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XIV. *Researches on Heat.—Fourth Series. On the Effect of the Mechanical Texture of Screens on the immediate transmission of Radiant Heat**. *By* James D. Forbes, *Esq., F.R.SS. L. & E., Professor of Natural Philosophy in the University of Edinburgh.*†

Arts. 1—12, *Laminated and Smoked Surfaces.* 13—29, *Rough Surfaces.* 30—34, *Metallic and other Gratings.* 35—53, *Powdered Surfaces.* 54—65, *Conclusions.*

1. On the 2nd September 1839, M. Arago communicated to the Academy of Sciences of Paris a letter by M. Melloni, containing some very interesting experiments on the transmission of Radiant Heat. M. Melloni finds that rock-salt (which is well known to transmit rays of heat from all sources yet tried with equal facility) acquires, by being

† From the Transactions of the Royal Society of Edinburgh, vol. xv. Part 1.

* The substance of the present paper was communicated to the Royal Society of Edinburgh on the 16th December 1839, in the words of the memorandum which forms part of this Note. The memorandum itself was read, with some verbal explanation and citation of additional facts, on the 6th of January. Every experiment to which reference is made in the present paper, was performed between the 12th November 1839 and the 4th March 1840. Since that time, I have not made a single experiment on the subject. Occupation of other kinds has prevented me from digesting, until now, the results of these experiments, and from stating the grounds of the conclusions which I formerly announced. The present paper, as it stands, having been submitted to the Council on the 15th May 1840, is printed by their authority. The following is the memorandum just referred to, reprinted from the Proceedings of the Royal Society of Edinburgh:—

"On the Effect of the Mechanical Texture of Screens on the immediate transmission of Radiant Heat. By Professor Forbes.—On the 2nd of September 1839, M. Arago communicated to the Academy of Sciences a letter by M. Melloni, containing some very interesting experiments on the transmission of Radiant Heat. M. Melloni finds, that rock-salt (which is well known to transmit rays from every source with equal facility) acquires, by being *smoked*, the power of transmitting most easily heat of low temperature, or that kind of heat stopped in greatest proportion by glass, alum, and (according to M. Melloni) every other substance. The experiments contained in the Third Series of my Researches on Heat, show that this is equivalent to saying, that substances in general allow only the more refrangible rays to pass; and as M. Melloni had been led by his previous experiments to the same conclusion, his statement amounts to this, that, whilst rock-salt presents the analogy of white glass, by transmitting all rays in equal proportions, every substance hitherto examined acts on the calorific rays as violet or blue glass does on light, absorbing the rays of least refrangibility, and transmitting only the others.

"M. Melloni believes, that the first exception to this rule, or the first analogue of red glass, is rock-salt previously smoked. I desire, however, first to call attention to the fact, that, in a paper published in May 1838 (Researches on Heat, Third Series), I described a substance having similar properties, namely, mica split by heat to extreme thinness, such as I employ smoked, the power of transmitting most easily heat of low temperature, or that kind of heat which is stopped in greatest proportion by glass, alum, and (according to M. Melloni) every other substance.

2. In the Third Series of these Researches, § 3, I have at-

in polarizing heat. In the month of March 1838, I had established by reiterated experiments, that the transmission of heat through glass, far from rendering it less easily absorbed by mica in this peculiar state, had a contrary effect, and also that heat of low temperature, wholly unaccompanied by light, was transmitted almost as freely as that from a lamp previously passed through glass.

"It even appears, from experiments I have since made with the same form of mica, that some specimens transmit *scarcely half* as much luminous heat previously passed through glass, as that from a body below visible incandescence.

"Mica itself, not laminated by the action of fire, possesses, as I have shown by contrasted tables in the paper referred to (Art. 23, 24), properties exactly the reverse; hence the effect is due to the peculiar mechanical condition of the body, and not to its elementary composition.

"It, therefore, at once occurred to me, on reading M. Melloni's communication, that the effect of smoking the salt might be merely owing to a mechanical change in the surface affecting the transmission.

"Roughening the surface was the most obvious experiment, and I found, as I anticipated, that heat of low temperature is very much easier transmitted by salt scratched by sand-paper in two directions at right angles, than luminous heat. Thus, a plate of salt which, when well polished, transmits 92 per cent. of heat derived from a lamp, and sifted by a glass plate, and also 92 per cent. of heat wholly unaccompanied by light, transmitted, when roughened, only 17 per cent. of the former and 45 per cent. of the latter.

"A thin plate of mica, when similarly scratched with emery-paper, so as merely to depolish it, transmitted much more nearly the same per-centage of heat from different sources than when *bright;* showing that the loss of polish affects the transmission of the more refrangible rays much more sensibly that that of the others.

"Yet this effect is not attributable to a variation in the ratio of the reflexion of heat of different kinds at the surfaces of the plate. For, in the *first* place, I have proved, and already communicated the fact to the Royal Society (see Proceedings for April 1839), that reflexion takes place at a polished surface, with almost, if not exactly, the same intensity for all kinds of heat; and, *secondly,* I have found, by direct experiment, that, at least for the higher angles of incidence, reflexion is most copious from rough surfaces for heat of low temperature, or the same kind which is most freely transmitted, proving incontestably that the *stifling* action of rough surfaces is the true cause of the inequality.

"That there is a real modification of the heat in passing through a roughened surface, as well as through laminated mica and the smoky film, appears from direct experiments which I have made on the heat sifted by these different media; which, when transmitted by any one of these, is found in a fitter state to pass through each of the others; and this modification is found to be more perceptible as the character of the heat is more removed from that which these media transmit most readily, that is, as the temperature of the source is higher. Thus, heat derived from a lamp, has 36 per cent. transmitted by a certain smoked plate of rock-salt. But if the heat transmitted by the smoked salt has previously been sifted or anatempted to demonstrate, directly and numerically, that the rays of heat which have passed through alum, glass, and indeed every substance which I tried, have a *mean refrangibility* superior to that of the rays before such transmission; and as M. Melloni had been led in a general way by his previous experiments to a similar conclusion, he inferred, and justly, that most diathermanous bodies absorb the less refrangible rays in excess, and therefore are to heat what green, blue, or violet diaphanous media are to light. Rock-salt alone (so far as we know) possesses the property of *indifferent diathermancy*, and is the single analogue of white transparent glass.

3. The generalization of this principle is a matter of much importance, and especially as it carries our knowledge a step higher in the scale of truth, by teaching us to refer to the quality of *refrangibility* certain properties of heat, which before were connected only with certain vague characters of the nature of the source whence it was derived. Amongst other things we find, what was long suspected, but what M. Melloni first conclusively proved, that the presence or absence of light is, to a great extent, immaterial; no doubt a *concomitant*, but

lysed by transmission through another plate of smoked salt, through laminated mica, and through roughened salt, the per-centage is raised from 36 to 41 in the two former cases, and to 40½ in the latter, proving incontestably the specific action of these transmissions in arresting the more refrangible rays.

"I next considered, that as a moderate number of scratches appeared to produce this modification, it might be practicable to obtain the effect by transmitting heat simply through fine wire gauze. I could not obtain it finer than sixty wires to the inch, and in this case, I could obtain no indications of differences in the transmitted ratios of one or other kind of heat. The proportion transmitted to the direct effect, was, in every case, almost exactly that of the area of the interstices of the gauze to its entire surface.

"When fine gratings (used for Fraunhofer's interference fringes) made of cotton-thread were used, even in this case no difference was perceived; here, however, the thread, having probably a certain degree of permeability, might mask the effect.

"When fine powders were strewed between salt plates, leaving minute interstices, the easier transmission of heat of low temperature was again apparent.

"Having procured delicate lines to be drawn with a diamond point on a polished salt surface, first dividing it into squares 1-100dth inch in the side, then into parallel stripes 1-200dth inch apart, and finally into squares of the latter dimension, in every case the effect resembled that of random scratches, and was more apparent as the surface was more furrowed.

"I have finally to observe, that the mere process of natural tarnishing by the exposure of salt to the air, produces a similar effect.

"These facts evidently point to phænomena in heat, resembling diffraction and periodic colours in light. I cannot doubt that the simple transmission through fine metallic gratings would produce effects similar to those of the striated surfaces of rock-salt.—*December* 16, 1839."

not an *indispensable* circumstance. Again, certain relations had been established at an early period in the history of the science of heat, between the *colour* of a surface and the quantity of heat which it absorbed, and this relation for any two surfaces compared (as black and white, of similar textures), was first clearly shown by Sir John Leslie, to depend upon the luminosity of the source of heat, to which conceiving it proportional, that philosopher based upon it the principle of his Photometer *. Professor Powell, of Oxford, conceived and executed an ingenious experiment, by which it is demonstrated that the interposition of a screen of glass, though it stops but little light, alters most materially the influence of colour on the transmitted heat, thus annihilating at once the principle of photometric measurement adopted by Leslie, except in a very limited class of cases†. M. Melloni has fully confirmed the experiments of Professor Powell‡, which therefore may be considered as establishing this conclusion, that the quality of *blackness* or *whiteness* of a surface affects its power of absorbing heat (*not* in proportion to the luminosity of that heat, as was formerly supposed, but) in proportion to its refrangibility.

4. It is both convenient and correct, therefore, to consider the refrangibility of heat as the cause of most of its distinctions of *kind* and *degree* of modification in our experiments, instead of making vague reference to the temperature of the source whence it is derived. Heat derived from the following scale of temperatures corresponds to heat of progressively elevated refrangibility; as, 1. Heat from ice has a less refrangibility than that from, 2. the hand, which again is below, 3. that from boiling-water: then comes, 4. that from a vessel of mercury under its boiling temperature, 5. a piece of smoked metal, heated by an alcohol lamp behind, but itself quite invisible in the dark, 6. incandescent platinum (a coil of wire in an alcohol flame), 7. an oil lamp (Locatelli's). Such is the scale of heat which has often been referred to in M. Melloni's researches and my own; but though our apprehension of the temperature of the source ceases to be so clear above this limit, and the colour and brightness of the light which accompanies the heat no longer varies distinguishably, the scale may

* Essay on Heat, 1804. † Phil. Trans. 1825, p. 187.

‡ *Ann. de Chimie, Avril* 1834. M. Melloni finds, for instance, that the rays from an oil-lamp falling on black and white surfaces, affects their temperature in the proportion of 1000 : 805. And the same proportion holds if they be transmitted through a plate of rock-salt; but if a plate of alum be used, though equally transparent for light with the salt, the proportion is now 1000 : 429.

be carried upwards indefinitely by interposing screens of different materials, which either may be proved *directly* (as I have done in the Third Series of these researches) to increase the refrangibility, or we may take Professor Powell's, or any similar test, which our experiments lead us to conclude to be co-ordinate with the fact of refrangibility. Such a prolongation of the scale of heat-sources would be,

8. Oil-lamp heat transmitted by Common mica.
9. ——————— Glass (Argand lamp).
10. ——————— Citric acid.
11. ——————— Alum.
12. ——————— Ice.

A clear appreciation of the scale of refrangibility as the important test for the qualities of heat cannot be too clearly apprehended and admitted. Heat from *any* source, if it admit of transmission at all through glass, alum, or water, will ultimately have the character of glass-heat, alum-heat, or water-heat, just as light from the sun, or from a candle, becomes red, blue, or green, by transmission through glasses of these colours.

5. Now, when M. Melloni had shown (and this experiment I believe was original to him), that substances which stop every ray of even intense light (as opake glass and some kinds of dark mica), yet transmit a sensible quantity of heat, it was not unnatural to inquire whether the *invisible heat* thus obtained from a *luminous* source, might not possess the qualities of heat from a dark source, in other words, whether bodies, like black glass and mica, instead of stopping the less refrangible rays like glass, alum, &c., would not suffer these to escape, and absorb the most refrangible rays, acting upon heat as a body does upon light, which stops the yellow, blue, and violet rays, that is, as red glass does.

6. Experiment partly fulfils this expectation, and partly not. The careful and complete series of experiments made by M. Melloni upon the qualities of the invisible heat thus obtained*, shows, that although it resembles low-temperature-heat, in so far as it is very feebly transmitted by alum or citric acid, yet low-temperature-heat (that from boiling water for instance) is but very faintly transmitted through the black glass or mica, which ought not to be the case if these bodies acted like a sieve, which arrested the more refrangible rays, and suffered the others to escape.

7. The direct test, however, of examining the refrangibility of the heat rays issuing from opake screens yet remained; and

* *Annales de Chimie, Avril* 1834.

in applying this, I proved that opake glass and mica act as clear glass and mica do in *elevating the mean refrangibility of the transmitted heat.* Hence I concluded that the effect of such media upon heat is to absorb the rays of greatest and least refrangibility, in short, to act as homogeneous yellow glass would do upon light, the *mean* refrangibility being on the whole, however, increased by transmission. I also pointed out that heat from luminous sources is probably far more compound in its nature than dark heat; that the darkness of heat is no test of its refrangibility; and that even the most refrangible rays may contain heat separable from the light which accompanies it*.

8. In all this, then, there appears nothing exactly equivalent to the action of red glass upon light,—no substance which transmits most easily heat of low refrangibility and temperature, and which separates heat of that description from the compound emanation from luminous sources. Reasoning probably upon the conclusions just stated, M. Melloni conceived the happy idea of combining an opake substance, such as smoke, with a solid, which itself should effect no specific change upon the incident heat. He therefore smoked *rock-salt*, and found that it presented a complete analogy to red glass, transmitting most easily heat of low temperature and refrangibility.

9. Whilst I give full credit to M. Melloni for the ingenuity and importance of his experiment, I must be permitted to state, that I conceive that I preceded him by eighteen months in the discovery of a substance possessing similar properties, although I very readily admit, that, having been led to that observation incidentally, I first pursued the remark into consequences which I considered important, after M. Melloni had called particular attention to the experiment with smoked surfaces. On the 27th February, 19th and 20th March 1838 (as appears by my Journal of Experiments), I proved that mica, split into very thin films by the action of heat, such as I employ for polarizing, possesses the property of transmitting in larger proportion several of the less refrangible kinds of heat, and in particular, that it transmits heat from a source perfectly obscure, in almost exactly the same proportion with the highly refrangible heat of a lamp transmitted through glass. I have no hesitation in saying, that no other substance known previously to M. Melloni's experiments with smoked salt, gave any approximation to the following results, which are taken from the Third Series of my Researches, art. 24.

* Researches on Heat, Third Series, art. 73, 81, &c.

Table of the proportion of Heat from different sources transmitted by the Polarizing Mica Plates I and K, contrasted with the transmissions by Mica in its usual state, and with Black Glass.

Source of Heat.	Mica split by Heat, Plates I and K.	Mica ·015 inch thick.	Opake Black Glass*.
Locatelli lamp, with glass...	100	100	100
Locatelli	116	79	70
Incandescent platinum	108	70	...
Brass at 700°..............	96	21	...
Heat at 212°..............	62	11	...

* A contrast experiment made at the same time, March 20, 1838.

10. This singular result of the mechanical condition of the mica did not fail to strike me greatly at the time, and was not published until after careful repetition. It afforded a triumphant reply to an objection against my experiments which I was then combating, that the quantity of heat absorbed by the polarizing plates had modified and even inverted the results, and having satisfied myself of that, I did not pursue the matter further. The moment, however, that I read M. Melloni's communication on Smoked Salt, I perceived the important light which the perfectly analogous case of the split mica might throw upon the phænomenon. It was evident that the results were similar in kind, it was probable that they might be made to approximate in degree. Instead, therefore, of interposing mica piles at the great and disadvantageous obliquities which I had employed (when I wished simply to test their action as polarizing plates), I took a split mica pile (frequently referred to in former parts of these memoirs under the designation H) and placed it *perpendicularly* to the incident rays of heat. I obtained the following results:—

Transmission through Split Mica H, at a Perpendicular Incidence.

Source of Heat.	Per 100 of Incident Rays.	Relative Transmission.
Locatelli, with glass	9·2	100
Locatelli	13·7	150
Dark hot brass	17·3	188
Hot water	16·3*	178

* This observation having been made at a different time from the others, and probably not under exactly the same circumstances, I have stated it in the way least favourable to the views I entertain: the per-centage actually observed was 19.

11. It appears, then, very clearly, that this peculiar condi-

tion of mica induces, in opposition to the natural quality of the substance (9), the same peculiarity which a film of smoke possesses relatively to the incident heat. It is truly for heat what red glass is for light, it transmits most freely rays of lowest refrangibility.

12. Seeing clearly from the first that the change of character in mica was due to the splitting up into an almost infinite number of minute surfaces the natural laminæ of the mineral mica; and attributing the character of redness (so to speak) to the multiplied and irregular reflexions and interferences which must so take place, it occurred to me as very probable, that the effect of smoke was due to the superposition of a prodigious number of minute opake points upon a transparent surface; and *that* not so much from any physical peculiarity of its carbonaceous material, as from the mechanical distribution of opake dust over the diaphragm of rock-salt.

13. This induced me to try the effect of *mechanical alterations of the physical surface* of the salt, expecting to find an effect analogous to that of smoking, and, guided by no other grounds of conjecture than those which I have stated, I roughened with sand-paper both sides of a polished plate of rock-salt, furrowing each surface rectangularly until it was quite dim. I then examined its transmissive power for heat from different sources, and was gratified to find my anticipation realized. The proportion of dark heat transmitted, compared to that from a lamp sifted by glass, was no less than as 3 to 1*.

* I state it as a proof of the conviction which I had of the real character of split mica with respect to heat, that the reasoning stated in the text was founded upon no experiments made subsequently to those of March 1838 already qnoted. The very first entry in my journal-book of last autumn contains *simultaneous* experiments, (1.) on smoked salt, to verify M. Melloni's observations: (2.) on split mica, to extend my own of March 1838 to perpendicular incidences: (3). on scratched surfaces, on the assumption that the two former would be realized. As M. Melloni thinks that I had not a clear idea of the properties of split mica, which, indeed, if I understand him, he still doubts, I will quote *verbatim* the passage in my laboratory-book alluded to.—" 1839, Nov. 12. M. Melloni having lately stated (*Comptes Rendus*, 2nd Sept.) that smoked rock-salt is the only substance known which transmits heat of low temperature easier than luminous, this is in the first place contradicted by my experiments of 1838, Mar. 20. &c. on mica split by heat, already published,—and in the next place, I felt [feel] some doubt whether [in his experiments] it was the quality of the *material* or only the *surface* which affects the result. To try this, and to verify previous experiments, I smoked a plate of rock-salt; I *roughened* another with sand-paper, first on one, and then on both surfaces; I had also the split mica plate marked H placed *perpendicularly* to the rays of heat."

[*Here follow the experiments.*]

"It clearly appears, then, that salt simply roughened transmits most dark heat. I presume that the effect of smoking is only superficial, and that roughening stifles luminous heat faster than dark heat."

This is the *first* entry in my book after the publication of M. Melloni's letter in the *Comptes Rendus*, and it is given *entire*.

14. It thus appeared that there are at least three conditions under which a medium can be found capable of transmitting heat of low refrangibility, and that two of these had reference *solely* to mechanical constitution. It was natural to generalize and attempt to include the case of the film of smoke, as well as the striated and the laminated surface, under one category. I have already said that the mechanical distribution of the opake carbonaceous particles offered a plausible analogy, which I proceeded to attempt to carry out.

15. The numbers in art. 10, may be compared with the following:—

Source of Heat.	Transmission per 100 of Incident Rays, by		Relative Transmission by	
	Smoked Salt.	Rough Salt.	Smoked Salt.	Rough Salt.
Locatelli, with glass ...	30	49	100	100
Locatelli	...	62	...	126
Dark hot brass	58	70	192	142
Hot water	67	77	223	157

16. It occurred to me that if the action of the smoke was entirely a *superficial* one, or due to the character of a rough surface applied to the plate of rock-salt, that the effect of two such surfaces upon the transmission of heat would probably differ from that of a single film of smoke, so thick as to produce an equal absorption of heat of any particular degree of refrangibility. For this purpose I smoked three plates of polished rock-salt, so that two marked D and E absorbed *together* as much dark heat (very nearly) as the third plate A did alone.

17. I may take this opportunity of mentioning the way in which I have succeeded in smoking inflammable surfaces without burning them, or crystallized plates, like rock-salt, which crack and fly by the direct application of the flame of a candle. A coarse gas-flame, surrounded by a wide metal tube 10 or 15 inches long, against the side of which the flame partly plays, affords a stream of comparatively cool smoke, which may be applied to any given surface. With these three smoked salt-plates I obtained the following results:—

	Source of Heat.		
	Locatelli, with Glass.	Locatelli.	Dark Heat.
	Per cent.	Per cent.	Per cent.
Smoked Salt Plate A	8·3	17·2	32·9
——— D	26	41	58
——— E	23·5	36	53·5
——— (D + E)	7·3	18	32·1

As most of these results are from single experiments, the first and the last line must be considered as almost identical, and certainly do not indicate any material specific difference in the absorbent qualities of one thick and two thin films of smoke, which might be expected if the action were a merely superficial one.

18. From these numbers we deduce another conclusion of some importance. Since a film of smoke transmits most easily heat of low temperature and refrangibility, we may expect that it will modify the quality of any compound beam of heat which it transmits, and that one such transmission will therefore render a second more easy. Now, we find that the plate D transmitted 26 per cent. of heat from the first of the above sources, and that of the 26 rays escaping from D, and falling upon a second smoked film E, E transmitted 7·3, or 28 per cent. of those incident upon it. But by the third line of the table E transmitted 23·5 per cent. only of the direct rays, consequently the capacity for transmission has been increased. In the same way for Locatelli heat we find the percentage for E raised from 36 to 44 by previous transmission through D; and for dark heat from 53·5 to 56.

19. Hence a useful application of smoked surfaces to which I have sometimes had recourse. It is often important to operate with more or less refrangible rays of heat under exactly the same circumstances of parallelism or divergence, and intensity. Having adjusted an oil-lamp with a salt lens, so as to afford a compound beam stronger than required, we may, by interposing a plate of smoked salt, absorb the most refrangible rays, and suffer the others alone to pass, and by then using a glass of proper thickness, the intensity of the heat may be reduced in the very same proportion, but the more refrangible (hottest) rays are alone retained*.

20. Now the results of (17), though not what I anticipated as most probable, do not altogether relieve us from some doubt as to the nature of the action of the film of smoke, although those experiments, as well as others which are to be detailed in this paper, incline me to M. Melloni's opinion, that the

* *Smoked glass* is evidently an excessively opake compound medium, being composed of two parts which absorb opposite ends of the heat spectrum. It is curious to reflect how little the true cause of the opacity of a film of smoke deposited upon glass was understood at the time that it was quoted as a convincing proof of the *immediate* radiation of heat through solid bodies. Far from smoke being the untransparent substance supposed (I use the word loosely in applying it to heat), it transmits a quantity of some kinds of heat really surprising, although the thickness of the smoke be considerable.

smoke acts by its own intimate constitution, and not by its mechanical arrangement. Though I have examined smoky films with a powerful microscope, I have failed in detecting the minutely divided particles of carbonaceous matter of which it must undoubtedly consist. Still the reticulation which fine powder strewed on a surface must form, if it act by the minuteness of the spaces which are left (as in diffraction-experiments on light), must act more intensely when by superposition such reticulations become more minute and complicated. And it may little matter whether the smoky screens are distinct, and deposited on separate plates mechanically placed in succession, or whether they are accumulated by continued smoking on a single surface. I do not state this with a view to maintain my own original opinion, which I am rather disposed to abandon, and to consider a smoked surface, *diathermanous*, as well as *transparent*, in the full meaning of the words; but in extending my experiments to roughened surfaces, I was rather surprised to find that the continued action of furrowing the surface by scratching it with coarse sand-paper, not only diminished the transmission of heat, but increased the *specific* action on rays of different refrangibility, whilst one would rather have imagined that the action being here due to the destruction of polish, and therefore *superficial*, any exaggeration of the roughness would not have increased the relative *diathermancy* to rays of low refrangibility.

21. Conclusive experiments, however, mark an increased sensibility to various kinds of heat by increased roughness. Two plates of salt, marked *a* and *b*, having been scored with sand-paper in rectangular directions on both sides, were placed so as to intercept similarly a parallel beam of heat. The difference of the following numbers is due to the less degree of roughness of *a*.

	Source of Heat.		
	Locatelli, with Glass.	Locatelli.	Dark Hot Brass.
	Per cent.	Per cent.	Per cent.
Rough Salt Plate *a*	30	48·5	59
———— *b*	16·6	28·5	45
———— $(a+b)$ ...	7·2	16	27·5
Per-centage of heat received through *a* transmitted by *b* ...	24	33	46·5
Ratio of *a* to *b*	100 : 55	100 : 58·5	100 : 76

Here, then, we find the per-centage of transmission raised in every case by a previous transmission through a rough surface. The increased facility of transmission is greater in proportion as the incident heat was more heterogeneous; dark heat undergoes very little change. It appears also by the last line of the table, that the increased roughness of *b* compared to *a*, had *enhanced* the characteristic effect (analogous to *redness* for light).

22. I have made a great many experiments to satisfy myself that the action of all the three media already specified (14) is precisely analogous, and that they actually insulate similar rays by absorption. The following table is a specimen, showing the increased facility with which rays of heat, from whatever source, are transmitted by smoked rock-salt after previous transmission through the same or other substances.

Table showing the Per-centage of Transmission by the Smoked Rock-Salt Plate E for heat from different sources, and modified by passing through the following Media.

Source of Heat.	Heat transmitted by			
	Nothing.	Split Mica H.	Smoked Salt D.	Rough Salt *a*.
Locatelli, with glass ...	23·5	...	28	29
Locatelli	36	43·5	44	40·4
Dark hot brass	53·5	56	56	55

23. It is very important to consider how this action of rough surfaces may be explained, and whether we have any analogous phænomena in the case of light. Can it be owing to the circumstance that the depolished surface reflecting differently the various kinds of heat, those kinds least copiously reflected persevere, and form the majority of the transmitted rays? To this it may be replied, that the intensity of reflexion at polished surfaces is so insignificant at a perpendicular incidence for either heat or light*, that were the *whole* specularly reflected heat, transmitted in the one case, and absorbed in the other, the difference, instead of amounting to 30 per cent. or more, of the incident heat (21), could not exceed 4 per cent.

24. Arguing from the analogous case of light, I anticipated, on the contrary, that the *reflected* as well as the *transmitted* beam, would be more intense from such a surface, as it is well known that polish becomes more specular for rays of light con-

* See Melloni, *Ann. de Chimie,* Dec. 1835, and my Memorandum on the Intensity of Reflected Heat and Light, Proceedings of the Royal Society of Edinburgh, p. 254.

sisting of longer undulations, the inequalities of the surface first becoming insignificant for red light.

25. In this I was not deceived. My purpose not being to investigate fully the subject of diffuse reflexion, I confined my attention to the establishment of the general fact. Employing an apparatus which I have not yet described, but which bears a great analogy to that figured in the Society's Transactions, vol. xiv. pl. xiii., and described in art. 51 of the Third Series, I observed the intensity of reflexion of heat from different sources at a *single* polished surface of flint-glass, and at a similar surface depolished with emery. I obtained at considerable incidences the following striking results as to the increased susceptibility of heat to be *regularly* reflected at a rough surface, when it is of low temperature or refrangibility.

Ratio of the Intensities of Heat reflected by a Polished and a Rough Surface of Flint-Glass.

Angle of Incidence.	Source of Heat.		
	Locatelli, with Glass.	Locatelli.	Dark Hot Brass.
60°	...	100 : 34	100 : 35·4
70	100 : 26·5	100 : 38·3	100 : 43·5

So far then the character of the action of depolished surfaces is consistent. *The stifling effect* (which diminishes both the reflected and refracted ray) *of a rough or laminated surface diminishes with the refrangibility of the incident heat.* That the same thing takes place in the reflexion of light we know; it is probable that it does so in its transmission likewise, though this has not been so distinctly observed. Most impure substances transmit a ruddy gleam, vapour of water does so whenever it is not colourless*, and every practical optician knows, that in a great majority of media the violet end of the spectrum is first absorbed.

[To be continued.]

XV. *Notices respecting New Books.*

On the Theory of the Moon, and on the Perturbations of the Planets. Part IV. [With a "*Note on the Calculation of the Distance of a Comet from the Earth.*"] By J. W. Lubbock, Esq., Treas. R.S., Vice-Chancellor of the University of London, &c.&c. Lond. 1840. 8vo. Pp. xiv., 355–417, and 1–6.

In the former parts of this work (the first of which was noticed in our fourth volume, p. 218) the author endeavoured to explain

* Edinburgh Transactions, vol. xiv. p. 371.