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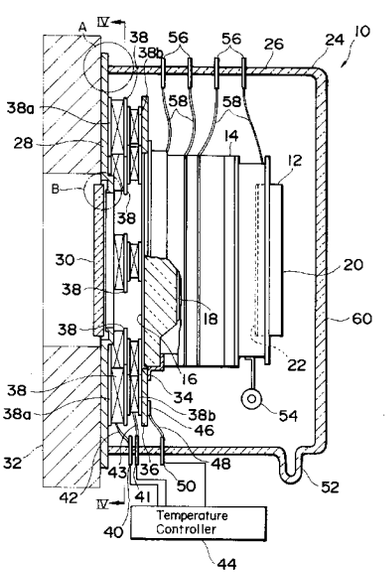
(54) Image device.

(57) An image device includes a housing for housing an image tube with a predetermined space therebetween, and a plurality of Peltier elements for cooling the photoelectric surface of the image tube. The heat absorption portion of each Peltier element is fixed to a portion near the photoelectric surface of the image tube, and the heat dissipation portion of each Peltier element is fixed to an end plate near the transparent window plate of the housing. The interior of the housing is set at a vacuum. Therefore, the photoelectric surface is free from external thermal influences and can be efficiently cooled by the Peltier elements. In addition, the housing is heated by heat from the heat dissipation portions of the Peltier elements to prevent dew condensation.

Fig. 3



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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to an image tube for converting an optical image, received by an incident window, into a photoelectric image through a photoelectric surface and reproducing the photoelectric image as an optical image through a reproduction window and, more particularly, is concerned with an image device including means for cooling the photoelectric surface of the image tube.

Related Background Art

An image tube has a substantially cylindrical closed vessel. One end plate of the closed vessel serves as an incident window for receiving an optical image. A photoelectric surface is formed on the inner surface of the incident window. An optical image incident on the incident window is converted into photoelectrons by the external photoelectric effect of the photoelectric surface. The photoelectrons are accelerated and focused by an electron lens to form an electronic image on fluorescent screen which is formed on the inner surface of the other end plate of the closed vessel. The electronic image formed on the fluorescent screen is then reproduced as an optical image. The other end plate will be referred to as a reproduction window hereinafter.

In such an image tube, the photoelectric surface emits thermoelectrons owing to heat even if no light is incident on the photoelectric surface. The thermoelectrons cause thermal noise, and a decrease in the S/N ratio of the image tube. As a method of restricting emission of such thermoelectrons, a method of using means for cooling an image tube, especially, a photoelectric surface thereof is available.

Fig. 1 shows one of conventional cooling means. This cooling means uses cooling elements 1 based on the Peltier effect. The cooling element will be referred to as Peltier element hereinafter. More specifically, the cooling means is designed as follows. An image tube 2 is covered entirely with a cylindrical housing 3, and the space therebetween is set at a vacuum. In addition, a plurality of Peltier elements 1 are arranged between the outer surface of the side wall of the image tube 2 and the inner surface of the side wall of the housing 3 in such a manner that a heat absorption portion 1a of each Peltier element is located on the side of the image tube, and a heat dissipation portion Ib of each Peltier element 1 is located on the side of the housing 3. With this arrangement, when voltages are applied to the Peltier elements 1, the heat absorption portions 1a are set at low temperatures to cool the side wall portion of the image tube 2. As a result, the photoelectric surface (not shown) formed on the inner surface of an incident window 4 of the image tube 2 is cooled.

However, since this cooling means is designed to cool the entire image tube 2, the cooling efficiency is very poor.

In addition, as a conventional cooling means, a device for cooling mainly a photoelectric surface, as shown in Fig. 2, is known (Japanese Patent Laid-Open No. 62-180930).

This photoelectric surface cooling device 5 comprises two annular metal plates 5a and 5b having transparent window plates 6a and 6b mounted on their central opening portions, and a plurality of Peltier elements 7 arranged between the metal plates 5a and 5b. Heat absorption portions 7a of the Peltier elements 7 are in contact with the metal plate 5b. When voltages are applied to the Peltier elements 7, the window plate 6b of the annular metal plate 5b is set at a low temperature. Therefore, since the window plate 6b is mounted on an incident window 4 of an image tube 2 so as to be in contact therewith, a photoelectric surface 8 on the inner surface of the incident window 4 can be cooled.

In this photoelectric surface cooling device 5, since the window plate 6b having a low temperature is in contact with the incident window 4 of the image tube 2, a reproduction window 9 is also cooled through the side wall portion of the image tube 2. Since the reproduction window 9 is exposed to the atmosphere, dew condensation may occur on the surface of the reproduction window 9. In addition, since most of the image tube 2 is exposed to the atmosphere, the photoelectric surface 8 cannot be sufficiently cooled owing to external heat.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an image device which can effectively cool the photoelectric surface of an image tube to suppress generation of thermoelectrons, thereby increasing the S/N ratio of the image tube.

It is another object of the present invention to provide an image device which can prevent dew condensation.

It is still another object of the present invention to provide an image device which can keep the temperature of the photoelectric surface of an image tube constant to stabilize the spectral sensitivity characteristics of the image tube.

The above objects can be achieved by an image device comprising (a) an image tube including a first end plate having a photoelectric surface formed on an inner surface thereof, and a second end plate located on the opposite side of the first end plate and having a fluorescent screen formed on an inner surface thereof, the image tube being adapted to reproduce on the fluorescent screen an optical image incident on the photoelectric surface through the first end

plate, (b) a housing adapted to house the image tube with a predetermined space therebetween and having an inner space substantially completely evacuated, the housing including a first transparent portion arranged to oppose the first end plate with a predetermined space therebetween, and a second transparent portion arranged to oppose the second end plate with a predetermined space therebetween, and (c) a plurality of Peltier elements for cooling the photoelectric surface of the image tube and supporting the image tube at a predetermined position in the housing, each Peltier element having a heat absorption portion fixed to the image tube at a position near the photoelectric surface and a heat dissipation portion fixed to the housing at a position near the first transparent portion.

Preferably, the housing comprises a transparent cup-like main body, an annular metal end plate airtightly fixed to an open end portion of the cup-like main body, and a transparent window plate airtightly mounted on a central opening portion of the cup-like main body, and the image tube is coaxially arranged in the cup-like main body. In this case, the transparent window plate is the first transparent portion of the housing, and the bottom plate of the cup-like main body is the second transparent portion. Also, it is preferable that the cup-like main body consists of a glass material, the end plate consists of copper, and the window plate consists of a glass material. In addition, the heat dissipation portion of each Peltier element can be fixed to the end plate of the housing. The heat absorption portion of each Peltier element can be fixed to an outward flange provided on an outer peripheral portion, of the image tube, which is adjacent to the first end plate.

Furthermore, the image device of the present invention may include a temperature detection means for detecting the temperature of the photoelectric surface of the image tube. Preferably, the temperature detection means is a temperature sensor for detecting the temperature of a portion, of the image tube, which is adjacent to the photoelectric surface.

Moreover, the image device may include a control means, electrically connected to the temperature detection means and the Peltier elements, for controlling voltages applied to the Peltier elements to keep the temperature of the photoelectric surface constant on the basis of a detection result from the temperature detection means.

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not to be considered as limiting the present invention.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art form this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view schematically showing a conventional means for cooling the photoelectric surface of an image tube;

Fig. 2 is a sectional view schematically showing another conventional means for cooling the photoelectric of an image tube;

Fig. 3 is a side elevational view of an image device according to the present invention, partly in section;

Fig. 4 is a sectional view taken along a line IV - IV in Fig. 3;

Fig. 5 is an enlarged view of a portion A in Fig. 3;

Fig. 6 is an enlarged view of a portion B in Fig. 3;

Fig. 7 is a graph showing the relationship between the temperature of a photoelectric surface and the number of thermoelectrons in the dark; and

Fig. 8 is a graph showing the spectral sensitivity characteristics of an image tube with respect to different temperatures of the photoelectric surface.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly, to Fig. 3, there is shown a partial sectional side view of an image device according to the present invention, which is generally designated by the numeral 10. The image device 10 includes an image tube 12. The image tube 12 is of a known type and has a substantially cylindrical closed vessel 14. One end plate (the end plate on the left side in Fig. 3) of the closed vessel 14 serves as an incident window 16 for an optical image, on the inner surface of which a photoelectric surface 18 is formed. The other end plate of the closed vessel 14 serves as a reproduction window 20, on the inner surface of which a fluorescent screen 22 is formed.

The image tube 12 is coaxially housed in a cylindrical housing 24 with a predetermined space therebetween. The housing 24 is constituted by a cup-like main body 26 consisting of a transparent glass material, and an annular end plate 28 consisting of a metal, preferably a copper material having a high thermal conductivity, and mounted on an open end portion of the cup-like main body 26. A window plate 30 consisting of a transparent glass material is mounted on a central opening portion of the end plate 28. The win-

dow plate 30 is arranged to oppose the incident window 16 of the image tube 12 with a predetermined space therebetween. The window plate 30 serves as an inlet for optical information to be imaged on the photoelectric surface 18 of the image tube 12. Therefore, it is preferable that the diameter of the window plate 30 is similar to or larger than that of the photoelectric surface 18. In addition, it is preferable that an air-cooled or water-cooled annular heat dissipation plate 32 is arranged on the outer surface of the end plate 28.

The end plate 28 and the cup-like main body 26, and the end plate 28 and the window plate 30, respectively, are airtightly coupled to each other so that the housing 24 has a hermetically sealed structure. Since it is difficult to directly couple a glass member to' a copper member, a plurality of metals such as chromium (Cr), nickel (Ni), copper (Cu), and indium (In) are preferably interposed between the end plate 28 and the cup-like main body 26 or the window plate 30, as shown in Fig. 5 and 6.

An outward flange 34 consisting of copper is formed on the image tube at an outer peripheral portion thereof which is adjacent to the incident window 16. An annular copper plate 36 is fixed to the flange 34. When the image tube 12 is arranged at a predetermined position in the housing 24, the annular copper plate 36 is arranged to oppose the end plate 28 of the housing 24 coaxially. As shown in Fig. 4, a plurality of (eight in this embodiment) Peltier elements 38 are arranged between the end plate 28 of the housing 24 and the annular copper plate 36 at equal intervals in the circumferential direction. A heat dissipation portion 38a of each Peltier element 38 is fixed to the end plate 28 of the housing 24, and a heat absorption portion 38b of each Peltier element 38 is fixed to the copper plate 36. With this structure, the image tube 12 is supported on the housing 24 only by the Peltier elements 38.

The Peltier elements 38 are connected to electrodes 40 and 41 extending through the cup-like main body 26, through lead lines 42 and 43 having a low heat conductivity. A temperature controller 44 located outside the housing 24 is connected to the electrodes 40 and 41. A temperature detector 46 such as a platinum temperature sensor is mounted on the annular copper plate 36. Although the temperature detector 46 serves to detect the temperature of the annular copper plate 36, the temperature of the photoelectric surface 18 can be calculated from a detection value from the temperature detector 46. The detection value from the temperature detector 46 is input to the temperature controller 44 through a lead line 48 having a low thermal conductivity and an electrode 50. The temperature controller 44 controls voltages applied to the Peltier elements 38 in accordance with this detection value, thus controlling the temperature of the heat absorption portions 38b.

The numeral 52 designates a chip tube, which is used to exhaust air from the housing 24 to set a vacuum therein after the image tube 12 is housed in the housing 24 and the end plate 28 is mounted. When the pressure in the housing 24 is decreased to a desired value, the chip tube 52 is closed by using a burner or the like.

Also, the numeral 54 designates a getter, which absorbs residual gases to maintain the degree of vacuum after the housing 24 is evacuated. The getter 54 is suspended from a side wall of the image tube 12.

Further, the numeral 56 designates electrodes extending through the cup-like main body 26. The electrodes 56 serve to apply voltages to the image tube 12 or extract signals from the image tube 12. These electrodes 56 are properly connected to the image tube 12 through lead lines 58 having a low heat conductivity.

In operation, optical information is incident on the incident window 16 of the image tube 12 through the window plate 30 of the housing 24, and an image is formed on the photoelectric surface 18 on the inner surface of the incident window 16. The optical image incident on the photoelectric surface 18 is converted into a photoelectric image by the external photoelectric effect of the photoelectric surface 18. The photoelectric image is accelerated and focused by an electron lens (not shown) in the image tube 12 and is reproduced as an optical image through the fluorescent screen 22. The reproduced image is output through the reproduction window 20 of the image tube 12 and a transparent end plate 60 of the housing 24 (i.e. a bottom plate 60 of the cup-like main body 26) which is opposed to and spaced from the reproduction window 20.

The Peltier elements 38 serve to absorb heat from the photoelectric surface 18 under the control of the temperature controller 44. More specifically, the heat absorption portions 38b of the Peltier elements 38 absorb heat from the photoelectric surface 18 through the incident window 16, the outward flange 34 and the annular copper plate 36, and the Peltier elements 38 dissipate the heat from the heat dissipation portions 38a to the annular heat dissipation plate 32 mounted on the end plate 28. Since the image tube 12 is supported only by the Peltier elements 38 in the vacuum in the housing 24, the image tube 12 is free from the influence of external heat, and hence the photoelectric surface 18 is efficiently cooled. In an experiment, when the external temperature was 20°C and the water-cooled heat dissipation plate temperature was kept at 20°C, the temperature of the photoelectric surface 18 could be decreased to -40°C. With the conventional arrangement shown in Fig. 2, the temperature of the photoelectric surface could be decreased to only -20°C. As described above, according to the present invention, the cooling efficiency with respect to a photoelectric surface is very high, and a

reduction in energy consumption can be achieved. Of course, this cooling temperature varies depending on the thermal capacities of the Peltier elements 38, the annular heat dissipation plate 32, the housing 24, and the like.

Fig. 7 is a graph showing the relationship between the temperature of the photoelectric surface 18 and the number of thermoelectrons (dark count) in the dark. It is apparent from this graph that the number of thermoelectrons is reduced with a decrease in the temperature of the photoelectric surface 18. When the generation of thermoelectrons is restricted, thermal noise is reduced and the S/N ratio is increased.

The heat absorbed from the photoelectric surface 18 is dissipated from the annular heat dissipation plate 32 through the heat dissipation portions 38a of the Peltier elements 38 and the end plate 28. However, part of the heat is transferred to the cup-like main body 26 of the housing 24 so that the temperature of the bottom plate 60 on the output side of the housing 24 can be set to be higher than the external temperature. As a result, dew condensation on the surface of the bottom plate 60 of the housing 24 can be prevented. In addition, since the heat from the Peltier elements 38 is also transferred to the window plate 30 on the input side of the housing 24, no dew condensation occurs on the window plate 30. It is apparent that no dew condensation occurs on the incident window 16 and the reproduction window 20 of the image tube 12 housed in the housing 24.

In the above-described experiment, the temperature of the window plate 30 of the housing 24 was 23°C, and the temperature of the bottom plate 60 on the output side of the housing 24 was 20°C.

In addition, as the temperature controller 44 can control voltages applied to the Peltier elements 38 on the basis of a detection value from the temperature detector 46, the temperature of the photoelectric surface 18 can be kept constant. Fig. 8 is a graph showing the spectral sensitivity characteristics of the image tube 12, which are obtained when the temperature of the photoelectric surface 18 is set to be -25°C and +25°C, respectively. As is apparent from this graph, the spectral sensitivity characteristics change with a change in the temperature of the photoelectric surface 18. Therefore, the spectral sensitivity characteristics can be stabilized, and the performance of the image tube 12 can be improved, by means of keeping the temperature of the photoelectric surface 18 constant by the temperature controller 44.

From the invention thus described, it will be obvious that the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An image device comprising:

an image tube including a first end plate having a photoelectric surface formed on an inner surface thereof, and a second end plate located on the opposite side of said first end plate and having a fluorescent screen formed on an inner surface thereof, said image tube being adapted to reproduce on said fluorescent screen an optical image incident on said photoelectric surface through said first end plate;

a housing adapted to house said image tube with a predetermined space therebetween and having an inner space substantially completely evacuated, said housing including a first transparent portion arranged to oppose said first end plate with a predetermined space therebetween, and a second transparent portion arranged to oppose said second end plate with a predetermined space therebetween; and

a plurality of Peltier elements for cooling said photoelectric surface of said image tube and supporting said image tube at a predetermined position in said housing, each Peltier element having a heat absorption portion fixed to said image tube at a position near said photoelectric surface and a heat dissipation portion fixed to said housing at a position near said first transparent portion.

2. An image device according to claim 1, wherein said housing comprises a transparent cup-like main body, an annular metal end plate airtightly fixed to an open end portion of said cup-like main body, and a transparent window plate as said first transparent portion airtightly mounted on a central opening portion of the end plate, said image tube is coaxially arranged in the cup-like main body, and said second transparent portion is a bottom plate of the cup-like main body.

3. An image device according to claim 2, wherein said cup-like main body of said housing essentially consists of a glass material, said end plate of said housing essentially consists of copper, and said window plate of said housing essentially consists of a glass material.

4. An image device according to claim 2, wherein said heat dissipation portion of each of said Peltier elements is fixed to said end plate of said housing.

5. An image device according to claim 2, wherein said heat absorption portion of each of said Peltier elements is fixed to an outward flange provided on an outer peripheral portion of said image

tube, said outer peripheral being adjacent to said first end plate.

6. An image device according to claim 1, further comprising temperature detection means for detecting a temperature of said photoelectric surface of said image tube.

7. An image device according to claim 6, wherein said temperature detection means is a temperature sensor for detecting a temperature of a portion, of said image tube, which is adjacent to said photoelectric surface.

8. An image device according to claim 6, further comprising control means, electrically connected to said temperature detection means and said Peltier elements, for controlling voltages applied to said Peltier elements to keep a temperature of said photoelectric surface constant on the basis of a detection result from said temperature detection means.

9. A photoelectric device comprising a photoelectric surface mounted within a substantially evacuated housing at least a portion of which is transparent, thereby to enable radiation from outside the housing to be incident in a first direction on said photoelectric surface and at least one Peltier element disposed within said housing with its cold surface facing in said first direction and its hot surface facing in a direction opposite to said first direction, thereby to cool said photoelectric surface.

10. An imaging device comprising a photoelectric surface and an imaging surface mounted within a substantially evacuated housing at least a portion of which is transparent, thereby to enable radiation from outside the housing to be incident on said photoelectric surface, the arrangement being such that, in use, such radiation causes photoelectrons to be emitted from said photoelectric surface which are then imaged on said imaging surface, there being provided at least one Peltier element disposed within said housing with its hot surface in proximity to said housing and its cold surface disposed so as to exert a greater cooling effect on said photoelectric surface than on said imaging surface.

Fig. 1

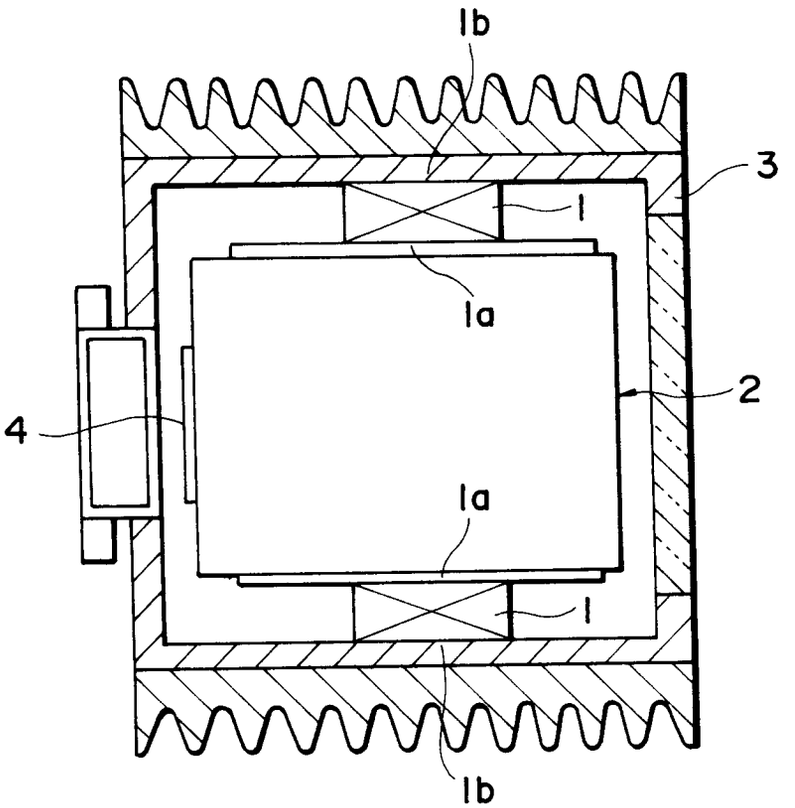


Fig. 2

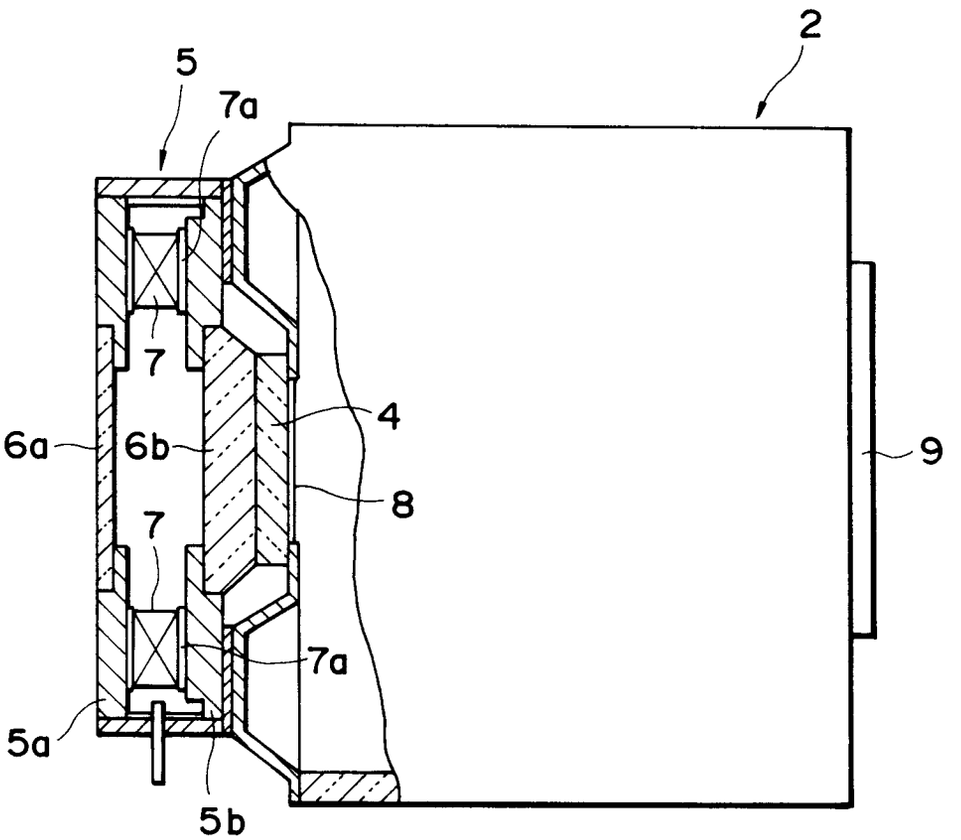


Fig. 3

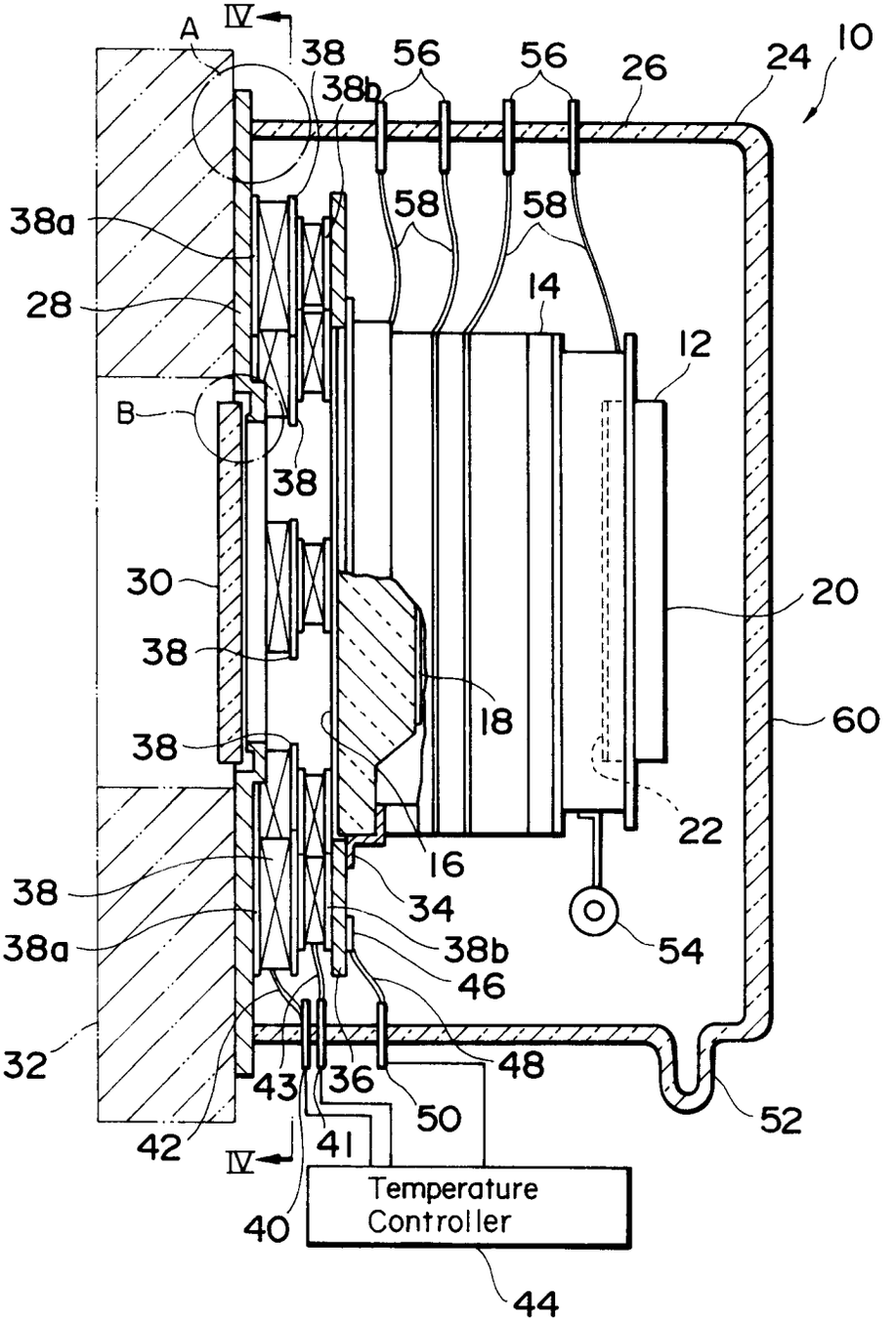

A
IV
38
56
56
26
24
10
38b
38a
58
58
28
14
12
B
38
30
20
38
18
38
60
22
16
38
34
38a
38b
54
46
32
48
43
36
50
52
42
41
IV
Temperature Controller
40
44

Fig. 4

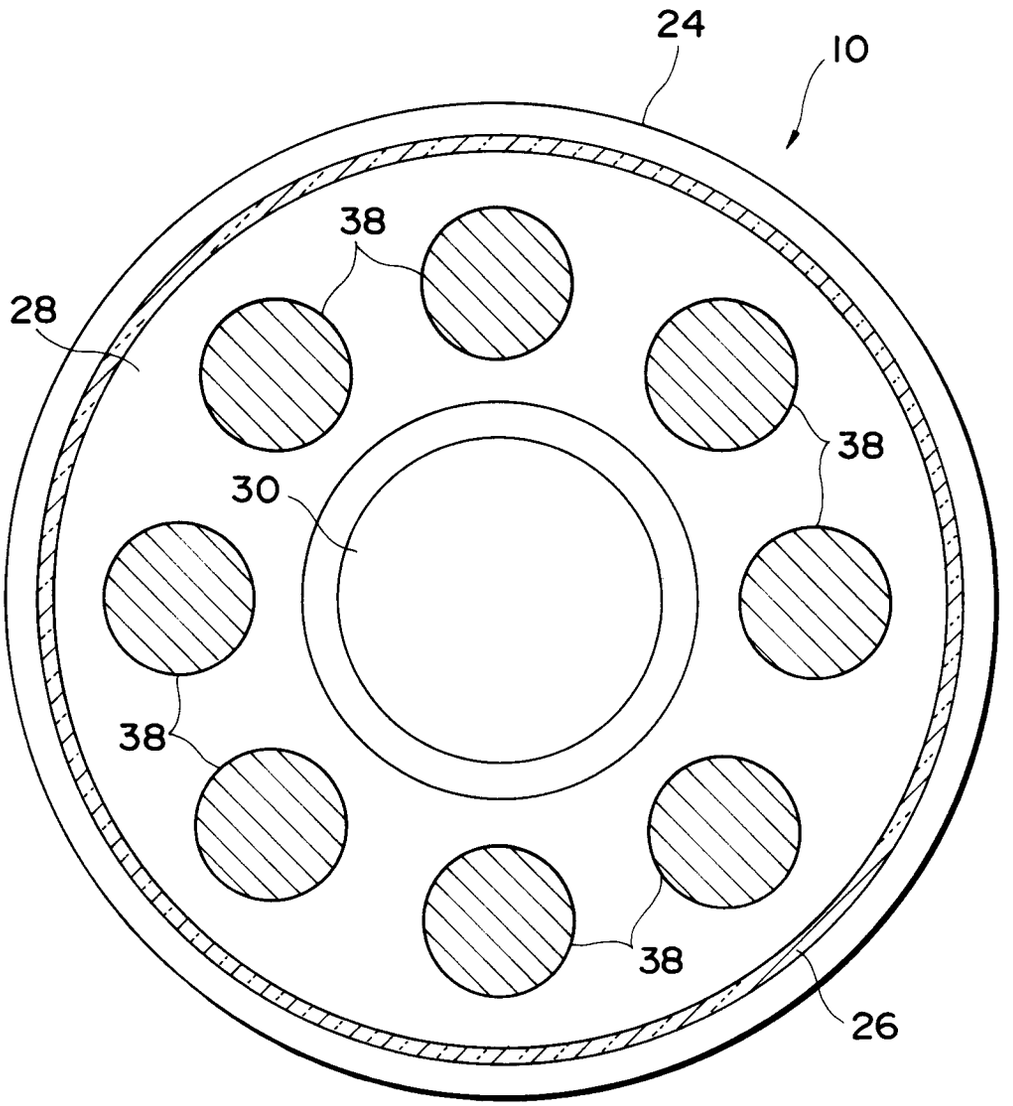


Fig. 5

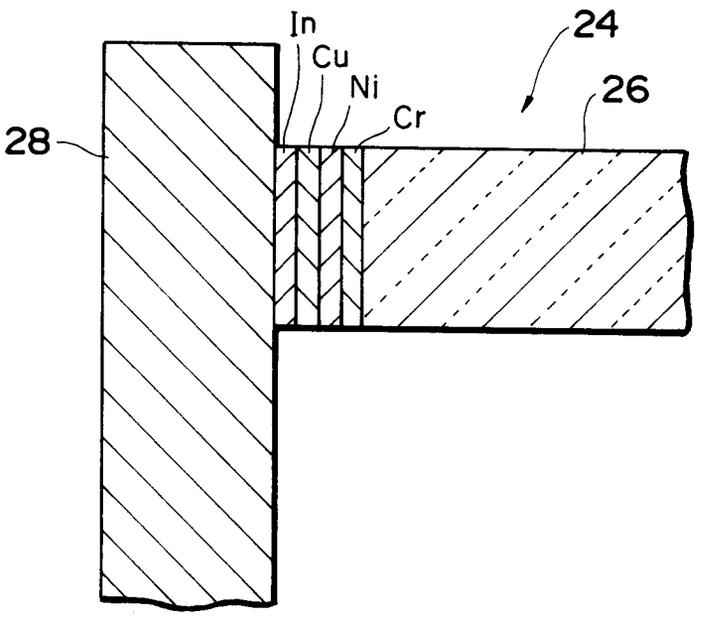


Fig. 6

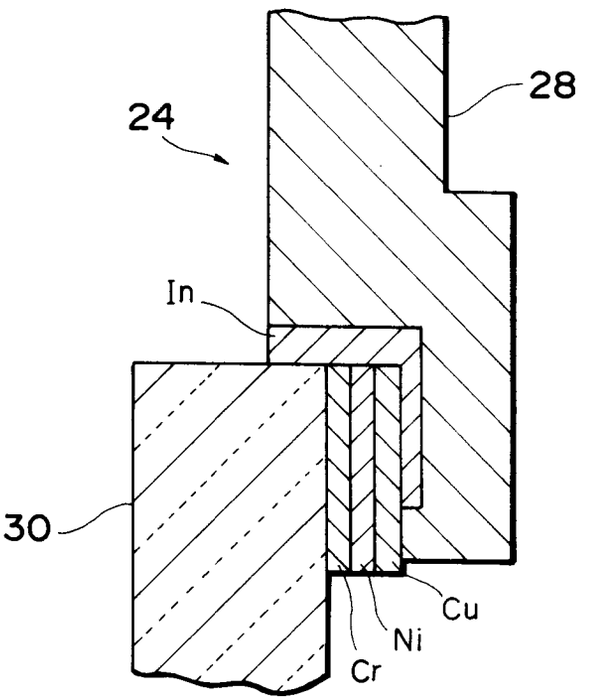


Fig. 7

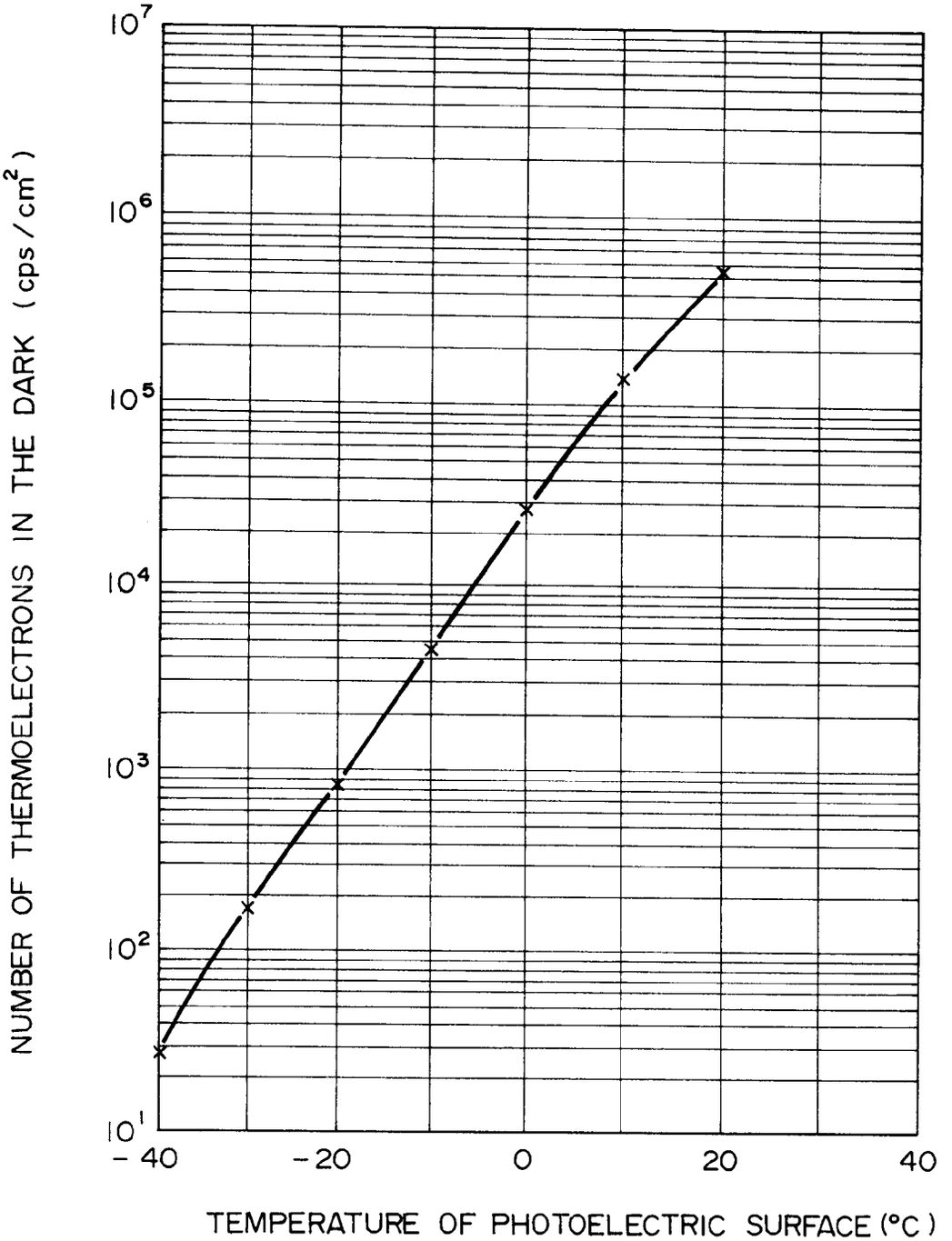
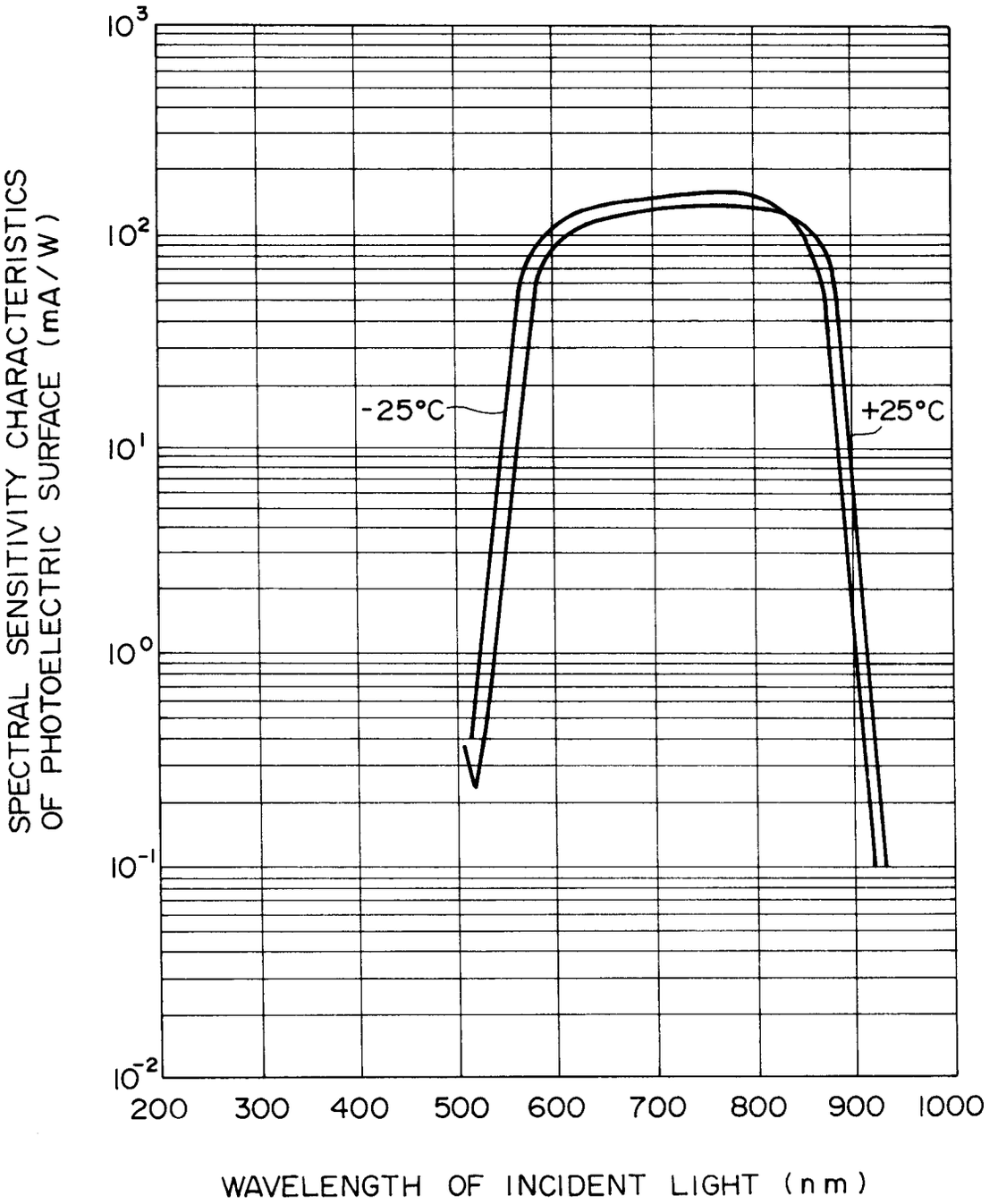

10^7
10^6
10^5
10^4
10^3
10^2
10^1
NUMBER OF THERMOELECTRONS IN THE DARK (cps / cm^2)
- 40
-20
0
20
40
TEMPERATURE OF PHOTOELECTRIC SURFACE (°C)

Fig. 8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10^1
10^0
10^{-1}
10^{-2}
-25°C
+25°C
200
300
400
500
600
700
800
900
1000
WAVELENGTH OF INCIDENT LIGHT (nm)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7605

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	US-A-3 712 986 (COLLINGS) * claim 1; figures 1-3 * * column 2, line 11 - column 3, line 16 * ---	1-3,9,10	H01J29/00
D,A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 24 (E-576)23 January 1988 & JP-A-62 180 930 (HAMAMATSU) 8 August 1987 * abstract * ---	1,9,10	
A	US-A-5 118 947 (HAMASHIMA ET AL.) * column 1, paragraph 1 * * column 3, line 50 - column 4, line 2 * * column 4, line 52 - column 5, line 4; figure 2 * -----	6,7	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

H01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 December 1993	Greiser, N

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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O : non-written disclosure
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D : document cited in the application
L : document cited for other reasons

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