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CONTENTS.

	PAGE		PAGE
Mr. Stanley on the Theory of Colour Vision.....	61	Further Notes on Guaiacol and Allied Phenoloid Com- pounds as Developers for Gelatine Plates. By Colonel J. Waterhouse.....	67
Enlarged Finger-Prints. By Francis Galton.....	61	Work of the Photographic Societies	69
Calculation of the Angle of View. By Philip Everitt	63	Society Notices	71
Enlarging. By Captain S. Garnett Radcliffe.....	64	Studio Gossip	71
Photography in its Relation to the Art of Printing...	64	Answers to Correspondents	72
Photographic Work in America	65		
Notes.....	66		

MR. STANLEY ON THE THEORY OF COLOUR VISION.

THE theory to account for the phenomenon of colour vision which is known as the Maxwell-Young-Helmholtz theory has for so long received almost universal acceptance amongst scientific men that it needs a bold pioneer to offer any serious opposition to it, unless supported by evidences such as will ensure the serious consideration of the most competent experts in the subject.

It may be as well to briefly recapitulate the accepted theory. In accordance with this theory, there are three sets of nerves in the normal eye, each sensitive to a certain range of the spectrum. Thus, one set of nerves is sensitive to the red, with a certain sensitiveness fading off into the orange and yellow; a second set is particularly sensitive to green, and, to some extent, to the rays on both sides of it; whilst the third set is sensitive to violet and blue. All the various shades of colour recognised by the eye are assumed to be due to stimulus applied to one or other, or two or three together, of these sets of nerves.

There has not been wanting a pretty strong accumulation of evidence in support of this theory, which is certainly, the one that, up to the present, has best explained the varied phenomena of colour vision. One of the easiest demonstrated is the fact that, by combining on a screen light consisting of two or three of the colours answering to the primary colour sensation, all—or, at all events, very nearly all—the colours of natural objects can be reproduced. Thus, a red disc of light thrown on to a white screen, and made to overlap a similarly produced green disc, shows at the overlapping portion a bright yellow. This is perhaps the most striking instance, as red and green pigments mixed will not produce yellow, nor, indeed, can yellow be produced with pigments of any other colours at all, and so for a long time yellow was looked upon as a primary colour.

In a paper on "The Functions of the Retina and the Perception of Colour," read before the Physical Society by Mr. W. F. Stanley, the accepted theory of colour is challenged on grounds which hardly seem to us sufficient for such an undertaking.

The theory proposed as a substitute assumes that diverse colours affect different depths of the sensitive layer on the retina. One objection to the three-nerve theory is raised on the ground that the image of a star could not possibly cover three nerve terminals at once. It appears to us that this is a mistaken assumption, and on several grounds it is quite possible that although the image of a star when brought to a focus by a lens of such short focal length as the eye, and having absolutely defining power, would not cover the three assumed terminals, yet these terminals may be so small and close together as to fill a larger space on the retina than the image shown by the most perfect eye, and possibly even than the image of the most perfect optical instrument yet made, which should have an equal angular aperture—equal power of light, that is, with the eye itself.

Mr. Stanley's views were contested by, amongst others, Captain Abney; but as this appears to be the first of a series of papers on the functions of the retina, we may hope for matter of further interest.

ENLARGED FINGER-PRINTS.

BY FRANCIS GALTON, F.R.S.

PERMIT me to suggest in your columns, what has already been suggested in my recent book on "Finger Prints," that photographers might find it worth their while to persuade customers to have enlarged prints made of the impression of one or more of their fingers, like the accompanying specimens.

These sign-manuals endure, in all their minutiae, from childhood to death, with such extraordinary persistence, that out of about seven hundred points of comparison between prints made of the same fingers at intervals of very many years, only a single instance of a minute change has

yet been found. The evidence on which this statement is made is fully set forth in the book. It seems not unreasonable to suppose that many persons would like to possess so curious and unchanging an evidence of their own identity, and that the wish to have prints taken of the fingers might become a fashion which photographers would find it lucrative to promote.

Enlargements to a six-fold scale, such as these, are more intelligible than smaller ones, and very much more so than the actual impressions, which are bewildering to an untrained eye. There is room in these enlargements to write, in red ink, reference numerals to the various forks and to the beginnings and ends of ridges, of islands and of inclosures, of which I count at least thirty-nine in fig. 1—which is the print of a well-known explorer

small island will be seen which contains a solitary pore, whose position is such that it could not be included in the sweep of the adjacent ridges, and therefore requires, and has got, an island all to itself. A close examination of the print shows other instances in which the dependence of the ridges on the pores, rather than that of the pores on the ridges, seems to be fairly well established. There is still more of this to be seen in the original photograph, which is, of course, somewhat more clear than the photograph made from it.

Any finger may be selected for printing, but the forefinger is the most variable; then the ring finger. The thumb is a little more troublesome to print from than any one of the fingers, and its greater size is disadvantageous in a six-fold enlargement, because a quarter-plate is hardly



Fig. 1.



Fig. 2.

—and thirty in fig. 2. Every one of these may be expected to persist, not only during life, but after death also, until they are effaced by decay.

There are contingencies in which sure means of identification are useful, to which youths who leave their country for distant lands are more liable than those who remain at home. It is, therefore, especially on occasions when a farewell portrait is taken of a lad about to emigrate that impressions of the bulbs of his fingers might be appropriately taken also, and one of them enlarged like these. Such prints are at least curious, and will be interesting in after years, while they are by no means unsightly if properly mounted.

Much interest attaches itself to such impressions as fig. 2, in which the open mouths of the sweat glands are very distinct. It shows how the run of the ridges has been determined by the position of those pores whose ducts they enclose and support. Look, for example, just above the third ridge from the bottom, and at about one-third of the width of the print, counting from the left. A

large enough than to contain the whole of the more characteristic features of its pattern.

The principal methods of obtaining good finger-prints have been fully described in my book, and it is only possible to epitomise them here. Impressions in printers' ink are, on the whole, much the best. They require the partial equivalent, at least, of a printers' roller, to spread the ink evenly over a slab of copper, zinc, porcelain, or glass. A small cylinder of wood, over which a bit of smooth india-rubber tube has been tightly drawn, answers well. The roller runs on an axle. It is *most important* that the layer of ink should be *very thin*, otherwise the pressure of the ridges will displace and force enough of the ink upwards into the furrows to choke them, and the print from the finger will be a blot.

The impression may be made on card, porcelain, or glass. Cards are the best for easy handling and for preservation. Porcelain gives a beautifully clear background, but the ink upon it dries very slowly. Glass, also, is objectionable on the score of the slow drying of its inked surface; but

It is valuable to serve as a transparency, from which an enlarged negative may be taken in the camera. Or the negative print left on an inked glass after the finger has pressed it may be used in the camera to give an enlarged positive upon paper. The great advantage of a transparency is felt during dull winter weather, on account of its shortening the time of exposure, which otherwise is tediously long in making these enlargements; a six-fold enlargement requiring thirty-six times as long an exposure as a reproduction on an equal or on a reduced scale. Smoked glass may be tried, but too much of the soot usually comes off on the fingers to leave a serviceable negative. When the blackened fingers are pressed on gummed paper that has been slightly damped, it leaves an admirable print. The inked pads used for office stamps are of use only when the ridges are prominent and well defined.

A photographer who proposes to undertake the supply of enlarged finger-prints should first master the art of making the simple impressions clearly. It is in daily practice at my anthropometric laboratory, in the gallery of scientific instruments at South Kensington, which is entered from the north side of the new Imperial Institute Road, at about one hundred yards from Queen's Gate (admission free).

As regards the enlarging camera, I used for some time a very rough arrangement made by myself, which acted perfectly for enlarging to a uniform scale. The board that carried the lens, and that against which the printed card was pressed from behind, were both fixtures. The latter had a small window with bevelled edges, in the optical axis. Behind was a backing of millboard that had enough elasticity to loosely hold a card that was pushed in between it and the board. When the right part of the card came in front of the window, the backing was clamped to the board, and the interposed card thereby secured tightly in its place. I now use an elaborate and costly apparatus, capable of varied adjustments and applications, but sometimes regret the serviceable simplicity of my old one.

The plates used are Mawson's photo-mechanical, for the sake of density. The paper is the ordinary Ilford, developed with amidol.

CALCULATION OF THE ANGLE OF VIEW.*

BY PHILIP EVERITT.

In the *British Journal Photographic Almanac* for this year there is to be found, for the first time, a table of natural tangents, by which the photographer may calculate the angle of view included on a given plate by a given lens, or, conversely, the focus of a lens to include a given angle on a given plate. Unfortunately the rules, formulated by the author of the article accompanying the table, are incorrect. As they may lead into error those who accept them without question, I offer this criticism and correction in the hope that the tables may thereby be made of value.

According to the first rule: for calculating the angle, half the length of the plate must be divided by the focus of the lens; the nearest natural tangent to the quotient should then be sought in the table, and the arc opposite it, multiplied by two, will give the angle.

The error is, the direction to take half the length of the plate. To demonstrate this in a simple way, compare the procedure with that of a draughtsman who wishes to make

a drawing, in perspective, of a room twelve feet wide by ten feet high, to scale of one inch to the foot. In the diagram shown there is a horizontal line, which must be at the height of the spectator's eye—say, four feet above the floor. Suppose the centre of vision removed two feet to the left of the middle of the horizon. Next describe a circle to represent the base of a cone of rays including the picture plane, no more and no less. This is done by taking the centre of vision as a centre, and the line to the farthest corner as radius. It is a rule in perspective that the line of direction shall be at right angles with the horizontal line, and terminate in the centre of vision. Assume the cone of rays to include 60° . The base of this cone is a circle. The draughtsman could now determine the exact position of the spectator. From the point taken as centre at right angles with the horizontal line, draw the line of direction. By means of a protractor, connect the corner with the place of the spectator, so that the angle includes 30° . The line of direction is now the principal ray of a cone of 60° , and represents on the plan the distance of the spectator from the picture plane. This line is seventeen one-third inches long, very nearly. As the picture formed by a rectilinear lens is in true perspective, and conforms to the same conditions, it can be said that a 12 by 10 plate, with the centre of vision removed two inches to the left of the centre of the horizon, at a height of four inches, will include an angle of 60° at about seventeen one-third inches focus.

Next work the problem by the method of the article in the *Almanac*. Divide the horizontal line in half. From the centre, and with half the horizontal line as radius, describe the circle. At right angles with this line, draw another line. With a protractor connect one end of the horizontal line with the line of direction at an angle of 30° . The circle is then the base of a cone of rays of 60° , and we have a new station point. But the circle does not include the whole picture, and the point transferred to the original line of direction shows a minus distance of about 6.93 inches. The photographer consequently would have used a lens of about $10\frac{2}{3}$ inches instead of $17\frac{1}{3}$ inches focus. Measure the angle. It will be found that from this station point nearly 88° have been included instead of 60° .

The nature of the error will be found in the assumption of a fixed centre of vision, at the centre of the horizontal line, with the horizon as diameter of the base of the cone of rays. In the example given, the centre of vision was removed two inches to the left, therefore the radius was from the wrong centre, and much too short. Artists rarely use the middle of the horizontal line as the centre of vision. They prefer to avoid it, because the centre of a picture is its weakest point. This may be proved by examining the pictures in our galleries, or, to come nearer home, consult the lecture before this Society by the late Mr. Norman Macbeth, printed in the *British Journal of Photography* for Jan. 6th, 1888. Mr. H. P. Robinson, in his book on "Pictorial Effect in Photography," also warns the reader against the use of the centre of the picture as the centre of vision.

The worthlessness of the rule becomes more apparent when we apply it to pictures of equal length, but different height.

Take the series 12 by 4, 12 by 6, 12 by 8, 12 by 10. The rule would give all these different pictures as taken under the same angle, regardless also of the fact that the centre of vision might be different in each case, an assertion which is obviously incorrect. Take a twelve-inch

* Abstract of paper read before the London and Provincial Photographic Association.