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HYSTERESIS PHENOMENA OF BIOLOGICAL SYSTEM

BY

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ABSTRACT:

In this work we tried to find the effect of cyclic stress on the behaviour of biological systems. The effect was repeated many time and the reponse of the biologioal system was measured. The stress was chosen to be the step changes in environmental pressure and the response was the respiratory rate. The experiment was repeated ten times.

INTRODUCTION:

It is well known that, nonlinear systems are classified into two clasees. The first class is nonlinear system with memory. The second class is memoryless nonlinear system. In the first class a hysterisis relation exsists between the stimulus and the response, and in the second, sucb relation can not exsists. However in a previous work [1], the relation between the change in environmental pressure and the respiratory rate of certain sample of biological system was shown to be in the first class of nonlinear system. The nature led us to study the effect of cyclic stress on the behaviour of biological systems. The study concerned the cyclic changes in environmental pressure, and the respiratory rate.

The animal was put in a special pressure chamber. The pressure in the chamber could be changed through special valves connected to it.

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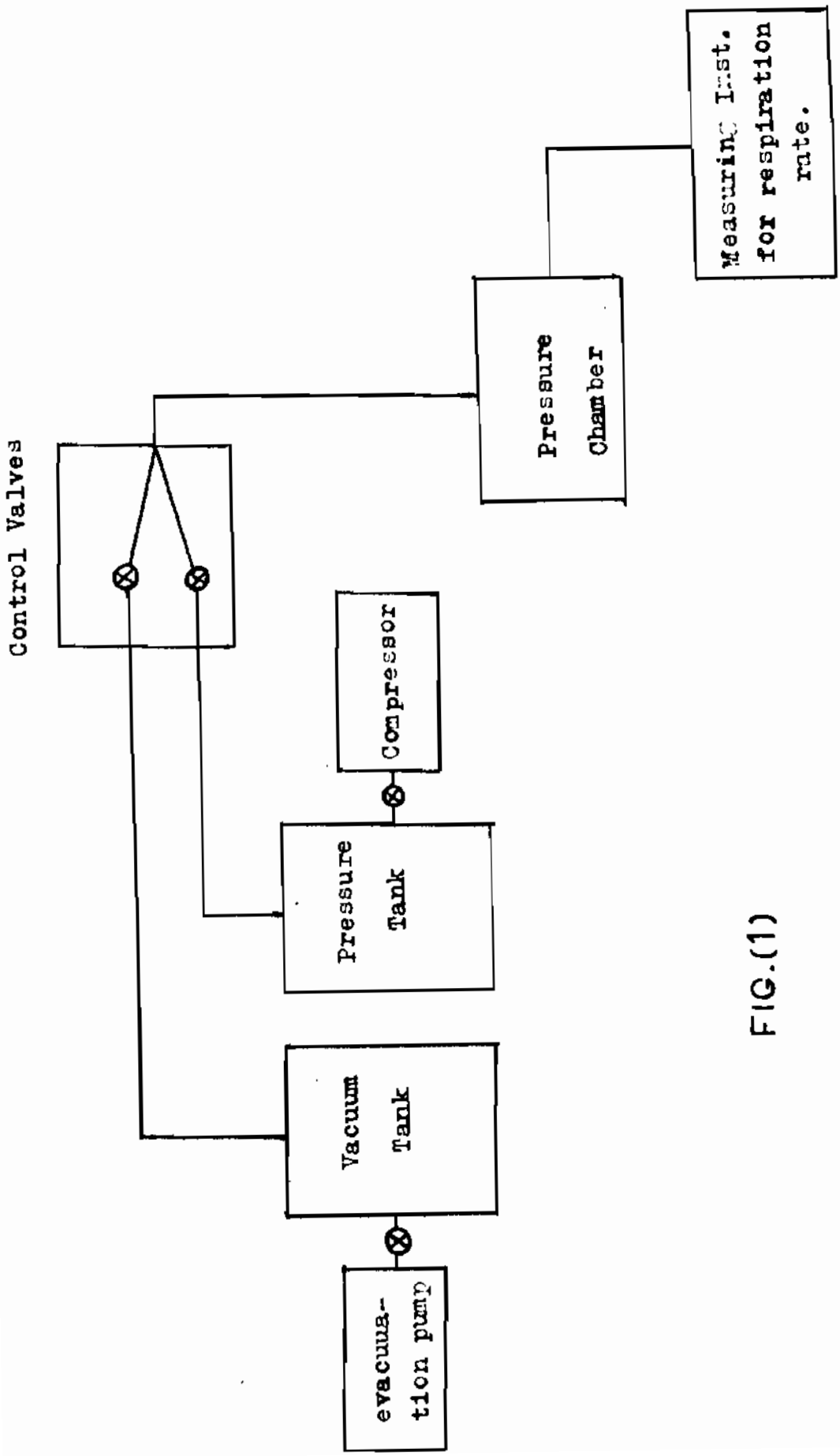

Measuring Inst. for respiration rate.
Pressure Chamber
Control Valves
Compressor
Pressure Tank
Vacuum Tank
evacuation pump

FIG.(1)

Ten samples (dogs) were selected for the study. Each sample was anaesthetised by pentobarbitone. A block diagram of the overall system is shown in Fig. (1).

THE TEST EXPERIMENT:

In an attempt to change the environmental pressure we needed a room which may indure changing the pressure by increase or decrease. The size of this room should be suitable for the size of the animal used which is the dog in our experiments and ten dogs were used. The dimensions of this room were designed to be 150 x 120x100 cm. Fig. (2).

Fig. (2) The Chamber used.

To let the required changes be smooth a metallic tank which can sustain a pressure of 10 atmospheres is connected

to the chamber through a control valve. The pressure in the tank is altered by a compressor. This tank is utilized when we want to elevate the pressure in the chamber above atmospheric pressure, as shown in Fig. (3).

Fig. (3) Pressure tank.

On the other hand for lowering the pressure an evacuation pump is used to evacuate other four tanks connected in series and these tanks are connected by another control valve to the room, Fig. (4).

The animals used were dogs the weight of which ranges from 15 - 20 kgm. Anesthesia was achieved by Ether inhalation followed by pentobarbitone given by the intera venous root, the pentobarbitone is a long acting anaesthetic.

The two electrodes of the transducer were inserted subcutaneously on the right and left hemithorax anteriorly, as illustrated in Fig. (2). The animal is then introduced inside

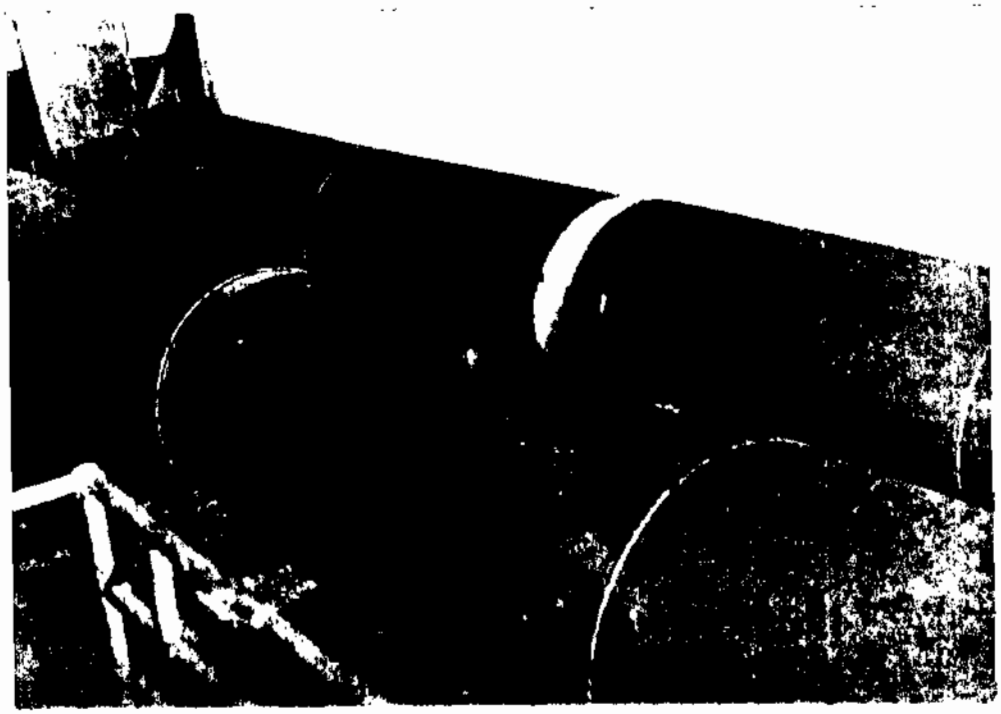


Fig. (4) Series Tanks.

the pressure room, which is then closed and the pressure inside it is changed by means of the control valves. At first the pressure inside the chamber is atmospheric and the respiratory rate and respiration curve are recorded on a paper. Then the pressure is decreased several times (-0.1, -0.3, -0.4, -0.5 atmospher) respectively, each time the respiratory curve are recorded. After recording the curve at the pressure of -0.5, the pressure inside the pressure room is increased several times in succession (-0.5, -0.4, -0.3, -0.1, zero) the same curves are recorded every time.

The pressure is then allowed to increase from zero level (atmospheric pressure) several times (+0.2, +0.3, +0.6, +0.8, and then +1.0) each time the same curves are recorded.

After reaching the pressure of +1.0, the pressure in chamber is allowed to drop gradually to (+0.8, +0.6, +0.3, +0.2, then zero level again) and the same curves are recorded.

In this way the animal is subjected to a cycle of changes starting by decrease of the pressure returning to normal level then increase in pressure and after wards returning back to normal.

The same cycle is repeated again and the same data recorded.

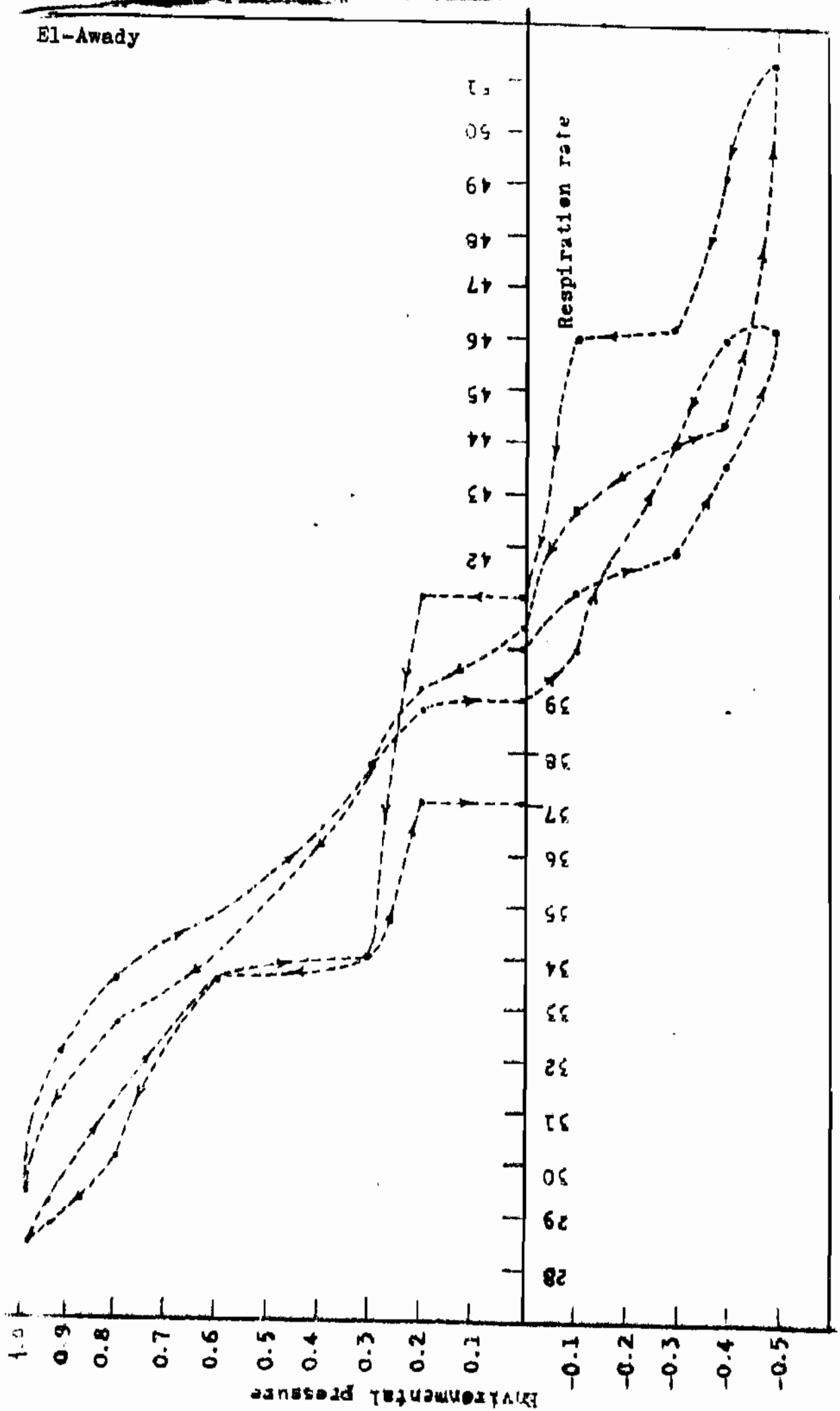
HYSTERESIS CHATACTERISTIC:

Table (1) and Fig. (5) shows the effect of repeating the cycle of changes in pressure twice on the same animal.

Table (1)

P	r/m = rate per minute
0	40
-0.1	41.1
-0.3	41.9
-0.4	43.6
-0.5	46.2
-0.4	46
-0.3	44
-0.1	42.7
0	40.4
+0.2	39.2
+0.3	37.7
+0.6	34.0
+0.8	32.7
+1.0	29.2
+0.8	33.5
+0.6	34.8
+0.3	37.7
+0.2	38.8
0	39.0

P	r/m = rate per minute
-0.1	40
-0.3	44
-0.4	44.4
-0.5	51.3
-0.4	49.1
-0.3	46.2
-0.1	46
0	41
+0.2	41
+0.3	34
+0.6	33.5
+0.8	30.1
+1.0	28.2
+0.8	31.1
+0.6	33.5
+0.3	34
+0.2	37
0	37



Fig(5) The hysteresis characteristic of the biological system.

DISCUSSION AND CONCLUSION:

From Table and Fig. (5) we found that on decreasing the environmental pressure the respiration rate exhibits on a certain way of change. On returning the pressure from -0.5 to zero again the change will exhibit on another way, and the value of respiration rate at the next zero will differ from the first one. The same will take place in case of increasing the preesure and then decreasing it. I.e. the biological system has a hysterisis character. Moreover on repeating this cyclic action, we found that the hysterisis character shifted to the left as in Fig. (5). Our explanation to this phenomena is that the biological system is a learning system.

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