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WASTE MANAGEMENT OF INSECT PRODUCTION SYSTEM

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ABSTRACT

We have designed and developed a Controlled Environment Insect Production System (CEIPS) for automated insect rearing. The goal is to establish a fully automated large-scale insect rearing system for the low-cost, large-scale production of new materials and substances with novel functions.

For the utilization of silkworm baculovirus expression in the production of useful substances, it is necessary to develop a fully automated silkworm rearing machine. The machine will be able to raise silkworms year round in an environmentally-controlled room. We have been attempting to develop an automatic silkworm rearing system that will facilitate inexpensive, stable, and perennial automatic rearing of silkworm.

This production system is gene recombinant technology. We need to pay attention to the treatment of waste materials. The excrements of silkworm, dead body of silkworm after the hemolymph is extracted, and washing water must be treated.

Therefore, a waste material treatment system was constructed. The drain is sterilized by a high-pressure steam sterilization device which is installed below the insect production building. An incinerator burns up excrement and carcasses. To incinerate materials completely, the incinerator is designed without a fire grate and has a floor shaped like a ship bottom.

In this system, we protect against an unexpected diffusion of waste substances even if the used baculovirus is completely innocuous to the human being and the other animals.

KEYWORDS. Automation, Biotechnology, Control, CEIPS, Silkworm, Rearing

INTRODUCTION

For the utilization of silkworm baculovirus expression in the production of useful substances, it is necessary to develop a fully automated silkworm rearing machine which is able to raise silkworms year round in an environmentally-controlled room. We have been attempting to develop an automatic silkworm rearing system that will facilitate inexpensive, stable, and perennial automatic rearing of silkworm. The growth of silkworms is highly dependent on the environment, and the optimal ambient temperature and humidity vary with the period of their development. Thus, it is important to maintain the temperature and humidity at the optimal levels for each stage of their development. Here, we describe a system integrating facilities and machines for mass automatic rearing of insects independent of natural environmental conditions. The Insect Factory System will use gene recombination technology in the bodies of insects to produce useful materials such as medicine. Figure 1 shows the concept of an insect factory for rearing of silkworms and the primary aspects of measurement and control.

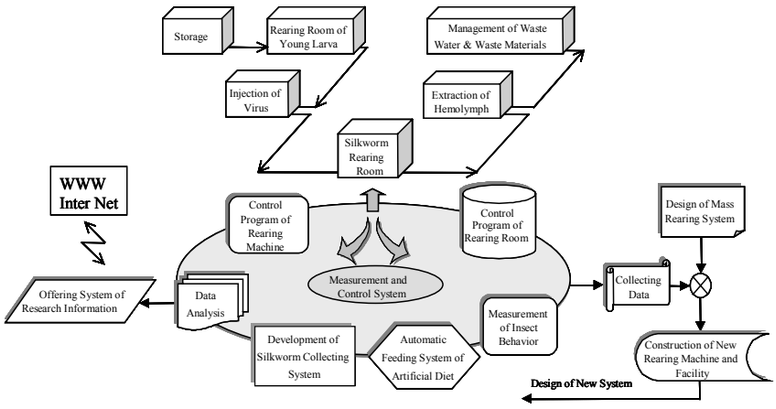

Figure 1. Schematic diagram of insect factory.

SYSTEM DEVELOPMENT

Development of An Automatic Environmental Control System

For this study, we constructed a measurement-control system, prepared a program, and evaluated the measurement method and control function for the environmental control of the fifth inster (stage of growth terminated by a molt) larval rearing room. The rearing room was 12 m long, 6 m wide, and 3 m high. This was a closed environment constructed originally for gene recombination operations. For the temperature and humidity control of the rearing room, the temperature and humidity measurement-control system consisted of a personal computer, temperature and humidity sensors, a temperature and humidity recorder, two RS-232C interfaces, and a signal input-output apparatus. Figure 2 outlines the measurement-control system.

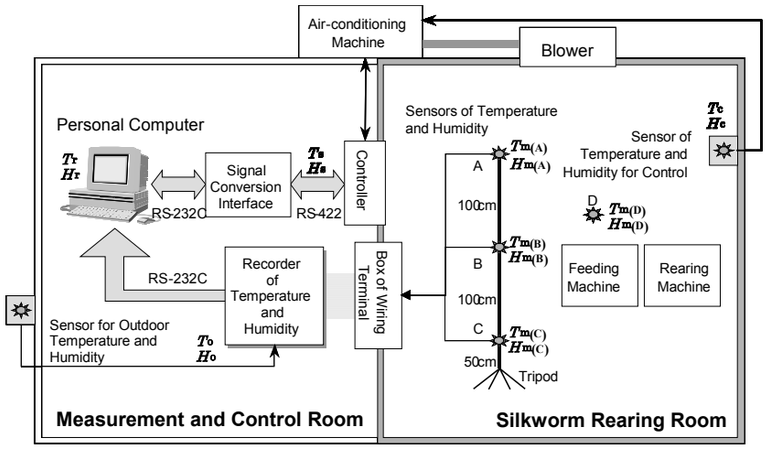

Figure 2. Schematic diagram of measurement and control program.

For automatic execution of temperature and humidity measurement-control, a measurement-control program was written using the Visual Basic Ver. 6.0 programming language. An outline of the measurement-control function is as follows.

The display shows the time series temperature and humidity data of measurement-control. The (a) temperature screen and (b) humidity screen shown in Figure 3 are displayed by clicking the "Temperature Graph Display" and "Humidity Graph Display" buttons, respectively, in the currently executed main operation screen.

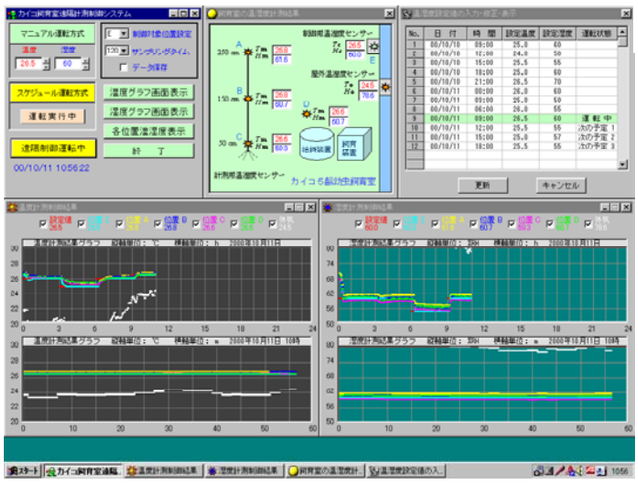

Figure 3. Temperature and humidity control program.

The constructed system makes computerized measurement-control of the temperature and humidity of the rearing environment of silkworms possible. The temperature and humidity measurement-control program allowed automatic setting of the optimal temperature and humidity according to hour-to-hour and day-to-day schedule, real-time measurement and collection of temperature and humidity data inside and outside the rearing room. Storage of the temperature and humidity data as data files, and detailed graphic display of changes in the temperature and humidity at 24-hour or 1-hour intervals on the CRT screen were controlled by the program.

DEVELOPMENT OF AN AUTOMATIC REARING MACHINE OF SILKWORM

We have developed a three-dimensional multi-layer circulation type silkworm rearing machine, with an automated operation system, to allow fully automated silkworm rearing. The designed rearing system, as shown in Figure 4, is composed of a rearing house unit and a work unit. A complete rearing system is 2,000 mm wide, 2,150 mm deep and 2,032 mm high. The rearing house is equipped with a vertical transport device and a horizontal transport device. The vertical transport device is designed as follows. The sliding plate on the bottom of the rearing box fits into the steel angle track, which moves the box up and down as the chains connected to the angled steel track move up or down. The horizontal transport device can move the highest and lowest rearing boxes forward and back. The highest box is moved by actuating a compressed air piston. The lowest box rests on a truck that moves horizontally on Teflon wheels. The truck is moved forward and backward by an air piston. To improve ease of operation and manipulation of rearing system, it is essential to control the automated operation from a personal computer.

Figure 4. Automatic silkworm rearing system.

The operation of the rearing device includes the feeding operation, the circulating mode and the stopping mode. The circulation mode and the feeding operation include basic motions such as moving the rearing boxes up and down, moving the boxes horizontally at a given vertical level and sending and returning the truck which transports the rearing boxes. The program also has a scheduling function which allows fully automated control of the operation. An operator in a control room can control the complete rearing system in the silkworm rearing room by remote control. When the operation control program is first started, the schedule data that was entered using Microsoft Excel is read into the program. After checking the current time, the schedule is checked to see if any operations need to be performed immediately. If there are operations scheduled for execution at that date and time, the commands for those control functions are dispatched to the sequencer. Then the rearing system will carry out these commands.

WASTE MATERIAL MANAGEMENT

The system for producing useful materials from silkworm is an application of gene recombinant technology, it is important to gain public acceptance to put this plan into practical use. We have to pay attention to the treatment of waste materials. These waste materials are silkworm excrements, dead body of silkworm after extracting hemolymph, and washing water etc.

The air inside the rearing room is purified using a High Efficiency Particle Air (HEPA) filter. The HEPA filter could catch virus, unwanted bacteria and other floating particles in the rearing room and give a clean air environment for silkworms and workers. The HEPA filter is equipped with an air inlet, air outlet line and circulation line to the air conditioner. Also, the rearing room is controlled at negative pressure level to protect against leaking air to outside.

Waste materials such as rubbish, trash waste paper, organic materials and silkworms excrement are gathered by mesh filter. Before taking them out of the rearing room, these waste materials are treated by a large autoclave shown in Figure 5. Operation condition of autoclave is120 degree centigrade for 20 min. This autoclave is also used to disinfect rearing tools before introducing them to the rearing room.

Figure 5. View of Autoclave used on waste materials.

After autoclaving, waste materials are transferred to an incinerating are through a pass box. The incinerator burns up excrements, dead bodies and waste materials. To incinerate materials completely due to the small size of excrements (5mm diameter), the incinerator is designed without a fire grate but has a floor shaped like the bottom of a ship. An after-burner and a scrubber on the chimney collect smoke and odor. Figure 6 shows incinerator and the inside offirebox.

Figure 6. View of incinerator and fireplace.

Drainage waste water in rearing room and drainage of air conditioner, is collected and sterilized by high-pressure steam sterilization device which is installed beneath the insect production building. Temperature of steam sterilizer is 120 degree centigrade, for 20 min.

Figure7 shows pass box and the controller for steam sterilizer and Figure 8 shows underground steam sterilizer. Sterilized water is discharged to a drain after being cooled to normal temperature.

Figure 7. Pass box and controller.

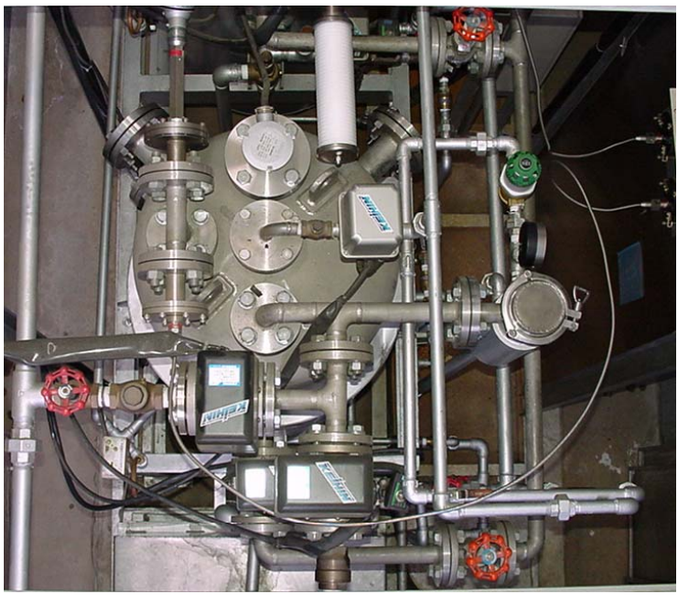

Figure 8. High temperature pressure type steam sterilizer.

In this system, we protect against an unexpected diffusion of waste substances even if the residual baculovirus is completely innocuous to the human being and the other animals.

CONCLUSION

We have designed and developed an automated and instrumented insect rearing facility. We assembled a measurement-control system for the environment of a silkworm rearing room. This system controls automatic setting of the optimal temperature and humidity, real-time measurements and recording of the temperature and humidity inside and outside the rearing room, and displayed results on the CRT screen.

We have developed a multi-layer rotational type rearing machine and an automatic control system. The automated operating function of the rearing machine gave us the following functions: (1) input and modification of the operating schedule, (2) display of the operation schedule, (3) automatic operation and display of the operation mode. When the operating

schedule based on the rearing plan is entered into the system program, the rearing machine can be operated automatically.

To gain public acceptance and a safe rearing environment, a waste material treatment system was constructed. Drainage was sterilized by a high-pressure steam sterilizer. An incinerator destroys excrement and dead bodies. We protect against an unexpected diffusion of waste substances even if the residual baculovirus is completely innocuous to the human being and the other animals.

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