

creases its adhesion to the plate. Finally, the operation is finished by beating down the edge of the tube that has been raised a little by the preceding pass. If this edge is already somewhat deteriorated, or if it is not very thick, tightness may be had by means of rings. The use of rings should be avoided as much as possible, because they diminish the section of the tubes, and render the cleaning of their interior more difficult. They should only be employed as an exception, and should be considered as an unavoidable evil. Even in old boilers, in which the holes have become oval, they should be considered only as a means of rendering a small number of tubes tight.

## 2. REMOVAL OF WORN-OUT TUBES.

The tubes are taken out independently of one another through the front tube-plate, after an incision has been made with a chisel through the part of the tube that is fixed into the back plate. When the holes in the front tube-plate are not greater in diameter than the external diameter of the tube, and the latter is incrustated, this process becomes very difficult, and the use of it often completely spoils the tube. In fact, we can only remove the tube by live force, and for this purpose we either use the shock of a heavy body or mechanical apparatus upon whose arrangement I shall not dwell.

In all cases the holes of the tube-plate are injured. The edge of these must, in fact, detach the scale from the tube before the latter can be removed from the boiler, and, when a little of this scale remains adherent, it produces grooves in the hole, which render it very difficult later on to make the new tube tight. It is consequently preferable to cut the tubes immediately back of the plates by means of a special apparatus consisting of a cone provided with a small circular steel saw.

This operation should be begun at the bottom of the boiler near the blow-off plug, and be continued in advancing toward the top. The cut tubes fall to the bottom of the boiler, and are removed through the blow-off hole of the front

The tube to be cleaned is submitted to a rotary motion around its longitudinal axis. The workman grasps it with a sort of wooden pliers whose jaws are provided with coarsely toothed steel plates, and, pressing the legs of this more or less tightly, slides it slowly along the tube. The incrustation is thus reduced to dust, and the tube, after the operation, is absolutely clean.

The apparatus used for revolving the tubes is shown in Figs. 1 to 3. It consists of quite a short shaft, which revolves in two pillow-blocks and receives its motion through pulleys. Outside of the bearing to the right, this shaft terminates in a cone provided with channels whose diameter is proportioned to that of the tubes.

The tube to be cleaned is firmly fixed upon the cone, and provided at its other extremity with a plug that serves to center it. As the cleaning is accompanied with much dust, it must be done in open air or in a special shop.

At the same time, a classification is made of the damaged tubes that can no longer be employed, except as ends of the tubes that may be employed in shorter boilers, and of those that are entirely unserviceable.

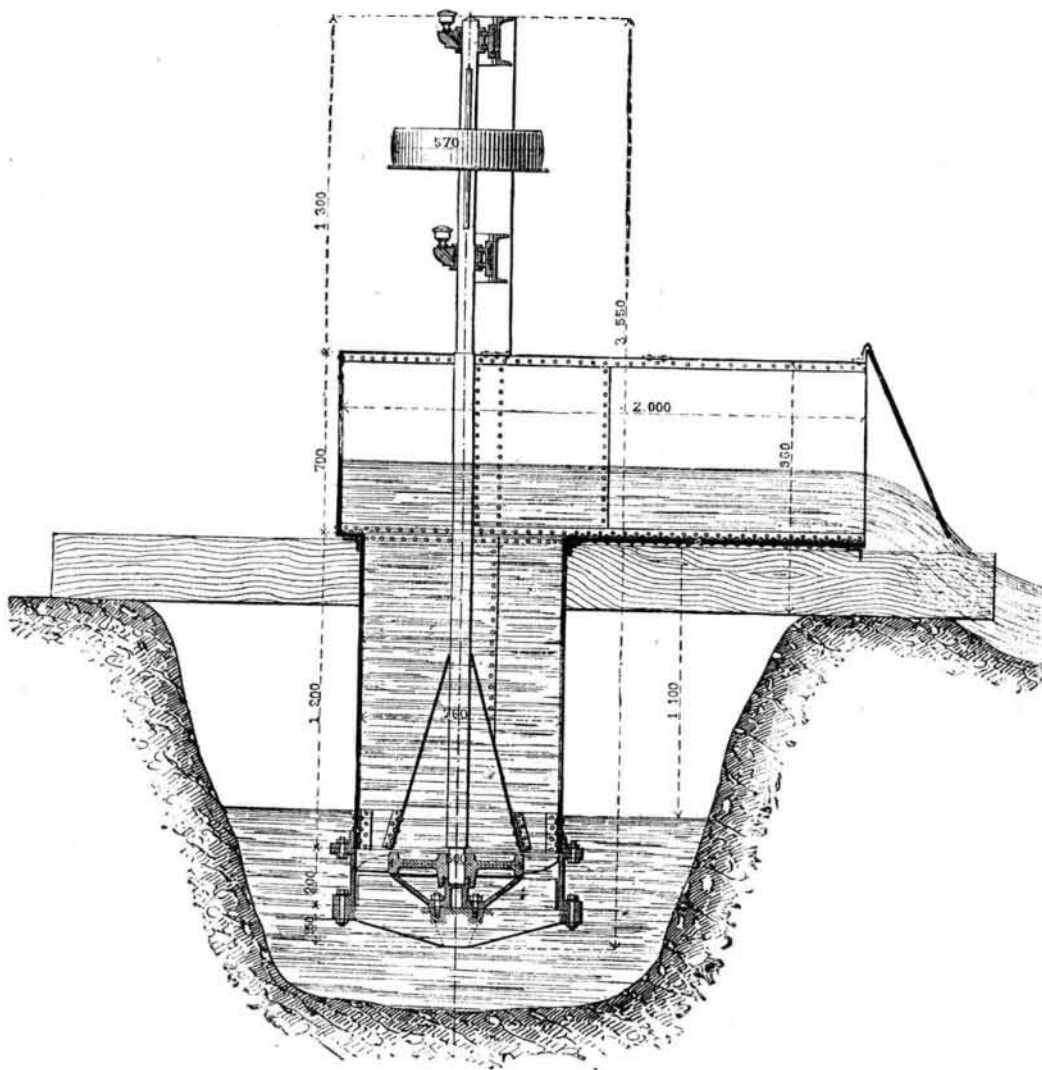
Every time a tube is removed it loses 70 to 80 mm. of its length in the two cuttings. When we have locomotives that are provided with shorter boilers, we have a direct use for the removed tubes, but if the contrary is the case the tubes must be lengthened. Such elongation is effected in three ways, viz., by drawing them out, by soldering copper ends to them, and by uniting iron ends to them with a hammer.

—P. W. Eichholz, in *Organ für die Fortschritte des Eisenbahnwesens*.

## GRULET'S SCREW FOR RAISING WATER.

The French Agricultural Machinery Company has recently made a very interesting application of the screw for raising water for submersion and irrigation, and, to our knowledge, it is the first of its kind.

It is only necessary to examine the accompanying cut and



GRULET'S SCREW FOR RAISING WATER.

tube-plate. The pieces of tube that remain in the plate are afterward easily removed by cutting them with a chisel.

If there are but few tubes to be removed, a passage is made for them toward the blow-off plug by removing a few of the tubes beneath. When the tubes to be removed are not too far from the plug, this method is very satisfactory. Even though there were a few more tubes removed, the cost of such removal would be more than compensated for, because this method is cheaper, and preserves the tubes and plates, and because the boiler, by receiving a larger number of clean tubes, will afterward utilize the fuel better.

## 3. REPAIR OF TUBES IN SERVICE, AND PUTTING THEM IN PLACE AGAIN.

Either when the removed tubes are to be employed anew, or when they are to be classed as old material, it is equally necessary to free them from the incrustation that covers them. The methods employed vary according to the shop.

The cleaning of tubes by beating or scraping the incrustation is very difficult, and requires much time. In some shops the tubes are dipped into an acid bath. In this way only the incrustation composed of carbonate of lime is dissolved, that into the composition of which sulphuric acid enters not being attacked.

In some large shops there are iron drums in which the tubes are placed. When these drums are revolved the incrustation becomes partially detached, but very rarely completely, and it is always necessary to finish the work by hand. It also happens that the bits of scale that become detached and that remain between the tubes produce grooves therein; besides, the cost of installing these drums is quite high.

Per contra, the writer has seen as yet, little known method employed in the shops of the Berlin-Hamburg Railway, one that he has used himself, that he has introduced into several shops, and that he can recommend as the best.

observe the dimensions of the machine (which was constructed according to plans of Mr. Grulet) to recognize the fact that we have here a really practical application.

The screw, which constitutes the principal peculiarity of the system, has six blades, with a pitch of 0.465 m. On making 210 revolutions per minute it is capable of raising about 435 liters (95 gallons) per second to a height of 1.2 m (about 4 feet). The shaft that drives it revolves in a bearing which is bolted to a cross piece that is affixed to the cylindrical chamber. This latter consists of a cast iron case that is easily taken apart, and of a strong cylinder of iron plate whose upper extremity is connected, by means of riveted angle iron, with the bottom of the sluice. In the interior of the cylinder there are two cones, whose bases embrace the hub of the screw in such a way as to obtain a continuous superposition of the layers of liquid, and prevent bodies in suspension from penetrating between the rubbing surfaces of the bearing. One of the cones is made of iron plate, and is connected with the principal cylinder by four radiating braces and small angle irons, and the other is cast in a single piece with the box of the pivot.

The rotary axis is guided above by two pillow blocks held by the cross pieces of a frame that is riveted to the sides of the sluice. Finally, this latter terminates in a hinged gate which regulates the flow of the water.

Two beams that rest upon the sides of a stream will suffice in most cases to support the entire affair.

The mechanical duty of the apparatus is estimated at about 65 per cent. In the apparatus put up by Mr. Grulet, the motive power is furnished by a portable 10 H.P. engine. The boiler is a return flame one, with movable fire place, and the steam cylinder has a diameter of 0.2 m. (8 inches) for a piston stroke of 0.3 m. (about 12 inches). Before the apparatus was finally put in place it was sent to the last exhibition at Carcassonne, where it attracted very much atten-

tion from visitors. Its great regularity in working was particularly remarked. This quality, and the simplicity of its construction and the ease with which it may be put in place, are valuable features in apparatus that are designed to be looked after by inexperienced persons, and to operate in open air far from repair shops.—*Revue Industrielle*.

## ON VARIOUS TONING BATHS.\*

By W. M. ASHMAN.

In alkaline toning with borax or acetate of soda, the first consideration is to free the paper as much as possible from the excess of silver nitrate remaining therein over and above the quantity used in the production of the print; this is termed washing away the free silver. That operation is satisfactorily performed by soaking the prints in a few changes of clean soft water, usually four, or until the water is no longer opalescent when tested with a few grains of salt. The washing water so obtained is collected in the manner described to you by Mr. F. W. Hart, and precipitated with dilute hydrochloric acid. The vessel employed should be scrupulously clean, either earthenware, porcelain, or wood answering the purpose.

*Experiment 1.*—The treatment of the prints is sometimes followed by passing them into a dilute solution of sodium acetate or ordinary common salt, about one per cent., such as here shown, and stirring them about for five minutes, when it will be seen they have assumed a brick-red color, the object of which is threefold: First, the fibers become charged with a substance which acts as a chlorine absorbent, a necessary property to be mentioned further on. Secondly, a definite color is insured to start with, thus obviating the possibility of mistaking fresh prints in the toning bath for those which have become purple by reason of the deposited gold, an important consideration when dealing with fumed paper. Thirdly, the last trace of free nitrate of silver is removed, thereby preventing a too rapid decomposition of the toning bath.

Theoretically considered, it is proper that the last trace of silver nitrate should be removed; but those who are engaged in the daily practice of commercial work do not insist upon the strict observance of such a rule in all cases. An especial exception is permitted and advocated when dealing with prints from weak or underexposed negatives, this class being found to yield richer tones by not washing any of the free silver out.

The plan of soaking prints in a solution of sodium acetate was originally recommended, in lieu of washing, by a member of this Association, Mr. A. L. Henderson, as long ago as 1861, the following being an outline of the method suggested by him: Slightly overprinted proofs were soaked in a bath composed of

Sodium acetate.....	240 grains.
Water.....	10 ounces.

The unwashed proofs were moved about in this solution at least ten minutes, in order to convert all the free silver nitrate into acetate of silver. After slight rinsing in clean water the proofs were toned with

Gold perchloride.....	4 grains.
Sodium acetate.....	240 "
Water.....	10 ounces.

Among the advantages claimed was an entire absence from mealiness, a defect, you will remember, we now avoid by the adoption of ammoniacal fuming.

Guide-books to the practice of printing usually recommended three rapid washings; the decomposing action thus set up by the quantity of free silver remaining in the paper materially quickens the speed of toning. To prevent a too rapid deposition of gold some printers prefer adding a small quantity of common salt to the toning bath, which turns the prints sufficiently red and acts in some respects equal to an intermediary bath.

Preserved papers—containing, as they generally do, a certain proportion of free acid—are liable to give some trouble in toning, owing to the retarding action of the acid present. When this occurs, it is in a great measure overcome by the use of an intermediate bath of an alkaline character and sufficient strength to neutralize the acid. Either the carbonates of ammonia or soda are found useful for this purpose, and I cannot do better than quote the one mentioned by Mr. Frederick York, which, it will be remembered, is composed of

Washing soda.....	1 ounce.
Water.....	1 gallon.

Prints treated in the manner described are ready for toning by the alkaline method to be dealt with later on.

This brings us to the consideration of toning baths generally. The properties of toning baths vary somewhat according to the mode of preparation. The term "toning," as we understand it, implies a certain change of color brought about by chemical means, such as the deposition of a stable metal upon one that is easily affected by the atmosphere—electrolysis, in fact.

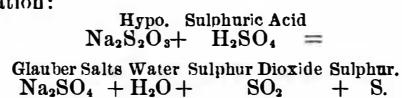
Evidently Mr. W. H. Fox Talbot was the first to use the toning bath in connection with paper photography, although he does not seem to have made much headway with his process at first; for it is recorded that from January, 1839, the date when Mr. Talbot communicated his discovery to the Royal Society, until 1845 very little improvement took place. These early paper pictures, be it remembered, were designated "photogenic drawings." Talbotype was not patented for some time afterward.

In the year 1845, however, it was found that steeping the paper in perchloride of gold vastly improved the results. It was not until 1853 that albumen took any part in the production of prints, the honor of its introduction being ascribed to Mr. Henry Pollock, although it seems that M. Le Gray, of Paris, about that time was producing stereoscopic pictures on albumenized paper. To M. Le Gray is due the credit of introducing gold toning in lieu of sulphur. The first toning then was performed by the decomposition of hypo., and known as "sulphur toning," by which fine black tones were obtained upon the addition of an acid, such as acetic, sulphuric, or other suitable oxidizing substance to the hypo., gold taking no part in this process. Unfortunately, prints so treated are said to be the least permanent of any; but of that I can bring no actual proof, never having employed the process.

*Experiment 2.*—*Toning by Sulphur.*—We have an unwashed silver print here in a twenty per cent. solution of hypo., and to that we now add a few drops of slightly-dilute sulphuric acid. It will be seen that a straw-colored substance is immediately liberated, which is sulphur in an exceedingly fine

\* A communication to the London and Provincial Photographic Association.

state of division, and this becomes attached to the print. Toning action goes on, through the silver image being tarnished, or, more correctly, converted into sulphide of silver. This liberation of sulphur may be expressed by the following equation:



With respect to the reaction which takes place when toning a silver image with sulphur, I will quote a few lines from the parent work of reference for nearly all recent writers, namely, Hardwich's *Photographic Chemistry*, wherein we find the following paragraph:

"It is well known that articles of silver plate become darkened by exposure to the fumes of sulphur, or to those of sulphureted hydrogen, of which minute traces are always present in the atmosphere. If the stopper of a bottle of sulphureted hydrogen water be removed, and a simply-fixed photographic positive suspended over it, the picture will lose its characteristic red tone, and become nearly black. The black color is even more intense than an experienced chemist would have anticipated, because analysis teaches us that the actual quantity of silver present in a photographic picture on paper is infinitesimally small; and it is well known that sulphide of silver, although of a deep brown color, approaching to black when in mass, exhibits a pale yellow tint in thin layers, so that a mere film of silver converted into sulphide possesses very little depth of color. To explain the difficulty it has been suggested that the toning action of sulphur on a red print is probably due to the production of a sub-sulphide possessing an intense colorific power, like the sub-oxide and sub-chloride of silver. When the toned picture is subjected to the further action of sulphur, is converted into the ordinary protosulphide of silver, and becomes yellow and faded."

The toning baths following the sulphur method were principally mixtures of gold terchloride and hypo. This latter substance was found to be a solvent of certain silver compounds by the Rev. J. B. Reade, in 1839, Mr. Talbot having previously fixed his prints with common salt. Prints, too, were fixed first in some cases, and toned afterward, washing away the free silver being more or less practiced in the mixed hypo. and gold and the sulphur toning processes. When fixing was employed before toning, it was usual to soak washed prints in a twenty per cent. solution of hypo. for a period of ten minutes, or until the soluble silver salts were removed, the resulting color being a disagreeable yellowish-brown. To improve the result so obtained the prints were passed into a solution of—

Gold terchloride ..... 10 grains.  
Water ..... 20 ounces.

When toning action quickly followed, the yellow color giving place to that of a dark sepia tint. From this stage to that of mixing these two substances together was only a natural sequence, and effected a diminution of gold to the extent of one-fourth, as will be seen by the following recognized formula:

Hypo ..... 7 ounces.  
Water ..... 20 "

When dissolved, add—

Gold terchloride ..... 5 grains.  
Dissolved in water ..... 20 ounces.

After mixing, a clear solution should result.

The *sel d'or* process followed, and was expected to give still better results. It was found, however, that the solutions would not keep; and as a considerable quantity of the gold salt was needed, it caused experimenters to search for a less expensive method. One decided point in its favor was the circumstance that prints suffered no loss of intensity during the operation, as they do in the case of all other toning methods. Briefly: the prints were well washed to extract free silver, and, after soaking five minutes in salt and water, they were passed into an alkaline solution composed of—

Liquid ammonia ..... 60 minims.  
Water ..... 20 ounces.

Here they became very red. After washing in clean water the surface was flooded with a toning solution composed of

Double hyposulphite of gold and sodium (*sel d'or*) ..... ½ grain.  
Hypo ..... 1 "  
Water ..... 1 ounce.

Upon the print assuming a purple-gray color it was withdrawn and fixed in a sixteen per cent. solution of hypo. to dissolve the unacted upon silver chloride. Gold, when in a fine state of subdivision, is of a rich purple color. The layer obtained by deposition upon a silver image is very finely divided; hence the color. The only object in continuing the toning action beyond the stage at which a good surface color has been reached is to obtain a deposit of sufficient density to completely neutralize the red color of the organic silver image beneath; therefore, it is preferable, in forming a judgment of toning action, to examine proofs by transmitted light rather than by reflected only.

Before dealing with the various formulæ for alkaline toning I should like to step out of the golden track to say a few words on platinum tetrachloride, PtCl<sub>4</sub>.

**Experiment 3.—Platinum Toning.**—The value of a platinum salt as a toning agent for silver images has been thoroughly demonstrated before you by Mr. Henderson, when he initiated us into the secrets of ceramic photography. My trials with this salt as a toning agent for paper proofs have only been partially successful. By that I mean that toning does take place when a dilute solution is employed, but the action is too tardy for demonstration here to-night, since anything like a black tone could not be obtained under half an hour. You will observe that the surface becomes covered with chloride, showing the necessity for copious washing. Yellow or discolored prints are bleached when toned in this bath, the whites becoming very pure. The formula here given is capable of producing a very good shade of brown in less time, and should be permanent, since platinum is a metal practically unaffected by the atmosphere; and I think there is good reason to suppose that if a thin coating of platinum could be deposited on the silver image, the protection offered would be more economical as well as stable. Something has already been done in this direction, but not in recent years.

The following is the composition we are now using:

Platinum tetrachloride, sirupy solution, color of old East India sherry ..... 5 minims.  
Hydrochloric acid ..... 150 "  
Water ..... 20 ounces.

Wash away the free silver thoroughly, warm the toning solution to 70° Fahr., and fix in a twenty per cent. hypo. bath.

Mr. A. Watt, in the second volume of the *News*, gives a formula which runs as follows:

Solution of platinum ..... 30 minims.  
Hypo ..... 3 grains.  
Hydrochloric acid ..... 5 minims.  
Water ..... 5 ounces.

This bath is said to act instantly, but I have not had an opportunity to test it. The strength of the platinum solution here given is indefinite, but any of our experimental members can soon ascertain the amount of dilution necessary to obtain the most favorable results.

**Alkaline Toning.**—Owing to the bleaching action which occurs in toning silver prints with gold, which is slightly acid, certain experiments were made, and it was found that bleaching increased in proportion to the quantity of hydrochloric acid added. Now, in the action of toning chlorine is disengaged, and in order to render this powerful bleaching agent inert it has been proposed to introduce a substance capable of combining with it, and thus, in absorbing it, prevent undue loss of vigor. To obtain this a slightly alkaline toning bath became a necessity, and to Mr. Waterhouse we are indebted for the introduction of the alkaline salts (Hardwich).

Here is an example:

#### Experiment 4.

Sodium carbonate (Na<sub>2</sub>HCO<sub>3</sub>) ..... 5 grains.  
Auric terchloride (AuCl<sub>3</sub>) ..... 1 grain.  
Water ..... 10 ounces.

Instead of the dry bicarbonate we will use a saturated solution. In this as well as the following experiments we shall tone three prints of the same subject, viz., ordinary, fumed, and preserved.

Mr. Maxwell Lyte has written on and investigated the properties of toning solutions a great deal more than most men, and we find the following emanating from Mr. Lyte:

Sesquichloride of gold ..... 15 grains.  
Phosphate of soda ..... 300 "  
Distilled water ..... 1½ pints.

And in the same communication it is mentioned that 180 grains of borax may be substituted for the phosphate with a like result. Therefore it will be seen that a borax toning bath is not of recent discovery, although it does not appear to have been quoted in many formulæ for at least a dozen years after its publication.

After the publication of Mr. Lyte's formulæ it was found that other salts behaved similarly; and among the first suggested we found sodium acetate, the qualities of which, extolled by the introducer, Mr. Hannaford, have since been verified by the whole photographic world. Here is one of the ordinary formulæ:

#### Experiment 5.

Gold terchloride ..... 1 grain.  
Sodium acetate ..... 10 "  
" chloride ..... 10 "  
Hot water ..... 20 ounces.

Mix twenty-four hours before use. Neutralize with chalk or whitening (carbonate of lime).

The name of M. Le Gray must be mentioned as the originator of the lime and gold toning bath; although the original formulæ differ somewhat from the one now used, the results are identical. The original formulæ consisted first in washing away a portion of the free silver by soaking the proofs for a few minutes in two changes of water, then submitting them to the action of an auriferous bath, composed of

Terchloride of gold, 1 per cent. solution .. 1 part.  
Hyperchloride of lime (white powder) ... 3 "  
Distilled water ..... 1,000 "

The action was complete in ten to fifteen minutes, when the prints required washing in two changes of water to free them from the chloride of lime remaining in the fibers previous to fixing in one to six of hypo. If the tone were satisfactory at the expiration of fifteen minutes, the ordinary washing could be proceeded with; if not, the proofs were submitted to a final bath composed of:

Gold terchloride ..... 2 parts.  
Hypo ..... 200 "  
Distilled water ..... 1,200 "

M. Le Gray says: "The proof ought not to be left in this bath less than fifteen minutes, as that is the minimum time necessary to insure the permanency of the picture; but it may be allowed to remain in it for as much longer as is requisite for obtaining the desired tone." Efficient washing in warm and cold waters completed the operation. Should any of our provincial members experience a difficulty in obtaining calcium chloride for their experiments, it can be easily made by causing dilute 7 to 3 hydrochloric acid to react on common whitening, and when neutral filter and set aside for the crystals to separate out.

**Experiment 6.**—The uranium and gold toning bath has many friends. The tones are said to be richer and to economize gold, while it is very easy to work. I am unable to give the author's name, but I can present a formula which has worked well in my hands. After washing away the free silver tone in the following mixture:

#### No. 1.

One grain acid solution of gold terchloride, 1 ounce.  
Water ..... 7 ounces.

Neutralize with sufficient of a twenty per cent. solution of sodium carb. (Na<sub>2</sub>HCO<sub>3</sub>).

#### No. 2.

Three grain solution of uranium nitrate .. 1 ounce.  
Water ..... 7 ounces.

Neutralize as in No. 1. Warm each to 70° Fahr., and mix. The bath is then ready for use. It can be used repeatedly if desired by acidifying with citric acid and neutralizing before use; but nothing is gained by using it a second time.

There are methods of toning which resemble more or less those which have occupied our attention to-night; among them may be mentioned the tungstate bath, likewise citrate of soda. The vermilion bath, too, might afford sufficient matter alone for a lecture. If some one experienced with it could be induced to bring it before us, I am sure it would prove interesting.

## COATING PLATES WITH GELATINE EMULSION.

To coat plates perfectly, says H. S. Starnes in *British Jour. of Photography*, I found the following points were necessary:

1. That a certain quantity of emulsion should be flowed in one even stream all over the plate, instead of pouring the emulsion in a pool in the center of the plate and then dispersing it over the whole surface; because in the latter mode of coating large plates the gelatine is apt to commence setting before it is equally distributed, and an unequally coated plate is the result.

2. The plate ought to be put on the leveling-table before coating, and not be moved before the gelatine is set; because in the dull light of the dark room it is so difficult to prevent the emulsion running off the plate when putting it down on the leveling-table.

3. I found that if the emulsion be rubbed (so to speak) on to the glass there is much less chance of frilling, etc., than if it were poured on. I think it is because in the former case the gelatine is in firmer contact with the glass. When the gelatine is poured on to the plate the cold glass instantly chills it, and by the time the emulsion has reached the edges of the plate it has so far set as to have partially lost its power of adhesion to the smooth surface of the glass.

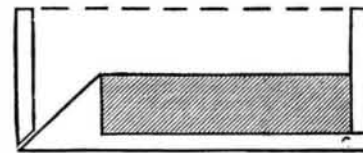


Fig. 1.—Showing melted emulsion in coater ready for coating.

Two or three years ago, when it was the practice to warm the plates before coating, I found from a series of experiments I then made that when a plate was warmed before being coated the emulsion commenced setting on the surface of the film, and of course in setting contracted, thereby leaving a partial vacuum between the film and the glass. On development frilling was the consequence. I found, however, that, when pouring the same emulsion on cold glass, on the portion of the plate where it was poured on, the film instantly chilled and commenced to contract on to the glass, and it never frilled there; but toward the edges of the plate, as the emulsion had commenced to chill before they were covered, the film was not in such perfect contact with the glass. Any person can try the experiment by first coating a plate in the ordinary way, and on the second plate just pour a small pool of emulsion on the center; let both dry, and he will then see after exposure which frills the easier on development.

After a series of experiments I found that by brushing a

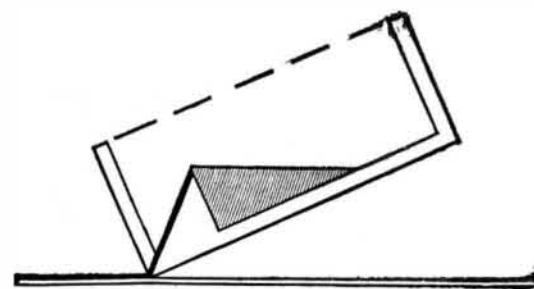


Fig. 2.—Showing emulsion flowing through the slit on to the glass.

substratum of emulsion on to the cold plate (with a brush made by binding a strip of wash-leather at the end of a strip of glass), and then pouring the full quantity of emulsion on to the substratum (for quarter-plates I used a small silver teaspoon, which held sufficient to cover that size of plate), I found I could coat plates far better and quicker and as easily as when coating with collodion, and I got over the difficulties of having frilling plates.

When only a few small plates are required—such as for experimental purposes—I believe this method is as quick and good as any; but when several dozen plates are wanted, any plan of coating them separately takes a long time. With my plate-coater I can coat a dozen plates in about the time I formerly took to coat one. When coating a number, I thought it would be best to lay them in rows on the leveling-shelves and draw the receptacle containing the emulsion over them, rather than keep the latter a fixture and run the plates under it either on an endless band or sliding shelves; because by the first mode the plates can be fixed close together, and the emulsion is less likely to get between them.

The coater is a species of wooden tray (of which the diagrams show the section), having a small slit in one of the bottom edges through which the emulsion passes in one even wave the whole width of the plate. The width of the coater is the same as that of the plate, though one six and a half inches wide can be used for either half or whole plates.

I find the best way of making it, so as to get the slit an equal opening the whole length of it, is to put the back, bottom, and two sides together first, as in Fig. 3. Then by putting a piece of very thin paper (A B) on the angle piece

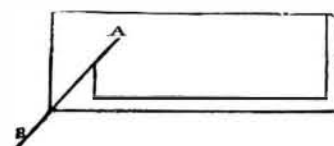


Fig. 3.

when the front piece of wood is put tight down on the paper and fixed in its place, and the paper is drawn out, it will be found that the slit is very even. In one coater I made I had the slit a little too wide an opening, and to reduce it I glued a piece of muslin over it. This I found was a great improvement, as it not only acted as a strainer, but it checked and caused a more even flow of the emulsion over the plate. I varnished the wood and muslin (except over the slit) with black Japan.