STUDIES FROM THE PHYSIOLOGICAL LABORATORY IN THE UNIVERSITY OF CAMBRIDGE, PART III

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From the *Journ. of Anat. and Phys.*, Vol. X.]

THE EFFECTS OF THE CONSTANT CURRENT ON THE HEART.

By M. Foster, M.D., F.R.S., and A. G. Dew-Smith, M.A., *Trinity College, Cambridge.*

The Frog and Toad were chiefly employed in the following observations. Several experiments however were made with the hearts of Tortoises and Dog Fish. For a supply of the latter the authors are deeply indebted to the kindness of Mr Henry Lee, of the Brighton Aquarium, and to the liberality of the Directors of that Institution.

The current was always applied by means of non-polarisable electrodes. Tracings of the heart's beat were generally taken by means of a very light simple lever, or levers, placed directly on the ventricle, or on the auricle and ventricle. Occasionally the endocardial method was employed, but all the main results were obtained by means of the lever. Undoubtedly the contact of even the lightest lever must be regarded as a stimulus; but this stimulus is at its maximum at the moment of application, and very rapidly sinks to zero. Practically there is no difficulty whatever in eliminating the effects of the lever from those of the currents.

The results of the observations may be naturally arranged according to the part of the heart subjected to the current, and according to the condition of the heart previous to the application of the current.

1. *The lower two-thirds of the ventricle.*

This portion was chosen as an especial object of study, because at the time our observations were begun it was generally admitted that a ventricle deprived of its basal third, on the one hand contained no ganglionic apparatus, and on the other never exhibited any spontaneous rhythmic beat. Since

our observations were made we have read the interesting observations of Merunowicz[1], who has succeeded in obtaining good spontaneous rhythmic pulsations from this moiety of the ventricle. We cannot but regard his results as corroborative of some at least of our own conclusions.

The results which we obtained on subjecting such a portion of the ventricle to a constant current directed longitudinally, that is from base to apex or from apex to base, differed according to the strength of the current employed.

With very weak currents, sometimes no effect at all is produced; sometimes there is seen a beat at the making of the current, or at the breaking, or at both making and breaking, the tissue during the passage of the current remaining perfectly quiescent. The beat thus brought about is in all its features a normal beat.

In very many cases the making beat was distinctly seen to proceed from the kathode and to travel towards the anode, and the breaking beat to proceed from the anode and to travel towards the kathode. This was most clearly seen when the ventricle was bisected longitudinally almost up to the apex, where a bridge of tissue was left, and the limbs of the V-shaped mass extended into almost a straight line and pinned out in that position. Under favourable circumstances the beat was seen to move as a wave from one pole to the other, from the kathode to the anode or from the anode to the kathode, as the case might be. But the experiment did not always succeed, and occasionally, when probably the bridge left was too small, the two portions acted as two independent masses. We may remark in passing that this experiment quite corroborates Engelmann's[2] views on the *physiological* continuity of the whole ventricular tissue, views which we have fully adopted in our paper on the Snail's Heart[3], where we perhaps ought to have called attention to Engelmann's previous remarks on physiological continuity[4] more specially than we did.

Thus far the cardiac tissue seems to differ in no way from ordinary muscular tissue, and the above results, which remain

[1] *Berichte k. Sächs. Gesellschft. d. Wissenschft.* 1875, p. 254.
[2] Pflüger's *Archiv*, XI. p. 465.
[3] *Proc. Roy. Soc.* XXIII. p. 318.
[4] Pflüger's *Archiv*, II. p. 243.

the same after the heart has been treated with urari or with atropin, are merely illustrations of Pflüger's law.

When however stronger currents are employed, distinct rhythmic pulsations are set up on the making of the current, continue during the passage of the current, and cease with its cessation. The beats thus produced are in all their characters like to normal spontaneous beats; indeed are indistinguishable from them. We were able to obtain these beats from any piece of the ventricle, however small.

The frequency and force of the beats depend on the strength of the current in relation to the irritability of the heart. Thus if a current which is just strong enough to produce simply a making and a breaking beat, be slightly increased, the result is that the making beat is followed at a considerable interval by a second beat while the current is going on, and this perhaps by a third or fourth; and the breaking beat fails to make its appearance. As the current is still further increased in strength, the beats become more frequent and at the same time more forcible, until a point is reached at which the maximum of pulsation is obtained, *i.e.* at which the beats are at the same time strongest and most rapid. Beyond this the increase of frequency still goes on, but at the expense of the force of the individual beats. The beats then tend to overlap and so to convert the rhythmic pulsation into an ordinary tetanus; but for this a very strong current is required; and indeed we were never able to bring about a complete tetanus, such as could be fairly compared with the tetanus of an ordinary striated muscle.

Of the rhythmic pulsation thus brought about many varieties presented themselves, varieties which we can only refer, without completely explaining them, to the varying irritability of the heart.

The most common type is that which, following the phraseology of the Leipzig school, we may speak of as consisting of an ascending and descending staircase. In this the making of the current is followed immediately or after a short interval by a feeble beat, this by a stronger one, and so on in an ascending series until a maximum is reached, which after being maintained for a variable time gives place to a