mounted up as slides, and are obtainable through the dealers. A more satisfactory method with many people will be to make them themselves, the operation not being a very difficult one, consisting, as it does, of a building up of the design on a glass slide with pieces of mica cemented together with Canada balsam. Crystallised benzoic acid, salicine, etc., also give very beautiful projected images with polarised light.

Slabs of glass held in a clamp in such a way that, while the image of the glass is on the screen, stress can be set up within the glass by means of a screw, exhibit in a very clear manner the changes set up by the stress which the polariscope reveals—changes which in no other way can be rendered visible.

Anderton's stereoscopic lantern, introduced a few years ago, is an example of an ingenious application of polarised light, with a view to enabling an audience to see the image on the screen stereoscopically or in relief. In order to effect this it is essential that two distinct images shall be seen by the two eyes, the two slides for the purpose being made from two negatives taken from different standpoints, side by side, so that one differs from the other by seeing a little more round one side or the other of the object. The two slides, which in all other respects are identical, are shown simultaneously upon a screen, the surface of which is composed of metallic foil, by means of a biunial lantern. After leaving the objective, the light from each of these lanterns passes through a polariser, these polarisers in the two lanterns being so arranged that the planes of polarisation are at right angles to one another. Each observer is provided with a little pair of analysers mounted like opera-glasses, but in each of which the analysers are arranged with reference to each other as are the polarisers in the lanterns, the effect of which is that only one of the blended pictures on the screen is seen with one eye, and the other picture with the other eye. The result, on viewing the two images on the screen through such an apparatus, is to eliminate from the field of view of one eye the picture from one lantern, and from the other eye that from the other; the brain combining the two pictures so as to give the impression of the objects standing out in relief, as in nature.

All optical lanterns are virtually lantern microscopes, as a moment's consideration will make clear. The slide, whatever it may be, is the object, an enlarged image of which is projected upon the screen. Hence there are many things which, needing only a small degree of magnification to render their details plain, can be exhibited without the aid of any further apparatus whatever. The writer had an opportunity a little time since of looking over a large number of what appeared at first sight to be very carefully drawn and beautifully coloured lantern slides of sections of various animal tissues, healthy and diseased, interesting more especially to veterinary surgeons. These turned out, on more careful examination, to be the actual preparations themselves, the vessels of which had been injected with various colouring matters, the whole tissues stained to show as far as possible their structure, and then mounted up as slides; and very beautiful they were, while their value for educational purposes was almost immeasurable. Such slides in the lantern were magnified thirty or forty diameters without difficulty.

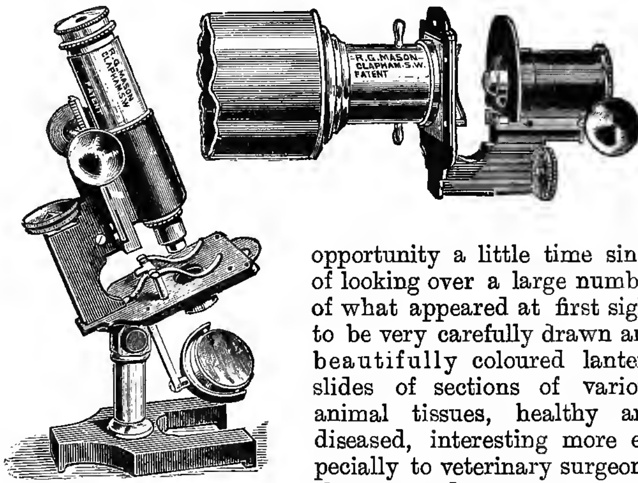

Fig. 72.
MICROSCOPE FOR TABLE AND LANTERN USE.

This is the simplest form of lantern microscope, but it is of course limited in its powers, and for greater magnifications it can be replaced by a slightly modified form of compound microscope, which is attached in front of the condenser of the usual lantern. In Fig. 72 a simple form of compound microscope is shown, which can in a few moments be removed from the stand on which it has served as a table microscope and placed on the lantern nozzle, as shown in the top right-hand figure. The objectives of various powers can be slipped into the racked mount, those most commonly supplied being 1- and 2-inch powers. An additional lens as a supplementary condenser is sometimes fitted between the chief condensers and the object, and when properly adjusted this much improves the illumination.

The real difficulty in microscopic projection has always been the proper illumination of the object. Lantern microscopes cannot be expected to yield as bright images on the screen as ordinary lanterns showing slides with but a fraction of the magnification. In consequence, the operator's attention should be given to the proper adjustment of the light and condensers. The light concentrated on the small surface of the slide will soon make it very hot unless prevented by means of an alum trough (see p. 84); this in micro-projection should never be omitted, or it will lead to the ruin of the slides.

The slides in the simpler forms of lantern microscope are fitted in wooden frames like ordinary lantern slides, only these frames are smaller. Frames can be obtained one end of which takes out to receive the usual size of microscope slide, for use in the lantern. These are a convenience, but it is decidedly preferable to have a microscope attachment with the usual form of plain sliding stage, so that the slides can be used direct without any further mounting. This is the case with the instruments shown in Figs. 72 and 73.

Too great a degree of magnification should not be attempted until the management of the lantern with low powers has been thoroughly mastered. A 1-inch objective will be found the most powerful which can be used in the ordinary way with satisfactory results, both as regards illumination and other qualities. On changing the objective the position of the jet should be altered until the best lighting is secured, as it will be found that lenses of different powers require the jet to be at different distances to yield the brightest images. Great care must also be exercised to keep the centres of the whole of the apparatus, jet, condensers, and objective in a perfectly straight line. When these various points have received attention it will be found that a large number of objects, parts of insects, sections of wood of different kinds, vegetable and animal tissues, etc., can be easily shown on such a scale as to be seen well by a large roomful of people.

A more elaborate form of lantern microscope is that shown in Fig. 73. With this instrument far more can be

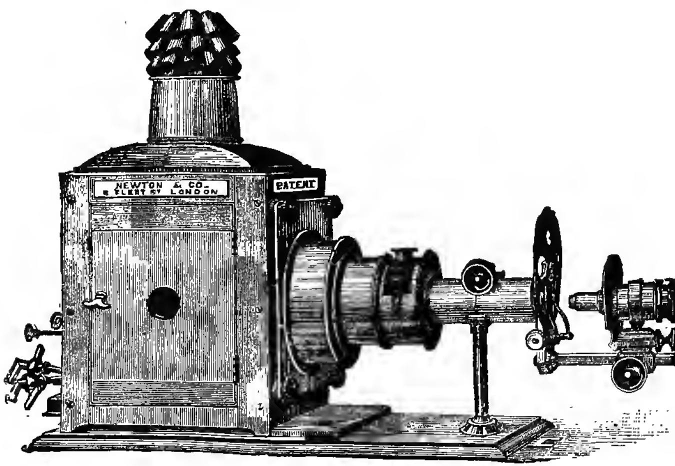

Fig. 73. The Lantern Microscope.

done than that to which we have alluded, but for details as to its manipulation larger works must be consulted.

CHAPTER XVI.

Animated Lantern Pictures.

In the beginning of 1896 a novelty in lantern work was first shown in London in the form of Mr. Birt Acres' Kinetic Lantern, as it was then called, by which street scenes and other moving objects were displayed on the screen in motion with a fidelity which was very remarkable. Almost immediately afterwards a number of other inventors were in the field with instruments for performing the same operation, and animated lantern pictures under all sorts of Greek and Latin names were quite the sensation of the moment.

The principle underlying all such projections is that known as "the persistence of vision." When an image falls upon the retina of the eye, no matter for how short a time, provided it is sufficiently brilliant to excite the sensation of vision at all, the result is not a mere momentary impression, but one more or less prolonged. It seems to take an appreciable time before the sensation of seeing has again departed. Hence, if a series of pictures in rapid succession are allowed to fall upon the eye, provided the interval between each is sufficiently short in duration, the pictures combine into one continuous impression. If we look at a rapidly revolving wheel, the spokes no longer appear as single objects, but merge into a semi-transparent disc. If a brilliant point of light is rapidly revolved, it appears no longer as a point, but as a circle. These and the Aerial Graphoscope of Mr. Eric Stuart Bruce, in which the lantern pictures are thrown upon a whitened lath revolving at a high rate of speed, and so appearing as a partially opaque screen only, are all examples of the employment of the principle of persistence of vision. The Kinetescope of Friese Greene, which Edison's machine, subsequently introduced and far better known, resembled at any rate in principle, contained the germ which led to animated lantern pictures. A long film of celluloid coated with a sensitive material was passed through a special form of camera, stopping several times a second, while a shutter uncapped the lens, and registered an exposure upon it. In this way upon development a long negative was obtained consisting entirely of a string of pictures one after the other all taken from the same standpoint, but each differing from its neighbours, when the subject was a moving one, by having the moving object in a slightly different position.

From such a negative it was a comparatively easy matter to make a positive transparency, and this when illuminated from behind, and looked at through a similar arrangement to that used for taking the negative, is the Kinetescope in outline. The eye blends the individual pictures seen one after another into one continuous view, in which the moving objects actually appear to move, and the fidelity with which every motion is registered is very surprising.

For lantern work it became necessary to run the film in the same way through a lantern, stopping it rapidly, and when so stopping uncovering the lens so that one picture after another might fall upon the screen. It must be borne in mind that in the lantern the images are enlarged up enormously; all the defects are magnified in the same way, and the defects become very much greater than when the film is simply to be seen as a transparency. This will be realised better when we mention that for convenience in the photographic and other operations, each individual picture on the film is not usually much larger than one and a half square inches.

Space prevents us from describing at any length the many instruments in the market for showing animated pictures upon the screen, known as the Biograph, the Kinematograph, etc., etc. They are all alike in principle. A long band of film is passed between the lens and condenser. As each picture comes exactly opposite the lens the film is stopped, the lens uncapped for the picture to fall on the screen, then capped, and the film moves on for the next picture to be shown in the same way, the whole cycle of operations not taking much more than a-tenth to an-eighth of a second. In some the shutter is dispensed with, and reliance is placed upon the rapidity of the movement of the film from one picture to the next to mask such movement from the eye, the duration of such a moving picture being but a very small proportion of that of the stationary picture. It is necessary in all of them for the film to be stopped while its image is thrown upon the screen, and then moved on.

Practically speaking, an instrument which will project the pictures can with slight modifications, or with none at all, be used for taking them, although, as a rule, a special form of camera is employed for the purpose.

The film is perforated on both sides with holes at a regular distance from each other. This perforation has to be most perfectly done to register, as upon it the perfection of the image when seen on the sheet depends very largely. Teeth or pins in the apparatus engage in the perforations, and so convey the film along its path.

The standard size of film is about $1\frac{1}{2}$ inches wide, the dimensions of the image which is projected being $1\frac{1}{8}$ inch wide by $\frac{7}{8}$ inch high. In the Lumière film there are two perforations, one on each side, for each picture. In the Edison film there are four perforations on each side. Some forms of apparatus are so made that the finished film is wound up on a spool after use. Before it can be shown again, however, it has to be rewound, as the wrong end for commencing is outwards when it has been wound up after going through the lantern. Very amusing results are sometimes obtained by putting films through the lantern backwards. There is in such case a great likelihood of damaging the film, and it should not be resorted to without fully understanding the risks which are run, since these long films are expensive.

The apparatus for taking the picture, as we have already pointed out, is very similar to that employed for projecting them. The spool of film is run through the camera, stopped, an exposure made, and it is then passed on until the whole length, or such part of it as may be required, is exposed.

Development is effected by winding the film on a drum or spool, so that the sensitive surface is entirely exposed, and immersing this in a trough of developer, of water, or of the fixing solution. Printing may be carried out either by means of a special apparatus, or, as is the case with the Lumière Cinematograph, by the actual projecting and exposing arrangement. In the latter the negative is again wound through the machine, but this time a length of film coated with a lantern slide emulsion is in contact with it. The lens of the instrument is removed, and at a suitable distance in front of the negative film a light is placed. The two films, the negative and the undeveloped transparency, are run into separate receptacles. The latter is developed, fixed, and washed in the ordinary way, and is then ready for projection.

Little need be said as to the precautions to be observed, and the routine to be followed in working the animated pictures in the lantern, since most of the information already given as regards lanterns generally applies equally to these. In selecting an instrument attention should be given not only to the smoothness and freedom from vibration and movement on the screen with which it works, but also to the treatment the film itself undergoes in passing through the instrument. Films cost money, as we have said before, and in some of the machines we have seen, the films have got sadly scratched and knocked about with only a few exhibitions. In examining an apparatus with a view to seeing whether it works without vibration, a film should be employed which is known to be free from this defect itself. If the camera has trembled during exposure the film will register this movement, and there is a likelihood that when the picture is seen on the screen the spectator might imagine the vibration, really due to camera movement in the first place, to be due to imperfections in the projecting apparatus which it does not possess.

The most unpleasant feature about a display of animated photographs is undoubtedly the flicker, from which no instrument up to the present is absolutely free. This is due to some extent to the use of the shutter, by which means the eye is looking alternately at a brilliantly lit picture and a darkened screen, and it is doubtful whether such a defect can ever be perfectly cured. True, the shutter has been done away with, but even this does not absolutely remedy the defect. Some of the vibration is undoubtedly due to the fact that both lantern and camera are usually actuated by the hand. In the Biograph, one of the latest forms of instrument, an electric motor takes the place of the hand movement, and the circular twist of such an apparatus is obviously less likely to cause vibration than the reciprocating movement of the hand in turning a wheel.

The instrument is at present quite in its earliest stages of development and there is no doubt that time will effect many improvements in details. The principle is one which it is almost surprising was not applied to lantern work before, although the extreme rapidity of the modern dry plate has undoubtedly rendered the problem which inventors had to solve much easier during the last three or four years. The mechanism required is not of a very elaborate character, and although it necessitates very fine workmanship, it will not be long before the best form of apparatus will be obtainable at prices which will no doubt lead to an enormous extension in its use.

Lantern = = Lenses (PATENT).

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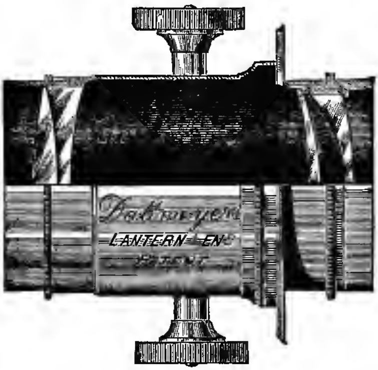

These lenses are specially constructed for use with the Optical Lantern and are *not* intended for Photographic purposes. They will be found to give a perfectly achromatic image, combined with an absolutely flat field, and great brilliancy of definition. The enlargements upon the Screen are perfectly true to the original, free from all distortion, and well defined throughout, whilst the equality of illumination obtained is a remarkable feature.

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