VII. Report presented to the class of the exact Sciences of the Academy of Turin, 15th August 1802, in regard to the Galvanic experiments made by C. Vassali-Eandi, Giulio, and Rossi, on the 10th and 14th of the same month, on the head and trunk of three men a short time after their decapitation

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India. In case of any distant expeditions, they would be found superior, being entirely free from all religious prejudices, and having no objection to the sea.

While Cochin China remains in its present distracted state, a favourable opening is presented to the first European nation that may attempt to obtain a footing in the country. Should the company, therefore, entertain a design of forming an establishment in Cochin China, no time should be lost in carrying it into execution.

VII. *Report presented to the Class of the Exact Sciences of the Academy of Turin, 15th August 1802, in regard to the Galvanic Experiments made by C. VASSALI-EANDI, GIULIO, and ROSSI, on the 10th and 14th of the same Month, on the Head and Trunk of three Men a short Time after their Decapitation. By C. GIULIO.*

THE First Consul, in a letter to Chaptal, in which he announced to that minister the two prizes he had founded to encourage philosophers to make new researches in regard to Galvanism, says, "Galvanism, in my opinion, will lead to great discoveries." This observation was just and profound: great discoveries have already been made; Galvani and Volta have immortalized their names, and several celebrated philosophers and physiologists have rendered themselves illustrious in this branch of science, so abundant in astonishing phenomena: yet it is only in its infancy, and there can be no doubt that many important discoveries still remain to be made.

Vassali, Rossi, and myself, have for several years been employed in researches on this subject. While the first examined the Galvanic fluid in every point of view, for the purpose of illustrating its nature by means of a great number of ingenious experiments, performed with that care and exactness which are peculiar to him, Rossi and myself attempted to explain the action of the Galvanic fluid on the different organs of the animal economy.

Sometimes I was obliged to interrupt my researches by unfortunate circumstances, and at others by my administrative functions: but I have now resumed them; and though success has not yet crowned my efforts by any brilliant discovery, we trust, and with confidence, that we shall be able to add some valuable facts to the history of the animal economy; to rectify errors; to confirm facts already received; and

to extend the domain of an inexhaustible agent fertile in wonders.

Volta had announced that the involuntary organs, such as the heart, the stomach, the intestines, the bladder and vessels, are insensible to the Galvanic action*: but we have fully refuted this great physiological error. Unfortunately, however, the Latin memoir containing the decisive experiments which we made on cold-blooded and warm-blooded animals in 1792, presented to the Academy soon after, and which, according to Sue, in his History of Galvanism †, “are curious, and contain very interesting observations,” did not appear till 1801, when it was printed in the last volume of the Transactions of the Academy.

In that interval Grapengieffer found, as we had done, that Galvanism, by means of zinc and silver ‡, has an influence on the peristaltic motion. Humboldt ascertained the Galvanic action on the hearts of frogs, lizards, toads, and fishes. Smuch observed the excitability of the heart by the Galvanic fluid; and Fowler changed the pulsations of the heart without the immediate application to it of armatures, and only by adapting them in warm-blooded animals to the recurrent nerve by means of the sympathetic §.

It is chiefly in regard to the experiments of these learned Germans that the historian of Galvanism states ||, that the involuntary vermicular motion of the intestines, according to the acknowledgment of all physiologists, obeys metallic irritation; whence it follows, says he, that the Italian philosophers have advanced an error when they said that Galvanism exercises no action but on the muscles, which depend on the will. As an accurate and impartial historian, how can Sue accuse the Italian philosophers indiscriminately of such an error, since he had our memoir before him when employed on the second volume of his History of Galvanism, and since he gave a short account of my experiments in his first volume? Nay, I gave an account of my experiments in a small work published in Italian in 1792. But as Italian works are not much read in France, and were less so at that period, I should not have reproached C. Sue with this act of injustice,

* Mezzini, Volta, Valli, Klein, Pfaff, Berhends, have denied that the heart could be moved by the Galvanic fluid. *Hist. du Galvanisme*, part i. p. 145. Bichat could obtain no contractions either in the heart of man or that of the dog. See *Recherches Physiologiques sur la Vie et la Mort*.

† Towards the end of the first part.

‡ See *Histoire du Galvanisme*, vol. ii. p. 81.

§ Ibid. vol. ii. p. 84.

|| Vol. ii. p. 83.

and his incorrectness in regard to the Italian philosophers, had not my Latin memoir been known to him, as it had appeared in the Transactions of the Academy.

Though we made a great many experiments before we attempted to combat a philosopher so justly celebrated as Volta, and to establish the influence of Galvanism on the involuntary organs; and though Grapengieffer, Humboldt, Smuch, Fowler, &c. ascertained this influence in certain cold-blooded and even warm-blooded animals; an object of so much importance to physiology required to be extended and confirmed, especially in man, by new experiments. We have been the more sensible of the necessity of establishing this fact in an incontestable manner, either in regard to the involuntary organs in general, or more particularly the heart, as the celebrated Aldini, professor of Bologna, in an Italian work replete with new facts and valuable experiments made on the bodies of decapitated criminals, has been obliged to acknowledge that he was not able to obtain any contraction in that organ by means of the electro-motor of Volta, which is so powerful.

We shall give an account, in particular memoirs, of the experiments we have already made, and of those which we propose to execute. In regard to the stomach, the large and the small intestines, and the bladder, we shall say only, in a general manner, that by armature of the different nervous branches we obtained contractions analogous to those described in regard to animals. The Galvanic action on the heart and arteries is the object of the present paper, as it is of the utmost importance to physiology, and deserves, under every point of view, to excite our attention and occupy our reflections.

Our experiments on the different parts of the head and trunk of the decapitated criminals were begun, on the 10th of August, in a hall of the large hospital of St. John, and resumed and continued yesterday in the anatomical theatre of the university, before a great number of spectators.

We tried the influence of Galvanism on the heart in three different ways:

1st, In arming the spinal marrow by means of a cylinder of lead introduced into the canal of the cervical vertebræ, and then conveying one extremity of a silver arc over the surface of the heart, and the other to the arming of the spinal marrow. The heart of the first individual subjected to our experiments immediately exhibited very visible and very strong contractions. These experiments, as seen, were made without

out any intervention of the pile, and without any armature applied to the heart. It is very remarkable, that when the former is touched first, and then the arming and spinal marrow, the contractions of the heart which follow are more instantaneous, and stronger, than when the arming of the spinal marrow is first touched, and then the heart. In a memoir on Galvanism, read in the last public sitting of the academy, I gave an account of a great number of experiments, made especially on frogs, which exhibited a similar phenomenon. In these animals I observed, a great number of times, that when the arming of the crural nerves was touched first, and then the muscles of the thigh, there were no contractions, or the contractions were exceedingly weak; and, on the other hand, that when the muscles of the thighs were first touched, and then the arming of the crural nerves, as long as the least vitality remained in the organs the contractions of the muscles were constant and violent. In the memoir already mentioned I have endeavoured to account for this phenomenon, to which I shall recur when, by a great number of trials, we shall have ascertained that it is as general in men as I found it in frogs and other cold-blooded animals.

The second manner in which we tried the influence of Galvanism on the heart was by arming the nervi vagi and the large sympathetic. The object of these experiments will be readily comprehended by anatomists acquainted with the details of neurology. In these, as well as in the first and other experiments where we armed the cardiac nerves themselves, we obtained contractions in the heart. In this, as in the former case, the contractions obtained when the heart was first touched, and then the arming of the nerves, were much stronger than when the arming of the nerves was touched first, and then the heart. In this method we even observed that the Galvanic experiments sometimes failed.

The third kind of experiments on the heart were performed by means of the pile. The pile we employed on the 10th of August, for the experiments on the first decapitated criminal, was composed of fifty plates of silver and as many of zinc, with pasteboard moistened with a strong solution of muriate of soda. The silver was mixed with a tenth part of copper. This is the proportion which we found most favourable to the intensity of the signs of Galvanism:

		Metre.
The diameter of the silver plates was	-	0.036
Their thickness	- - -	0.0015
The dimensions of the pieces of pasteboard were the same.		

The

			Metre.
The diameter of the zinc plates was	-	0.042	
Their thickness	-	0.0035	

The pile employed for the experiments on the 15th of August was composed of fifty plates of pure silver, and twice that number of plates of zinc and pieces of pasteboard; the latter moistened in a solution of muriate of soda.

			Metre.
The diameter of the silver plates was	-	0.038	
Their thickness	-	0.001	

The dimensions of the pieces of pasteboard were the same.

			Metre.
The diameter of the zinc plates was	-	0.04	
Their thickness	-	0.001	

By making the negative extremity of the pile to communicate, by means of respective conductors, with the spinal marrow, or merely with the muscles of the back or breast, laid bare, and the positive extremity immediately with the heart, instantaneous and violent contractions were obtained; and the contractions were produced also when the heart was made to communicate with the negative extremity of the pile, and the spinal marrow with the positive extremity.

We shall observe, in regard to contractions of the heart, that of all its parts the apex is the most susceptible of motion, and the most sensible to the Galvanic influence: we must observe also, that the contractions produced by communication with the pile were not only strong, but that they continued a long time even after all the communication was removed.

A very remarkable circumstance is, that the heart, which of all the muscles retains longest, in general, its contractility in regard to mechanical stimulants, is the first to become insensible to the Galvanic influence. The muscles of the arms, and those of the back and breast, continue to be excitable by Galvanism for whole hours; and the heart had lost its excitability about forty minutes after death.

The experiments made yesterday in the anatomical theatre exhibited nearly the same results in regard to the heart as those already mentioned. The great arteries, such as the aorta and some of its branches, being injected with water raised nearly to the same temperament as that of the blood in the living individual, when subjected to the Galvanic action exhibited contractions. But it is probable that they will appear stronger when trials of this kind shall be made on bodies endowed with a higher degree of vitality than those of yesterday, and when the interval between the period of

decapitation

decapitation and that of the experiments shall be less. With this view, indeed, we have provided a hall much nearer to the place of execution; for the results which we obtained in the man decapitated on the 10th of August, in which case the experiments were begun five minutes after the decapitation, were all comparatively more striking, and stronger, than those obtained in the experiments of yesterday, which were begun more than twenty minutes after decapitation, and which were performed, as appears, on bodies endowed with a much weaker degree of vitality.

In the experiments made on the arteries, we armed the nervous plexus, which envelop the trunks of the coeliac and mesenteric arteries, several branches of which are even interwoven around the aorta: a communication was established between the positive or negative extremity of the pile and the aortic artery itself. It was by these means that we obtained visible contractions.

If the effects of Galvanism on arterial contractions are constant, as I presume, all those discussions which have been agitated so long, and with so much violence, in regard to the irritability of the arteries, which does not manifest itself by the action of different mechanical and chemical stimulants, will at length be terminated in a positive and irrefragable manner; all doubts will at length be removed; and we shall be indebted to the Galvanic fluid, which is the most energetic of all agents applied to the animal fibre, for having fixed the opinions of physiologists on a point of so much importance to the animal economy.

Whence comes it that Aldini, even with the help of the most powerful electro-motors, was not able to obtain contractions in the heart of man, which we so evidently obtained by the same means which always withstood his efforts? How happens it that we obtained contractions by means much weaker?

The first experiments of Aldini on the human heart were begun an hour and a half after death*. The trunk had been exposed a long time to the open air, the temperature of which was no more than + 2. It is probable that the cold, and the long interval between the period of death and that of the experiment, had already annihilated the irritability of the heart†. In the fifty-third experiment, the heart of another executed

* Saggio di Sperienze sul Galvanismo di Gioani Aldini; Bologna 1802, p. 14, clip. 28.

† If the celebrated Bichat failed in his experiments on the human heart, as well as Aldini, it was, perhaps, owing to the same causes. The temperature

44 *Vassali-Eandi, Giulio, and Rossi's Galvanic Experiments*

executed criminal constantly remained motionless and insensible to the Galvanic current. But in this experiment, before trying the heart, a considerable time was employed in making trials on the voluntary organs, the sensibility of which to Galvanism had already been acknowledged. But the very reverse of this method ought to be followed; for I will here repeat, that excitability, by means of the Galvanic fluid, is extinguished in the heart a long time before it becomes extinct in the voluntary muscles. This is so certain, that while no part of the heart, tried externally and internally, presented any sign of contractions, the diaphragm, and the muscles of the upper and lower extremities, gave very strong ones.

In our experiments which were begun five minutes after death, the heart ceased to be sensible to the Galvanic agent about the fortieth minute; and this was the case in the temperature of $+ 25$; while the voluntary muscles retained their Galvanic excitability for whole hours. In other experiments made by Aldini, the contractility of the voluntary muscles existed three hours, and even five hours, after death.

In the oxen subjected to Galvanic experiments by Aldini, the excitability of the heart must have been extinguished sooner, since the action of the Galvanic fluid of the pile produced no contractions, though applied immediately after death.

If contractions were observed in the voluntary muscles under the same circumstances, it was because these muscles, which lose much sooner than the heart their excitability in regard to mechanical stimulants, retain it much longer than that organ in regard to the Galvanic agent. What then is the cause of this diversity, which seems contrary to every analogy, and which, however, is proved by facts? It is still involved in much obscurity: but it is not yet time to tear the dark veil which conceals it; we are not yet enlightened by a sufficient number of facts; and the few scattered data which we have been able to collect, cannot yet be connected in a manner capable of encouraging us to attempt to rend the veil at present.

We shall not here speak of the astonishment with which the spectators were struck when they saw the contractions of

perature was cold, and the interval between the time of execution and that of the experiment too long. "I was authorized," says Bichat, "in the winter of the year 7, to make various trials on the bodies of unfortunate persons who had been guillotined. I had them at my disposal from thirty to forty minutes after execution. It was always impossible for me to produce the least motion by arming either the spinal marrow and the heart, or the latter organ and the nerves which it receives from the ganglion by the sympathetic, or from the brain by the par vagum.

the

the frontal muscles, those of the eye-lids, the face, the lower jaw, and the tongue; when they beheld the convulsions of the muscles of the arms, the breast, and of the back, which raised the trunk some inches from the table; the contractions of the pectoral muscles, and the exterior and interior intercostal muscles, which diminished the intervals between all the ribs, and made them approach each other with violence, raising the inferior ones towards the superior, and the latter towards the first rib and the clavicle; the contractions of the arms, which, when the uncovered biceps muscle was touched, as well as its tendon, were so speedy and violent, that complete flexion of the fore-arm on the arm took place, and that the hand raised weights of some pounds fifty minutes after decapitation. Similar experiments may be seen in the work of Aldini: our object in this report was merely to speak of the Galvanic influence on the heart and arteries of man, which had not yet been observed.

These new and important results, which we obtained in regard to the heart and arteries of man, will be confirmed by other trials. We shall repeat our experiments as soon as an opportunity occurs, and we shall take care to give you an early account of the most remarkable observations we shall make.

VIII. *A Review of some Experiments which have been supposed to disprove the Materiality of Heat.* By WILLIAM HENRY*.

THE following remarks on the subject of heat were written soon after the publication of Count Rumford's Inquiry concerning the Source of the Heat evolved by Friction; and of the interesting Essays of Mr. Davy, which appeared in Dr. Beddoes's West Country Contributions. They were transmitted to Dr. Beddoes, for publication, about the close of the year 1799; but circumstances, with which I am unacquainted, have, I believe, induced the doctor to decline the continuation of his periodical work. These circumstances I deem it necessary to state; because, had the essay been written nearer the period of its publication, it would probably have assumed a very different form. At present, I have not leisure to review the subject, or to attempt any material alteration; and still less to examine whether I have been anticipated by any of the authors whose essays have been published during the two last years.

* From the *Manchester Society's Transactions*, vol. v. part 2.