



XLVIII. On the double refraction of rock crystal, and another dioptric property of that mineral substance

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exposed to the fire thus produced. This, however, may have been caused by the iron contained in the carburet; for the fused earths and plumbago generally adhered to each other.

There is a peculiar species of native coal found on the banks of the Lehigh in this state, which it is extremely difficult to ignite; but when exposed to a high degree of heat, and a copious blast of air, it burns, yielding an intense heat without either smoke or flame, and leaving little residue. By exposure to the gaseous flame on this coal, both magnesia and lime exhibited strong symptoms of fusion. The former assumed a glazed and somewhat globular appearance. The latter became converted into a brownish semivitreous mass.

The heat of the gaseous flame is very much dependent on the proportional quantities of the gases emitted. On this account, the perforations in the keys of the cocks N, n, fig. 1st, should be narrow and oblong, to admit of a more gradual increase or diminution in the quantity of gas emitted.

I have now concluded my communications on the subject of this paper, and shall be happy if they have been found worthy of the time and attention bestowed on them by the society.

XLVIII. *On the double Refraction of Rock Crystal, and another dioptric Property of that Mineral Substance.* By C. P. TORELLI DE NARCI, attached to the Council of Mines*.

DDOUBLE refraction, that singular property of rock crystal †, and of several other minerals, has long engaged the attention of mineralogists and philosophers, though they employed it in no other manner than as a distinguishing character. C. Haüy says ‡: “It would be difficult to find a more striking character than that deduced from double refraction, since it depends on the essence of the minerals in which it exists.”

C. Rochon is the first philosopher who employed this property of rock crystal to measure small angles; and he read on the 26th of January and 9th of April 1777, to the Academy of Sciences, two memoirs on the application he made of it, and the exact results he obtained. This discovery must be of the greatest utility, if means should be found to construct the instrument he invented at so moderate a price as to bring

* From the *Journal des Mines*, No. 66.

† Limpid hyalin quartz. Haüy *Traité de Mineralogie*, vol. ii. p. 427.

‡ Vol. i. of his *Traité*, p. 254.

it within the reach of those who might have occasion to measure angles with it.

A desire to accomplish this object induced me to undertake some researches in regard to the cutting of rock crystal, and experiments on its double refraction, founded on those made by Beccaria and Rochon. With rock crystal alone I formed *mediums doubly* refringent. This is the name which Rochon gives to these instruments cut cylindrically and composed of two or three prisms of this substance, which are perfectly achromatic, and produce very strong double refraction. I constructed one with three prisms, in which the angle of double refraction is one degree eight minutes: and I find that larger may still be obtained.

I shall not here indicate the direction in which I cut my different prisms of rock crystal in order to obtain the *maximum* of double refraction, because I have still some experiments to terminate before I can acquire a thorough knowledge of them. Among those which I cut for my experiments, there is one which produces effects so singular that I think it my duty to describe it.

This prism, the section of which is an isosceles triangle, has one of its angles obtuse, and of more than 100 degrees. When one looks through the two faces which form the obtuse angle, and in a direction parallel to the face opposite to it, the object appears neither displaced nor sensibly coloured, but only inverted in such a manner, that what is on the right appears on the left; and *vice versa*. If a capital L, for example, cut out and applied to the pane of a window, be looked at, the horizontal line of that letter, instead of being on the right below the vertical one, appears to be situated on the left. By continuing to look at this letter, if the prism be turned on itself, and in such a manner as if it were traversed by an axis parallel to the direction in which the letter is viewed, the image of the letter turns at the same time as the prism; but it moves twice as quick—so that, if the prism makes one turn, the image of the letter makes two. I made other very singular experiments with this prism; but as it would be too tedious to detail them here, I shall reserve them for a memoir, in which I shall explain the means I employed to ascertain the rules which must be followed to cut rock crystal in the direction that produces the *maximum* of its double refraction, and to be able to construct, without repeated trials, the instrument invented by Rochon, to measure, with very great precision, distances of every kind. I shall treat of its application to mines; and shall describe the

method I pursued to measure the deepest wells and the longest galleries.

I shall conclude this note with a succinct account of some experiments which I made with the isosceles prism of rock crystal already mentioned. By applying it to a simple *camera obscura*, the objects painted in an inverted position, when this prism is not used, are made to appear in their proper situation. By adapting it to astronomical telescopes, the same effect will be produced in regard to objects, which, when seen through the two convex glasses that compose it, appear inverted.

This prism supplies the means of shortening telescopes destined to view terrestrial objects, because, by employing it with a convex eye-glass only, and an object-glass simple or achromatic, instead of three, four, or five eye-glasses, objects which without its interposition would have appeared inverted, will be seen in their proper position. By these means, one, two, three, or even four eye-glasses would be saved, and the telescope might be shortened by nearly the whole length occupied by these eye-glasses. Light also will be gained; for this prism occasions no loss in this respect, the matter of which it is formed being exceedingly transparent; nor will any thing be lost in regard to distinctness; for, as the prism is very near the eye, the faults which might arise from any inexactness in the polishing of its two surfaces will not be sensible.

In employing this telescope it must be remembered, that at the same time that it inverts objects by turning them upside down, it turns them from right to left, and what appears on the right in the field of the telescope is really on the left: for example, if a man going from right to left be viewed with it, he will appear in the telescope as if going from left to right, but in his natural situation: whereas, if viewed with the same telescope, taking from it the prism of rock crystal and leaving only the eye-glass which inverts the objects, the man would appear not only to be proceeding in a direction contrary to that in which he really is advancing, but he would appear also inverted—the common effect of telescopes which have only a convex eye-glass.

Experience alone can show whether this method of shortening land telescopes can be as useful as it appears curious, and whether it will be possible to construct one at such a moderate price as to maintain a competition with common telescopes, without which this instrument would remain among the number of those discoveries which are rather curious than useful.