



## LXXI. An essay on the degree of warmth of coloured rays

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equal to the complement of the latitude of the place; and the arm that moves the speculum acting in the direction of this plane, will evidently cause it to follow the sun in its diurnal motion, whatever may be its declination. As the experiments concerning light and colours must be made in the dark, the whole machine, when made use of for this purpose, must be shut up in a case or box; and we may have the rays thrown by means of it in any required direction during the whole of the time he is above the horizon, if the situation be open; or, if otherwise, as long as the rays are not intercepted by surrounding objects.

Another instrument of this sort is described by Mr. Benjamin Martin, in page 469 of vol. ii. of his *Mathematical Institutions*, which he considers as an improvement of one described by M. Klingenstiern in the *Petersburg Commentaries* for 1747 and 1748: it may also be found in his *Philosophia Britannica*, p. 89, vol. iii. edit. of 1771: but the expense of such a machine it is feared will prevent its being commonly applied, although it would be extremely useful for moving telescopes round upon a polar axis, in making observations of the heavenly bodies, and pursuing them, in an uniform manner, notwithstanding the earth's diurnal motion.

The late ingenious Mr. Ramsden, whose care in the construction, and accuracy in the execution of astronomical instruments, could only be equalled by his genius and originality in inventing them, had once an idea of adapting an instrument of this sort to a clock that kept time very exactly, with a view to avoid the necessity of using *time* in particular cases of astronomical measurements.

Christ's Hospital, June 7, 1815.

LXXI. *An Essay on the Degree of Warmth of coloured Rays.*  
By M. l'Abbé ROCHON, late Member of the Academy of  
Sciences of Paris, &c. &c.\*

IN this memoir we confine ourselves to examine, whether the rays of light of different refrangibility produce degrees of heat that differ in their degree of sensibility on the thermometer.

This research requires without doubt that the colours should be distinct and well separated; but this analysis of them cannot be made without diminishing prodigiously the intensity of the light; which, when thus decomposed, no longer gives any sensible sign of warmth in our common thermometers.

It is therefore necessary to resolve or to collect on the ball of

\* For some remarks on this paper, see the preceding communication from Dr. Evans, page 401.

a thermometer a sufficient quantity of these rays, to produce effects that are evident; or else to use thermometers of a sensibility proportionate to the loss of intensity which is inseparable from the light thus decomposed. We can always collect into a small space a quantity of rays of a colour that will be sensibly homogeneous, either by disposing in a proper manner several prisms of different angles which shall make each species of rays to coincide on the ball of a thermometer; or by using the burning mirror of M. de Buffon, known by the name of the Mirror of Archimedes, whose burning line is very nearly the same for a considerable length.

This instrument is an assemblage of small plane mirrors, which by their respective positions will cause as large a quantity of light as may be desired to fall on a prism placed in their common focus. Now the united rays which form this focus, or rather this burning line, approach so much the nearer to the parallelism necessary for the success of the experiment in question, as the distance of the prism from the mirrors is more considerable.

We know that this method requires a large room; but the one in which the experiments I am going to relate were made, not being of a proper size, I thought that very sensible thermometers would sufficiently fulfil the object which I proposed.

Those which I have used were air-thermometers. It is well known that they owe their effect to a bubble of air introduced into the ball which contains the fluid. The slightest degree of warmth dilates this bubble, and causes the spirit of wine to mount in the capillary tube of the thermometer: but this ascent would scarcely be sensible if the top of the tube were hermetically sealed; it is therefore necessary to leave it open, and consequently the exterior air, which is susceptible of many variations, acts on the fluid in such a way that it is necessary to have recourse to the barometer to know the effect of the dilatation, which is found to correspond with the greater or less elasticity of the exterior air.

These defects, joined to the evaporation of the liquor, obliged me to reject these thermometers, notwithstanding their prodigious sensibility. Although in my later researches I have not had these inconveniences to discourage me, it being sufficient to compare the different effects of each kind of rays that took place in a very short space of time, I have nevertheless endeavoured to avoid them altogether, by soldering to the tube of the thermometer a large ball filled with air, which contains a common thermometer. This ball is dipped into a fluid whose temperature is easily kept uniform, whether we choose to have it at the freezing point or at any other temperature.

By

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By this method the full degree of sensibility is given to the thermometer, without its having any communication with the external air.

For experiments of so delicate a nature we know that a perfectly serene sky is necessary, and an unvarying temperature without the least agitation of the air: this necessarily reduces the experiments on which we may depend to a very small number; and among the great variety of those I have made, I acknowledge that there is not so much as one with which I am completely satisfied.

I used a large prism of flint glass, of which the refringent angle was  $45^{\circ}$ ; I permitted an equal quantity of rays to pass through in each case, and they successively traversed the same lens, which I inclined according to the sun's altitude; for I had at that time no heliostata, and the want of this instrument has rendered my results still less accurate.

All my experiments were made between the hours of eleven in the morning and two in the afternoon; my air-thermometer was too sensible to allow of my approaching it without occasioning variations, so that I observed the divisions by a small telescope at the distance of fifteen feet, and I raised or lowered the indexes by means of a string passing over some pulleys.

Although from the year 1775 I have made a great number of experiments. I do not think them worthy of being related, because I was not then sufficiently acquainted with the precautions that are necessary in such delicate inquiries: those made in 1776 are more conclusive; they give the ratio of the warmth of the red rays to the violet rays as 8 to 1; for, by warming the ball of the thermometer for two minutes with these two kinds of rays, the index would mark from four divisions and a half to seven, for the violet rays; whilst for the red rays it was necessary to place the index from 39 to 44 divisions. These observations were made in the month of June, Reaumur's thermometer only varying during the whole time they were made from  $16^{\circ}$  to  $17^{\circ}$ .

The following are the observations of this month:

|        |                |     |    |
|--------|----------------|-----|----|
| Violet | $4\frac{1}{2}$ | Red | 4* |
|        | 6              |     | 40 |
|        | $4\frac{1}{2}$ |     | 43 |
|        | $5\frac{1}{2}$ |     | 39 |
|        | 7              |     | 44 |

It is necessary to remark, that it is the red approaching to the orange, and the violet approaching to the blue, that I have used. It is so difficult to decompose the light with sufficient perfection to obtain the same shade of colour constantly, that we must not

\* Most probably this is an error of the press, and ought to be 40 It is so considered in the general result given in page 406.

be surprised at the variations I have experienced, although they are considerable.

In the month of July of 1776, the thermometer having only varied from 18° to 20° during the course of the experiments :

|                  |                  |                  |                  |
|------------------|------------------|------------------|------------------|
| The violet was 3 |                  | Green 31         | Red 38           |
| 4 $\frac{1}{2}$  |                  | 39               | 40               |
| 3 $\frac{3}{4}$  |                  | 27 $\frac{1}{2}$ | 37               |
| 5                |                  | 30               | 36 $\frac{1}{2}$ |
| Violet 6         | Yellow orange 49 | Green 33         | Red 40           |
| 7                | 52               | 34 $\frac{1}{2}$ | 39 $\frac{1}{2}$ |
| 6 $\frac{1}{2}$  | 48               | 36               | 45               |
| 8                | 64               | 48               | 60               |

In the month of August Reaumur's thermometer rose from 19° to 23°, during the following observations :

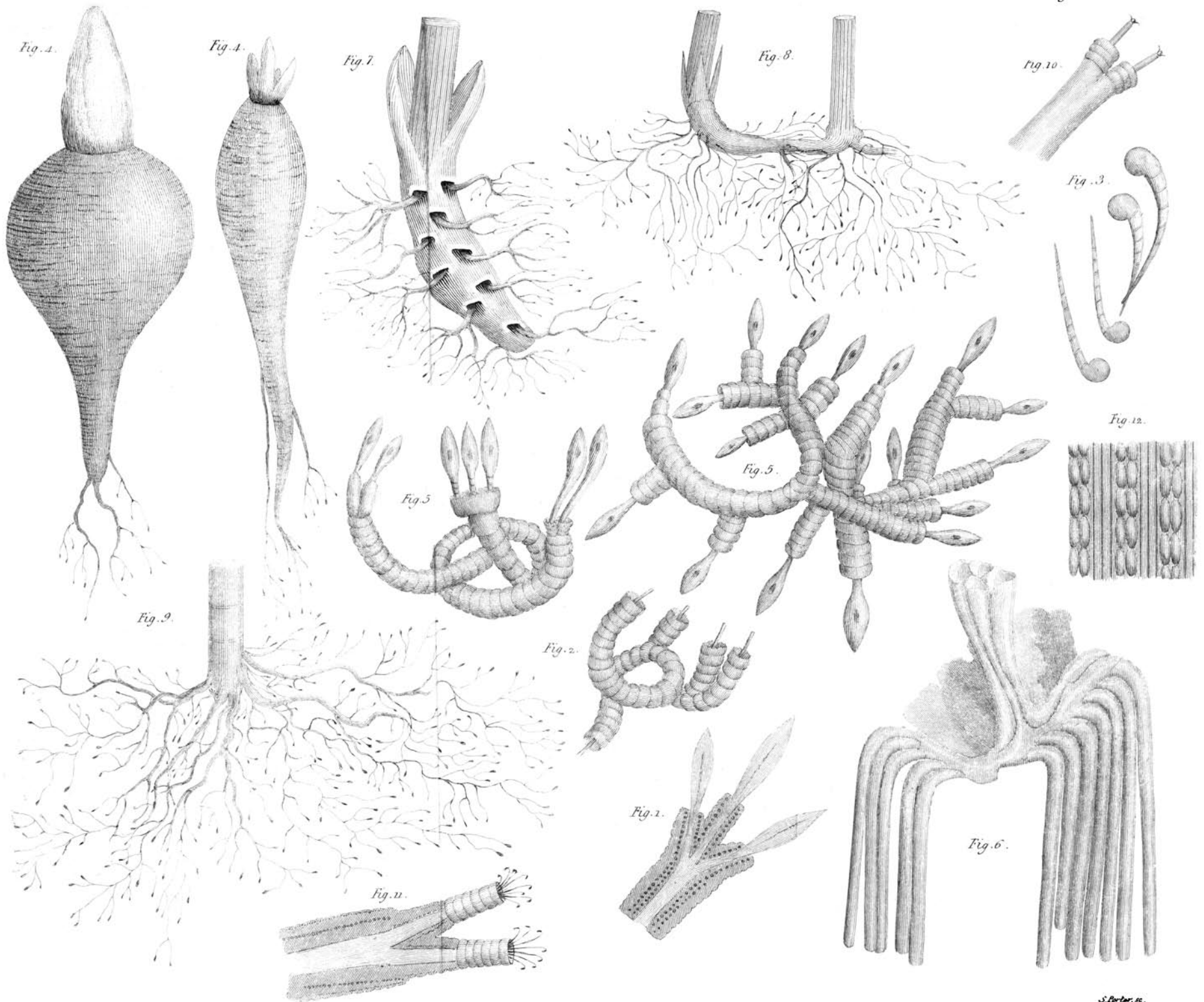
|          |                  |          |        |
|----------|------------------|----------|--------|
| Violet 7 | Orange 60        | Green 43 | Red 56 |
| Violet 6 | yellow orange 62 | green 39 | red 55 |
| Violet 7 | orange 38        | green 45 | red 64 |
| 5        | 51               | 39       | 48     |

In the month of September, I used a thermometer of the construction represented by fig. 5, Plate VIII. on which the exterior air had no influence; the bubble of air was always similarly exposed, for two minutes, to the action of the coloured rays, as in the preceding experiments; but the sensibility of the thermometer no longer continued to be so great.

In the month of September, Reaumur's thermometer varied from 19° to 16° in the course of the observations :

|                 |                  |                  |                  |
|-----------------|------------------|------------------|------------------|
| Violet 2        | Yellow orange 18 | Green 13         | Red 17           |
| 2               | orange 17        | 14               | 18               |
| 2 $\frac{1}{4}$ | orange 22        | 16               | 21               |
| 2 $\frac{1}{2}$ | 20               | 16               | 22               |
| 6               |                  |                  | 40               |
| 4               |                  |                  | 42               |
| 5 $\frac{1}{2}$ |                  |                  | 39               |
| 7 $\frac{1}{4}$ |                  |                  | 44               |
| 3               |                  | 31               | 38               |
| 4 $\frac{1}{2}$ |                  | 29               | 40               |
| 3 $\frac{1}{4}$ |                  | 27 $\frac{1}{2}$ | 37               |
| 5               |                  | 30               | 36 $\frac{1}{2}$ |
| 6               | orange 49        | green 33         | 40               |
| 7               | yellow orange 52 | 34 $\frac{1}{2}$ | 39               |
| 6 $\frac{1}{2}$ | orange 48        | 36               | 42               |
| 6               | 50               | 35               | 43 $\frac{1}{2}$ |

It follows from all these experiments, and notwithstanding the great differences which are to be found amongst them, and however attentive I was in making them; first, that the ratio of the warmth of clear red to the most lively violet, is nearly as 8 to 1,  
for



for the extreme rays cannot be compared. Secondly, that the warmth of the yellow orange differs but little from that which the red produces: so that it may be presumed that the warmest rays are between the clear red and the yellow: and from this point the warmth of the rays diminishes considerably more on the violet side than on that of the deep red.

I was desirous of using coloured liquids and glasses, but both these substances, when coloured, transmit heterogeneous rays in too great a quantity to be used with success in experiments of so delicate a nature: besides, How are we to estimate the reflected rays, and those that are lost in these substances? In other respects, although I have taken all possible precautions, that depended on myself, to ensure the success of these experiments, I am still very far from being satisfied with my labour.

LXXII. *Some Experiments and Observations on the Colours used in Painting by the Ancients.* By Sir HUMPHRY DAVY, LL.D. F.R.S.

[Concluded from p. 359.]

VI. *Of the Purple of the Ancients.*

THE πορφύρα of the Greeks, and the ostrum of the Romans, was regarded as their most beautiful colour, and was prepared from shell-fish.

Vitruvius\* says that the colour differed according to the country from which the shell-fish was brought; that it afforded a colour deeper and more approaching to violet from the northern countries, and a redder colour from the southern coasts. He states, that it was prepared by beating the fish with instruments of iron, freeing the purple liquor from the shell containing it, and mixing it with a little honey: and Pliny says, that for the use of the painters argentine “creta†” was dyed with it: and both Vitruvius and Pliny say, that it was adulterated, or imitations of it made, by tingeing “creta” with madder‡, and “hysginum.” The finest purple, Pliny says, had a tint like that of

\* Lib. vii. cap. 13.

† Probably a clay used for polishing silver. The ancients were not acquainted with the distinction between aluminous and calcareous earths, and *creta* was a term applied to every white fine earthy powder.

‡ Madder was extensively used by the ancients in dyeing, and from this passage it is probable that they were acquainted with the art of making a lake from it similar to that used by modern painters. It was probably one of the colours used by the Egyptians in dyeing their stuffs of different colours from the same liquor, by means of mordants. If we can trust Pliny's account, they practised calico-printing in a manner similar to the moderns. Lib. xxxv. cap. 42.

a deep-