THE CINEMATOGRAPH.

By Jules Fuerst, in Journal of the Society of Arts.

In introducing to your notice the Lumière cinematograph, I may state, to begin with, that to-day the subject of animated photography is so well known that, strictly speaking, nothing of a novel character is presented to the audience. I need hardly say that animated photographs have come to stay, and before dealing with the Lumière machine and its efficiency in particular, a few historic notes as to the origin of chronophotography, or the photography of movement, may not be out of place.

In the early part of the century Platau produced an instrument termed the phenakistoscope, demonstrating the principles of the persistence of vision, and this subsequently gave rise to the zoetrope, or wheel of life, in about 1845. This instrument showed a series of images depicting the successive attitudes of objects in motion.

Later, in about 1870, the praxinoscope, by Renault, and the photographic revolver, by M. Janssen (in about 1874) appeared. At the same period M. Muybridge obtained a series of moving photographs taken by means of several dark chambers provided with lenses which were worked electrically at convenient intervals, and I believe this apparatus, or an improvement on it, was shown before this society in 1882.* Muybridge and Anschutz, by their photographic studies of animal locomotion, and the exhibition by projection of the results, undoubtedly brought us nearer to the realization of animated photography as we now know it.

Mr. Friese Greene introduced his camera for taking a series of photographs in rapid succession at the photographic convention in 1890, but the extent of its capability was not recognized then, as the pictures were not shown on the screen. Mr. Friese Greene read a paper at that time dealing with the subject of the persistence of vision and its relations to animated photographs.

It was, however, M. Marey (a Frenchman) who gave us the most successful results, having constantly utilized chrono-photography for studying the movements of animals and various physiological phenomena. There were other scientific men who worked in the same direction; it may be said, however, that all these scientists generally sought to produce successive pictures in small numbers constituting an analysis of movement and destined to be studied at leisure. The reconstitution of that movement, that is to say, the synthesis, was first commercially and practically illustrated on the appearance of the Edison kinetoscope in 1893, but the film on which the photographs were taken having a continuous movement, each picture could not be seen except during $\frac{1}{7000}$ part of a second, rendering the condition of transparency to light extremely feeble, and consequently the scenes or views had little depth—at least thirty photographs being necessary to leave a sufficiently continuous impression upon the eye.

When Lumière's cinematograph was first shown in July, 1895, in Paris, the defects mentioned had been removed, the machine permitting the reduction of the number of photographs to fifteen per second, any three of which showed movement. The working principle of the apparatus has long been well known, and is the same as with the instruments previously stated, viz., the persistence of the luminous impressions upon the retina, which is easily understood.

If we observe an object, the image in the eye is transmitted to the nervous membrane called the retina. If the object ceases to be illuminated suddenly, the image in the retina is progressively removed, and so long as it has not entirely disappeared, the optic nerve continues to be impressed, and the eye continues to see the object as if it had remained illuminated. The duration of the persistence of the luminous impression on the retina varies with the amount of light on the object; for a normal illumination it is about $\frac{3}{45}$ second, and is prolonged for another $\frac{2}{45}$ second, although the illuminated object may have disappeared suddenly. Consequently, if an illuminated object is presented to the eye and masked by an opaque screen during $\frac{1}{45}$ second for instance, its image persists in the eye $\frac{1}{45}$ second, and we do not even perceive its passing eclipse. Let us assume, therefore, a number of photographs on a film at $\frac{1}{15}$ ($\frac{3}{45}$) second intervals, showing the successive movements of an object; the various pictures obtained are like each other, that is to say, if any two thereof are superposed, the parts which represent the fixed objects are exactly the same, whereas those which correspond with the object in movement occupy positions of which the displacement has been accomplished during the time in which two pictures have been taken. Having said so much, let us assume that we have taken 900 successive proofs during a minute, and let us project the same on a screen by means of any lantern. Let us eclipse image No. 1 by interposing between the luminous source an opaque screen which masks the light during $\frac{1}{45}$ second, and, as we have said, the eye will continue to see the projected image, not only during the whole of the passage of the opaque screen (or shutter), but even after it has passed, during the time equal to the difference between $\frac{2}{45}$ second (duration of persistence) and $\frac{1}{45}$ second (duration of the passage of the shutter), that is $\frac{1}{45}$ second. We will assume, then, that a second image has been substituted for the image No 1 when the shutter again unmasks the source of light; we still see during $\frac{1}{45}$ second image No. 1, evidently weaker, but superposed by the image No. 2, and as the immovable parts coincide exactly, our eye perceives the sensation of the moving object, attitude No. 1 succeeded by attitude No. 2.

If we substituted in the same way during successive and rapid periods No. 3 for No. 2, No. 4 for No. 3, and so on up to No. 900, it is evident that the eye sees always the same image in which the moving object passes progressively from attitude No. 1 to attitude No. 900. The eye therefore sees marching on the screen photographs of the object.

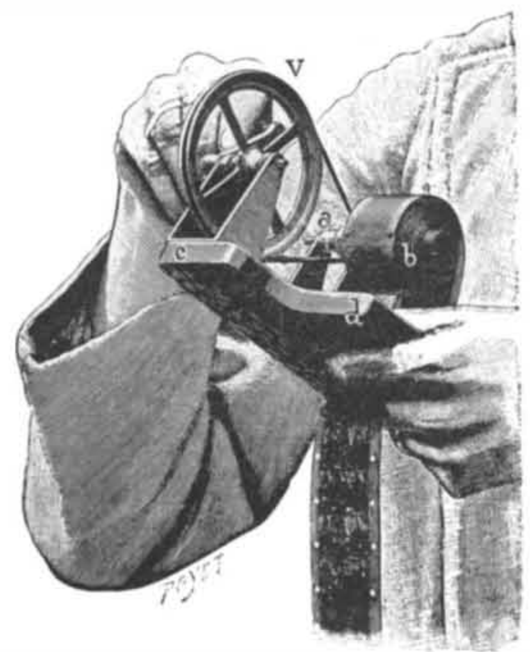


Fig. 2.—FILM WINDER.

It is necessary to have an apparatus to produce thus within one minute the 900 light eclipses by which 900 substitutions of successive images are obtained.

In Lumiere's cinematograph these eclipses are obtained by means of an opaque shutter, which revolves at the rate of fifteen times in each second, and is attached so that during its movements it intercepts the light coming from the projecting lantern at each turn, and consequently the illumination on the screen on which the image is projected disappears during a fraction of $\frac{1}{45}$ second. To operate the substitution of images, the 900 successive photographs are made on a flexible film about 55 feet long and $1\frac{3}{8}$ inch wide. The dimensions of each picture are 25 mm. wide and 20 mm. long. On either side of the film are perforations (two holes to each picture) at exact distances from each other, into which sprockets periodically penetrate with the object of pulling the film downward, and displacing it at each passage of the rotating shutter. The sprockets remount immediately in order to attack the next two holes, and so on.

It will be seen that the construction of an apparatus to accomplish such operations must be extremely exact in all its movements in order to keep the fragile film uninjured and to be capable of using films a great many times.

The Lumière instrument, thanks to the alternate movement given to the crank by an eccentric triangle (which is the fundamental part of the Lumiere patent), is to-day the most unique and perfect apparatus of its kind. Thus the rapidity of departure and rapidity of stopping the sprockets is as progressive as possible. The movement of the sprockets does not commence until after the absolute rest of the film, so as to catch the perforation accurately, i. e., not to injure the holes. As a result, the film rests immovable during two-thirds of the time which separates two consecutive phases of reconstituted movement, the other one-third of the time being employed in substituting the following image.

All these advantages considered, the Lumière cinematograph can be employed with all safety, and furnishes results which no other machine can give, and it is a well-known fact to-day that Lumière's films (taken with the Lumière machine) are used by nearly all those who have machines on the Edison plan, i. e., four holes to each picture, but who cannot obtain with those machines such perfect results. It may be of interest to mention that by adjusting the sprockets in Lumière's machine they take positives with Edison perforation (four holes to each picture).

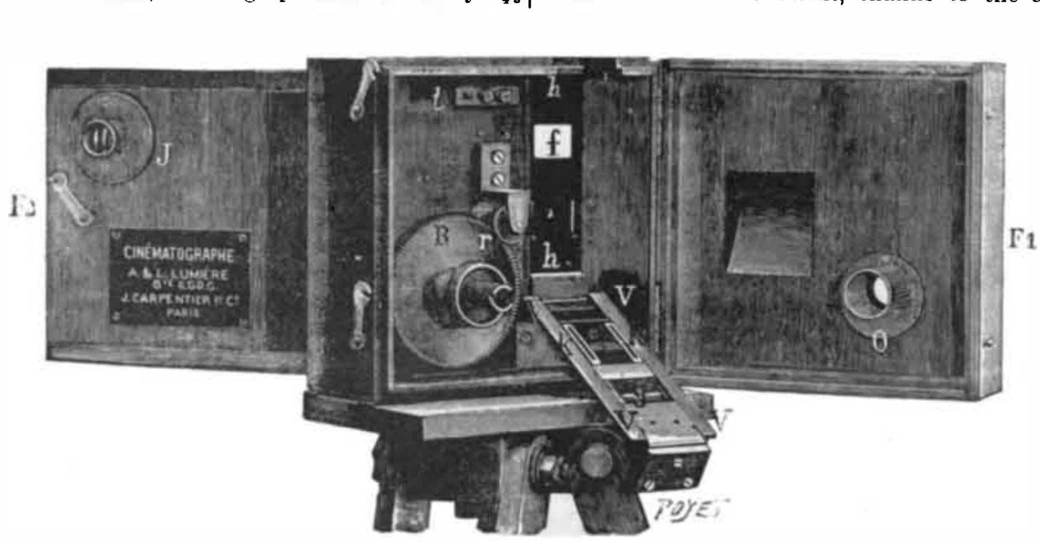


Fig. 1.—THE CINEMATOGRAPH CAMERA.

A few notes on the apparatus may be of interest. The cinematograph actually is composed of two essential mechanical parts:

1. The Eccentric Crank.
2. The Sprocket Frame and Sprockets.

While the crank rotates once, the eccentric transmission rotates eight times. The crank is manipulated by a handle which the operator must turn very regularly, about two turns per second; consequently, the eccentric transmission will make sixteen turns per second.

The triangular eccentric is fixed behind the transmission, and moves the sprockets continuously in a circle. The movements of these sprockets during their rotation are slightly deformed, so as to engage the film in one case, and in the other case to disengage it. At the end of the crank is fixed a shutter, which is composed of two light metallic sections, which can be regulated so as to increase or decrease the size of the same.

Respecting accessory mechanical parts, there is a bridgelike arrangement on hinges which can be lowered or kept in position by a latch. This bridging has two springs, within which the sprockets play. It has also a square glass provided with springs which presses lightly on the film when operated, so as to avoid damage to the film in case of any unforeseen accident. The wall is provided with velvet to keep the film from deteriorating, and on the upper part of this wall is a rectangular window, which allows the image to be projected or photographed.

To obtain the negative, it is necessary to have a tripod, a dark slide, a receiving slide and a film roller.

The receiving slide is entirely made of metal, and is designed to roll up the exposed film as it is unrolled when photographing.

The film roller is used for rolling the film by hand; the film is introduced into a slit on the roller, subsequently rolled, and thus about 50 to 60 feet of the film are rolled in a few seconds.

In taking the negative the following operations are necessary:

a. Introducing the film into the dark slide.
b. Focusing the scene.
c. Attaching the film to the receiving box, after which the door is closed, and the handle inserted ready to take the scene.

Focusing the object is a very delicate operation requiring all the care of the operator. It is clear that the negative film should have the greatest possible sharpness, because the positives obtained therefrom by contact depend on it and are subject to extreme enlargement when projected. The smallest defects in the negative are very much exaggerated when projected on a large scale.

The negative lens is provided with three diaphragms —one small, one medium and one large size. The smaller the aperture of the diaphragm, the smaller is the amount of light passed, and therefore the smaller diaphragm increases the general sharpness of the image, and it is recommended therefore to use it when a sufficient amount of light is available.

A small piece of plain matte film will make a very fine ground glass screen for focusing.

DEVELOPMENT, WASHING AND FIXING THE EXPOSED FILMS.

Prepare the following developer:

Water	20 pints.
Amidol	2 oz.
Sulphite of sodium	10 "

A stock solution of water and sulphite of sodium, which keeps indefinitely, may be always kept ready, and the amidol can be added as required. The relative proportion of amidol or sulphite of sodium may also be altered to suit requirements.

The above quantity of developer is made up so as to enable the employment of ordinary sized galvanized iron pails. It is preferable that these should be enameled in white on the inner side. For development, take two pails filled with the developer. The film roll is suspended over the pail, and then passed very rapidly into the first pail, and when the end has been reached into the next pail of developer, so as to insure even development. Care must be taken that the emulsion side is touched by the fingers as little as possible.

We repeat, the operation must be performed very quickly, continuing this process of passing from one pail to another until development is complete. The time occupied by the above developer is very short. Afterward plunge the film in a pail of plain water, taking same from the second pail when doing so. Under these conditions development will be sufficiently uniform over the whole length of the film.*

The same operation is repeated in the fixing bath, the strength of which should be one in four. Once fixed, place the film in a receptacle where the water runs continuously, and it must be left in the washing for several hours.

To avoid the film contracting after it has been fixed, it requires glycerining, and the following is the formula:

Water	15 pints.
Absolute alcohol	5 "
Glycerin	10 oz.

This operation must not take longer than five minutes; the temperature for drying should be 67° to 70° Fah.

MAKING THE POSITIVES.

For this purpose a dark slide is used. This dark slide has two axles. On the lower axle the negative is placed emulsion side outward, and around the upper side the sensitive film, emulsion side inward. The two ends are passed through the slit in the box. This operation must be done in the dark room. Subsequently proceed to expose the same as for negatives, only with this difference, that the positive film alone

* Journal, vol. xxx., p. 838.

* There are various other methods and devices for developing, which need not, however, be gone into.

is introduced in the receiving slide, whereas the negative film will unroll outside, through an opening arranged at the base of the apparatus.

The shutter must be arranged so as to form a complete semicircle. To make the exposure, close the apparatus, unscrew and remove the lens, and place before the circular opening at a convenient distance, a light, either a gas flame or petroleum lamp. The distance which this light must be placed depends on the nature of its intensity and the density and transparency of the negative. No precise instructions can therefore be

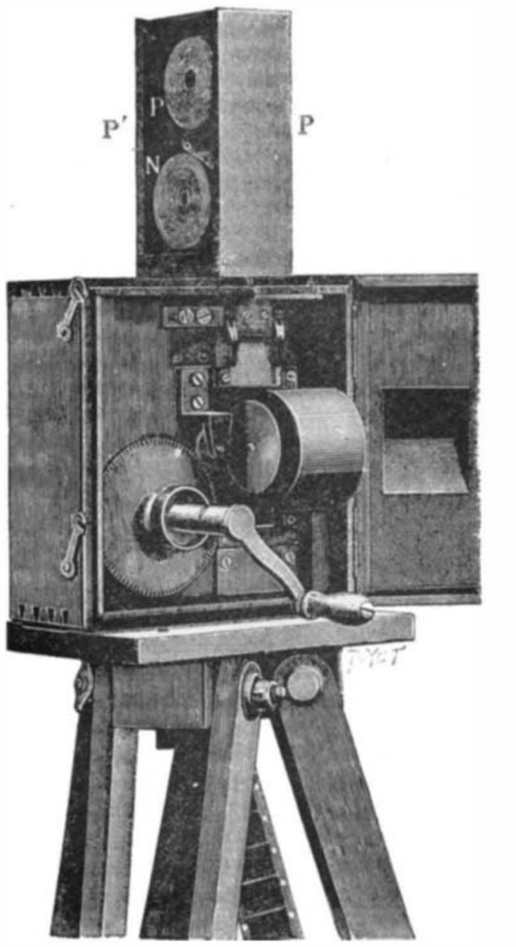


FIG. 3.—CAMERA AND PRINTING SLIDE.

given, but a few small strips exposed will give the necessary information to the operator.

PROJECTING.

The additional material necessary for projecting with the cinematograph is a projecting lens, an electric lantern, resistance coil, a stand and a screen.

The lantern, containing the regulator, is provided with a condenser, in the shape of a globular glass bottle containing water, which concentrates the light of the arc onto the projecting machine. In order to regulate the carbons, a side window is provided. The water should preferably be distilled, or a few drops of acetic acid may be added. The condenser is cased in a metal frame, fixed with four pins to the lantern, and each having a screw. The casing has a prolongation in the shape of a cylindrical tube, at the end of which is a movable window with a ground glass. This window is opened at the moment of projecting. When regulating the light, turn the globe containing the water until the light is at its maximum. This water globe replaces advantageously the glass condensing lens. As a matter of fact, the glass condensing lens has many disadvantages, and especially that of concentrating the heat rays on the film when same is stationary. By

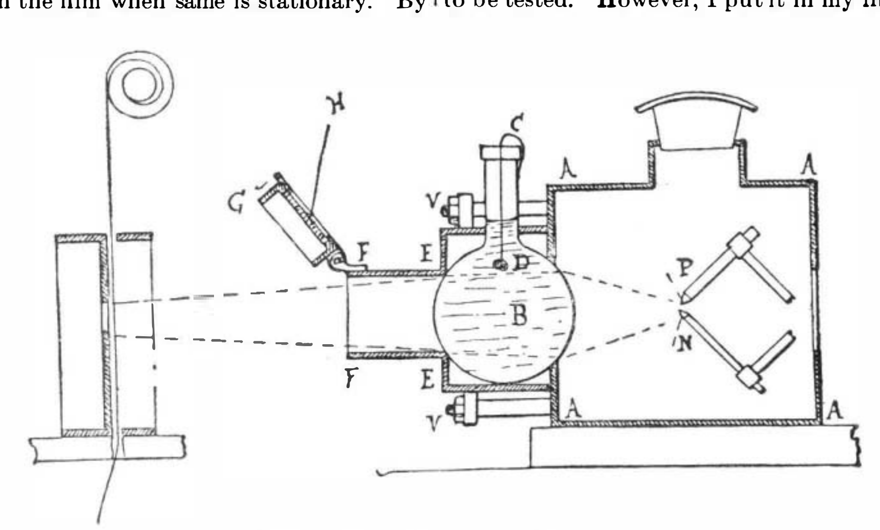


FIG. 4.—SAFETY LANTERN.

the glass globe this is avoided, as the water absorbs all the heat, and the power of lighting is increased. The light is white, the greenish coloration of the lens being suppressed. Should the water, after say about an hour, begin to boil, it is only necessary to insert a small piece of coke attached to a wire, and the evaporation will proceed with the greatest regularity.

This arrangement avoids any accidents due to carelessness on the part of the operator, as the concentrating object absorbs the heat rays.

If the projecting is done by transparency, i. e., if the screen is between the spectators and the apparatus, it is necessary to wet the same with glycerine and water in the proportion of 1 in 10. This renders the screen very transparent. These transparent projections give inverse images to those which are projected from the front of the screen.

If it is necessary to re-establish the pictures on the screen, and to show same in their proper way, that is, from the right, it suffices to turn the film so that the emulsion side is rolled inwardly.

It is hardly necessary to point out that the electric installation should be provided with safety fuses in case the current becomes too strong. We recommend the employment of continuous electric current; it is far preferable to the alternating current; in the latter case the lighting being variable and less brilliant.*

When projecting, the shutter should be placed so that the two disks cover each other exactly. This permits the maximum illumination of the screen, and care should be taken before pictures are shown that the maximum illumination on the screen is obtained from the lantern.

The films must be kept in a state of regular elasticity. For this purpose a tin box is supplied; this box has two compartments. The lower part should have a piece of felt or sponge impregnated with water, over which is placed a wire sieve, on which the circular boxes containing the films (the lids of the same being off) are placed. The films are left like this overnight, and can be used again the next day.

I might mention that, to give the audience an idea of the cost, an outlay of £80 is necessary to acquire Lumière's complete apparatus, capable of taking the negatives, making positives and projecting and reversing same. This sum also includes a number of scenes or film views, and their number can be added to by purchasing them at a further cost of about £2 10s. each view. These once purchased, and if properly handled, will last for a very long time, and it has been shown that a film is capable of being projected through the machine from 500 to 800 times, thus rendering the working of this machine extremely economical.

In conclusion, I may say there is no doubt that at no distant date those who can afford it will have their animated photographs taken, show them to their friends in their private houses, and then hand them down to posterity. The same may be said of historic events, such as the 1897 Jubilee processions, etc.

[The paper was illustrated by a varied series of animated photographs thrown upon the screen by Mr. Fuerst.]

EXPERIMENTS ON THE GLOW LAMP.†

By HIRAM S. MAXIM.

IT was, I think, about eighteen months ago that a very clever American, whom I knew to be an important man in the electric light business in the States, came to me with what purported to be a new and economical lamp. It was claimed that this lamp would save about one-third of the current. I think about six months were consumed in experimenting after the first call, before the lamps were actually brought to me in quantities to test. I purchased a quantity of lamps direct from the best known makers, and put the new lamps in competition with these, with the result that the former proved themselves to be slightly better as regards duration, but the new lamps gave more light for the energy consumed, the difference being about as 3½ is to 4. The purchased lamps began to give out at 300 hours, and were not so long lived as I had been led to believe. Wishing to know how much current was consumed per candle power, I had various lamps tested. I also made inquiries at electric light stations. At Knightsbridge station I was informed that the average commercial lamps now in use required nearer six than five watts per candle power, notwithstanding that they claim four. I also found that there were some two and one-half watt lamps for sale by various companies, but all of these were extremely short lived. After testing the new lamps brought to me by the American, I decided that there was not enough in the invention to make it of any value, and commenced a series of experiments myself.

I think it was last June that I put up a number of new lamps made on a new plan. One of them, on testing, was found to be less than two watts per candle power, and it was not thought advisable to put this up to be tested. However, I put it in my library. It was found to be 42 candle power. At the end of about two months it had gone up to 54 candle power. It is still running, and at the last testing was 46 candle power. This is the lamp that was seen by the American newspaper reporter, and the one which has been so much discussed in the American press. While the light is still very strong, there is a slight discoloration observable in the glass, but it is of a transparent nature and does not seem to interfere to any appreciable extent with the light. I have made a great variety of lamps, and it appears that a considerable saving is obtained by the changes which I have made. I know I can save 25 per cent.; my experiments appear to show that I can even save 33 per cent. The filament is manufactured and treated on a new plan, and a new form of combined mechanical and mercury pump quickly and cheaply produces a degree of vacuity which is, I think, considerably above that employed in the ordinary commercial lamps. So far I am quite able to make lamps of 2·5 watts per candle power and below, which last a long time without any appreciable diminution of light. The usual tests are 1,000 hours, though some have been tested 1,200.

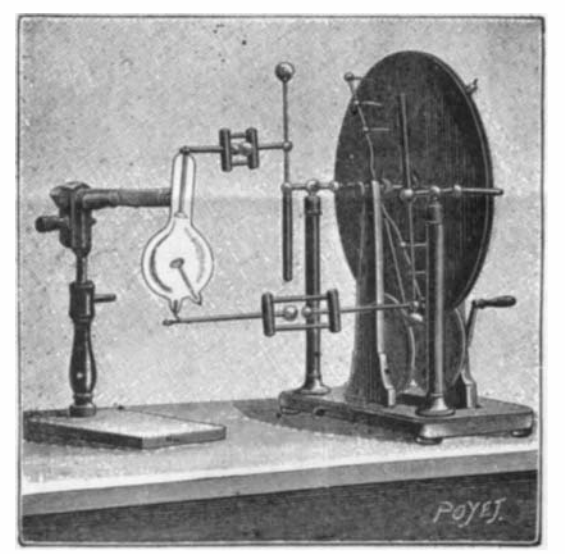
The greater part of the filament is carbon, but the resistance and tenacity is increased by the addition of a compound consisting of several substances. I have experimented with many substances. I know it has been said by those high in authority that no substance can be mixed with the filament of an incandescent lamp that cannot be volatilized out of it. Later on I shall be pleased to submit some lamps and let the parties attempt to drive out the nonconducting material that they contain. I do not think they will succeed. The new lamp promises so well that I have taken a small shop, and am now getting ready to make a quantity of the lamps. With new and improved apparatus I shall be able to make all my lamps as good as the best of them are now made. What has been done can be done again, and I see no reason why we should not put into the market a lamp which in light-giving power and lifetime will be considerably better than the best lamps now in the market. As far as patents are concerned, I presume it will take about half a dozen to cover the filament and the system and appliances for making it and preparing the lamp for the market. No patents are completed yet; they are only applied for. A great number of materials experimented with were found to be absolutely useless. I presume we shall be selling lamps inside of six months —perhaps sooner. I would say that one of the new features of the lamp is that the filaments, before being mounted in a lamp, are subjected to a much higher temperature than has been heretofore possible. This, of course, has a tendency to prevent any change taking place in the filament after it has been mounted in the lamp. It will also be understood that it only requires a very slight augmentation in the temperature in order very greatly to increase the light-giving power of lamps.

* It is quite possible, however, to use limelight with satisfactory result.

† From London Lighting.

THE STATIC MACHINE IN RADIOGRAPHIC EXPERIMENTS.

STATIC machines with condensers may answer for radiography, but if it is a question of radioscopy, there



NEW STATIC MACHINE FOR RADIOGRAPHY.

are obtained upon the screen scintillations that fatigue the eyes. Without the condensers, the static machine gives but a feeble and inadequate discharge.

The Ducretet establishment has, since 1874, been fixing to the base of the static machines that it constructs two ball columns that can be drawn out at will. These can be extended to any distance, and even be brought into contact with the balls of the exciter of the machine. In this way there are obtained sparks of variable length, which increase the tension. The columns are connected with the experimental apparatus.

In 1896, Dr. Destot used the static machine for radioscopy, and in the circuit of the apparatus arranged an interrupter formed of two balls facing each other. These balls had a certain capacity, and a discontinuous and very rapid discharge was produced between them. This arrangement gave very excellent results. The tube became intensely illuminated, and the light obtained remained nearly steady. Dr. Destot placed the conducting rods that carried the balls in a glass tube. Upon the passage of the spark, condensation and discharges upon the sides of the glass occurred.

M. Bonetti, a manufacturer of electric apparatus, has adopted the same principle and has just constructed a special apparatus, which is illustrated in the accompanying figure borrowed from La Nature.

In an ebonite insulating frame slide two metallic rods, each of which terminates in a ball. One rod is connected with one of the poles of the static machine and the other communicates with the tube.

Experiments have been made with a certain number of Crookes tubes, and the best results have been given by the "bi-anodic focus" one. The discharge may be easily regulated at will by varying the distance between the balls.

With properly arranged apparatus, a static machine with disks 18 inches in diameter has furnished the same results as an induction coil giving a 6 inch spark. The use of the static machine in experiments in radiography is, aside from the special advantages that it affords, of interest from many points of view.

It cost $55,000 for coal to take the British cruiser "Powerful" out to China.