**Optics of photography : on a new process for equalizing the definition of all the planes of a solid figure represented in a photographic picture / by A. Claudet.**

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# OPTICS OF PHOTOGRAPHY.

## ON A NEW PROCESS FOR EQUALIZING THE DEFINITION OF ALL THE PLANES OF A SOLID FIGURE REPRESENTED IN A PHOTOGRAPHIC PICTURE.

BY

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ONE of the greatest deficiencies of photography in the representation of solid figures is the impossibility of obtaining a well-defined image of all the various parts situated on different planes; for it is well known that the best object-glasses can give a sharp image only for the plane in focus; the images of the objects situated before and behind are more and more confused as they are more and more distant from that plane.

To obviate this, or rather to equalize the effect to a certain degree, it is customary to reduce as much as possible, by means of diaphragms, the aperture of the lens. The object of such diaphragms is to cut off all the oblique rays, and to employ only the rays which emerge from the lens at the least angle possible. It is evident that when the rays are emerging from the centre of the lens, they follow a course so nearly parallel that any equal points of the object on various planes are included between spaces not varying much in size; so that although these points are distant from the plane which is represented at the mathematical focus with the greatest definition, they form their image within a circle of confusion so near the circle of definition that the eye

* Read at the British Association, Nottingham Meeting, 1866.

cannot easily detect the difference, and the image of the solid figure appears well defined in its various planes.

But this result cannot be obtained without sacrificing a great amount of the light which falls on the lens and is stopped by the diaphragm; consequently the time of exposure for the formation of the image is to be increased as much as the surface of the lens has been reduced. It is then obvious that, in the case of portrait-taking, the advantage which would be gained in point of definition is lost by the unavoidable unsteadiness of the sitter, and at all events is more than counterbalanced by the constrained expression resulting from a long sitting.

Even supposing that the person could sit sufficiently long without moving, and preserve all the while the same expression, it is a question not difficult to decide in an artistical point of view, whether a photographic portrait showing all the pores and asperities of the skin, with the smallest of its wrinkles, would ever be an agreeable or artistic production.

Excessive minuteness is the greatest reproach which has been made by artists to the best photographic portraiture; and in order to obviate it, some have gone so far as to suggest that it would be desirable that photographers should take their portraits *a little out of focus*. But these artists, forgetting certain laws of optics, failed to observe that it was impossible to represent the whole of the figure in *the same degree* out of focus. If, for example, the nose was a little out of focus, the eyes would be considerably more so, and the ear still more; in fact some parts of the figure would be quite indistinct and confused, whilst one part only would be a little softened down by a slight deviation from the plane of sharp focus.

Although such a method is therefore unavailable, this suggestion, being made in a true spirit of progress, was worthy of consideration; and a very useful lesson was to be learned from the well-meant recommendation that photographic portraits, to be agreeable and artistic in effect, should not partake too much of the mathematical truth which is inherent to the action of the most perfect lenses, and which is particularly observable in the part of the image situated in the plane of the exact focus of the lens.

Convinced myself of the advantage which, in an artistical point of view, would result from photographic portraits being taken in such a manner that they should as much as possible resemble a work of art, in which all the features are marked by light touches of the brush or pencil, softly blending from light to shade, such an important subject has for a long time occupied my attention. My precise object has been to discover a method of removing, if possible, from photographic portraiture that mechanical harshness which is due to the action of the most perfect lenses.

In the best works of art all the effects are produced by a soft and harmonious treatment; nothing is hard or dry, nothing is too minutely delineated: in fact the hand of the artist is not capable of microscopic correctness—and fortunately so, for its work is not intended to be examined by a magnifying lens; still the general effect may be sufficiently minute for the artistic purpose.

Notwithstanding its defects, photography is the great teacher to artists: they find in it the true reflex of nature; it shows the correct distribution of light and shade with all its delicate half tints; its perspective drawings are perfect, and it represents the folds and texture of draperies in the most exquisite manner. But if art derives a great advantage from the imitation of photographic productions, art is in its turn a very competent and valuable teacher of photographers. Their works indeed have no value if they do not partake of a certain character which distinguishes the best works of art. And therefore photographers must not despise the recommendations of true artists; for in trying to imitate art they will often improve their own productions. Therefore as artists have nothing better to do than to imitate photography, so photography has nothing better to do than to be guided by art.

By the laws which regulate the action of lenses, it happens, as has been already pointed out, that in the representation of a solid figure there is strictly only one plane of that solid which can be taken in perfect focus. The image therefore of that plane is not in harmony with the images of the other planes, which are not so sharply defined. This inequality in the texture of the image cannot but be considered a defect; and it would be a great advantage if it were possible to equalize the effect, even at the cost of losing the mathematical accuracy of the plane in focus. I hope to show indeed that such a loss would be really a considerable gain. If photographic portraits should not exhibit all the pores, wrinkles, and defects of the skin, it is still less desirable that only one part of the face should be in that condition, while all the others should gradually lose their sharpness as they are more and more distant from the plane of definition.

We can at will bring the focus upon any plane of the figure. In taking portraits not smaller than miniature size, we may choose the nose, the eyes, or the ears; but we cannot have the three equally sharply defined; and photographers endeavour to focus upon a middle plane, for example upon the eyes, in order to have the nose and the ears in the same degree of less perfect definition, not very far from that of the eyes.

Perfection in the portrait would be attained, were it possible to do so, first by taking the image of the nose, then, after having

altered the focus, the image of the eyes, and finally, after again altering the focus, the image of the ear, and then, from these various images, forming a collective portrait. Such an idea may appear impracticable, possibly even absurd, and it is sure on first thoughts to be rejected and condemned. Yet I seriously, and after mature consideration both of the practice and of the theory of such a scheme, propose its adoption as one of the greatest improvements which will have been introduced in photography since its discovery. I beg to be allowed to explain the method in which I conceive I have solved the difficulty I have above alluded to.

Let me premise a few words upon the effect produced by the experiment of taking the photographic image off the focimeter. This instrument, I may be permitted to remark, was invented by me upwards of twenty years ago, and has been constantly used in my operating-room in order to test in what degree the chemical and visual foci of lenses coincided or differed. Until it came into use, nobody had ever dreamt that they did not exist in the same plane when the object-glasses were as much achromatic as those of the best telescopes. This fact being demonstrated by the instrument I refer to, was the cause of a complete change in the construction of lenses for photographic purposes; and from that time opticians have endeavoured to calculate, and succeeded in discovering curvatures the combination of which, to invent a phrase, achromatize, with the visible rays of light, the invisible rays which are exclusively endowed with the chemical action. The use of the focimeter I have found indispensable since the further discovery I have made that the two foci undergo continual changes from various atmospheric influences; and no photographic studio, therefore, should be without this instrument; for no optical combination is capable of preserving an invariable coincidence of foci, and the photographer must have the means at any moment of testing the then state of the elements, and of the light itself, in order to ascertain any change in its refraction and to act accordingly.

My focimeter, a model of which is on the table, is made of eight separate segments of a disk, mounted spirally on a horizontal axis of 12 inches, corresponding with the optical axis of the lens; the segments are all separated and distant about $1\frac{1}{2}$ inch from each other. In a front view they form on the ground glass the image of a complete and regular disk. The segments are covered with some uniform and well-defined devices; and the centre of each is marked with its number, from 1 to 8. The first segment is the nearest, and the last the furthest from the lens.

By moving slightly and slowly forward and backward the fo-

cusing or ground glass, any one of these segments, and all in succession, may be brought into focus. If we focus upon No. 4, for example, we see that the segments before and behind gradually lose their sharpness, in a greater or less degree, according to the quality of the lens; and from that experiment we may judge empirically of what is called the depth of focus of the lens. By comparing at the same time the photographic image with the image we had on the ground glass, we see if the visual and chemical foci agree, or to what extent they differ. But our present object not being to test whether the chemical and visual foci agree, we will take a lens in which we know that they coincide.

Now, supposing that we focus upon No. 1, we shall find that the photographic image of that segment will be very well defined, No. 2 a little less, No. 3 and all the others until No. 8 gradually losing their sharpness, so that No. 8 will be the most indistinct. In the same way, if we take a portrait so that the nose is on the plane of No. 1, this part of the face will be well defined; the eyes, which are on the plane of No. 2, will be a little less well defined; the ear, on the plane of No. 3, still less defined; and if the body is obliquely turned, the shoulder, which corresponds with the plane of No. 8, will be considerably confused.

Experimenting again upon the focimeter, let us suppose that, after having operated with No. 1 in focus, we move the frame holding the plate to a point previously marked on the camera-board where No. 8 is in perfect focus. If we then expose the plate a second time, or rather continue the exposure, we shall find that upon the first confused image of No. 8 a new image well defined has been impressed, and at the same time a confused image of No. 1 will have been impressed upon the first image of No. 1 which was well defined.

In examining the result, we shall find it better than if the second impression on both segments, No. 1 and No. 8, had not been taken. In the middle of a confused image of No. 1 and No. 8 we shall have one perfectly defined, the whole having the appearance of the shadow of a pin not quite in contact with the surface; that shadow being slightly blended from dark to light, but still sufficiently defined to show the exact form and size of the pin.

Now what has been done for the two extreme segments of the focimeter Nos. 1 and 8, can consecutively be done for the intermediate segments Nos. 2, 3, 4, 5, 6, 7, and 8; and in fact it is unavoidably done during the movement of the plate from No. 1 to No. 8; and the result is that every segment has the image of any small spot delineated upon it as if that spot was seen through a thin vapour.

This being well understood, let us apply the same mode of

operating to the taking of a portrait; and while the person is sitting, let us move the frame holding the plate from the point of the focus of the nose to the focus of the furthest point of the figure. It is evident that during the movement of the plate the various planes of the figure will have been consecutively *in* focus and *out of* focus during one part of the exposure, and all in the same degrée. Thus we have by a very simple contrivance found the means to realize the wish of true artists, viz. to take a photographic portrait without hard lines, but with the light and shades blended in the most artistic harmony.

We now arrive at the most important part of the discovery. The result may be obtained in greater perfection without having to move the frame holding the plate in order to adapt it consecutively to the focus of each of the planes of the figure. In moving the frame, it is evident that in one direction we increase, and in the other we reduce the size of those parts of the image which are consecutively brought into focus. The result is to exhibit more conspicuously than when these parts were out of focus the exaggeration of perspective which is inherent to all photographic representations taken by lenses not very distant from the figure—an exaggeration, I may remark, so disagreeably apparent in all large portraits taken by too short-focus lenses. To obviate this increase or reduction of the size of the image of the various planes of the figure, it would be necessary, if this were practicable, during the operation to change the lens and rapidly to substitute another having a focus appropriate to the distance of the new plane without altering the distance of the plate, so that the plate should not have to be moved forward or backward for the adaptation of the various foci according to each distance of plane.

It happens fortunately that this change of foci may be effected with the same object-glass when that object-glass is a double combination of lenses. The focus and power of such double combination being the result of the distance which separates the two lenses, it may be increased or reduced merely by altering that distance. Now if during the operation we bring nearer or further the two lenses, by this simple means we adapt the focus of every plane to the immoveable frame holding the plate; and we are enabled thus to represent consecutively on the plate an image of every plane, with a less reduction or increase of size than when the power of the double combination remains the same; for it happens fortunately that, to reduce the focus, we must separate the lenses, by which the power is increased. The alteration of the distance which separates the two lenses is effected by a rack and pinion acting upon a tube containing the back lens, that tube sliding into another containing the front lens,

which remains fixed during the adaptation of the focus to the distance of every plane by means of a gradual movement communicated to the back lens during the sitting. The inspection of the apparatus, which I submit to the Meeting, will enable any visitor interested in the question to understand its action.

It is marvellous when we reflect that there is nothing to wish for in the shape of contrivances having for their object the perception of vision, and that from time to time man invents, or thinks he invents, what nature had done in the most perfect manner. The eye is supplied with a lens in the same way as the camera obscura; the retina is the screen on which, like the ground glass of the camera, the light reflected by all the natural objects form their image. By various humours through which the light is refracted, the spherical aberration is corrected and the most perfect achromatism is produced; the eye is endowed with muscles which enable it to alter the focal distance of the lens according to the various distances of the objects. Optics is able to imitate all these beautiful contrivances except the last, which is available only on account of the way in which we exercise the perception of vision. We see at once only a very small part of the image—that part which is projected on the centre of the retina; and the eye can adapt its focus to the distance of that part, and, as rapidly as thought, when directing its attention to another part it adapts its focus to that new distance. Therefore it matters not whether the other parts are in focus; we have only the perception of what we want to see, and, by the proper adaptation, that sensation conveys to our mind only a well-defined image. It cannot be so with the camera obscura, because, the photographic image produced by it being at once permanently fixed entire by the same exposure, we cannot change it in changing the focus; the only thing we can do is to impress a stronger image on a fainter image. The artificial optical instrument being destitute of a self-acting changing adaptation to the focus of all the other planes, can represent only one plane *in focus*; but if it had that adaptation, the surface receiving the impression of the image in a permanent manner (not like the retina, which does not retain the impression), that impression would consist of a number of images superposed one upon another. For this reason nobody would ever have thought of proposing to employ a lens which, moving during the exposure, would adapt itself consecutively to the foci of all the other planes of the image. But from the fact that the eye can easily and usefully alter its focus according to the distance of the plane it wants to examine, and unconsciously discard the image of the other planes while they are out of focus, it is possible to learn what may be a very useful modification of the artificial optical instrument called the camera obscura. If we cannot

discard the superposed images out of focus, and see only among them the one in focus, it happens fortunately that the image in focus is stronger, better defined, and consequently more conspicuous than all the others. If we cannot discard entirely the images out of focus, they at all events appear only like a number of blended shades of the principal image. Therefore in this process for changing the power and the focus of the double combination of lenses according to the distance of the various planes, we do nothing but imitate one of the most beautiful and indispensable of natural contrivances, by which the eye is so wonderfully well calculated to perform all the exigencies of perfect vision, and is one of the most marvellous and splendid works of the Creator.

This new plan of operating not requiring a longer sitting than the old process, the interposition of the usual diaphragms will, by cutting off the oblique rays, increase the definition of the compound image. It follows that, as much as the intensity of light will allow, the smaller the aperture of the diaphragm is, the more perfect will be the result.

One of the great advantages of the method I have described is that the various planes of the figure are represented with the same intensity of light, which is not the case when the rays are more condensed on the plane of exact focus than on the other planes. For it is obvious that the difference of intensities of light on the various planes produces an unnatural effect, and destroys so far the harmony of the picture.

I have felt justified in bringing this matter before the Association, from the confident hope that, by the examination of scientific photographers, a new era may henceforth begin in the art of photography. If the plan I propose is in its present state deficient in many practical points, as must be the case in almost all new inventions, I am sure that, with the cooperation of so many ingenious and active minds which are constantly engaged in the task of progress, the science of optics will be able to supply photographers with a camera obscura which in its working will approach as near as an artificial instrument can approach the beautiful instrument which gives to man the most perfect perception of all the wonders and beauties of nature.