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RECENT EXPERIMENTS MADE IN CONNECTION WITH THE CASE OF M. GROUX.

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With the indulgence of the Society, I propose to offer an abstract of my recent experiments made in connection with M. Groux. And I do this, not with the expectation or intention of presenting you now any absolute mathematically exact results, nor with the attempt to point out, thus prematurely, the conclusions that may follow from a knowledge of the facts already obtained. All this, I am aware, requires much mature deliberation, and a rigid comparison and weighing of all the circumstances of the case. It is my object, rather, merely to describe the nature of the experiments themselves, and the conditions under which they were made, and to put on record here, as it were, the main facts, dates and localities in reference to them and the approximate results. And it is my purpose, at a future day, to draw up fully and minutely such statements as will bear the test, I hope, of scientific analysis and investigation. To this end, instruments are being constructed with a mechanism more perfect and delicate than any I have yet been able to obtain, and which shall exhibit and record with unquestionable accuracy the minutest possible intervals of time. In the

recital of the descriptions which follow, I may have to repeat some particulars which many of the gentlemen now present have already heard.

To proceed—The experiments, now under consideration, were directed primarily and mainly to the elucidation of a single point in connection with the malformation of M. Groux—which point has, however, from the first, been made an essential element in the proper understanding of his remarkable and almost unique case, and about which the most eminent authorities have widely differed. This is, I need not say, the question of the synchronism or non-synchronism of the various motions of the heart and great vessels as displayed by M. Groux. To particularize still further, it is whether the impulse of the principal beating tumor (the main body of it) seen in the middle of the sternal fissure is, or is not, synchronous with the shock of the heart as usually felt at or about the space between the fifth and sixth ribs. In regard to this question of difference, let me quote from some of the authorities who have made particular mention on this point.

M. Bouillaud, among the French, says: "The pulsations (referring to the medio-sternal tumor) are synchronous with the pulsations of the carotid artery, the subclavian, radial, and with the shock of the heart." Prof. Hamernik, of Prague, says the pulsating tumor "is the right auricle, and not synchronous with the heart's apex." Dr. Ernst, of Zurich, writes: "It is clear that the part of the heart seen and felt contracts when it moves downward. This motion," he continues, "is synchronous with the shock of the heart which is slightly felt between the fifth and sixth ribs." Dr. C. J. B. Williams says: "The visible pulsation in the middle third of the sternal vacuity immediately precedes the ventricular systole," &c. Dr. Gairdner, of Edinburgh, observes, that "the upper visible pulsation" (meaning that of the medio-sternal tumor) "precedes the apex beat by an interval appreciable, but not so easily appreciable." Dr. F. W. Pavy, of Guy's Hospital, says: "The tumor occupying the position of the right auricle pulsates with the contraction of the ventricle and the production of the first sound of the heart," and he concludes, for this reason, that the tumor, which he admits to be the auricle, is put in motion by the contraction of the ventricle beneath. The

Committee of the New York Pathological Society, appointed to examine the case of M. Groux, say, in their recently-published Report:* "The contraction of the tumor is synchronous with the impulse of the heart, at the level of the fifth rib." Again, most of those who believe these motions to be not synchronous, agree that the pulsation of the tumor in question precedes that of the others in point of time. M. Marc. d'Espine, of Geneva, however, avers that "the pulsation in the middle of the sternal fissure *follows* so immediately, indeed, each systolic shock of the heart, that these two motions *seem* synchronous."

The delicate and beautiful instrument of Dr. Scott Alison, of Edinburgh, called the sphygmoscope, has added much to the facilities for determining this vexed point. But it has not settled the question, nor can it, in my opinion, be settled by this instrument alone, since it is impossible for the eye to observe with equal distinctness two points at the same time, however proximate they may be. How much is this difficulty increased when, as in the case before us, these two points are in motion—still more, since those motions are unequal. Not so when the ear is appealed to. Any one skilled in the appreciation of harmony, *knows* that he can measure and determine, not two alone, but several sounds, resolving the component notes of a chord, struck severally at the same time, with unerring accuracy. With much greater facility can the ear—a musical ear—discriminate the minutest interval in a succession of sounds, especially if of different pitch. I might here enter into the discussion, as to how limited an interval can be appreciated between any two sounds before their impulses become blended, so as to form a continuous or musical tone. But this is unnecessary to our present purpose. If there is, to the ear, an appreciable difference in time between two sounds, caused by the motions under consideration—provided the motions themselves are conveyed in equal times—then, I submit, these motions are manifestly not synchronous.

Such train of reasoning it was, as to the greater nicety of discrimination of the ear over the eye, so to speak, that led me naturally to the consideration of these experiments. Let me say, however, that I did not arrive unaided at the present form of their

* This Committee consists of Dr. Peaslee, President of the Society, with Drs. Dalton and Metcalf.

demonstration. Two ways, indeed, of accomplishing these results, at once occurred to me—one, and the more simple and obvious one, in the rude manner here depicted (of which this is the original pencil diagram*); the other by calling in the aid of electro-magnetism. But of this latter agency I knew only of its ability to accomplish what I wished, somehow—by what precise manner of mechanism, I knew not. Fortunately, I applied to my old friend and college-mate, Mr. Farmer,† who relieved me of all difficulties on that score, by immediately suggesting the manner of accomplishing the ends desired, by means of the agency contemplated. The scientific reputation and ability of Mr. Farmer have long been recognized and acknowledged. All I can say in his praise would be wholly superfluous. I went so far with the first plan as to have a float made, with a piston attached, the object of which was to impinge directly against some light sonorous body, suspended or fastened in some way above. Such float, of delicate and ingenious construction, was devised by Mr. Joseph C. Wightman, which was admirably adapted to the purpose. Without fairly trying the first mode, however, it was determined to resort at once to the second.

But without further preliminaries, I will pass to a brief consideration of the experiments themselves. The first trial was made on Tuesday, Dec. 21st, at the rooms of Mr. Farmer, in Washington street. There were present, Mr. Farmer, and his assistant Mr. Rogers, M. Groux and myself. My original idea was to break the electro-magnetic circuit, by means of the motion, at the upper end of the delicate float, produced by the rise and fall of the fluid in the tube, as seen in the rough diagram I have before alluded to. At the first trial, however, Mr. Farmer suggested a modification of this mode, by dispensing altogether with the float, and attaching to the upper end of the tube a bell-glass and diaphragm, of the same nature as that already employed to receive the impulse from the heart—the medium of communication being air alone. Our operations were now confined to an attempt at breaking the circuit, so as to bring out, with two successive beats, their corresponding sounds from the electro-magnetic machine—a feat

* It should be stated that a bell-glass, with an elastic diaphragm, after the manner of Mr. Scott Alison's sphygmoscope, is employed to receive the impulses from the heart and circulatory vessels. For want of time, the diagrams which ought to have accompanied these descriptions are not given.

† Mr. Moses G. Farmer, Electrical Engineer, and co-inventor, with Dr. Wm. F. Channing, of the City Telegraphic Fire-Alarm System.

which was only accomplished after a long and patient effort, since it required, on the part of M. Groux and myself, the most careful and delicate adjustment of one end of the instrument upon the heart, while the other was brought by Mr. Farmer, with the unaided hand, against the circuit breaker of the electro-magnetic machine. In this way the whole of the first session, of some two hours duration, was employed.

On the next trial, which was made in the same place a couple of days afterward, we returned essentially to the first-named plan for interrupting the circuit, substituting for the material float of glass a few drops of acidulated water upon the top of the contained fluid, (within the glass tube), which, as it rose and fell with the heart's impulse, came in contact with the end of a conducting wire, and thus served the purpose intended. The instruments, of which we used two (and which, for the present, we may term the *sphygmosphone*), then being applied, simultaneously, to the proper points, and the wires delicately held, each by an operator, we were able, by careful manipulation, to produce two or three sounds in succession from both the impulse of the medio-sternal tumor and the shock of the heart at its apex, and even now, though imperfectly, to demonstrate to the satisfaction of us all, the *non-synchronism* of these two movements. But the difficulty here, as with the sliding piston, was to follow the eccentric movements of the fluid, in the tubes, which rose and fell unequally with the slightest variation of pressure against the body. To obviate this, resort was again had to the double diaphragm, as presenting, at all times, a known point; moreover the distal ends of the sphygmosphone, being, in this case, themselves fixed, allowed, by means of a simple mechanism, a very accurate adjustment of the circuit-breakers. A continuous elastic tube was, also, substituted for the glass cylinders which had hitherto intervened, and water, instead of air, used for the communicating medium. By these modifications our manipulations acquired, at once, more ease and certainty, and, being found to answer well our purpose, no further time was lost in perfecting the mechanism.

At the next session, therefore, we found ourselves in condition to obtain and to note satisfactory results. And our first design being to ascertain beyond question whether the impulse of the prominent pulsating tumor, in the middle of the sternal fissure, is

or is not synchronous with that of the apex of the heart, we made use of an instrument called the "Telegraphic Repeater,*" which is so constructed that of any two motions, that which is first, by ever so brief an interval, moves its armature and produces its sound, to the entire exclusion of the other. It mathematically follows that, if the two communicated motions are *synchronous*, neither armature will move; this, however, presupposes a high degree of perfection in the mechanism. Suffice it to say, that, with this apparatus, the instruments being applied to the medio-sternal tumor and to the apex, it was the impulse from the first which invariably set in motion the corresponding armature and gave out its sound.

In our subsequent sessions, the "Repeater" was set aside, and a "Morse's double register" used in its place. This was so adjusted as to give forth two sounds, differing in pitch, and at the same time record the motions on paper, in the same way that ordinary telegraphic communications are written. Then, by the intervention of the electric clock, which was also made to mark its seconds on paper, it was easy to measure the time of the pulse-beats themselves, as well as the interval in the pulsation of any two points in the round of the circulation.

Not to go, at this time, too minutely and tediously into description, I will only give the result by calculation of a few of these trials, including some witnessed by gentlemen present on the evening of the 5th of January inst., and afterward repeated in connection with the delicate chronographic apparatus in the Observatory at Cambridge. Before doing this, however, let me briefly allude to the Cambridge experiments, since they were in their nature, it is believed, both novel and interesting. They were done in the afternoon and evening of the 8th of January, Mr. Bond having, in the kindest manner, placed his beautiful apparatus in the Observatory at our disposal. Our forces were, on this occasion, divided—Mr. Groux, Mr. Farmer, Mr. Rogers and myself taking our position in the private apartment of the City Telegraph rooms in Court Square; and Mr. Stearns, the present able and efficient Superintendent of the Boston Fire-Alarm System, accompanied by Mr. Kennard, recently of the St. Louis Fire-Alarm Office, going over to the Observatory. The telegraph between the central of-

* This is an instrument used in telegraphing *through* messages over long lines. It is the joint invention of Mr. Farmer and the late Mr. A. F. Woodman, of Portland.

fice in Boston and the Observatory, let me add, was also kindly placed at our disposal—and, furthermore, I will say that the instruments used here were furnished from the City Fire-Alarm Office, and were the best of their kind.

At half past 3, P.M., a telegraphic notice from the Observatory signified that everything was in readiness there. But from the exhaustion and great nervous agitation of M. Groux, consequent upon recent illness, it was impossible to commence immediately the regular series of experiments, and nearly a couple of hours were spent in preliminary trials and tests. The line being found in perfect working order, the experimental apparatus at both ends also working beautifully, and Mr. Groux being now in a condition of comparative quiet, operations were commenced in earnest at about half past 5 o'clock. Some extracts from the original records, taken down in Boston and Cambridge simultaneously, will perhaps more graphically portray the nature of our proceedings.

To begin—the beat of the pulsating tumor in the medio-sternal space was tried. We were able to get several consecutive beats, which were also duly recognized at the Observatory. Next, a series of apex-beats was obtained, and recognized at the Observatory. The Observatory clock was now put in connection, and its tickings made audible and recorded in Boston.

The experiments then proceeded, as follows:

The impulse of the medio-sternal tumor and of the pulse at the wrist were taken together, and at the same moment recorded at the Observatory. As the experiments now went on, they were interlarded with telegraphic queries and answers; and for the sake of clearness, we will prefix, when necessary, the words *Boston* and *Cambridge* to the parts of this dialogue, according as they emanated from the one place or the other.

After the experiment just alluded to, information was conveyed that it would be repeated.

Cambridge.—"Aye, aye."

Boston.—"Good signals these, save them."

Camb.—"Shall we put in the clock now?"

Bost.—"Yes. And as our next experiment, we will try the apex and wrist."

Camb.—"Go ahead."

Bost.—"Any good signals then?"

Camb.—"Yes, one or two."

Bost.—"We will try that again. Any of these good?"

Camb.—"Some of them very good."

Bost.—"About what difference in time between the beats in this experiment?"

Camb.—"About two tenths of a second."

Bost.—"In which does the difference appear greatest, this or the preceding experiment?"

Camb.—"Should say the former."

This question being repeated after additional trials, the reply was, "Wait till we can calculate them"; and, shortly afterward, an answer was received, "The *former*, by a minute interval."

Bost.—"Now we will pass to another experiment. Do you get a single or double stroke?"

Camb.—"No good double stroke, but something that looks like it."*

Bost.—"Try again; how is that?"

Camb.—"Better."

Bost.—"Once more; how now?"

Camb.—"Better still."

Bost.—"We will now repeat these three experiments in succession."

Toward the close of the session, the operators at the Observatory were requested to count the beats to be sent over during the space of one minute. I then applied the instrument to the radial artery at my own wrist, an assistant taking the pulse at the other wrist. It was ascertained by counting to be sixty-six in the minute. The question was now put to Cambridge, "How many?"

Camb.—"Sixty-six."

Bost.—"Once again."

Mr. Groux now applied the instrument to the medio-sternal tumor, for the period of a minute, and its pulsations were found to be seventy-two. The query was again put, "How many?"

Camb.—"Seventy-two."

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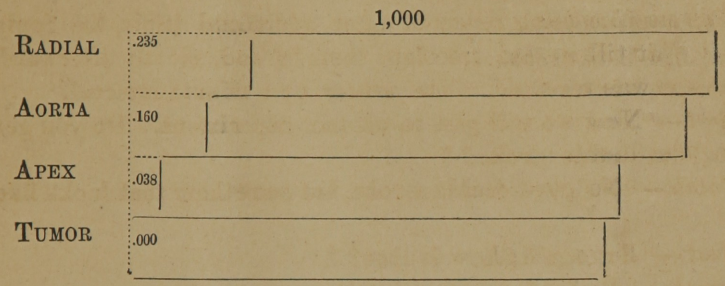
* The operators at the Observatory were not informed previously of the nature of this experiment. It was an attempt to record the medio-sternal and apex beats by applying the sphygmosphones to these points direct—an exceedingly delicate test, tried repeatedly with success in our private experiments. Prior to the response from Cambridge, Mr. Farmer remarked, that with a single line of communication only, it would be impossible to note clearly so minute a double beat at the Observatory.

But the above will suffice to show the nature of our proceedings; this session was continued without intermission for six hours.

The following are some of the important results obtained which bear upon the question at issue: the whole number of sessions thus far has been ten, of an average duration of two hours each—the calculations (made by Mr. Farmer) are based on the average of selected examples taken from all the experiments. They are expressed, in a rude way, by the diagram below:



and may be thus stated. The whole duration of the pulse-beat is represented by 1,000. Then the commencement of the beat proceeding from the medio-sternal tumor being .000, the interval to the apex-beat was found to be .038; to that of the ascending aorta, at its junction with the arch, .160; that of the radial artery at the wrist, .235; being in thousandths of a pulse-beat.*

Lastly, when at the final session (on the day preceding M. Groux's departure to Philadelphia), the ends of both the instruments were placed, as nearly as possible, over the apex of the heart, the result, both to the ear and as recorded by the chronograph, was absolutely a synchronism of sounds. Calculations were also made as to the time in which the heart's impulse is transmitted to the carotids, the temporal arteries, the abdominal aorta, and other points in the circulation, which, with other experiments, may be given at some future time.

As to any practical advantages which may be derived from a knowledge of these facts, it would, perhaps, be premature now to speak. I would venture to suggest, however, as one probable result of these and similar illustrations, some additional means to our resources for diagnosis in aneurism and other obscure diseases

* Taking the Cambridge experiments alone, and the above intervals would be expressed by the figures .054, .156 and .237 respectively.

of the aorta and great vessels, concealed in the cavities of the thorax and abdomen. But let me say, in conclusion, as I intimated at the outset, that the results above given and the opinions offered, as well as the experiments themselves, in their present stage, are at best imperfect, and that before any ultimate scientific deductions can with safety be made, the experiments must be repeated, again and again, with the most perfect apparatus possible, and all errors and inaccuracies eliminated by a multitude of trials.

31 *Chesnut Street,*
Boston, Jan. 24th, 1859.