



# LVII. Experimental researches on the supposed diathermancy of rock-salt

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The ratios of energy are :—

$$\frac{\text{transmitted}}{\text{incident}} = \frac{b^2}{A^2 + B^2}$$

$$= \frac{1}{9} \left\{ 5 + \frac{-2AB \cos \gamma \pm 4C\sqrt{A^2 + B^2 - AB \cos \gamma}}{A^2 + B^2} \right\};$$

$$\frac{\text{single reflected stream}}{\text{incident}} = \frac{a^2}{A^2 + B^2}$$

$$= \frac{1}{9} \left\{ 2 + \frac{AB \cos \gamma \mp 2C\sqrt{A^2 + B^2 - AB \cos \gamma}}{A^2 + B^2} \right\}.$$

If  $\gamma=0$ , or  $\cos \gamma=1$ , and  $A=B$ , we have the case of prop. V. This determines the employment of the upper signs before the roots in the present results, in which case these results coincide with those of prop. V., giving  $\frac{8}{9}$  of the whole transmitted, and the remaining  $\frac{1}{9}$  divided between the reflected streams. If  $\cos \gamma=0$ , or the component systems differ in phase by  $\frac{1}{4}$  of a period, the whole energy is transmitted, or the geometrical composition takes place unaltered. This is immediately seen from the vanishing of the term  $(2AB \cos \gamma)$ , by which  $C^2$  differs from  $A^2 + B^2$ .

In all these discussions it has been assumed that the incident wave-systems were not subject to constraint, which would prevent them from yielding to the reflected impulse; and in cases of interference in air constraint is frequently absent. But where the two wave-systems are supplied, say, by tuning-forks close to the point of meeting, the forks are capable of maintaining their movement unchanged and acting as a constraint. Under these circumstances more work is done by the sources, and the geometrical composition of the systems is maintained.

In the next note I propose to apply the principle of the flow of energy to the divergence of sound in air.

LVII. *Experimental Researches on the supposed Diathermancy of Rock-Salt.* By JOHN RUSHTON HARRISON\*.

[Plate III.]

IT is almost universally accepted that pure rock-salt transmits more than 92-per cent. of the total radiation from heated bodies. I would ask permission to glance for a moment at the mode of experiment by which Melloni arrived at this conclusion.

\* Communicated by the Author.

A thermopile is placed at a distance from the source of heat, the radiation from which causes a deflection of the galvanometer-needle. This arrangement completed, the substances to be examined are introduced between the source and the pile, their different powers of absorption and transmission being determined by the different values of the deflections. Taking a single instance, it is assumed that a plate of ice  $\frac{1}{10}$  of an inch thick absorbs all the incident radiation from copper heated to  $400^{\circ}$  C.; while a rock-salt plate of the same thickness transmits 92.3 per cent. of the total radiation from the same source of heat. That the ice *does* absorb the heat is proved by the liquefaction of the substance; but that 92.3 per cent. of the total radiation *passes through* the salt is not, I think, equally certain; in fact the experiment points, not to diathermancy, but to the unequal *absorptive* powers of the different substances examined.

In 1869\* Professor Magnus endeavoured to account for the diathermancy of rock-salt by saying:—"The great diathermancy of rock-salt does not depend on a small absorbing-power for different kinds of heat, but upon the circumstance that it emits only one kind of heat, and only absorbs this one, and that almost all other bodies at a temperature of  $150^{\circ}$  C. emit heat which only contains a small portion, or none at all, of the heat which rock-salt emits." There will be little doubt that this conclusion is based upon the doctrine of periods, although the result of another experiment with fluor-spar, noticed in the same paper, is *fatal* to that conclusion.

It is less, I think, from an experimental point of view than from unsuccessful attempts to explain *why* a solid substance should be diathermanous, that any one would be led to doubt the value of Melloni's conclusions; and here I would state that the experiments recorded in this paper, by which opposite results have been obtained, were not originally suggested by any apparent inefficiency in the mode of experiment adopted by this great philosopher.

The apparatus by which these results have been obtained is as follows:—Two thermometers, each 3 inches long, with bulbs  $\frac{1}{10}$  of an inch diameter, registering from  $0^{\circ}$  to  $200^{\circ}$  C. One of these thermometers is enclosed in a rock-salt case  $3\frac{1}{2}$  inches long, bored out so that the bulb stood at a distance of  $\frac{1}{10}$  of an inch from the salt; the scale of the thermometer is plainly visible through the salt case, which consists of two pieces, as shown in fig. 1, afterwards cemented together with a thin film of transparent glue. The sides of the case are  $\frac{1}{10}$  of an inch

\* Philosophical Magazine for November 1869.

thick ; a few threads of unspun silk wound round the head of the thermometer-tube hold it in position. This I will call the "enclosed" thermometer, and the other the "naked" one ; both thermometers are fixed to one cork and placed in a glass tube. The whole apparatus is seen in fig. 2. C is the cork with thermometers attached, the bulbs of which are at a distance of one inch from each other ; T, a glass tube 12 inches long and  $1\frac{1}{2}$  inch internal diameter containing them ; V, a glass vessel 8 inches long and 4 inches internal diameter, fitted with a cork to admit the tube T ; this vessel is filled with water at the boiling-temperature ; *t*, a tube to convey the steam given off by the water to condenser K. The mode of performing the experiment is as follows:—

The thermometers being in their places, the tube containing them is placed in a freezing-mixture and allowed to remain till both thermometers register  $0^{\circ}$  C. The water in the vessel V is heated by the aid of a spirit-lamp which is withdrawn when the water boils ; when ebullition has ceased the tube is taken from the freezing-mixture and quickly passed into the vessel V, and the rise of both thermometers noted from minute to minute. When the enclosed thermometer has reached its maximum temperature, the tube is then withdrawn, placed in the freezing-mixture, and the descent from minute to minute noted. The result of the experiment is seen in the following Table:—

Registration of both thermometers at commencement of experiment,  $0^{\circ}$  C.

<i>Naked thermometer.</i>				<i>Enclosed thermometer.</i>			
After the lapse of	1 minute, $35^{\circ}$ ;	gain in temp.	$35^{\circ}$	After the lapse of	1 minute, $9^{\circ}$ ;	gain in temp.	$9^{\circ}$
" 2	55	"	20	" 2	20	"	11
" 3	64	"	9	" 3	28	"	8
" 4	69	"	5	" 4	35	"	7
" 5	70	"	1	" 5	40	"	5
" 6	70	"	0	" 6	45	"	5
" 7	71 (max.)	"	1	" 7	49	"	4
" 8	71	"	0	" 8	52	"	3
" 9	71	"	0	" 9	55	"	3
" 10	70	Loss	1	" 10	58	"	3
" 11	70	"	0	" 11	60	"	2
" 12	69	"	1	" 12	61	"	1
" 13	69	"	0	" 13	62	"	1
" 14	68	"	1	" 14	63	"	1
" 15	67	"	1	" 15	63	"	0
" 16	66	"	1	" 16	63	"	0
" 17	65	"	1	" 17	64(max.)	"	1
" 18	65	"	0	" 18	63	Loss	1
" 19	64	"	1	" 19	63	"	0
" 20	64	"	0	" 20	63	"	0
" 21	62	"	2	" 21	62	"	1

The tube containing the thermometers was then placed in the freezing-mixture.

<i>Naked thermometer.</i>					<i>Enclosed thermometer.</i>				
After the lapse of	22 minutes, 35°;	gain in temp.	27°		After the lapse of	22 minutes, 52°;	gain in temp.	10°	
"	23 " 16	"	19		"	23 " 40	"	12	
"	24 " 8	"	8		"	24 " 30	"	10	
"	25 " 5	"	3		"	25 " 20	"	10	
"	26 " 3	"	2		"	26 " 17	"	3	
"	27 " 0	"	3		"	27 " 15	"	2	
After the lapse of	5 " 0		0		After the lapse of	5 " 7		8	
"	5 " 0		0		"	5 " 3		4	
"	5 " 0		0		"	5 " 1		2	
"	5 " 0		0		"	5 " 0		1	

It will be noticed that the naked thermometer reached its maximum temperature 71° C. in seven minutes, at which time the enclosed thermometer registered 49° C. The former remained stationary at 71° C. for two minutes, and then slowly descended; after the lapse of ten minutes from the time it first reached its maximum, and seventeen minutes from the commencement of the experiment, it had fallen 6° C. and now registered 65° C. During this time the enclosed thermometer steadily increased in temperature, and now registered its maximum (64° C.), it having risen 15° C., while the naked thermometer had fallen 6° C. This reverse action proves beyond doubt that the heat incident on the bulb of the enclosed thermometer had been radiated from the salt as an independent source, and not diathermanously transmitted.

The following experiment, though void of numerical value, is still, I think, interesting, as a different source of heat is employed. The apparatus used is shown in fig. 3: T is a test-tube with foot, 8 inches long and 1½ inch internal diameter; t, a second tube passed into the first and held in position by means of a cork, c (this inner tube is ¾ of an inch internal diameter, and stands half an inch higher than the outer one); P, a pivot fixed in the inner tube to support the source of heat—a round bar of hot copper 2 inches long and half an inch cross section; C, a movable German-silver cap open at both ends and polished on both sides; its smallest circumference passes into the inner tube, and its larger circumference passes into the outer one. One surface of a piece of white blotting-paper is coated with a thin layer of melted white wax, care being taken that the wax does not penetrate *through*; when this layer is dry, others are applied till the texture of the paper is well filled.

The experiment is performed as follows:—

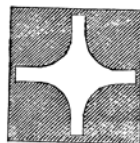
The outer tube being filled with water, the bar of copper heated to a dark red is placed in the inner tube, the cap adjusted, and a rock-salt plate  $\frac{1}{20}$  of an inch thick shaped thus



placed on the top of the cap, the blotting-paper

with its waxed surface downwards brought immediately over but not touching the salt: the heat ascending melts the wax, and a well-defined outline of the rock-salt plate is produced on

the upper surface of the blotting-paper, thus



If the experiment be performed without the rock-salt plate, the melted wax first shows itself as a dark spot in the centre of the blotting-paper, and then spreads towards the edges. Different shaped plates were used with similar results. In performing the experiment care must be taken that the heated copper stands fairly perpendicular under the centre of the cap.

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LVIII. *On the Thermal Phenomena of the Galvanic Pile, and Electromotive Forces.* By E. EDLUND\*.

§ I.

1. FROM the experiments which have been instituted for the purpose of studying the thermal phenomena of the galvanic pile and its conductors the conclusion has been drawn, that the heat which arises in consequence of the passage of the current through the entire conduction (including the pile itself) during a certain time is exactly equal in quantity to that which is produced in the pile by chemical processes during the same time,—that is to say, provided that the current performs no external work (for example, induction, chemical decomposition, &c.); and among the processes mentioned, only those must be understood which are primary and in direct connexion with the formation of the current. In the following, to distinguish these two quantities of heat from one another, we will name that which is occasioned by the passage of the current through the conductors the gal-

\* Translated from a separate impression, communicated by the Author from Poggendorff's *Annalen*, vol. clix. pp. 420-456.

Fig. 1.

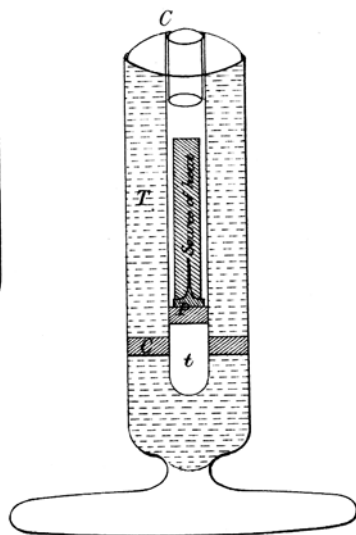
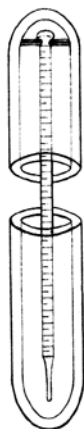


Fig. 3

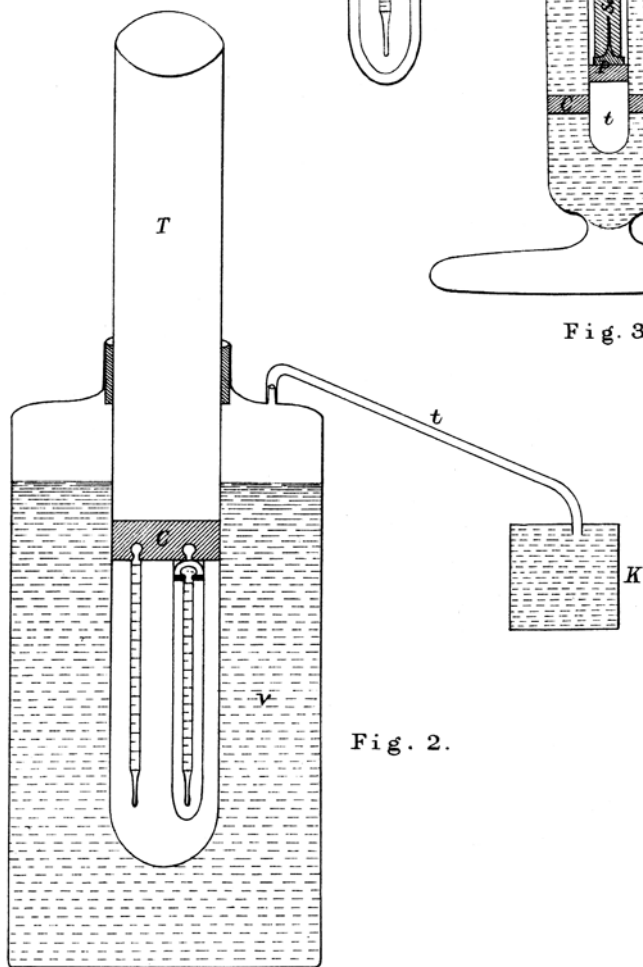


Fig. 2.