

NEW HARDWARES FOR THE LATEST CLEAN ROOM

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1 INTRODUCTION

In semi-conductor industries, various light exposure equipment require high constant temperature and humidity performances as well as super high clean space.

As for temperatures, an electron beam illustrating device, reduced projection exposure device, etc. the objective size of which is about $1\text{ }\mu\text{m}$ require most high constant temperature performance, and as wafer diameter increases, temperature fluctuation width of the environment of the working area must be controlled within plus or minus 0.1°C when a difference between coefficients of thermal expansions of silicon wafer and glass mask is taken into consideration. Next, as for humidity, to form as extremely fine pattern, it is important to improve tightness between wafer and resist at the time of resist painting, and influence of humidity cannot be disregarded. Further, when influences of attached foreign matters are taken into considerations, it is desirable to handle wafers at as lowest humidity as possible, and relative humidity and humidity fluctuation width must respectively controlled within 30 to 40% and plus or minus 2 to 5%. In addition, as for cleanliness, such a high level as shown below is required.

- Particle diameter range: 0.1 to $0.2\text{ }\mu\text{m}$ At 256 K bit
- Cleanliness: 50 to 100 particles/cu. ft
- Particle diameter range: 0.05 to $0.1\text{ }\mu\text{m}$ At 1 M bit
- Cleanliness: 10 particles/ cu. ft

HEPA filters of $0.1\text{ }\mu\text{m}$ class are now used practically.

Fuji Electric calls an equipment having the above described three elements (cleanliness, temperature and humidity) "Thermal Clean Booth" or "Thermal Clean Cube".

The thermal clean booth and thermal clean cube are used to control cleanliness, temperature and humidity, and air is the objective of the research and development. On the other hand, however, temperature controls of pure water, resist, chemicals and gas (N_2 and compressed air) are also essential in a wafer processing line. For example, even if temperature fluctuation width of a work space is maintained within plus or minus 0.1°C , the extremely fine pattern may be damaged if temperature fluctuation width of the resist is plus or minus 1 to 2°C . In this scene, Fuji

Electric has developed a water temperature stabilizing equipment having a high flexibility to maintain manufacturing equipment and materials such as various liquids, solids and gases under a constant temperature.

This paper introduces the standardized series of thermal clean booth, thermal clean cube and water temperature stabilizing equipment.

2 THERMAL CLEAN BOOTH AND THERMAL CLEAN CUBE

Figs. 1 and 2 respectively show the appearances of the Fuji thermal clean booth and thermal clean cube, and they are described as follows.

2.1 Outline

(1) Classification

The thermal clean booth and thermal clean cube are generally classified by their applications, constructions and system methods as indicated below.

(a) Application (Common for both thermal clean booth and thermal clean cube)

- (1) For mask aligner
- (2) For reduced projection exposure equipment
- (3) For electron beam illustrating equipment
- (4) For pattern detection
- (5) For storing wafers, reticle, etc.
- (6) For X-ray exposure equipment

(b) Classification by construction and system method

As for the constructions, they are classified into booth type and cube type.

As for the system methods, they are classified into refrigerator built-in system and cold water system. Both of these systems are suited to control temperatures of a comparatively small number of equipment separately by individual equipment. It is also possible to install a large number of equipment. However, it is disadvantageous to install many number of refrigerator built-in type units because of the maintenance and space requirements, and it is rather advantageous to use cold water type.

2.2 Features

Fuji thermal clean booth and Fuji thermal clean cube

Fig. 1 Thermal clean booth (WLK16V11-1TR)

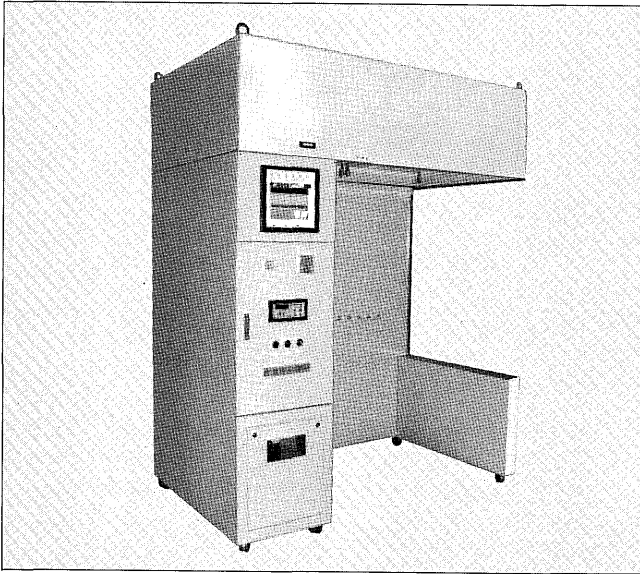
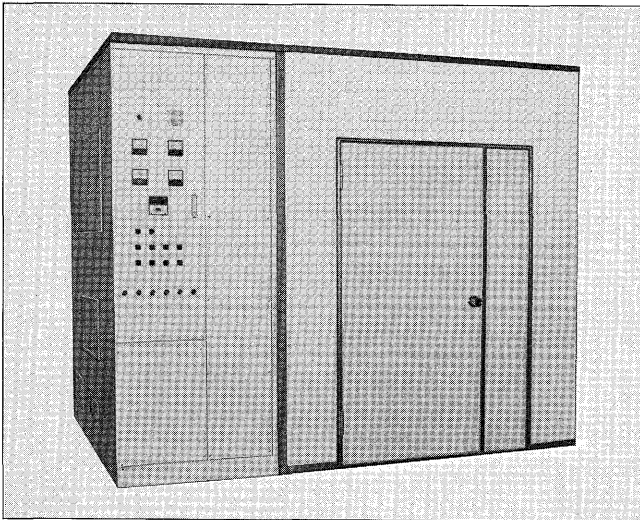


Fig. 2 Thermal clean cube (WLK18H17-1TC)



have the following features.

(1) Energy saving

Conventionally, a water cooled type hermetic refrigerator was used alone as a cooling source. Fuji Electric has developed various models by utilizing cold water, which is normally provided in the factory. These models feature the high dew-point temperature and reduced output of electric heater.

(2) Space saving

Installing the entire air conditioning unit on a ceiling part. Fuji Electric has developed various models which are similar to those conventional clean booths. With these models, work area can be expanded, more number of units can be installed and the units can be easily associated with production lines.

(3) Construction and maintenance ease

Inspection openings are provided at significant points. For example, in case of HEPA filter, all the necessary

works can be made from the circumference without entering the work range. Therefore, construction and maintenance can be made far easily.

(4) Low vibration

Main causes of vibration are air pressure and rotation of the associated blowers, and vibration adversely affects the devices accommodated in the thermal clean booth and peripheral equipment. To be more specific, in case of a 4-pole motor, 25 Hz (when the source frequency is 50 Hz) is the peak frequency because of the frequency characteristics, and this appears to be a vibration. To eliminate this, a special vibration absorbing spring which uses a metal spring and rubber is used to cope with this problem.

(5) Rich options

Not only temperature and humidity controls, but static electricity elimination and radio wave magnetism shield can also be built in, and further, exhaust duct, N_2 , vacuum piping and various receptacles can also be built in.

2.3 Performance

(1) Performance and construction

Constructions and temperature control methods of Fuji thermal clean booth and Fuji thermal clean cube are described.

As shown in Figs. 3 and 4, the air conditioning unit is in the same construction for both the thermal clean booth and thermal clean cube. The difference is in the HEPA filter installing method. Under the standard specifications, the thermal clean booth uses a vertical laminar flow system, and thermal clean cube uses a horizontal laminar flow system. In case of thermal clean cube, however, it is also possible to use vertical laminar flow system depending on the shape of the internally accommodated devices and method of use.

The thermal clean booth is surrounded by a vinyl curtain, and in some cases, it is possible to take advantages in the management and working efficiencies by joining multiple number of thermal clean booths. Since a thermal clean cube composes one chamber, in many cases, thermal clean cube is installed independently.

Fig. 3 Cross-sectional view of thermal clean booth

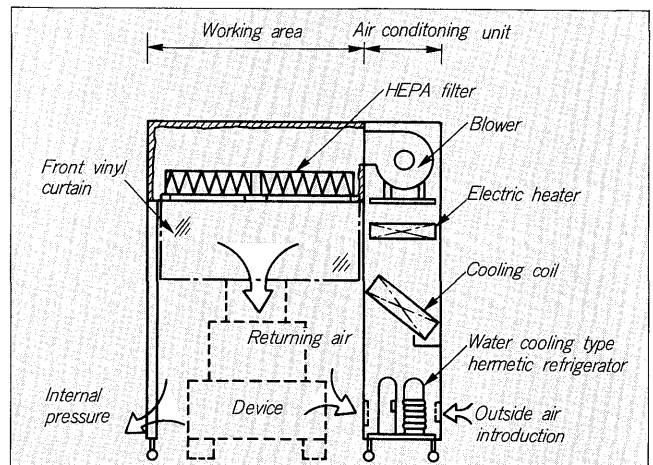


Fig. 4 Cross-sectional view of thermal clean cube

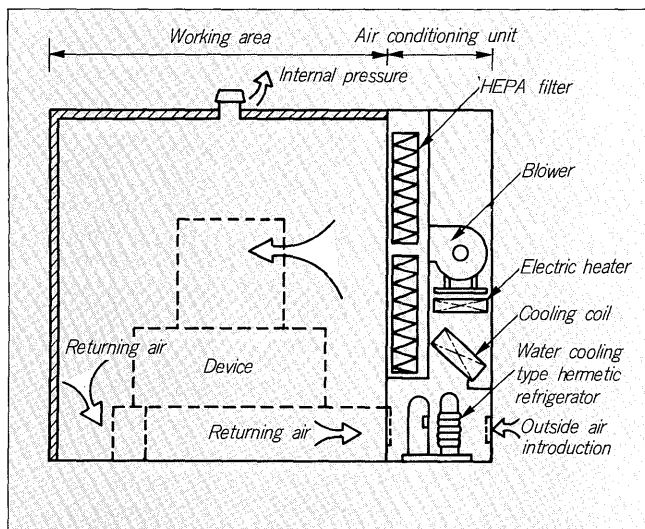
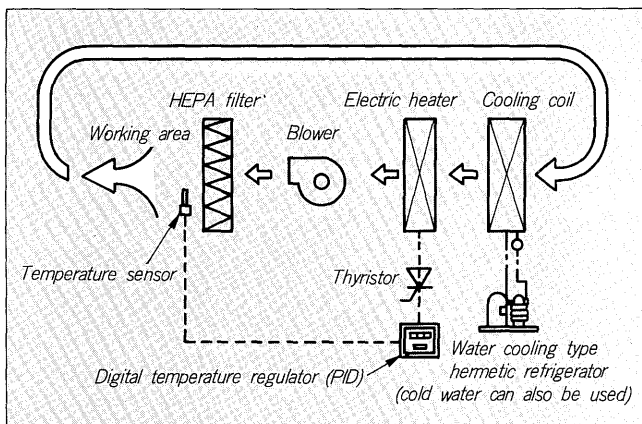


Fig. 5 Temperature control flow



In many cases, aluminum material sealed with foamed urethane which is often used for prefabricated refrigerators is used to compose the chamber of a thermal clean cube, and this construction features that the treatment and assembly can be made simply at the site. The floor is finished with Ronleum to prevent dust occurrence.

When those internally accommodated devices are affected by radio wave, magnetism and electromagnetic noise, they can be built in a shield cube.

Referring to Fig. 5, temperature control method is explained next.

Normally keeping cooled condition by the use of a refrigerator (or cold water) and cooling coil, temperature fluctuation width is kept within plus or minus 0.1°C by continuously controlling output of an electric heater with a thyristor.

The digital temperature regulator controls temperature with PID (proportion, integration and differentiation)

The temperature sensor uses a temperature measuring resistor (JIS Pt 100).

(2) Cooling method

In comparison with the size of thermal clean booth,

a larger horsepower (refrigerating performance) of the refrigerator and a larger capacity of the electric heater are required. This is because the thermal clean booth is likely to be affected by the ambient temperature and humidity. In other words, volume of the outside air led into the booth is large (30 to 40% of circulated air volume), and if this is small, cleanliness of the work range cannot be maintained. Another reason is that the booth must always keep a constant temperature night and day regardless of summer or winter, and the capacity is large because the booth must follow changes of the ambient conditions.

3 WATER TEMPERATURE STABILIZING EQUIPMENT

3.1 Outline

(1) Construction and specifications

Figs. 6 and 7 show the appearance and construction of Fuji water temperature stabilizing equipment respectively. The internally accommodated components are an air cooling type hermetic refrigerator (a water cooling type may also be used depending the cooling load and conditions), water tank, circulating pump, cooling coil and electric heater. With this equipment, water temperature fluctuation range is maintained within plus or minus 0.1°C.

3.2 Features

(1) Small in dimensions

Installing area is small, allowing the equipment to be installed in any place.

(2) Use ease

Since constant temperature water is forcedly circulated by the circulation pump, the equipment can be used simply by connecting power.

Fig. 6 Water temperature stabilizing equipment (FWC-250W)

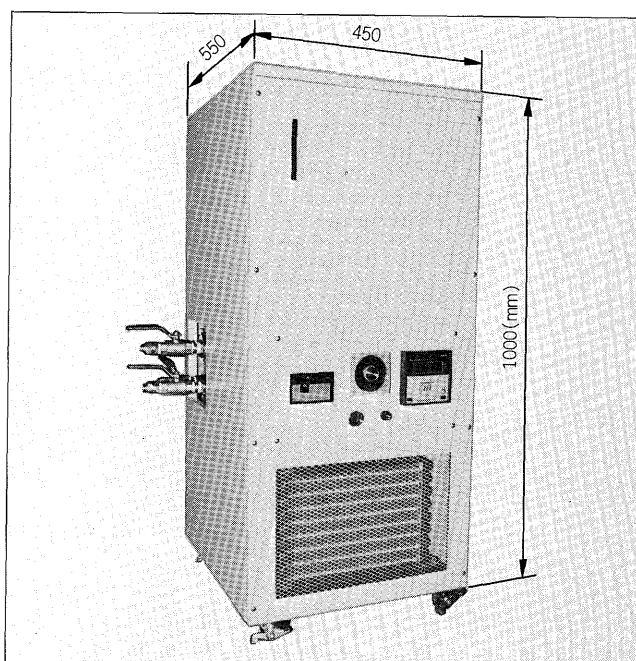
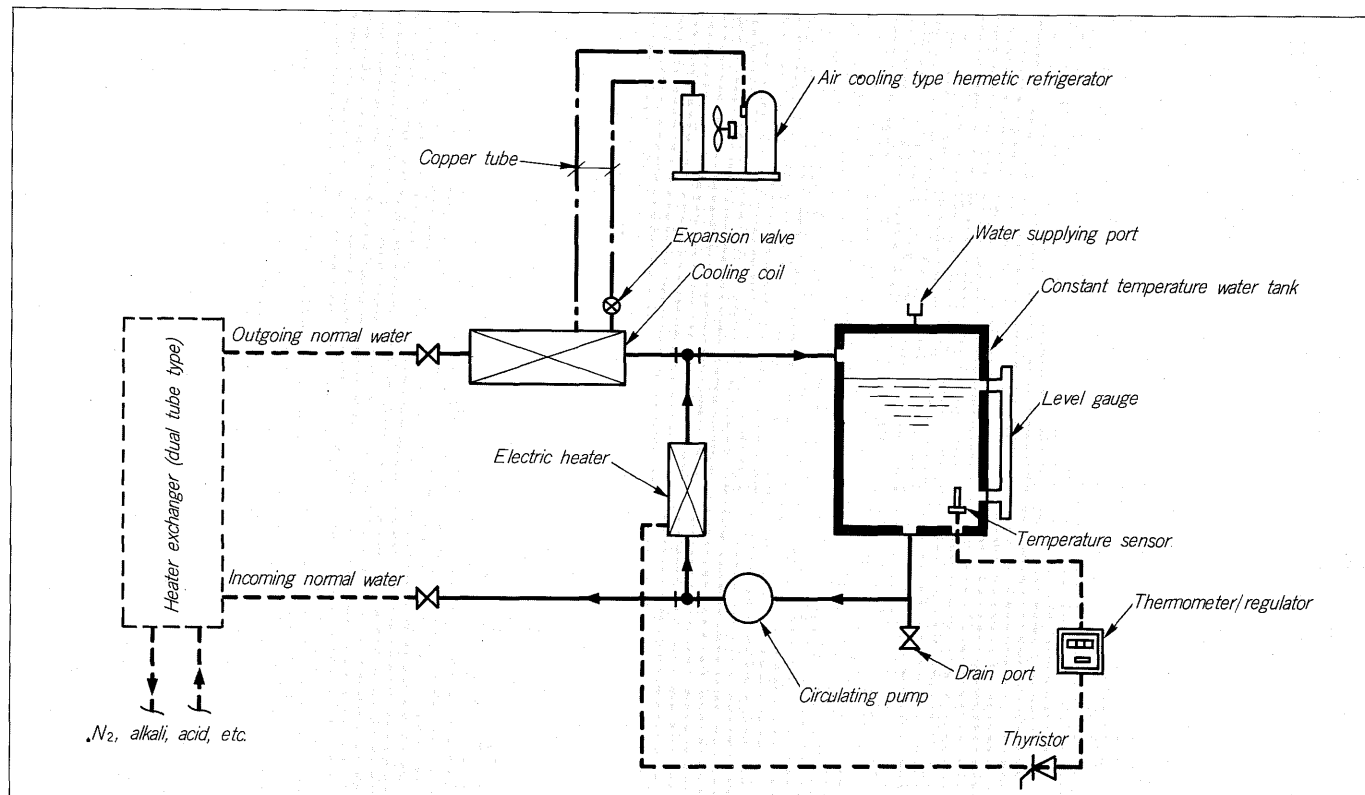


Fig. 7 Block diagram of water temperature stabilizing equipment



(3) Free combinations

Regardless of the object, pure water, chemical liquid or air, temperature can be controlled immediately by preparing a dual controlling type heat exchanger.

Further, the water temperature stabilizing equipment can be used as is for internal cooling of a precision machine.

(4) Free shape

The main unit of the water temperature stabilizing equipment can be separated (the air cooling type refrigerator can also be installed by itself alone), or the shape can be changed extremely simply so that the equipment can be accommodated in a precision machine.

(5) Use of rust-proof material

The piping materials are completely rust-proof materials, and rust and scale are not anticipated. If pure water or distilled water is used for the water circulating system, the effect can be further improved.

water temperature stabilizing equipment are outlined above. It is obvious that a higher integration and automation of manufacturing line will be enhanced in the semiconductor industries. In other words, cleanliness of a local place, temperature and humidity controls and controls of temperatures of chemical liquid, air, etc. will be required, and thermal clean booth, cube and water temperature stabilizing equipment must realize high stability, energy saving, space saving and systemization (central management).

The air, water and other material temperature and humidity control technologies obtained through manufacturing thermal clean booth, cube and water temperature stabilizing equipment will be applied to other fields of the industry (precision machine manufacturing industries, food industries, pharmaceutical industries, etc.). Fuji Electric will concentrate its efforts more and more in the R & D, coping with new needs.

4 POST SCRIPT

Fuji thermal clean booth, Fuji thermal clean cube and