Physiology. — *"The electrocardiogram of the foetal heart."* By Prof. J. K. A. WERTHEIM SALOMONSON.

In 1906 CREMER published an electrocardiogram of a human embryo in utero, taken in a healthy woman during the last period of pregnancy. The curve showed oscillations caused by the heart of the mother, between which less conspicuous deviations could be seen, caused by the foetal heart-action. These latter had the form of monophasic deviations, but probably they should not be considered as a true representation of the actual electrical potential differences.

CREMER's investigations were repeated by FOA, who was not able to extend our knowledge in this respect and could only confirm CREMER's statement.

I have tried to get some further insight in the peculiarities of the foetal electrocardiogram by investigating it in the embryo of the chicken. This very obvious way was clearly indicated, as ZWAARDEMAKER had shown that an electrocardiogram could be taken from partly-hatched eggs. He published a foetal electrocardiogram in his Treatise of Physiology.

Though my researches on this subject were commenced about a year ago and are not yet completed owing to a lengthy interval during the autumn and winterseasons, I may be permitted to show some of the results of my experiments.

Long before the conclusion of the first 60 hours of the incubating period, we can see in the chicken's embryo a strongly pulsating tubular heart, slightly curved to an s-form. In this early condition I have not been able to register any electrical potential difference [1]). The reason is that probably at that time the potential differences caused by the heart beats are exceedingly small. The electrical resistance of the substance in which the foetal heart is embedded and which contains albuminous and fatty matter is rather high. This combination of a low potential difference acting on a high resistance makes it very difficult even with an instrument so delicate as the string-galvanometer to detect the potential difference. The string-electrometer gave me no better results

In the end of the first week we can generally without any particular difficulty lead off electrical oscillations from the foetal heart. These are very regular, isochronic with the heart beats, and show a simple monophasic deviation. Generally the ascending part has a slighter slope than the descending part. The descending part is followed immediately, without an isoelectric interval, by the next

[1]) I have since succeeded in doing so.

deviation, so as to give a regularly rising and falling line. No

Fig. 1.

difference between the different beats could be observed. The maximal P.D amounts to about 20—30 microvolts.

On the 8th day we get a curve which is perfectly differentiated. Instead of a series of continuous simple, nearly sinusoidal deviations we get deviations which may be grouped in series of 3 each, each group belonging to one heart beat. In each group the first and second deviation have the same polarity and are followed by a third peak of opposite polarity. The first peak seems to be somewhat higher than the others. I suppose that we may consider these three deviations as identical with the summits P, R, and T in the normal human electrocardiogram. The largest potential difference, that of the

Fig. 2.

P-deviation, amounts to some 50 or 60 microvolt. The duration of P is of the order of 0.07 second. The R-peak has a shorter duration. In a few records I believe I have also found slight indications of a Q and an S-peak. The electrical activity represented by the T-peak extends over 0.15—0.18 second.

I am not yet prepared to speak about the extremely important question as to how the differentiated electrocardiogram of the 8th day develops from the undifferentiated curves derived before the 6th day.

After the 8th day, as the foetal heart grows stronger, the electrocardiogram also grows stronger. It shows more markedly all the points generally visible in the electrocardiogram of the full-grown embryo and in that of the new-born chicken. This latter shows some similarity to the mammalian or human electrocardiogram.

On the 12th and 14th day electrocardiograms with higher potential oscillations, up to 0,5 millivolt, can easily be recorded. After that

Fig. 3.

time the maximal PD rises very slowly till the chicken is fully

hatched. In the last week no further changes in the form of the curve are to be found.

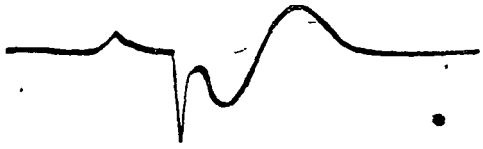

Fig. 4.

During my experiments, the results of which have been here broadly summarized, I found a few other noteworthy details. So a record taken on the 14th day gave a definite biphasic oscillation instead of the ordinary monophasic P-peak. Another complication in the form of the curve was caused by an unusual form of the T-peak, which also showed a tendency to alter into a diphasic

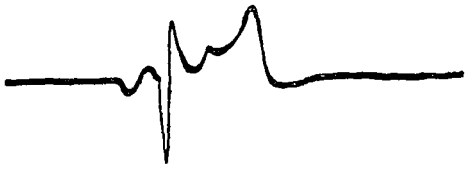

Fig. 5.

deviation (figs. 4 and 5) and to start before the R-deviation had completely subsided (fig. 5).

Contrasting with these rather complicated forms, I sometimes found more simplified ones in which it was not possible to differentiate with certainty more than two elementary summits.

Lastly I found no small number of complexes which had to be considered as pathological forms. The principal of these were caused by block; even isolated P-deviations could be found. The form represented in fig. 6 seems to me to be also a pathological form.

Fig. 6.

The pathological processes in these cases are probably caused by changes in the temperature, by lesions occurring during the preparation, or by the gradual death of the heart itself.