drops of A and pour over the plate, rock gently and rotate the action carefully. Be content to go slowly, and use as little ferricyanide as you can, the less the better, as with some brands of plates there is a tendency to stain the film. The negative should be withdrawn just before sufficient reduction has taken place, and well washed. This is the reducer to use for a negative described as flat and dense, as it has the properties of attacking the shadows before the highlights, and if used for a harsh negative we would be simply exaggerating our contrasts and make the evil greater than before.

Recently a new agent has been introduced, namely, ammonium persulphate. Some difference of opinion at present exists as to its correct formula and what happens when a solution of it is made in water, and also its action on the bromide of silver film. These points do not concern us, as so long as we obtain the wished-for result we need not enter into argument on these points. The salt is now an article of commerce and is obtained from any photographic dealer. In appearance it is of a white crystalline powder. The most convenient strength to use it is

Water 5 ounces
Ammon. persul. 1 drachm

The salt easily dissolves. If when dissolving the bottle he held close to the ear a curious crackling sound is heard. The negative must be thoroughly freed from all traces of the hypo, or brown stains will result. If we wish for a more energetic solution we can use

Persulphate of ammonia..... ½ ounce
Sulphuric acid 10 minims

and ten ounces of a nearly saturated solution of alum. The acid arrests the action and the alum counteracts any tendency of the film to frill, which often happens when the persulphate is used strong. The negative when placed in the reducing bath does not at first show any effect, but action soon begins and proceeds steadily. The plate should be withdrawn as soon as the correct density has been arrived at, and immediately placed in a ten per cent solution of sulphite of soda, which stops any further action of the reducer. The first negative I reduced by this method I omitted this precaution, and after reduction placed the negative under the tap to wash. When I came to put it to dry there was no image left, only a brown stain; reduction had been proceeding while the negative was washing.

The great point about this reducer is, besides being simple and clean, it tends to reduce contrasts as well as reduce density, and hence is of especial value in the case of a negative rather underexposed and overdeveloped.

Not very long ago a salt was introduced under the name of anthion as a specific for the elimination of hyposulphite of soda from the negative. This is closely related to ammonium persulphate, and is in fact potassium persulphate. It may in a like manner be used as a reducer, but it possesses no advantages over the ammonium persulphate, besides being more costly and less soluble in water. I have now, gentlemen (as much as the scope of a short paper will allow), enumerated the various forms of intensifiers in general use, for the process is one little known by the average amateur, who has a certain dread of the process, but when once tried he will be surprised how simple it really is.—The British Journal of Photography.

ON THE PERFORMANCE OF THE PNEUMATIC RETARDING DEVICE OF PHOTOGRAPHIC SHUTTERS.*

By EDWARD W. MORLEY, Ph.D., LL.D., and DAYTON C. MILLER.

We have made some experiments to learn what degree of accuracy and constancy are to be expected from the pneumatic retarding device used with photographic shutters. The sector shutter of Goerz and the volute shutter of Bausch & Lomb are so constructed as to promise the best performance of any on the market, and we procured for our use two of each of these shutters. Simple observation showing less uniformity in their action than had been expected, we were led to set up an apparatus with which the times given by each setting of these shutters could be accurately measured by readings made on permanent records. The results may be of interest to others.

The time spent in opening and closing, as well as the whole time of exposure, were determined by a modification of the method used by Abney. It will be remembered that he photographed, on a moving plate, the image of the shutter in the act of opening and closing. Before the camera containing the plate was placed the shutter to be measured, the plate and shutter being in the conjugate foci of the lens of the camera. In contact with the shutter was a horizontal slit, so adjusted as to become a diameter of the circle formed by the opening of the shutter. Suppose the plate to be in motion; at each instant, there is formed on it the image of that part of the slit which is at that instant uncovered by the shutter. On the whole photograph we shall see, first, a widening triangle corresponding to the process of opening; then, a parallelogram answering to the period of full opening; and, lastly, a narrowing triangle showing the process of closing. In Fig. 1, if the plate moved in the direction shown by the arrow, *a* is the beginning of the record, *ab* shows the time used in opening, ten or twelve thousandths of a second; *bc* shows the time of full opening, twelve-thousandths; and *cd* shows the time used in closing, seventeen-thousandths.

To measure these times, Abney interrupted the light passing through the shutter by means of a rapidly-revolving wheel; and the passage of each spoke before the shutter caused a blank in the photographic negative, whose appearance is shown in Fig. 2. The dark lines are successive images of the slit, while the white spaces indicate the periodic cutting off of the light. If the interruptions occurred at the rate of two hundred and fifty in a second, the dark bands are photographs showing how much of the slit was uncovered at successive two-hundred-fiftieths of a second, and by counting on this scale, we can determine the length of the

whole exposure, or of some definite part of the whole exposure.

In our measurements, we interrupted the light by means of tuning forks kept in uniform vibration by a suitable electrical attachment. In some cases, the whole light falling on the slit was cut off, in which case the photograph had the appearance shown in Fig. 2. In other cases, the light falling on the central portion of the slit was interrupted, but not that falling near its ends, and the photographs obtained were such as shown by Fig. 3.

With this apparatus, we measured the times given the four shutters mentioned, as well as those given by a volute and a sector shutter lent to us by friends. One sector shutter was also measured in the inverted position in which it was attached to the pocket camera of our friend. Each shutter was measured repeatedly for all exposures not over half a second. By comparing the average for one shutter with that for the same setting of another shutter, we learned the accuracy with which shutters agree with the professed times, and with each other. By comparing the individual measurements for the same setting of a given shutter, we learned the accuracy with which the setting repeats a desired time of exposure.

I. Each shutter opens in less than four-thousandths of a second. The volute shutter brings two springs into action for short exposures, and its time spent in closing varies; Fig. 2 shows the two times, which are about eight-thousandths for longer exposures, and four-thousandths for the shortest exposures. The sector shutter always closes in the same time, which is less than three-thousandths of a second, as shown in Fig. 3.

II. The accuracy with which the average time given

FIG. 1.—IRIS DIAPHRAGM SHUTTER SET FOR $\frac{1}{50}$ SECOND.

FIG. 2.—VOLUTE SHUTTER.

FIG. 3.—SECTOR SHUTTER.

COMPARATIVE DIAGRAMS OF THREE DIFFERENT SHUTTER SPEEDS.

by a shutter answers to the time marked on it is shown by Table I.

TABLE I.					
Time by scale.			Time by scale.		
Average actual time three volute shutters.			Average actual time three sector shutters.		
1	2	3	4	5	6
sec.	sec.	sec.	sec.	sec.	sec.
1/150	0.006	0.007	0.009	1/150	0.011
1/100	0.005	0.009	0.009	1/100	0.011
1/50	0.010	0.009	0.009	1/75	0.014
1/25	0.045	0.087	0.064	1/20	0.076
1/5	0.222	0.109	0.109	1/10	0.107
1/2	1.14	0.33	0.23	1/5	0.207
				1/3	0.36
				1/5	0.46

The average deviation of the actual time from the professed time is a little more than thirty-five per cent.

III. To determine with what accuracy a given setting of the same shutter reproduces the same time of exposure, we measured each setting three times and noted the difference between the longest and the shortest exposures. There were ten such sets of three for the volute shutter, and twenty for the sector shutter. Table II. gives the number of sets for each shutter in which this difference had the values indicated.

TABLE II.		
Number of cases in which the difference had certain values.		
Volute shutter.		
Less than 20 per cent	0	11
20 " "	3	3
25 " "	1	
30 " "	1	3
35 " "	1	2
40 " "	1	1
50 " "	2	
80 " "	1	

For the sector shutter, the difference between the shortest and longest exposure out of three is as much as twenty per cent in nine cases out of twenty; for the volute shutter, the difference was as much as twenty per cent in all cases.

IV. The sector shutter is sometimes applied to small cameras in an inverted position. Table III. shows the nominal times and the actual times for the shutter which was lent to us so adjusted.

TABLE III.			
Times given by sector shutter in two positions.			
Time by scale.	Average actual time, piston up.	Average actual time, piston down.	
sec.	sec.	sec.	
1/150	0.010	0.007	
1/100	0.012	0.011	
1/75	0.013	0.014	
1/20	0.014	0.043	
1/10	0.064	0.139	
1/5	0.197	0.290	
1/3	0.400	0.443	
1/2	0.493	0.667	

It is obvious that in some cases the difference in the times given in the two positions is enough to occasion disappointment unless taken into account.

V. The volute shutter can be set to give exposures longer than half a second. Table IV. gives the measured times given by these settings.

TABLE IV.				
Long exposures of the volute shutter.				
Time by scale.	1	2	3	
sec.	sec.	sec.	sec.	
1	1.25	0.52	0.36	
2	1.80	0.90	0.72	
3	4.80	1.23	1.23	

Some of the conclusions justified by our experiments may be stated.

1. It is difficult to see the advantage of the automatic timing of exposures longer than half a second. Not many would fail, after half an hour of tuition or trial, in making by hand exposures more accurately timed than those of Table IV.

Our further conclusions depend on the time which the amateur demands for his shortest exposure. That which we devise when the fiftieth of a second is short enough is very different from that which commends itself to us when the same shutter must give exposures of less than a hundredth of a second as well as exposures between the tenth and the fiftieth of a second.

2. When the fiftieth of a second is sufficiently short, we think it better to use a shutter having no pneumatic retarding device, but giving two or three different times by varying the tension of a spring or by calling reserve springs into play for shortening the time. Good shutters of this kind are much used on certain forms of camera. They are not diaphragm shutters, it is true; but the shutter acts between the components of the lens, and the result cannot be distinguished from that given by the diaphragm shutter. These shutters, at least some of them, give the times of exposure which are most commonly serviceable, and they give them with unfailing accuracy. One such we measured at one of its velocities forty-two consecutive times, and there was no variation greater than five per cent. Another we measured sixty times, at its three velocities, which were 0.031, 0.025, and 0.022 seconds. There were but two cases in the sixty where the variation was as much as ten per cent.

With this constancy of time of exposure, we may compare the results of similar repeated measurements of those two shutters out of the six mentioned above which were selected as the most accurate. We set these one hundred twenty-five times for an exposure of the twentieth of a second. The times actually found varied from fifty-five per cent less to thirty-seven per cent greater; in more than half the exposures, the variation from the average was more than twenty per cent.

We are inclined to urge that this form of shutter ought to be developed and improved. It would not be difficult, by bringing into play either one spring, or two or more springs, at will, to increase the longer time given by it to a fifteenth or twentieth of a second. An exposure of half a second can be easily and accurately given by hand, after no long practice, with more accuracy than by the pneumatic retarding device. Exposures of a third or a fifth or a tenth are harder to give with accuracy; until one has learned to do so, he must make the time half a second and use a smaller stop. The amateur who uses such a shutter will have at command, with all desirable accuracy, the most frequently useful times of exposure, from a fifteenth to a fiftieth of a second.

3. When the shutter which gives these times must also be capable of giving times as short as the hundredth of a second, our advice is different. The pneumatic retarding device is, at least for the present, inevitable, and we recommend a certain modification in it.

The pneumatic device occasions the greatest uncertainty in those exposures which call for but a slight retardation. Times such as the twentieth, thirtieth, and fiftieth, are included within this region of greatest uncertainty. It seemed to us not unlikely that, if the piston were made to move with so much less friction and air resistance that the whole retardation were reduced to a tenth of a second, this region of greatest uncertainty might be removed from the desired exposures of a twentieth and a fiftieth of a second to some shorter exposure where it might do no harm. We accordingly made new pistons for that one of the two selected shutters which was the less accurate of the two. One of these gave an exposure time of 0.056 second when set at one-half on its former scale. Table V. gives the marks of the former scale, new times which might be marked at the same points, the average times given at these settings, and the greatest variation from the new average times.

With this shutter as at present readjusted, we can give exposures of the one-hundred-and-fiftieth of a second; we can give the most frequently used expos-

* Paper read before the Winter Meeting at Washington, D. C., of the American Association for the Advancement of Science.

TABLE V.

Times and variation of times of readjusted shutter.			
Former scale.	Proposed scale.	Average times.	Greatest variation. Per cent.
sec.	sec.	sec.	
1/2	1/18	0.056	4
1/3	1/23	0.044	4
1/5	1/31	0.032	4
1/10	1/45	0.022	5
1/20	1/80	0.012	20
1/75	1/100	0.010	
1/100		0.009	
1/150		0.007	

ures from the forty-fifth to the eighteenth of a second with an accuracy amply sufficient, and we can give exposures of half a second or longer by hand. Until considerable improvements in design and workmanship shall make the pneumatic retarding device much more trustworthy than at present, this is the practice which commends itself to us. If others should come to the same conclusions manufacturers would be led to make retarding devices to give only exposures not longer than a tenth of a second, but giving them with accuracy, and leaving to the operator the timing of all longer exposures.

PAINTING BY THE ACRE.*

THE average houseowner who paints his dwelling once in five years considers that he is discharging his whole duty in the direction of keeping up appearances, although there are fastidious persons who insist upon a fresh coating as often as every third year. In fact, there may be found a few instances of men—regarded in their own neighborhoods as slightly unbalanced mentally—who redecorate the exterior of their dwellings every year.

But what would be the feelings of the householder who complains of the trouble and expense of this infrequent process if he unexpectedly became the owner of an ocean liner? When he learned the requirements necessary to keep his great floating palace in presentable dress, his first impulse would be to apprentice himself to the painters' union. If the modern Atlantic flier is a glutton for coal, she is no less a glutton for paint, and her bills on this account in the course of a year amount to as much as the salary of the average bank president.

Under ordinary circumstances the ships of the largest and most carefully managed lines are painted at the end of every voyage. Take, for example, one of the American Line steamers, as the "St. Paul" or the "New York," running between New York and Southampton. Every time one of these ships arrives in New York she is repainted. And this is no patchwork undertaking, like covering up bald spots here and there. Every inch of the vessel's outside area above the water line—sides, deckwork, funnels—from stem to stern is carefully gone over and receives a complete fresh coating. As the vessel makes from ten to fifteen round trips in the course of a year, this means that they are entirely repainted, except as to interiors, an equivalent number of times. And the painting of the interior woodwork—saloons, staterooms, storehouses, and all her hundreds of compartments—is renewed whenever the vessel is given a complete overhauling, which occurs ordinarily once a year.

When one contemplates the great size of the modern passenger ship and figures the extent of her area, he does not need to be told that this represents in the aggregate a vast undertaking for each of the big steamship companies. The sides of the average first-class liner from water line to rail represent an area of about an acre. The outworks of decks and cabins amount to almost as much more, while the outside surface of the giant's two great funnels and her masts totals over half an acre. Thus there is an area approximating two and a half acres to be covered on the biggest liners at the end of every round trip voyage.

There are 140 steamers in the International Mercan-

tile Marine Company alone, which includes of course the largest of all passenger fleets. Assuming that the average area to be painted on these ships is two and a quarter acres, and that each vessel makes only ten round voyages in the course of a year, and that one hundred of the ships are continually in commission, the big shipping combination still has as one of its

ent is the soft coal burned in the furnaces. The dust and cinders from this coal are fairly ground into the paint in the course of a voyage, so that it is almost impossible to remove the former without taking off the latter. A thorough scrubbing is always necessary before the painting operations actually begin, and sometimes, indeed, this serves the purpose so well

ADJUSTABLE SCAFFOLD FROM WHICH THE SMOKE-STACKS ARE PAINTED.

ties the painting of some 2,250 acres each year. This is a job which would require the services of nearly one hundred men working steadily, and of course it would consume hundreds of thousands of gallons of paint. Its cost, while among the minor expenses in the operation of the company, must be between a quarter and a half million of dollars a year.

This seems an immense sum to expend for the single item of paint, but its expenditure is essential to the preservation and the presentability of the great steamers. There are two very obvious reasons why the Transatlantic flier is refurbished so frequently. One is to prevent corrosion of her metal work; the other is to keep her always spick and span in appearance. The spray of the salt sea waves is much more destructive to paint than ordinary land weather, while it is an accepted doctrine among all steamship managers that their vessels must be bright and shining whenever they leave port if they are to hold the favor of the traveling public.

The greatest enemy to the beautiful whiteness in which the steamer's upper works are usually resplend-

entirely oftener than every other voyage.

As soon as the liner is in her berth and the passengers ashore, the work of the painters begins. A force of from twenty-five to thirty is maintained by each of the large companies as a part of the regular "onshore" crew. The funnels present the most difficult and also one of the most important tasks, and work on them is started without delay. The giant smokestacks of a great liner, often large enough to run a double line of trolley cars right through them, are so heavy and massive that one would hardly believe that they could be injured by anything the workmen (who look like particularly large flies swung against them on their lofty stagings) might do. As a matter of fact, however, these great pipes are particularly susceptible to injury and must be handled very carefully. Any pounding or hammering against them would cause holes to appear, and after that they would go to pieces in short order. The old paint and the dirt must be carefully scraped and scaled off before the actual painting begins, and this is really the more difficult part of the task. The work of actually applying the paint moves rapidly, as the surface is a broad and unbroken one, and the paint is mixed thin and put on with big brushes.

While this is in progress another group of painters is busy with the steamer's towering sides. They work from floats or from stagings suspended from the rail, and are armed with broad, long-handled brushes like those that bill-posters use in covering dead walls with paste. The amount of space that one of these men will cover in the course of a day is astonishing to a person familiar only with the more deliberate methods of land workmen. The paint used in this marine work is of special preparation, and contains a large proportion of oil. It is spread very thin, moreover, since otherwise the steamer's sides would be badly gummed in a short time from the frequent coatings.

The deckwork, although in some respects less difficult than the painting of either the sides or the stacks, proceeds more slowly, as the preliminary scrubbing must be more thorough, the surface is more broken, and the operation must be carried on without interfering with the other activities of the ship. Most of the liners have their deckwork painted white, their sides black, and their stacks of some light tint with a distinguishing band around them—so that altogether four colors are usually employed in covering a vessel.

Nearly all the painting of the great Atlantic fliers is done on the American side for a reason that is pertinent enough, although it might not occur to the ordinary observer. This reason is found in the weather conditions. There is a much larger proportion of fair days in the United States than in England or the Continental ports. Consequently nearly all the Transatlantic lines, whether or not they have their headquarters in the United States, have their painting done in American ports. Thus it is that whenever one visits a liner in this port between voyages, one is likely to see men slung aloft painting the funnels, men on floats painting her lower sides, other men hanging from the rail painting the upper portions of her sides, and still others on deck with tarpaulins spread all about painting every inch of exposed space.

PAINTING THE TOPSIDES OF AN OCEAN LINER IN PORT.