

[54] **APPARATUS FOR PROVIDING TEMPERATURE GRADIENTS**

[75] Inventors: Akira Nobe, Tokyo; Toshitaka Nakae, Okayama, both of Japan

[73] Assignee: Tokyo Kagaku Sangyo Kabushiki Kaisha, Tokyo, Japan

[22] Filed: Dec. 9, 1970

[21] Appl. No.: 96,319

[52] U.S. Cl. 195/139, 195/127 R, 195/140, 73/15 R, 165/47

[51] Int. Cl. C12k 1/00

[58] Field of Search 165/11, 14, 30, 48, 47, 165/58, 80; 73/15 R, 190 H, DIG. 7; 195/127, 139, 140

[56] **References Cited**

UNITED STATES PATENTS

2,691,885	10/1954	Farnham, Jr.	73/15 R
3,018,663	1/1962	Dunlop	73/190 X

FOREIGN PATENTS OR APPLICATIONS

1,080,435 8/1967 Great Britain 73/15 R.

OTHER PUBLICATIONS

Landman, O. E. et al. Temperature Gradient Plates, Journal of Bacteriology, Vol. 83, pgs 463 to 469, 1962.

Oppenheimer, C. H. et al. Multiple Temperature Optima, Journal of Bacteriology, Vol. 80, pgs 21 to 24, 1960.

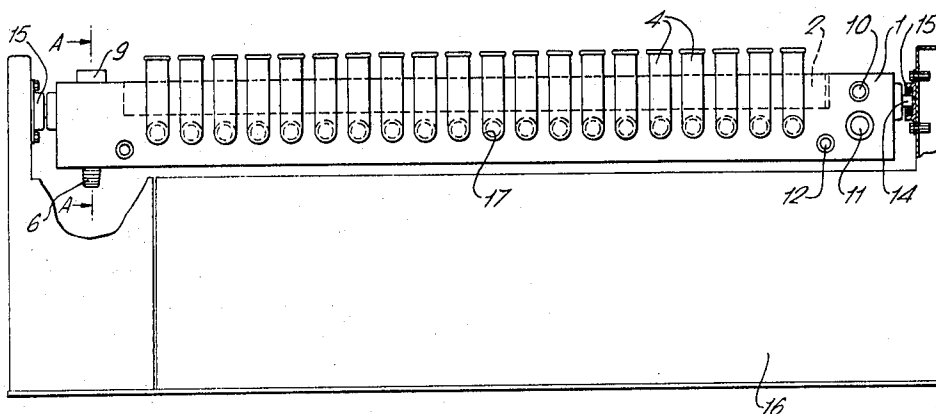
Primary Examiner—Albert W. Davis, Jr.

Attorney, Agent, or Firm—Arnold Robinson; William D. Lucas; Frank J. DeRosa

[57] **ABSTRACT**

Apparatus for providing temperature-gradients, incorporating a block of thermally-conductive material provided with a heating source at one end and a cooling source at the other end, and adapted to subject a group of like specimens to different temperatures.

9 Claims, 5 Drawing Figures



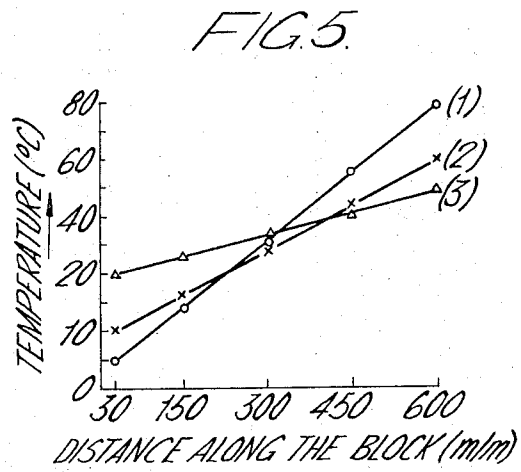
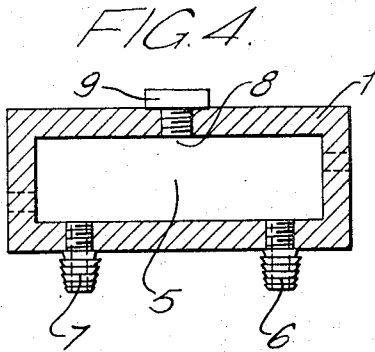
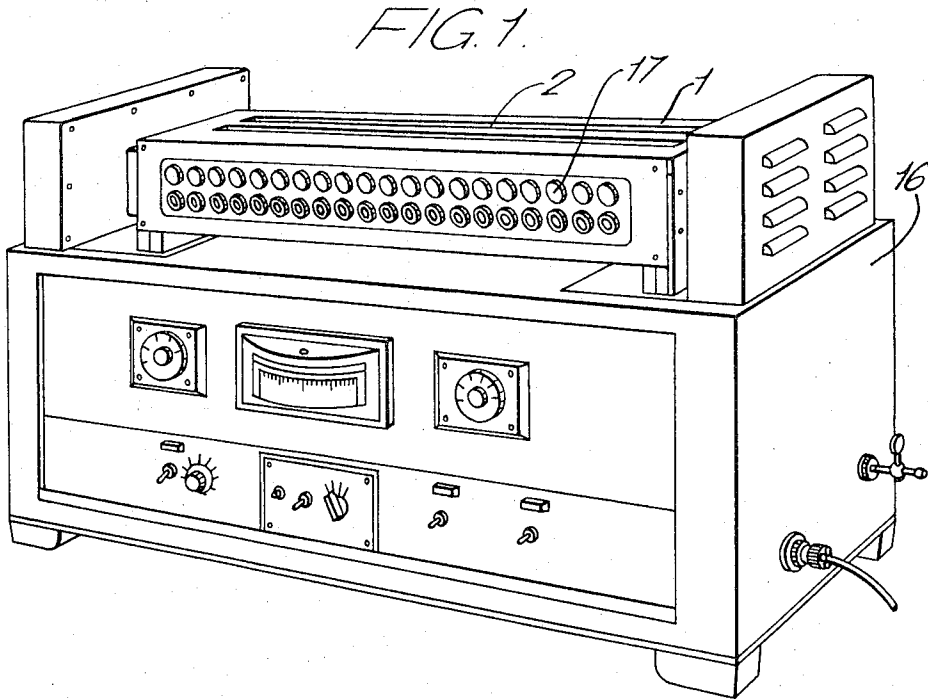
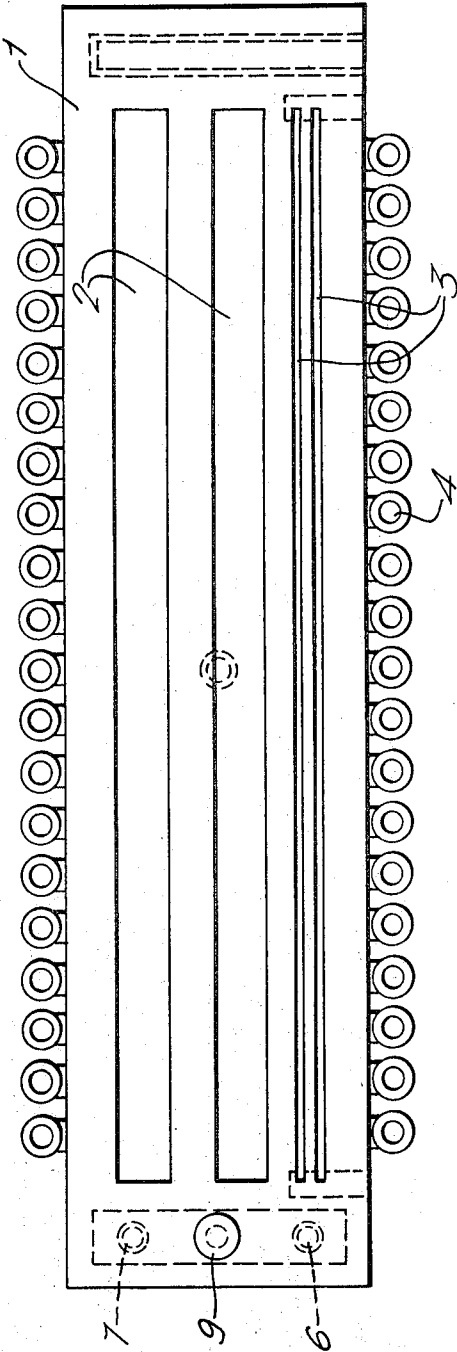
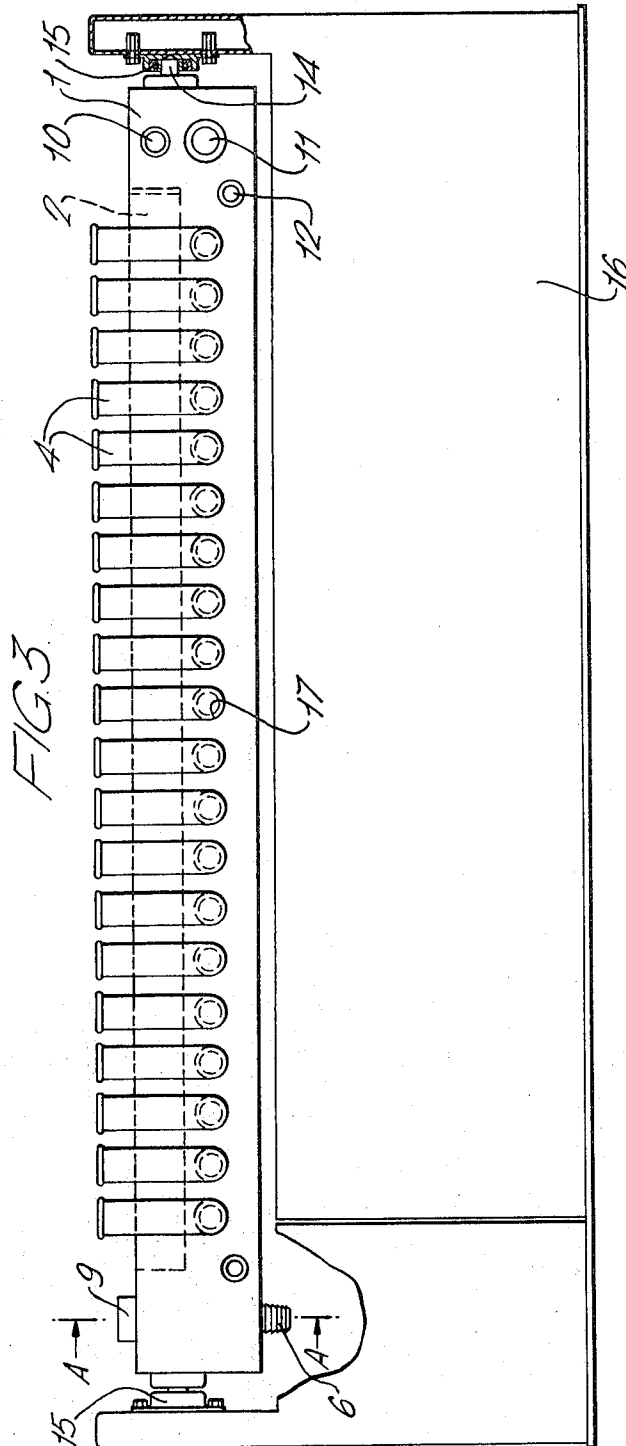


FIG. 2





APPARATUS FOR PROVIDING TEMPERATURE GRADIENTS

This invention relates to apparatus for producing temperature-gradients to enable the study of a group of like specimens simultaneously at various temperatures. The apparatus comprises a thermally-conductive metallic block in which a heating source is provided at one end and in which a cooling source is provided at the other end, the metallic block being designed to accept various types of specimen containers.

The types of specimens which may be studied with the apparatus embodying applicants' invention are many and varied. Microorganisms often must be studied at many different temperatures within a certain range in order to simulate the natural conditions in which they live. Metals and alloys must be tested to ascertain their resistance to corrosion by various fluids over a wide range of temperatures. In these exemplary cases, it is desirable from the experimental point of view that both the ongoing interaction between each specimen and its environment and the examination and recording of that interaction be carried out simultaneously. Moreover, the gradients of temperature must be regularly and consistently produced. It is also important that the temperature gradients are produced as quickly as possible. For improved results, the apparatus can vibrate the specimen-containing metallic block during the operation at the operator's option.

It is well-known that microorganisms have been cultivated in a single container whose temperature is set by an associated heating device. With this known method, it is necessary to adjust the heating device very often, or otherwise it is necessary to provide many containers, each with its own separate heating device. Even if such an arrangement is devised, it is nevertheless impossible to establish continuous gradients of temperature for the microorganism cultures. The present invention overcomes the difficulties and disadvantages involved in the known method, and meets the requirements pointed out above.

According to the present invention an apparatus comprises a bar-like block of thermally-conductive material, such as pure aluminum, the block including a heating source at one end and a cooling source at the other end, and having its surfaces bored and grooved, so as to accept containers of the specimens to be studied.

A better understanding of the present invention may be had by reference to the accompanying drawings, of which:

FIG. 1 is an isometric view of an apparatus constructed as a preferred embodiment of the present invention;

FIG. 2 is a plan view of a metallic block including a heating source at one end and a cooling source at the other end;

FIG. 3 is a side view of the apparatus shown in FIG. 1, the parts being broken away to reveal internal construction;

FIG. 4 is a vertical section taken along the line A-A shown in FIG. 3; and

FIG. 5 is a graph showing the temperature gradients produced by apparatus embodying the present invention.

Referring now to FIGS. 1, 2, 3 and 4, a bar-like block 1 of metal, such as pure aluminum, is mounted on a bed

16, with its trunnions 14 supported in bearings 15 of the bed 16, so as to be capable of oscillating or swinging around the axis of rotation, about which the bearings 15 are disposed. This can be accomplished by providing the block 1 with a crank (not shown) driven by an electric motor. The block 1 is provided with grooves 2 and 3 in its axial direction, to accept Petri dishes of thermally-conductive material such as stainless-steel, in which microorganisms such as bacteria are placed for growing and examining purposes. The grooves 3 are smaller than the grooves 2, and are particularly adapted for accepting fine tubes of glass in which microorganisms may be cultivated free from air. Microorganisms may also be directly placed in these grooves in admixture with gelatin, so that the microorganisms can freely move along the length of the grooves to attempt to find their optimum thermal condition. The sides of the block are preferably bored transversely with respect to the axial direction, the bores being shown by the reference numeral 17, in which L-shaped test-tubes 4 are securely inserted with each open end directed upward (FIG. 3), ensuring that the content of the test-tubes is safely kept in. This will be of particular advantage when the block is vibrated in the above-mentioned manner.

The block 1 includes a heating source at one end and a cooling source at the other end. The cooling source consists of a chamber 5 through which water flows from an inlet 6 to an outlet 7. The water is previously cooled to 0°C by a refrigerator (not shown) mounted in the bed 16. An anti-freezing agent is added to the water. The temperature of the water is constantly monitored during the circulation in the chamber 5 by means of a thermostat. An opening 8 is used for introducing both the water and the anti-freezing agent, and is normally closed by a plug 9. Instead of using a chamber 5, an extension of block 1 can be provided at the underface of the cooling section, with the block extension submerged in a tank of constant-temperature water, thus maintaining the end of block 1 at a predetermined low temperature.

The heating source consists of electric heaters 10 and 11 (FIG. 3) mounted in the end opposite to the cooling source. The output of the heaters 10 and 11 is controlled by monitoring circuitry including a thermistor 12. For superior results, an automatic regulator of temperature can be fitted near the heating source. Preferably, the regulator includes a chamber lined with stainless-steel, an agitator and an electric heater, whereby the temperature in the heating section is kept within a certain range with a negligible margin of error.

Referring now specifically to FIG. 5, the gradients of temperature produced by the disclosed apparatus embodying the present invention are shown in the graphs of this figure. As pointed out earlier, the block 1 of that apparatus is made of thermally-conductive material, such as aluminum and silver, but from an economy point of view pure aluminum is preferable. It has been demonstrated that, with a block 1 of pure aluminum, the variation of temperature is smooth and regular, as evidenced by straight line plots (1), (2) and (3) in FIG. 5. The temperatures in plot (1) vary from -10°C to 80°C, those in plot (2) vary from 0°C to 60°C, and those in plot (3) vary from 20°C to 50°C. These temperature gradients can be reproduced regularly and consistently, which is helpful for the execution of such experiments. This advantage of the present invention

has been repeatedly demonstrated by the applicants.

In summary, the apparatus embodying the present invention provides temperature gradients automatically and within a variable predetermined range. Moreover, when desired, the specimens under scrutiny may be vibrated. Accordingly, experimenters are afforded great ease of operation. The apparatus can accommodate many kinds of containers, thus enabling microorganisms to be successfully cultivated in either a liquid or a solid bed. The temperature gradients are linear and repeatable, which is of particular advantage for growing microorganisms and examining chemical changes of metals at many different temperatures. A further advantage is that culture growth and examination can be carried out at one time. Otherwise, scores of apparatus would be needed for the same work. The apparatus embodying the applicants' invention has many commercial applications, e.g., in the fields of fermentation, lactic-acid bacteria production, food manufacture, brewing, and various other chemical fields.

The advantages of the present invention, as well as certain changes and modifications of the disclosed embodiments thereof, will be readily apparent to those skilled in the art. It is the applicants' intention to cover all those changes and modifications which could be made to the embodiments of the invention herein chosen for the purposes of the disclosure without departing from the spirit and scope of the invention.

What we claim is:

1. Apparatus operative to subject a plurality of specimens in a predetermined testing environment to a predetermined temperature gradient which comprises:
 1. a thermally-conductive receptacle member having first and second ends;
 2. means for mounting said thermally-conductive receptacle member at opposite ends thereof;
 3. heater means positioned at said first end of said thermally-conductive receptacle member;
 4. cooling means positioned at said second end of said thermally-conductive receptacle member and operative in cooperation with said heater means to establish a variable, predetermined temperature gradient along the length of said receptacle member between said heater means and said cooling means; and
 5. said member having receptacle means comprising a thermally-conductive block having a plurality of different openings therein for receiving a plurality of specimens in at least one testing environment for

subjecting said plurality of specimens in said testing environment to said predetermined temperature, said openings comprising a plurality of bores for holding test tubes extending into a side of said block and a plurality of grooves extending into the top surface of said block.

2. Apparatus according to claim 1 wherein said thermally-conductive receptacle members is rotatably mounted at said first and second ends.

3. Apparatus according to claim 2 further comprising means for imparting a predetermined type of motion to said thermally-conductive receptacle member.

4. Apparatus according to claim 1 wherein said plurality of grooves extend from said first end to said second end to receive specimen material, and said plurality of grooves comprises at least two grooves of different dimensions.

5. Apparatus according to claim 1 wherein said plurality of bores extends from said first end to said second end to receive said tubes containing specimen material.

6. Apparatus according to claim 1 wherein said heater means comprises at least one electric heater mounted in said first end of said thermally-conductive receptacle member.

7. Apparatus according to claim 1 further including a thermistor mounted in close proximity to said heater means and associated with monitoring circuitry operative to regulate the output of said heater means.

8. Apparatus according to claim 1 wherein said cooling means comprises:

1. a chamber formed in said thermally-conductive receptacle member in proximity with said second end thereof, said chamber having an inlet port and an outlet port; and
2. means for circulating cooling fluid through said chamber by means of said inlet and outlet ports and for maintaining said cooling fluid at a predetermined low temperature.

9. Apparatus according to claim 1 wherein said cooling means comprises:

1. a block extension of said thermally-conductive receptacle member;
2. a tank of water in which said block extension is submerged; and
3. means for maintaining said tank of water at a predetermined low temperature.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,801,467 Dated April 2, 1974

Inventor(s) Akira Nobe and Toshitaka Nakae

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In Column 1 before [52] insert:

-- Foreign Application Priority Data

December 24, 1969 Japan, 103462/69--

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents