photographers to give greater attention to it by making the pictures of a more artistic character than is now the case, say, by introducing something like the hatched or scroll effects of Sarony, or anything else that will give a novelty to the work. In passing, it may be mentioned that the hatched effects are far better adapted to cabinet size portraits than they are to the carte-de-visite, the size in vogue when this style was introduced. It does not follow that an idea that may in reality be old would not be a novelty if reintroduced. It would be a pity, we think, if the vignetted portrait were to become obsolete, for it is a very excellent picture when skilfully produced, and, what is not unworthy of consideration, it commands an enhanced price.

THE PRINCIPLES OF DIRECT COLOUR PHOTOGRAPHY BY PRISMATIC DISPERSION.

(A Paper read before the Paris Academy of Sciences.)

In order that a photographic print shall reproduce all the colours of the original, two conditions must be fulfilled:—

(1) The sensitive plate should preserve the slight differences which exist between the different radiations which occur in the incident light; it should, in other words, analyse each incident ray of light.

(2) To reconstitute the incident light in colour at one operation, the system should be reversible, so as to effect synthesis from the elementary colours.

Following from this general statement, we may ask whether any physical phenomenon which permits of two elementary colours being distinguished cannot be made to serve as the principle of a system of direct colour photography. Such a phenomenon, for example, is prismatic dispersion, as it occurs in a spectroscope, and does actually supply a solution of the problem of direct photography in colours.

A photographic spectroscope consists essentially of a slit, *f*, a prism, a lens, and a sensitive plate. It determines the analysis of the light which falls on the slit. It can be shown that the apparatus is reversible, and that it is able to re-compose the coloured light falling on the slit.

Suppose that the sensitive plate has been developed, and that a positive from it has taken its place. If the slit has been lighted by red rays, these rays will give in the spectrum an image, *r*, of the slit. This image (transparent in the positive) forms a kind of slit which, on the plate being returned to its position, is the conjugate image of the slit, *f*. Inversely, *f* is the conjugate image of *r*, according to the principle of the inverse course of rays. This double condition is satisfied for the red rays which have formed the image, and for them only; rays of any other refrangibility would have a different course, and would fall on neither *f* nor *r*.

Hence it follows that if *f* is illuminated with white light, the transparent region *r* receives only the rays which have formed it, and only allows these latter to pass. If the light be made to pass in the opposite direction—that is to say, if the positive transparency is lighted with white light—the slit receives and allows to pass only the rays which have come from *r*.

This reasoning is applicable to rays of any refrangibility, and to rays existing simultaneously with others. In other words, the photographic positive being in position and exposed to white light, the slit receives a light of precisely the same spectral composition as that which fell upon it during exposure. If the negative is substituted for the positive transparency, the slit is illuminated by the exact complementary of the light which is received during exposure. In this case, the portion *r* occupied in the spectrum by a given set of rays is an opaque area. These rays, therefore, cannot reach the slit, since the only rays of this kind which would be able to fall on the slit are those which would have passed through *r*. In short, with a transparent positive photograph in the position of the spectrum, the only rays to pass are those which acted during the exposure; these rays are replaced by their complementaries if the negative is substituted for the positive.

In order to apply this principle to the reproduction of colours, I have arranged the following apparatus:—Instead of the single slit of a spectroscope, I use a series of slits all very close together. They are fine transparent lines of a ruled screen of five lines per mm., such as is employed in photographic reproduction This screen is fixed to the front of a photographic enlarger, i.e., to a box provided at its extremity with a sensitive plate, and carrying a converging lens at about the plane midway between its two ends. In front of the lens I fixed a prism of small angle, with its edge parallel to the transparent lines of the screen.

The image to be reproduced is projected on the screen, the sensitive plate is developed and put back in place. On illuminating the apparatus with white light an image is seen in colours. Each line of the screen acts as the slit of a spectroscope, and, as the lines are not visible at the distance of distinct vision, the image appears continuous.

The first experiment on these lines was made with the spectrum of the electric arc, which was reproduced in colours by means of a positive transparency. When a negative was used the red was replaced by its complementary, blue-green, and the green by purple. A red and green stained glass window applied to the screen was likewise reproduced in its colours, and afterwards in its complementaries.

It is necessary that the prism fixed in the apparatus shall have an angle so small that each spectrum has a length less than the interlinear space, otherwise the spectra encroach on each other. It is also essential that the photographic plate occupies exactly the same position as during exposure, a condition which is easily fulfilled in the case of solidly constructed apparatus. If the positive is moved in its frame, the colours rapidly change; if it is turned, there is a coloured moirée effect. On bringing the plate back to its original position these effects disappear.

Rapid commercial orthochromatic plates may be used, and the exposure is much shorter than in the interference process.

On the other hand, it is not at all convenient to have to put the positive back in the apparatus whenever it is desired to see the colours Examined in the hand, the positive is black and white, just like an ordinary transparency. Viewed with a lens, it is seen to be broken up into lines, each line divided into small zones, which are the parts of a spectrum.

It will perhaps be possible to improve this process so as to avoid the use of an apparatus to observe the colours, and to make the plate sufficient in itself.

Suppose that a sensitive plate be placed in an ordinary camera, without a prism, but with the interposition of a ruled screen, and suppose that on the screen (which, we will say, has 5 lines per mm.) we superpose a grating of 500 lines per mm.; each luminous point thus projected on to the screen then spreads as a spectrum, and is photographed. On applying the screen, with its grating, to the developed positive, we should see the colours of the original—that is to say, if the eye can occupy the place of the lens. The optical system, as explained in the earlier part of the paper, is reversible.

GABRIEL LIPPMANN.

The following note is also communicated to the Academy of Sciences:—

A NOTE ON THE THEORY OF THE INTERFERENCE PROCESS OF COLOUR PHOTOGRAPHY.

IN the theory which I have set forth of the photography of simple and compound colours, I have confined myself to the particular case of plane waves. But in practice the waves are not plane; they are appreciably spherical, since the plate receives the projection of points. It is, therefore, well to put the theory in correspondence with practice, an operation which leads us to the conclusion that theoretically we may replace the mercury mirror by other devices.

I will assume the perfect objective, giving an image P (reduced to a point), of an external point. The point P and its image, P^1, given by the mercury mirror behave as two synchronous sources. The interference fringes (with one exception) are not plane, but have the form of hyperboloids, with P and P^1 as foci. These are the fringes which are embedded in the sensitive film in the form of silver deposit possessing a feeble reflecting power.

Suppose the films are formed by light of wave length λ, and that we cause white diffused light to fall on the plate. Any incident ray whatever which passes through P cuts the series of hyperboloids, corresponding to the maxima of the light, in a series of points, M, M^1, M^{11}. . . . . and the straight lines MP, M^1P^1, etc., are equally inclined to the surface of the hyperbolic fringe. Thus the corresponding reflected rays make part of a conical bundle, with its apex in P^1. Moreover, the reflection is selective, that is to say, it affects only the rays λ, which form the system of fringes.

Thus, when one passes from a point M to a point following in the series, the "difference de marche" between the two reflected rays increases from λ the difference of the corresponding phase is equal to zero if the incident ray has the wave length λ, and only so in this case. The only vibrations reflected appreciably are those which have formed the bundle of interference fringes.

In the above demonstration, P and P^1 are two synchronous sources, images of the same distant point, and there is nothing to imply that the point P^1 should be obtained by reflection in a mirror. It may therefore be concluded that the system of these two sources may be obtained by means of any of the devices used for producing interference fringes, such as a bi-prism or a double Fresnel mirror, fixed before the lens.

Theoretically, we may replace the mirror by any one of these systems, but practically it is not possible, for the points P and P^1 should be close together, and this condition is not fulfilled in the case of the bi-prism or the Fresnel double mirror. There is no doubt that the system of two semi-transparent mirrors is the only one likely to be successful experimentally.

GABRIEL LIPPMANN.

THE TONING OF BROMIDE PRINTS.

THE following notes conclude the extracts from the recently published work by Dr. E. Sedlaczek on the principles of the processes employed in the toning of bromide prints. For the full text of the author's experiments and conclusions the original German work, published by W. Knapp, of Halle a/S., should be consulted.

The Copper Process.

Whilst with iron and uranium the ferricyanides are soluble and the ferrocyanide insoluble, in the case of copper the ferrocyanide is insoluble. The correct proportions of sulphate of copper $CuSO_45H_2O$ and potassium ferricyanide are as 4:3. The correct way to mix copper toning solutions is to add an organic salt to the copper sulphate solution, and then add the ferricyanide. If the organic salt is added last much more will be required to dissolve the cupric ferricyanide.

The copper baths may be used in an acid neutral or alkaline state, but weak ionised acids must be used, if a highly ionised acid is used insoluble copper salts are precipitated. An excess of an organic acid does not prevent the toning action, but it will frequently give rise to a fogging of the image by the formation of basic copper compounds. Care must be taken to avoid, too, the use of salts which easily form cuprous compounds, such as the sulphocyanides and bromides.

The tones obtained with copper stand the action of alkalies better than those with iron and uranium.

The following baths are recommended; as they do not keep well they should be mixed just before use:—

RED TONES WITH A BROWN TINGE.

Potassium citrate, 10 per cent. sol.	150 minims.
Copper sulphate, 10 per cent. sol.	24 minims.
Potassium ferricyanide, 10 per cent. sol.	18 minims.
Ammonia alum, sat. sol.	60 minims.
Water	1 oz.

BRICK-RED TONES.

Potassium citrate, 10 per cent. sol.	75 minims.
Copper sulphate, 10 per cent. sol.	24 minims.
Potassium ferricyanide, 10 per cent. sol.	18 minims.
Ammonium carbonate, 10 per cent. sol.	6 minims.
Water	1 oz.

This bath has a tendency to give double tones, that is, the deep shadows show a blackish tinge. A very beautiful cherry-red tint with a violet shade is obtained by replacing the citrate solution in above bath with quarter-oz. of 10 per cent. solution of ammonium oxalate, but the whites are often tinged.

RED-BROWN TONES.

Potassium oxalate, 10 per cent. sol.	60 minims.
Copper sulphate, 10 per cent. sol.	24 minims.
Potassium ferricyanide, 10 per cent. sol.	18 minims.
Tartaric acid, 10 per cent. sol.	6 minims.
Water	1 oz.

A faint tinge is imparted to the whites by this bath. If the tartaric acid is replaced by acetic acid a browner tone is obtained. If the quantity of oxalate is doubled, and 60 minims of alum sat. sol. added to the above, a purer brown is obtained with tinged whites, which give the effect almost of toned papers.

COPPERY-RED TONES.

Ammonium oxalate, 10 per cent. sol. ...	120 minims.
Copper sulphate, 10 per cent. sol.	24 minims.
Potassium ferricyanide, 10 per cent. sol.	18 minims.
Oxalic acid, sat. sol.	6 minims.
Water	1 oz.

This gives a slight tinge to the whites.