1. Introduction

Recently, decentralized control system has received considerable attention in the field of control engineering for the control of large-scale and complex systems. The decentralized control system has a multiple number of control centers. Each of them controls its own subsystem with specific goal and need to coordinate its activity to satisfy the overall goal.

On the other hand, animal has a high degree of ability to organize autonomous activities of individual organs into one ordered behavior of corrective motion. For example, when starfish is placed upside down, it turns itself over by coordinating the motions of five arms. It should be noted that coordination is preceded by individual random motion of each arm during which the leading arm for coordination is selected from the five arms. Thereafter the individual random motions are inhibited and a systematic turn-over motion starts. (1)

In the author’s opinion, animal system can be conceived as a typical example of the decentralized control system.

What mechanism controls this organized process? Answer to this question might be interesting for system engineer as well as for neurophysiologist.

We have taken rhythmic behaviors such as locomotion, swimming as the first step to be studied.

It was found that these rhythmic behaviors are controlled by mutually coupled endogeneous neural oscillators. For example, the coordinated movement of swimmerets in the crayfish is controlled by the distributed neural oscillators in abdomen interacting each other. (2)

The problems are now reduced to the investigation of the behaviors of coupled oscillator neurons and to find how to control them.
of electrotonically coupled neurons. (7) Studying our model according to the theory of Hopf bifurcation, we found the conditions over the diffusion constants of the electrical junctions which give two kinds of periodic solutions. One is the solution where two neurons oscillate in phase synchrony. The other is the solution of 180 degree out of phase oscillation.

Furthermore, the general two-oscillator system was used to explain the splitting phenomena which were first found by Pittendrigh in circadian rhythms. By the theory of Hopf bifurcation, we could show two stable periodic solutions. One is the in-phase and the other is the anti phase solution. The latter corresponds to a splitting pattern. (8)

3. Control of coordinated rhythmical behavior of crayfish swimmeret System

It has been suggested that the rhythmical behavior of invertebrate such as locomotion, swimming or flying are controlled by the neural networks which receive control signals from the command fibers. The crayfish swimmeret system is a good example to find the control mechanism of such rhythmical behaviors. Wiersma and Ikeda (9) showed that rhythmical motor activity can be released in crayfish swimmeret system by stimulating command fibers with constant frequency pulse trains. They found that the period of the rhythm and the latency depend on the stimulus frequency of command fiber. Stein (10) studied intersegmental coordination in swimmeret and proposed the existence of coordinating neuron of interappendage phases.

In this paper, we will show the relationship between the stimulus frequency of command fiber and the burst period more quantitatively and the interappendage phase constancy. The phase is kept constant even when the burst period changes more than twofold. These results are analyzed in terms of a neural model consisting of Wilson Cowan type oscillator.

3.1 Physiological Experiment

The preparation for recording the burst periods was as follows: The abdomen detached from thorax was dissected in the way described by Kennedy and Takeda (11), except that the sternal ribs of the segments were cut along their long axis in the saline solution (Van Harreveld’s