ANALYTICAL PHOTOGRAPHY.

By FRANCIS GALTON, F.R.S.

So far back as the year 1881, I submitted to this Society my method of composite portraiture, which, as many of you are aware, consists in throwing the images of different pictures successively upon the same screen, giving to each a proportionate fraction of the total length of exposure required to produce an ordinary photograph; the result being that what is common to all the pictures has been adequately exposed and is retained in the resulting photograph, and what is individual to each of them has been too under exposed to leave any image at all, and consequently disappears. At that time the idea of a converse process occurred to me :—a composite shows what is common to all, the converse process should show what was individual to each. I thought of this from time to time, but could not see my way to effect it. Last summer however, on returning from abroad, I made a few experiments which proved that the process was feasible, and I produced preliminary results, but not sufficiently good for exhibition. I then wrote a short letter published in *Nature* on the 2nd August last, describing the outlines of the process and stating that I felt it very difficult to proceed further without special apparatus, such as might perhaps exist in some physical laboratories but which I could not instal in my own house. However, within a week after the appearance of my letter—such is the zeal of the editors of newspapers—the editor of *Photography* had not only mastered and practised my process, but had actually written and published a very effective article upon it, illustrated by two of his own pictures. The article appeared in the issue of *Photography* for August 9th, 1900, copies of which are passed round for you to look at.

I had no sooner posted my letter to *Nature* than—as I believe, very commonly happens to persons who are working at new things—it flashed upon me that I had "thrown up the sponge," as it were, too soon. I saw that a small apparatus could be planned that would do what was wanted, and in fact such an apparatus is now on the table. Without going into details at this moment, you will see that there are bright lights at three of the four corners of the instrument; opposite to each of them is a photographic transparency, and at the fourth corner is a ground glass screen upon which the combined images of the three transparencies are thrown, and where they can be seen all together or singly or in any other desired combination. The construction of the lighting portion of the apparatus is by my own hand and consequently rather ramshackle, but it acts. The method that first occurred to me of combining the three images did not prove successful, at all events in the form in which it was carried out; and then Mr. Dallmeyer, your President, suggested the plan that has been used here. I was away from England during the autumn, and the construction of the instrument was thereby delayed, but when it was made its lenses and their adjustments acted perfectly, which is rarely the case with new forms of optical apparatus. The only difficulty then lay in procuring full illumination, a matter which occupied me so long that the photographic results I have been able to prepare for this meeting are far inferior to the optical ones that the instrument can produce. Though I cannot show you much I shall be able to exhibit the process fully.

Let the two pictures whose differences have to be isolated be called *A* and *B*. The process requires that a faint transparent positive *pos. a*, and a faint transparent negative *neg. a*, should be made of each of them. I place *pos. a* in one corner of the apparatus, and *neg. a* in another corner, and in the third corner I place *pos. b*. These three images are seen in superposition on the ground glass screen which occupies the fourth corner. There are means for adjusting the transparencies independently of one another, and this is done to them in turns until they are exactly fitted and form as good a composite as may be. Then *pos. a* and *neg. a* will antagonise one another, all the features of *a* practically disappear, and those two images produce in combination a uniformly grey ground, upon which *pos. b* is projected; so the result of compositing the three images is to produce a darkened representation of the faint *pos. b*. Now shut off the light from *pos. a*; what remains is a composite of *neg. a* and *pos. b*, which,

as has just been seen, has this property, that when added to *pos. a* it will transform *pos. a* into a darkened *pos. b*. Each step of the process can be watched and repeated by turning the various lights off and on. I call the composite of *neg. a* and *pos. b* the "transformer" of *a* into a darkened *b*. It is obvious that this transformer exhibits the various excesses of the darkened *pos. b* over *pos. a*, in other words it exhibits the differences between them, as expressed in the form of darkened *pos. b, minus pos. a*. Similarly the composite of *neg. b* and *pos. a* exhibits those same differences in the form of darkened *pos. a, minus pos. b*, the relations of the two transformers are thus those of a positive and its negative. This, in brief, is an account of the principle of analytical portraiture, in which some points require, and will receive further explanation. In the meantime a few of the purposes may be named to which the process admits of being applied. It must be clearly understood that it records differences and nothing else, so that if the portraits *a* and *b* were the same except that one of them had, say, a wafer stuck on it, then the result of the perfect process would be to produce a uniformly grey surface with only the wafer upon it. Speaking generally, the results of analytical portraiture are neither pleasing as pictures nor intelligible to an untrained eye; on the other hand, they give materials for an exact study of differences in such important cases as the following. Changes of expression, in which the process shows exactly what are the additions and what are the subtractions to be made from *pos. a*, which expresses the features in repose, to convert it into a darkened *pos. b*, which expresses the same features under the new expression. Alterations due to growth, as in flower or foliage or even in animals. Those that are due to decay or wear. Differences between copies of the same original. Differences between the features of different races, in which the features characteristic of each race have been severally defined by composites of many individuals. Similarly as regards family likenesses and the individual differences of each member of a family from the family as a whole.

An illustration will make the character of the result more easily understood. Suppose we require the differences between the composites *a* and *b* representing respectively the characteristic features of two different races. Lay a sheet of perfectly transparent paper over *a* and paint upon this paper with transparent shades, using as few as possible, until a darkened likeness of *b* is produced by the combination of what is on the transparency with what lies beneath it. The transparent paper on being removed, will exhibit exactly what is given by the photographic process of analytical portraiture.

Light and Dark Tones.—I must now enter more closely into certain topics which have thus far been lightly touched. The first of them regards light and dark pictures. Suppose a scale of nine tones, ascending by equal steps from o as pure white, to 8 as perfect black. I have here a box of te-totums which I made for conveniently isolating any one of these tones; their originally white faces are painted with black sectors of the several angular widths suitable for the purpose; that is, in increasing stages of 45°. The medium tone is where the angular width of the sector is 180°, that is where the te-totum, or whirling disc, is painted black on the whole of one side of its diameter. I call those pictures faint that are painted in tones up to and including the medium value which ranks as four on the scale, and those pictures will be called dark that are painted in tones both deeper than and including the same medium value. I exhibit three sketches of the same portrait to show the differences of effect under these conditions, and how very little the mere question of more or less likeness is affected by them. All the tones from o to 8 were used in painting the first picture. Then a grey mixture that matched the medium grey was made in one corner of a palette, and pure white was squeezed out upon another corner. The artist by using mixtures of this grey and white, and nothing else, made the second picture as a copy of the first. It is evident that its resemblance is not affected by the limitation of range in the tones. The third picture was made on the same principle as the second, except that black and medium grey were employed instead of white and medium grey, and here again the resemblance to the original is perfect. It follows that the value of the analytical process is not much affected by the fact that it is unable to transform, in other words that it cannot produce a transformer, or in still other

words that it cannot isolate the differences between *any* two portraits, but only those between a light half-toned copy of the one and a dark half-toned copy of the other. It should be remarked that although the light-toned *a* and the dark-toned *b* severally contain one-half of the complete scale of tones, yet the transformer of the light-toned *a* into the dark-toned *b* contains the complete scale. For, going back to the illustration of the transparent paper, if a grey spot in the faint *a*, which corresponds to a black spot in the original full-toned picture A, has to become the representative of a white spot in the full-toned B, it must appear as a grey spot in the darkened *b*, because the lightest spot in a dark half-toned picture is a medium grey. Consequently nothing is painted on the transparent paper over that spot; it is simply left transparent; that is, white. Again if a white spot in the faint *a* has to be transformed into a black spot in the darkened *b*, pure black must be put on the transparent paper at the place above the white spot in *a*.

Scales of tone : —real, perceived, and *actinic.*—I daresay many of you who have thought of these subjects will say that what is true with the real scale of tones is not wholly true with the scale of perceived or sense-tones. The middle tone as estimated by the eye is not the real mid-tone ; and again, the actinic scale is different both to the real and to the sense-scale, but for all that the differences are inappreciable so far as resemblance is concerned, in evidence of which I submit two pictures in mosaic squares of the same flower, one of which is painted in tones numbered according to the real scale (as given by the te-totums), the other in corresponding values of sense-tones, so I am content to ignore differences between the three scales and to argue solely from the real scale.

Conversion of full tones into faint tones.—The conversion of an ordinary picture into a faint one may be effected in many ways. The ideally perfect one would be that of an engraving or lithograph that contained a full scale of tones when printed in black ink on white paper, but which was printed in grey ink on white paper to form a faint picture, or in black ink on grey paper to form a dark one. The simplest plan, however, is to use a short exposure and to stop development as soon as the darkest part of the picture becomes of the half-tone that is desired.

Obliteration of a positive by its negative.—In the perfect positive and negative, if the positive is put over the negative it antagonises it, and if they are both faint the result approximates to a uniform grey as I will now show.

[Slides shown.]

But negatives and positives do not wholly obliterate one another. They do so to all intents and purposes when the tones are not very far from the middle of the scale ; an extreme white is not nearly obliterated by its negative.

I will now show the transformation of a St. George's Cross into a St. Andrew's, first by a diagram, in which the various toned mosaic squares of which the crosses are severally composed, are represented by numerals corresponding to their several scale values, and then by their actual photographic transformation.

[Slides shown.]

(As it would take too much space to reprint the diagrams, they are replaced by the lines below, which represent the transformation of one band of four mosaic squares of different tones into another band in which the squares are differently arranged. EG.)

1	A (original full-toned portrait) ...	...	6	4	2	2
2	B (,, ,, ,,) ...	...	4	6	2	6
3	*pos. a* (faint half-toned) ...	...	3	2	1	1
4	*neg. a* (,, ,,) ...	...	1	2	3	3
5	*pos. b* (,, ,,) ...	...	2	3	1	3
6	darkened *pos. b* (4 added to each entry) ...	...	6	7	5	7
7	*pos. a + neg. a* (uniform grey) ...	...	4	4	4	4
8	*neg. a + pos. b* (the transformer) ...	...	3	5	4	6
9	*pos. a + neg. a + pos. b* (same as 6) ...	...	6	7	5	7

One of my very earliest successes was to turn an F into a G.   I have here all the stages of it; positive G and negative G; positive F and negative F; then I got the transformer, and that clapped on to the original F turns it into a G, and a very good G, too.

Now let me show you some others, but I have greatly to apologise.   I have been compelled to prepare these slides at the last moment, and I really have not proper ones to show.   The only faint photographs I possessed were some old composites; they were convenient for the purpose, because they had all been reduced to the same scale, but by a piece of strange ill luck, the transformer has disappeared and I cannot find it, so I can only show you the other stages.

(Mr. Galton next proceeded to explain his apparatus and to exhibit it at work; also an instrument which he had used last summer, for accurately adjusting photographs and registering them by means of crossed wires and needle-pricks.)

A vote of thanks was passed to Mr. Galton.