plane figure on a plane. Plan and elevation of a line which is inclined at given angles to the co-ordinate planes. The meaning of the terms "trace of a line," "trace of a plane."

The difference between a *scalar* quantity and a *vector* quantity. Addition and subtraction of vectors.

Slope of a line; slope of a curve at any point in it. Rate of increase of one quantity $y$ relatively to the increase of another quantity $x$; the symbol for this rate of increase, namely, $\frac{dy}{dx}$; how to determine $\frac{dy}{dx}$ when the law connecting $x$ and $y$ is of the form $y=ax^n$. Easy exercises on this rule.

In setting out the above syllabus the items have been arranged under the various branches of the subject.

It will be obvious that it is not intended that these should be studied in the order in which they appear; the teacher will arrange a mixed course such as seems to him best for the class of students with whom he has to deal.

## *ANALYTICAL PORTRAITURE.*

IT seems well to put on record the principal results of experiments that I have recently made to *isolate the particulars* in which one portrait differs from another. They had a measure of success, but not enough to deserve illustration or lengthy description. The objects I had hoped to attain are important; namely, to define photographically the direction and degrees in which any individual differs from the race to which he belongs, the race being represented by a composite picture of many individuals belonging to it. Or, again, to define the particulars in which any variety of a plant or animal differs from its parent species. Or to define family features; or to isolate expressions, recollecting that these consist both of subtractions from, and additions to, the features as seen in repose.

My starting point was that the exact superimposition of a rather faint positive upon its rather faint negative produces an approximately uniform grey, when they are viewed as a single transparency. Thus, I photographed a rotating disc that had been faced with white paper and divided into concentric rings. The innermost disc was left white, the outermost ring was painted black, and the intermediate rings contained successively increasing proportions of black to white. The photographic negative showed rings of graded tints, and from this I took a positive by contact. Subsequently applying the positive to the negative, film to film, and viewing them as a transparency, a nearly uniform grey surface was produced. It was necessary to superimpose them with exactness; otherwise the edges of the rings were conspicuously dark in one part, and light in the opposite part. Another test experiment was to paste together thicknesses of tracing paper—two-fold, three-fold, &c., up to twelve-fold—to cut distinctively shaped snippets of these and to variously distribute them over the surface of a glass plate, which was then photographed, and a positive taken as well. On treating the positive and negative as above, all the tints between those of the three-fold and the nine-fold inclusive produced a uniform grey.

Let A and B be any two pictures whose respective negatives and positives will be called *neg. a*, *pos. a*, *neg. b*, *pos. b*. My object was to produce photographically a third pictue X which should express the difference between A and B; that is, should be equal to A—B, or else a fourth picture Y which should represent B—A.

It will, however, be simpler to treat the problem at first as an optical one, based on the following equations:—

(I.) *pos. a* + *neg. a* = *grey*; (II.) *pos. a* + *x* = *pos. b*

(if treated as a photographic problem, (II.) would be replaced by *pos. a* + *x* = *neg. b*). From these we obtain

(III.) *pos. a* + {*pos. b* + *neg. a*} = *pos. b* + *grey*

and

(IV.) *pos. b* + {*pos. a* + *neg. b*} = *pos. a* + *grey*.

Calling the terms within brackets by the name of "transformers," the transformer of *b* into *a* is the negative of the transformer of *a* into *b*. The two terms within brackets may be "composited" together on equal terms, then the result may be composited with the first term, allowing two-thirds of the total time of exposure to the transformer, and one-third to the first term. Or, what comes to the same thing in the end, all three terms may be composited in equal shares, allowing one-third of the total time of exposure to each. The transformers in (III.) and (IV.) being respectively *x* + *grey* and *y* + *grey*, are nearly equivalent for the purposes of the inquiry to *x* and *y*, because the addition of a uniform shade of grey has little or no effect on pictorial resemblance. A portrait does not cease to resemble the original when it has become somewhat browned by exposure to a London atmosphere, or when it is viewed in shade, or under a tinted glass. Its distinctiveness depends on the *differences* (not the ratios) being preserved between the tints of all adjacent elements of its surface. Of course the grey must not be too dark; otherwise the deeper tints of the portrait would appear indistinguishably black.

This method of transformation succeeds fairly well. I changed an F on a white ground into a good G on a grey ground, and I changed with passable success one portrait A on white ground into another portrait B on grey ground, but the transformer itself gave little of that information to the eye which I had expected. It *must* have nearly isolated, but it failed to exhibit in an intelligible form the differences between A and B. Then I photographed two faces, each in two expressions, the one glum and the other smiling broadly. I could turn the glum face into the smiling one, or *vice versa*, by means of the suitable transformer; but the transformers themselves were ghastly to look at, and did not at all give the impression of a detached smile or of a detached glumness.

Part of the ghastliness was due to the different densities of the superimposed positives and negatives, which did not neatly obliterate one another in the unchanged portions of the face, and part was due to their not being superimposed in the best possible way. There can be no doubt of the best fit when engaged in making the transformer of an I into an L; but the eye must determine the best fit and proportions of the two components of the transformer of one portrait into another. I cannot yet make up my mind whether or no the process admits of substantial improvement, but feel sure that the only satisfactory experiments now would be those made by two converging lanterns on a screen, one at least of which admits of easy and delicate adjustment in direction and in the intensity of its illumination. The most suitable portraits for the attempt are apparently such as are popularly, and sometimes reproachfully, termed "artistic," that is to say, with blurred outlines and medium tints; certainly not those which in photographic language are called "plucky." I have no means in my house for experiments of this kind, but perhaps a trial might be made in some laboratory where they exist. The point is to ascertain whether the images of *neg. a* and *pos. b* can be so combined on the screen as to give an intelligible and useful idea of the differences between A and B.

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## *A RECOLLECTION OF KING UMBERTO.*

HOW enthusiastically the late King of Italy could devote himself to the welfare of science and art, those of us who were at Como last September had an opportunity of seeing. One very hot day he arrived with the Queen and the Duke of Naples by train from their palace at Monza, near Milan. First they made an official inspection of the galleries and machinery in the Silk and Electricity Exhibition, then they visited the Exhibition of Sacred Art, and, after lunch, they opened