acid secretions. The dominant quantity of nerves, therefore, from one or the other system determines the chemical character of the secretion. One single secretion, that of the skin, makes an exception to this observation, for the sweat is acid. But my experiments induce me to hope to be able soon to resolve this difficulty; it is probable that the sweat owes its acid character to the influence of the air.

Idem.

Heat of Electricity.

Mr. Humbold presented in the name of M. Riess a memoir printed in German, containing some new experimental and analytical researches on the quantity of heat which electricity produces in metallic wires. The results are as follows:

If an electric battery is discharged through a silver wire 118.7 inches in length, through a gold wire 88.8 inches, and through a platina wire 15.5 inches; they will, when of equal thickness, experience an increase of temperature very different; but if we suppose them surrounded with ice after the discharge, they will each melt equal quantities of it in returning to their primordial temperature.

The calorific force of a metal, that is to say, the quantity of heat developed in each metal by an electric discharge, may be found by dividing the retarding electric force by its capacity (specific heat) and its specific weight.

When different metallic wires are united for the discharge of a battery, the quantity of heat developed is proportionate to the retardation which each wire produces during an electric discharge.

M. Arago observed that these results coincide in many points with those obtained by M. Peltier, in his researches on the same subject.

Idem, No. 252.

Electricity in a Vacuum.

A note being presented at the session (October 8th) from M. Masson, for the purpose of showing that, in certain conditions, the electric current did not pass through a vacuum between the poles of a strong pile, M. Arago observed that M. Savary had long ago succeeded in producing magnetization by the discharge of electricity of tension, developed by friction, and instantaneously discharged through a vacuum. For example, a glass tube, void of air, and a brass rod sensibly equal in diameter to the tube, being placed in the same circuit, the discharge magnetized needles in an equal degree, placed at the same distance from the tube and the rod. It results from this experiment, that electric motion may develop magnetism without the intervention of ponderable matters directly in its course.

Idem.

Progress of Physical Science.

Upon the alleged Influence which the Roughness and the Polish of Surfaces exercises upon the Power of Bodies to emit Heat, in reference to the Experiments of Professor Sir John Leslie. By M. MELLONI.

When we measure the intensity of calorific radiation which takes place from the two sides of a metal vessel filled with boiling water, having the

one of its longitudinal sides highly polished and brilliant, and the other, though at first polished, yet subsequently more or less streaked or furrowed with emery, or with the graver, or the file, we discover that the quantity of heat emitted by the streaked or unpolished surface, is always superior to that which emanates from the brilliant one. These variations sometimes exceed the ratio of two to one. Hence a deduction has been drawn, that the observed increase is owing to those inequalities which have been impressed upon the vessel, and that, consequently, the superficial asperities of bodies have the property of facilitating the exit of the heat which they contain. I beg the honour of communicating to the Academy the abstract of a series of researches, whence it seems decidedly to follow that this proposition is wholly erroneous; so that if the superficial layers clearly and decidedly contribute to make a difference in the quantity of heat emitted by a hot body, the state of the surface has no part in the production of this phenomenon.

First, I must avow that, in spite of the authority of great names, the influence of this polish in calorific emission, has always appeared to me very doubtful. It is said, the interior heat experiences in quitting the body the same action of the surface which it undergoes in penetrating it in the way of radiation. Be it so. But why should these small shining *facets* (*facettes miroitantes*) which you produce by streaking the polished plate, reflect interiorly less heat than the surface *uniformly polished*? Take a vessel of copper, having two polished sides slightly obscured by exposure to the air: make with the graver on one of these sides, a series of parallel furrows; the little furrows thus produced, will certainly be more brilliant than the rest of the vessel, and, notwithstanding, the furrowed surface will emit more heat than the smooth one.

It is now nearly two years since I imparted this objection and some other experiments of the same sort, to Messrs. Bache, Henry, and Locke, distinguished professors of physics from the United States, who were then in Paris. Now, however, that the question appears to me decided, I lay aside all indirect objections, and pass immediately to the exposition of results which conduce directly to the proof of the alleged fact.

I took a cubic vessel of copper, whose four faces were very carefully formed; externally, I soldered on its lower angles and edges, grooves provided with springs, for the purpose of supporting firmly against the vessel plates of two or three lines in thickness; and having afterwards procured two pairs of plates, one pair of jet, and the other of ivory, I applied them to the four sides. Each pair was composed of plates in every respect alike, except as it regarded the external surface, one of which was very smooth and brilliant, and the other was not polished, and was streaked with emery. On precisely measuring with the thermo-multiplier, the quantities of heat projected by the two polished faces, when the vessel was filled with hot water, and in comparing them with those which emanated from the corresponding streaked faces, I could only perceive differences to the extent of one or two hundredths (*centièmes*;) and these sometimes on the one side and sometimes on the other. The mean of twenty observations yielded only a variation which scarcely amounted to a few thousandths (*millièmes*;) and, consequently, might be altogether disregarded.

To this experiment it may perhaps be objected, that in spite of the precautions taken for the establishment of a perfect contact betwixt the plates and the vessel, we have nevertheless no certainty that the two plates which composed each of the pairs submitted to experiment, possessed the same

temperature. To avoid this objection, I caused a square reservoir to be hollowed out of a small block of marble, the sides of which were reduced to a perfectly equal thickness, and the external surfaces of which were differently prepared. The first was smooth and brilliant; the second was equally smooth, but unpolished and tarnished; the third was streaked in one direction; and the fourth in two, crossed at right angles. The vessel was then filled with hot water, and *projected the same quantity of radiating caloric from each of the four sides.*

Hence, it appeared that the more or less irregular state of the surface has no influence upon the emissive power, when the radiating body is not of a metallic nature.

I then covered with lamp-black one of the faces of my marble vase, as well as one of each of the pairs of plates I had employed in the preceding experiment. As it has been agreed to represent by the number 100, the emissive power of lamp-black, I could easily determine, by successive comparisons, the proportional numbers which represented the emissive powers of ivory, jet, and marble. The whole three were found to be comprised between the numbers 93 and 98. But here might it not be said, that if in the substances which were thus employed, the influence of the unpolishing is nothing, this is owing to their emissive power reaching the limit of maximum, beyond which an augmentation can scarcely occur, because the emissive surface no longer supplies a hindrance to the escape of the heat; whilst in metals, far removed from this limit, the alteration of the state of the surface must necessarily exercise all its influence, and render it sensible by a marked variation in the quantity of caloric emitted?

Although this reasoning is based upon a pure hypothesis, viz. that lamp-black opposes no resistance to the radiation from the surface; and although the emissive powers of the three substances employed are indeed, on the one hand, so far removed from the number 100, as to permit us to appreciate the variations produced, and yet, on the other, are so energetic that the smallest proportion of change occurring in their values, would make them overcome the whole distance which separates them from this number; notwithstanding, let us for a moment abandon all these non-metallic substances, and endeavour to determine the question from the bodies themselves with which we are now more especially concerned.

Copper, zinc, tin, and tin-plate, so far as I know, are the only metals which have hitherto been employed in the experiment described at the commencement, on being exposed to the action of the air, are quickly covered with a slight film of invisible oxide, the presence of which is deduced, in a very satisfactory manner, from certain electrical phenomena. Now, it is known that the emissive power is much stronger from oxides than from the metals themselves. It may happen then, that the streaked surface, presenting a greater number of points of contact to the air, is more oxidated than the polished surface, and thus augments its radiating power by the simple effect of oxidation, without the more or less regular arrangement of the superficial parts having any thing directly to do with the result.

For ascertaining if this explanation could be maintained, all that was required was to make the experiment with gold and platina, and this I speedily did; when I found that the streaked plates of platina and gold always yielded a much more abundant calorific emission than the polished surfaces of either metal.

Oxidation then, as well as the influence of *polish in non-metallic substances*, being put out of the question, the inquiry still remains, what is the

alteration peculiar to metals which, in these bodies accompanies the change, more or less considerable, of the superficial layer?

It is no other, in my opinion, than a change of hardness or of density. Jet, ivory, and marble are, in fact, substances which are almost entirely destitute of compressibility, or at all events they do not possess, in any sensible way, the property of permanently retaining the modifications of density and hardness impressed on them by the action of mechanical force. They also readily arrange themselves in the form of plates without being subjected to pressure. On the contrary, the metals are compressible; and the common metal plates of commerce are obtained, as is known, by subjecting the metals to an extremely severe pressure by means of the hammer and rollers. Finally, experiment also proves that these plates, as well as wires, have a specific weight, and a hardness superior to those of cast metal. Who is the individual that will tell us, that this augmentation of hardness and density is uniformly distributed throughout every part of the mass? Is it not, on the contrary, probable that, during this operation, the surface undergoes a pressure and condensation greater than any other part; and that the plate is truly covered by a kind of envelope, whose density and hardness is superior to that of the internal layers?

This conceded, it is evident that by streaking the surface of a plate the less dense and hard parts will be exposed. Upon turning, then, to the tables which represent the emissive powers of bodies, it will be at once perceived that these powers follow, in general, the inverse ratio of their density. Let us admit that, according to all analogy, the same law holds regarding the different degrees of condensation of the same substance, and we may hence conclude, that, in producing these small furrows at the surface of the plate, we must obtain an augmentation of the radiating power. To this we have to add, that the parts which compose the superficial layer being loosened by the separation of their contiguous particles, must become softer, and thus acquire, by the diminution of density, an emissive power which will more nearly approach to the softer layers of the interior.

This being the case, it will result, *1st*, that a polished plate of any given metal radiates a quantity of heat so much greater in proportion as the density or the hardness of its superficial layers is less; and, *2d*, that, in the case of inferior density and hardness, the increase of the radiating power produced by the *unpolishing* will be inferior to that obtained when the plate is denser and more thoroughly compressed.

It is almost unnecessary to add, that, for the verification of these theoretic conclusions, we must avoid employing a metal which is oxidated at a low temperature, for a plate of metal of this kind is imbued with a tendency to augment its emissive power, which varies every moment with the condition of the superficial layers, and so much the more as these layers are soft and detached.

Violent percussion, on the one hand, and a very slow transition from the state of fusion to solidity, on the other, are the two means by which we succeed in endowing metallic substances with greater or less degrees of density. Accordingly, I ordered two pairs of plates to be made of very pure silver, and gave directions that one of each pair should be hammered to a high degree, and the other should be cooled down very slowly in its sandy mould. Out of these I constructed, with the addition of a metallic bottom, a small rectangular cistern, the sides of which were united by means of soft solder, so that there might be no risk of altering their densities or tempers, during the operation. When so united, the four sides

were perfectly polished, which process had been accomplished by means of pumice-powder and charcoal, without the help of either the hammer or the burnisher. I then took coarse emery paper, and strongly rubbed, in one direction, one of each pair of the plates; the images of objects which appeared very distinct and bright upon the surfaces which were left in all their pristine polish were completely effaced upon the rubbed surfaces, which were quite obscure and covered with striae. The vase, thus prepared, was filled with hot water; and the four sides, successively presented to the opening of my thermo-electrical apparatus, produced the following effects upon the galvanometer:—

The forged and polished plate,	10°
The forged and roughened plate,	18°
The cast and polished plate,	13°7
The cast and roughened plate,	11°3

In comparing these four radiations, we perceive, 1st, as to the *polished* plates, that the cast metal affords nearly one-third more than the forged metal; which most clearly demonstrates the influence we have assigned to the inferior density; and, 2d, That the effects of the streaking upon the two sorts of plates differs not only in intensity, as we had foreseen, but also in *kind*, for if the radiating power of the forged plate received an *augmentation* of four-fifths by the roughening action of the emery, on the other hand, that of the cast silver experienced a *diminution* of nearly one-fifth.

This unexpected result, which irrefragably proves the truth of our fundamental proposition, is most satisfactorily explained by the theory we have just been developing: for the pressure of a hard body, such as the emery, upon the soft surface of the cast metal, somewhat compresses and condenses the rubbed parts, and makes the bottom of the striae, produced upon the superficial layer, harder than the whole surface of the corresponding plate.

I have to regret that I had not an opportunity of making the same experiment upon vessels of gold and platina, where the same kind of manifestations, in all probability, would exhibit themselves upon a large scale, on account of the very great difference of density we can impart to these metals by means of fusion and percussion.

And now, turning to the first observations of the late Professor Leslie, we observe that the different metallic plates which he subjected to experiment, gave constantly a greater emissive power when they were rough and irregular, than when they were smooth and polished. This being the case, nothing appeared more natural than to conclude, regarding the phenomena of the emission of caloric, that, apart from the influence dependent upon the quality of the superficial layers, there was some peculiar influence dependent upon their degree of polish, so far at least as the metals were concerned. This was the conclusion drawn from the facts observed by Mr. Leslie; and, notwithstanding, this conclusion—so simple and direct in appearance, was unwarrantable.

Here, then, is a beacon where needed, against the unfortunate precipitancy with which some experimenters hasten to dignify as general laws, the consequences which result from their first experiments. Sometimes we have only to take up an instrument and use it in some research, in order to stumble upon some new fact. But in prosecuting the work with becoming assiduity, in varying our modes of experimenting, and in analyzing the phenomenon in different aspects, it will most generally be found, either that the novelty is only apparent, and that the true explanation may be found among the already established truths of science; or if, on the other hand, it turns

out to be a real discovery, it will almost invariably contradict those alleged general laws which first of all presented themselves to our minds with so much apparent certainty and clearness.—(*Comptes Rendus de l'Académie des Sciences.*

Edin. New Philos. Jour.

On the Effects of Light and Air in restoring the faded Colours of the Raphael Tapestries. By MR. TRULL; communicated by MICHAEL FARADAY, Esq., D. C. L., F. R. S.

To the Editors of the Philosophical Magazine and Journal.

GENTLEMEN,—You probably remember an exhibition in July last of certain Raphael Tapestries in the Haymarket, and the extraordinary effect the exposure to light and air had in restoring and altering colours which had faded during centuries of exclusion from these mighty agents. I have received letters from the proprietor, Mr. Trull, and if you think parts of them worth publication at this time, when the action of light in the service of the fine arts is so much dwelt upon, they are entirely at your service.

April 21, 1839.

MICHAEL FARADAY.

To Professor Faraday.

Warwick-row, Coventry, March 12, 1839.

SIR,—The interest you took in observing the changes of colour in the Raphael Tapestries, after being exposed to light in London last July, made me anxious to communicate to you the extraordinary effects since produced, by the simple means suggested by yourself and other scientific gentlemen, of a more perfect exposure to light and air, which have for the last seven months been obtained, in a finely situated factory here.

I feared to trespass on your valuable time, but could not resist, after hearing of the great public interest now excited by the new process, called, I believe, "sun painting."

Light and air have done wonders for my tapestries, in dispelling the damp, clearing up the colours, and reproducing others, obscured by the effects of many years' close packing up in boxes. I regret not to be able to make scientific remarks on the progress of the recovery, which others acquainted with chemistry might have done.

The results cannot fully be appreciated but by those who recollect the work when up in London, where the first effects of change unexpectedly commenced.

The greens had all become blue; you, Sir, anticipated a return to the original tints, which has, almost throughout, taken place.

The robes and full colours generally had become dull and heavy; this has gradually gone off, and left a brilliancy of colour and beauty of effect hardly to be excelled. The gold also, as you hinted, has become more clear and bright.

The flesh parts of the figures, which had become pallid, almost to white, have recovered the high tint and deep shadow, and the strong anatomical effect of Raphael.

A renewed freshness now reigns over the whole, and the clearing up of the light in many of the landscape parts is most extraordinary, giving a depth and breadth the cartoons themselves do not now convey, particularly in the Keys to St. Peter, St. Paul at Athens, and The Death of Ananias; where