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Mr. Rainey can increase the power of a horse-shoe magnet of tempered steel, which has been magnetized in the usual way, to the same strength as the *weakened* magnet, by means of perfectly soft iron, then it must be admitted that the lifter can by its *reaction* induce a greater degree of magnetism than the *prime motor* itself possessed. Till then we must admit the truth of the Newtonian law of action and reaction without exception or reservation.

LX. *On the Optical Phænomena of certain Crystals.*

By H. F. TALBOT, Esq., F.R.S.*

SOME time ago I had the honour to communicate to the Royal Society an account of my invention of the polarizing microscope†. This instrument possesses so great a power of developing the internal structure of transparent bodies, even in their minutest visible particles, that I feel confident the employment of it will lead to many new and interesting results. At present I mean to confine myself to the description of a phænomenon which shows strikingly the beautiful order and regularity with which nature disposes the fabric of some of her minutest visible works.

The object I speak of is a kind of minute crystallization which may be obtained in peculiar circumstances, and I doubt not, in many different ways; but the manner in which it has presented itself to my observation is as follows.

A crystal of borax is placed in a drop of phosphoric acid somewhat diluted upon a plate of glass, and then moderately heated until the crystal dissolves in the acid. It is then set aside to crystallize. It is well to prepare a number of these plates at once, varying the relative proportion of the acid and salt, in order that the desired kind of crystallization may be found in one or other of them; for there is a considerable variety in the crystalline forms obtained by this method, some of which indeed are very singular. But when that kind of crystallization takes place which it is more particularly my intention to speak of, the field of view of the microscope is seen covered with minute circular spots, each of which is like a tuft of silk radiating from a centre, and is composed of a close assemblage of delicate acicular crystals forming a star. But besides these, are seen interspersed among them a number of circular transparent bodies, which are evidently modifications of the former,

* Read before the Royal Society May 5th, 1836: and now communicated by the Author.

† See Lond. and Edinb. Philosophical Magazine, vol. v. p. 321.

being, in fact, tufts or stars of acicular crystals in such close assemblage as to be in optical contact with each other and to produce the appearance of a single individual. Now let us suppose a group of these circles to be under examination with the polarizing microscope, and when the polarizers* are crossed, we observe the following phænomenon. The field of view being dark, the little circles become luminous, and we see upon each of them a well-defined and dark cross, dividing the crystal into four equal parts. All these crosses are placed similarly, and are parallel to each other, and their direction remains unaltered when the crystals are turned round in their own plane by revolving the plate of glass upon which they stand. This beautiful appearance can be seen with a moderate magnifying power. I measured the diameter of some of the larger crystals, which I found to be from $\frac{1}{300}$ to $\frac{1}{600}$ of an inch. But there are many much smaller, and indeed they may be seen decreasing in size, until nothing remains visible of their structure but the four luminous quadrants, appearing like four minute dots of coloured light placed close together.

I proceeded to examine the circles with a high magnifying power, and under favourable circumstances of illumination, and I observed in them a very admirable structure.

Each circle has upon it one or more coloured rings arranged concentrically, but the number as well as the colour of these rings is different in different individuals.

The innermost ring is deeply coloured or black, and incloses a central space of white light, which is traversed by the arms of the cross intersecting in the centre. This part of the cross, which stands within the innermost ring, is beautifully well defined, and perfectly black. The general appearance resembles the figure 98, in Brewster's Optics, which is a representation of the rings seen in uniaxal crystals. It especially resembles it in the circumstance above mentioned, viz. the more defined outline of the part of the cross which is within the innermost ring.

We have hitherto supposed the polarizers to be crossed, but if we place them in a parallel position we shall see a phænomenon complementary to the above. The circle now presents four patches of coloured light, one in each quadrant; and we generally see near the centre four black or obscure spots, which correspond to the arms of the cross in the other position.

Such is an outline of the microscopic appearances presented

* By this term, for the sake of brevity, I here designate the polarizing and analysing prisms of single-image calcareous spar, or the plates of tourmaline which may be employed in their stead.

by these little crystals, which are probably the minutest bodies in which so complicated an optical structure has hitherto been witnessed. I find that the smaller the circles are, the more perfect is their form and the brighter their colours.

These crystals, as I have already observed, probably consist of spicula diverging from a point, but which are in the closest possible contact, and in a state of complete mechanical cohesion. It seems to follow as a consequence from such a structure that their density must increase from their circumference towards their centre. Now it is worthy of remark, that Sir David Brewster has discovered very similar phænomena by polarized light in the crystalline lenses of certain fishes, which are known by direct experiment to increase in density towards the centre. Indeed the figure which he has given of the lens of the codfish in the Philosophical Transactions for 1816 (Plate XII. fig. 1.) is so like the appearance of one of the crystals which I have described, that it might be supposed to have been intended for a representation of it.

Having pointed out this resemblance, I may also mention another class of facts to which I think those I have described possess a considerable analogy. I mean the optical figures which Brewster has discovered in spheres of glass whose density was rendered variable by heating them.

He says* that, "if we take a cold sphere of glass and immerse it in a trough of hot oil, placed in a polarizing apparatus, we shall observe *a black cross with four sectors of polarized light*. If the sphere is turned round it will exhibit in every position the very same figure. If we now suppose the trough to be filled with such spheres they will exhibit the same phænomena in whatever direction the polarized light is transmitted through them, and even if they were in a state of motion. A fluid composed of such spherical particles would exhibit the same polarizing structure in every possible direction, and even if it were in a state of rapid gyration. If the particles possessed the structure that produces circular polarization the fluid would develop the phænomena exhibited by oil of turpentine, &c."

And again†, "The structure of the particles of a circularly polarizing fluid must be exactly the same along every one of its diameters; that is, the structure must be symmetrical round the centre of the particle, or analogous to that which takes place in common polarization when a sphere of glass has its density regularly increasing or regularly diminishing towards its centre."

* Library of Useful Knowledge, art. "Polarization of Light," p. 51.

† p. 45, *ibid*.

I have quoted these remarkable passages at length, because it appears to me that what is there advanced merely as a hypothesis, acquires a considerable degree of probability from the facts which I have stated, since I have succeeded in rendering actually visible circular particles of excessive minuteness, in each of which the microscope detects the very structure imagined by Brewster, viz. the black cross and four sectors of light. So that it appears not improbable that the circular-polarizing properties of fluids may be owing to the presence of multitudes of particles similar to these, which they hold in solution.

LXI. *Proceedings of Learned Societies.*

ROYAL ASTRONOMICAL SOCIETY.

Nov. 13, — THE following communications were read:—
1835.

I. Two elementary solutions of Kepler's Problem, by the angular Calculus. By William Wallace, A.M., &c. &c., Professor of Mathematics in the University of Edinburgh.

II. Observations of *Mars* at the opposition 1834-35, made at the Observatory, Cape of Good Hope. By Mr. Maclear.

These observations, which, including the stars observed with the planet, are nearly 200 in number, were made between November 23, 1834, and February 10, 1835. They are entirely made with the mural circle, and appear to have been forwarded immediately to England.

III. Letter from Mr. Snow to the Secretary, dated October 9, 1835, on the latitude of his observatory at Ashurst.

The method here adopted by Mr. Snow was invented by the celebrated Römer, above 130 years ago, but has ever since remained unnoticed, till within these few years, when it has been used in the determination of the latitudes of places, in some geodesical measurements on the Continent. The method is described by Bessel, in Schumacher's *Astronomische Nachrichten*, a translation of which is given in the *Philosophical Magazine* for May, 1825 (First Series, vol. lxx. p. 354.); and it is also noticed by Dr. Pearson, in his *Astronomy*, vol. ii. p. 594. If the declination of the star can be relied on, the method is capable of great accuracy: the mode pursued was as follows.—A transit instrument was placed with its *axis* north and south, so that the eastern and western passages of a star over the prime vertical might be observed, and the latitude might then be deduced from the known declination of the star. The assumed declinations were taken from Pond's catalogue of 1112 stars; the instrument was kept carefully adjusted for level, and the error of collimation, known to be small, was eliminated by reversing the telescope on different evenings. The transit telescope was of twenty inches focal length, and the