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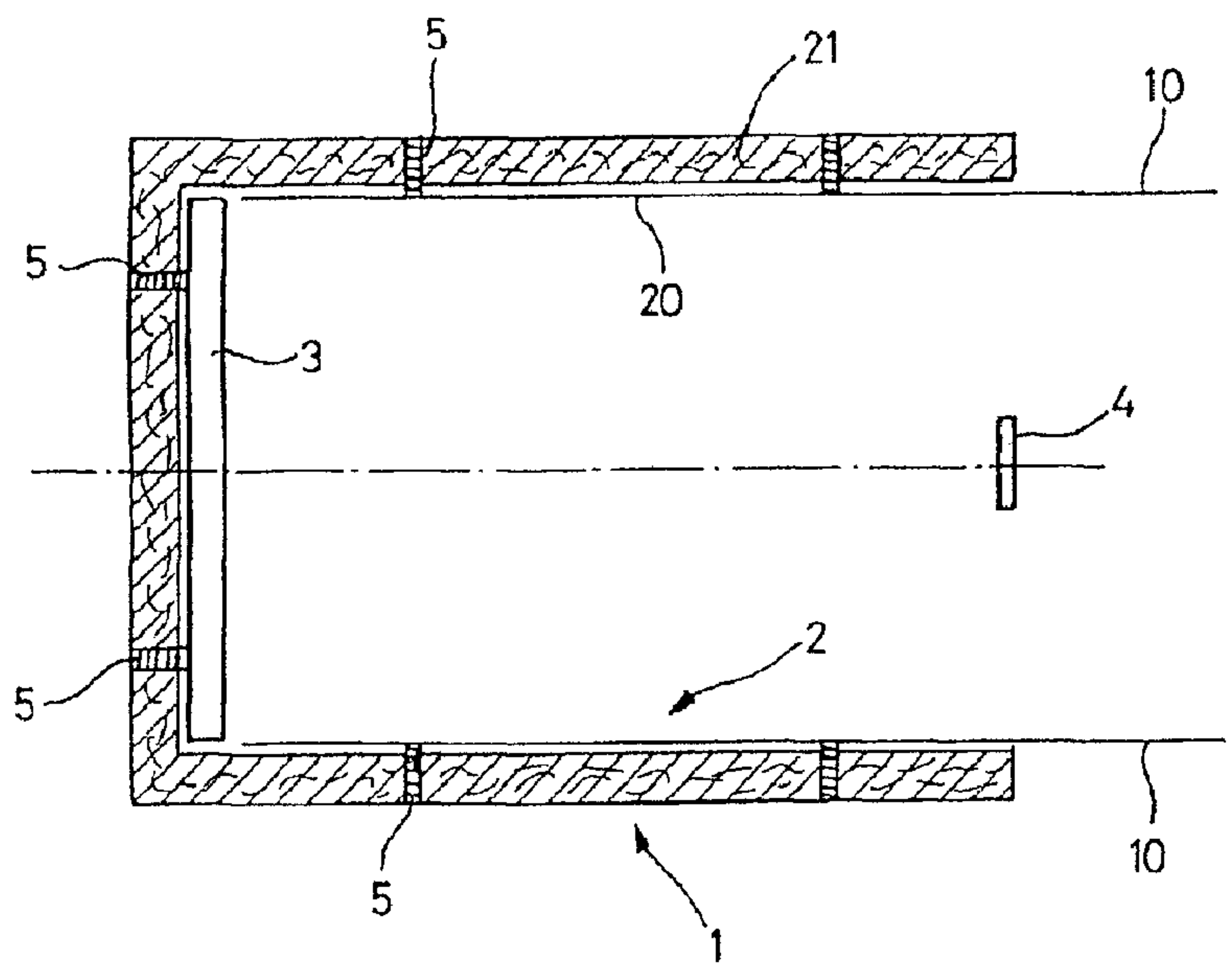
(54) **Titre : INSTRUMENT OPTIQUE COMPRENANT UNE CAVITE D'ENTREE DANS LAQUELLE EST PLACE UN MIROIR**
(54) **Title: OPTICAL INSTRUMENT COMPRISING AN ENTRANCE CAVITY IN WHICH A MIRROR IS PLACED**



(57) **Abrégé/Abstract:**
The invention concerns an optical instrument (1) comprising at least one mirror called primary mirror (3), arranged in a cavity (2) and comprising an active surface capable of being subjected to instantaneous variations of the incident radiant flux. The invention

(57) **Abrégé(suite)/Abstract(continued):**
is characterized in that the cavity (2) comprises an inner rigid envelope (20) around the mirror made of a material having thermal inertia so as to dampen the instantaneous variations of the incident radiant flux thereby enabling the temperature fluctuations of said cavity to be limited, and hence, the fluctuations of the mirror.

The invention is applicable to the field of space technology.

ABSTRACT

The invention relates to an optical instrument (1) comprising at least one mirror called the primary mirror (3), placed in a cavity (2) and comprising an active face capable of being subjected to instantaneous variations of the incident radiative flux. According to the invention, the cavity (2) comprises a rigid internal casing (20) around the mirror consisting of a material having a thermal inertia so as to damp the instantaneous variations of the incident radiative flux thereby making it possible to limit the temperature fluctuations of this cavity and, consequently, the temperature fluctuations of the mirror.

The invention applies to the space field.

Figure 2.

OPTICAL INSTRUMENT COMPRISING AN ENTRANCE CAVITY IN WHICH A MIRROR IS PLACED

The invention relates to an optical instrument comprising an entrance cavity in which a mirror called the primary mirror is placed.

The invention applies to any optical instrument comprising a mirror requiring a very great thermal stability, in order to limit the thermoelastic deformations, in particular over short periods, for example one to two hours.

The invention applies most particularly but not exclusively to the optical instruments used in the space field such as the optical instruments on board satellites (typically telescopes).

Specifically, certain optical instruments such as telescopes require a very great geometric stability of their primary mirror at ambient temperature, both over the long term and short term.

With the use of new ceramic materials (silicon carbide-based: CeSiC, SiC, etc.) for producing mirrors, this constraint results, amongst other things, in a high thermal stability in terms of variation of gradient in the thickness of the mirror and in terms of temperature fluctuation of the active face. These mirrors, called primary mirrors, situated in an entrance cavity of the instrument, are subjected directly or indirectly to the external flux variations (solar, terrestrial or albido) on the orbit, and all the year round.

Hitherto, the thermal regulation of such mirrors has been provided by an active regulation of the rear face radiative type. "Active" regulation is carried out conventionally by heaters driven by thermostats or by onboard software coupled to thermistors. This type of regulation makes it possible to maintain the temperature of the mirror at a defined level and to compensate for the variations of flux absorbed by the front face during the year. On the other hand, this type of regulation does not make it possible to compensate for the orbital fluctuations in the context of a satellite in low Earth orbit, because of the purely radiative mode of exchange between the heaters and the mirror.

Other solutions, of the active optical type, exist but are costly and complex to apply because of the use of dedicated electronics and complex functional tests on the ground, and they have a risk of failure.

A direct thermal regulation of the active face would make it possible to obtain an equivalent level of stability of the mirror, but this solution is, to the knowledge of the applicant, not achieved and would present risks of thermoelastic deformation.

The object of the present invention is to solve this problem.

Specifically, the invention proposes a solution to the problem of very great thermal stability demanded at the primary mirror of an optical instrument. Its object is to provide a solution notably with respect to fluctuations of short periods in the case of satellite optical instruments from low Earth orbit to geostationary.

The proposed solution consists in producing an entrance cavity of the instrument comprising a rigid casing creating a thermal inertia of all or a portion of the cavity.

The thermal inertia of this casing, situated in the immediate vicinity of the primary mirror where the radiative exchanges are the greatest, makes it possible to limit the temperature fluctuations of the cavity and, consequently, the temperature fluctuations of the mirror.

More particularly, the subject of the present invention is an optical instrument comprising at least one mirror called a primary mirror placed in a cavity, the primary mirror comprising an active face capable of being subjected to instantaneous variations of the incident radiative flux, characterized in that the cavity comprises a rigid internal casing around the mirror forming at least a portion of the cavity, this casing consisting of a material having a thermal inertia so as to dampen the instantaneous variations of the incident radiative flux thereby making it possible to limit the temperature fluctuations of this cavity and, consequently, the temperature fluctuations of the mirror.

To limit the weight of the instrument, the rigid internal casing extends over a first portion of the cavity defined as being close to the mirror, this portion going from the mirror to a distance d less than the total length l of the entrance cavity of the instrument.

Advantageously, the first casing is made of aluminum or any other materials having a high thermal inertia (e.g. beryllium).

Advantageously, the aluminum casing has a thickness of approximately 1 mm.

According to another feature, the cavity also comprises a second casing consisting of a thermal insulating material placed over the whole perimeter of the cavity and at the bottom of the latter, that is to say behind the mirror.

If the second casing forms a first cavity portion, the second casing covers the first and extends this first cavity portion to form a second portion in continuity with the first.

Advantageously, the second casing consists of a Multi-Layered Insulation (MLI) structure.

According to another feature, the instrument also comprises active means for controlling the temperature of the mirror.

The invention applies to telescopes on board satellites irrespective of the size of their primary mirror.

Other particular features and advantages of the invention will clearly appear on reading the description which is made below and which is given as an illustrative and nonlimiting example and with respect to the drawings in which:

- figure 1 represents a longitudinal section of the optical instrument according to one embodiment,
- figure 2 represents a longitudinal section of the optical instrument according to a second embodiment.

The instrument 1 described comprises a cavity 2 making it possible to receive the mirror 3, called the primary mirror, and to attach it to the instrument by conventional attachment means 5. Usually, the mirror is in a tubular cavity with a diameter slightly greater than its own so as to come on the periphery of this mirror. The mirror 3 is centered in the cavity and its active face is turned toward the entrance of the cavity, the place for the location of a secondary mirror 4.

In the prior art, the cavity is made by a thermal insulation casing made by an insulation cover called MLI (Multi-Layered Insulation) painted black on the inside of the cavity and having great temperature variations.

Rather than using a conventional insulation casing, the proposed solution consists in using an entrance cavity for the optical instrument 1 having a great thermal inertia. For this, the cavity 2 comprises at least one portion made of a material with high inertia with respect to the rapid temperature fluctuations. Therefore, the entrance cavity of the instrument produced according to the invention is less sensitive to the external fluctuations, notably with respect to rapid fluctuations of the orbital type.

For this purpose, the entrance cavity 2 of the optical instrument 1 comprises a rigid internal casing 20 around the mirror 3 consisting of a material having a thermal inertia damping the instantaneous variations of the incident radiative flux. The thermal inertia casing limits the temperature fluctuations of the cavity and, consequently, the temperature fluctuations of the mirror.

The thermal inertia rigid casing 20 is of tubular shape and forms all or a portion of the entrance cavity of the optical instrument 1. Two exemplary embodiments corresponding to these two alternatives are illustrated by the diagrams of figures 1 and 2.

In the diagram of figure 1, the casing 20 forms all the cavity 2. In this case, the length of the casing 20 corresponds to that of the entrance cavity 2. The casing, in this case, goes from the primary mirror 3 to the entrance of the cavity which corresponds to the location of the secondary mirror 4.

However, in certain applications, for reasons of limiting the weight of the optical instrument, the casing 20 will preferably have a length that is less than that of the entrance cavity while remaining sufficiently long to perform its function of damping instantaneous variations of the incident radiative flux. This exemplary embodiment is illustrated by the diagram of figure 2, the casing 20 forming only a portion of the cavity 2.

The diameter of the casing 20 is slightly greater than that of the primary mirror 3 so that the latter can be placed on the periphery of the mirror 3.

In all cases, the cavity portion having a thermal inertia or the whole of the cavity having this thermal inertia relative to the thermal fluctuations is covered with a thermal insulation casing 21 of the multi-layered type "MLI".

If only a portion of the cavity comprises a thermal inertia rigid casing as shown in figure 2, the insulation casing 21 covering this cavity portion extends over the whole length of the entrance cavity, its inner surface being in the extension of the inner surface of the thermal inertia casing 20.

A material such as aluminum having a high calorific capacity and a good thermal conductibility may advantageously be used to produce the thermal inertia casing.

The inner face of the cavity portion A made of aluminum 20 is painted black for optical reasons, and the outer face is insulated from the instrument 1 with the MLI-type multi-layered insulation casing 21 in order to maintain a temperature level sufficiently low that makes it possible to regulate the mirror at approximately 20°C.

Depending on the requirement, the proposed solution may be further enhanced with means 6 and 7 illustrated in figure 2, conventionally used to control temperature, namely:

1) an active control 7 of the temperature of the rigid casing with the aid of a regulation of the Proportional-Integral-Derivative type, for example, which makes it possible to further reduce the thermal fluctuations of the casing and hence of the mirror.

2) the association of an active regulation of the mirror on the rear face of the radiative type 6 which becomes, with the presence of the high thermal inertia cavity, markedly more effective for compensating for the short-duration fluctuations, of the orbital type. This is due to the fact that the instantaneous variations of the radiative flux originating from the close cavity are damped, because of the inertia of the cavity, relative to the variations originating from a cavity comprising only an insulation of the MLI type.

3) the association of an active regulation of the mirror on the rear face of the radiative type, whose control loop is driven by the temperature of the cavity, thereby making it possible to anticipate and compensate for the temperature fluctuations of the mirror.

As an example, a thermal model of an assembly comprising:

one primary mirror 3 with a diameter of 1.3 m

- the cavity 2 being furnished with a rigid aluminum casing 20 of approximately 1 mm over the half A of the length, that is a length of 1.2 m,

- the cavity 2 being covered with an insulation casing 21 of the MLI type covering the aluminum casing and extending the casing 20 to form the other half B of the cavity,

one secondary mirror 4

one entrance baffle 10,

has made it possible, for a satellite in low Earth orbit, to quantify the gains obtained according to the invention:

Structure of the cavity of the optical instrument	Orbital variation of the mean temperature of the primary mirror (active face)	Orbital variation of the thermal gradient in the thickness of the primary mirror
	(mK)	(mK)
Conventional (cavity covered with MLI)	310	12.4
Half of the cavity with rigid aluminum internal casing, not regulated	110	4.8
Half of the cavity with aluminum internal casing, regulated	90	3.6
Active regulation of the mirror (radiative type) and half of the cavity with aluminum internal casing (not regulated)	16	1.7

Therefore, the modification of the structure of the entrance cavity of the optical instrument as proposed makes it possible to attenuate the incidence flux variations seen by the active face of the mirror, and notably the fluxes originating from the near cavity.

A cavity comprising an aluminum tubular casing 1.2 m long and 1 mm thick in the environment close to the primary mirror with a 1.3 m diameter is sufficient to obtain these results.

An optimization of the length of the rigid casing is necessary depending on the stability requirements demanded and the increased weight generated.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An optical instrument comprising:

at least one primary mirror placed in a cavity, each primary mirror comprising an active face capable of being subjected to instantaneous variations of incident radiative flux;

a rigid internal first casing around the at least one mirror and forming at least a first portion of a sidewall of the cavity, the first casing formed of a material having a thermal inertia so as to dampen the instantaneous variations of the incident radiative flux thereby making it possible to limit temperature fluctuations of the cavity and, consequently, temperature fluctuations of the at least one mirror; and

a second casing positioned to cover the first casing and extending to form a second portion of the sidewall of the cavity, the second casing being formed of a thermal insulating material.

2. The optical instrument as claimed in claim 1, wherein the first portion of the cavity is defined as being close to the at least one mirror, said first portion extending from the at least one mirror to a distance d less than a total length l of the cavity.

3. The optical instrument as claimed in claim 1 or 2, wherein the first casing is made of aluminum.

4. The optical instrument as claimed in claim 1 or 2, wherein the first casing is made of beryllium.

5. The optical instrument as claimed in claim 3 or 4, wherein the first casing has a thickness of approximately 1 mm.

6. The optical instrument as claimed in any one of claims 1 to 5, wherein the second casing is placed over the whole surface of the cavity including at the bottom of the cavity behind the at least one mirror.

7. The optical instrument as claimed in claim 6, wherein the second casing forms the second portion in continuity with the first portion.

8. The optical instrument as claimed in claim 6, wherein the second casing consists of a Multi-Layered Insulation (MLI) structure.

9. The optical instrument as claimed in any one of claims 1 to 8, further comprising active means for controlling the temperature of the at least one mirror and of the rigid casing.

FIG_1

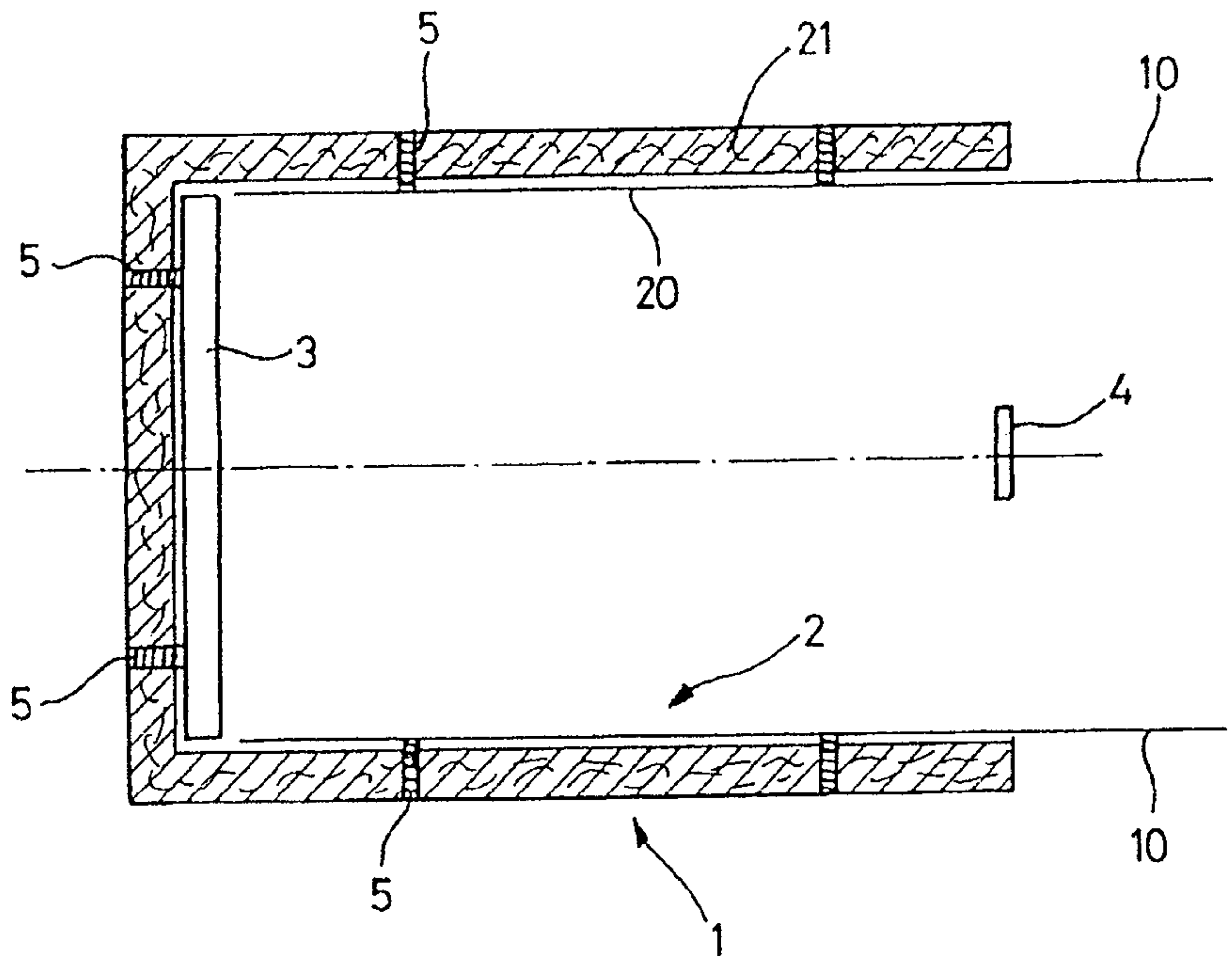
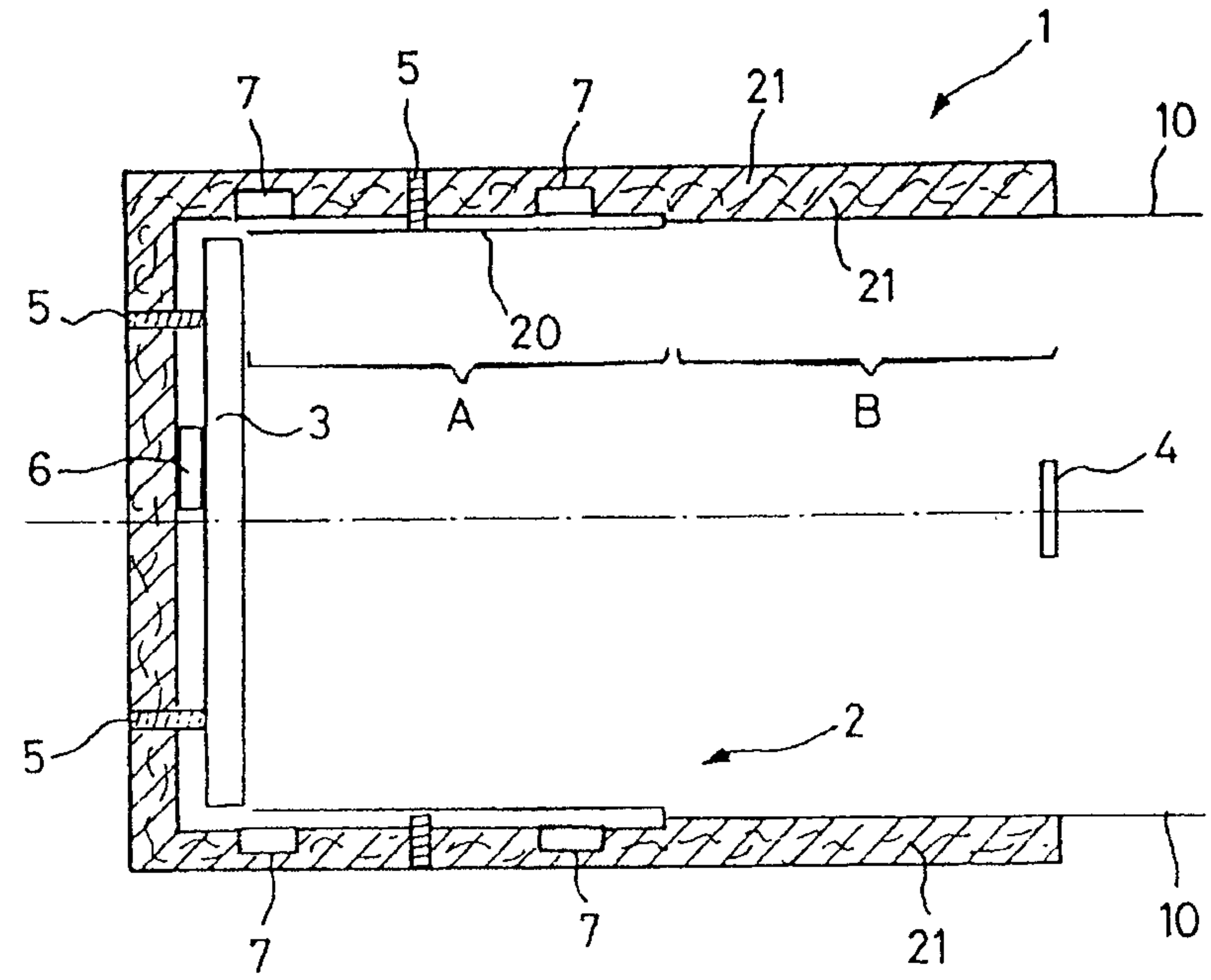
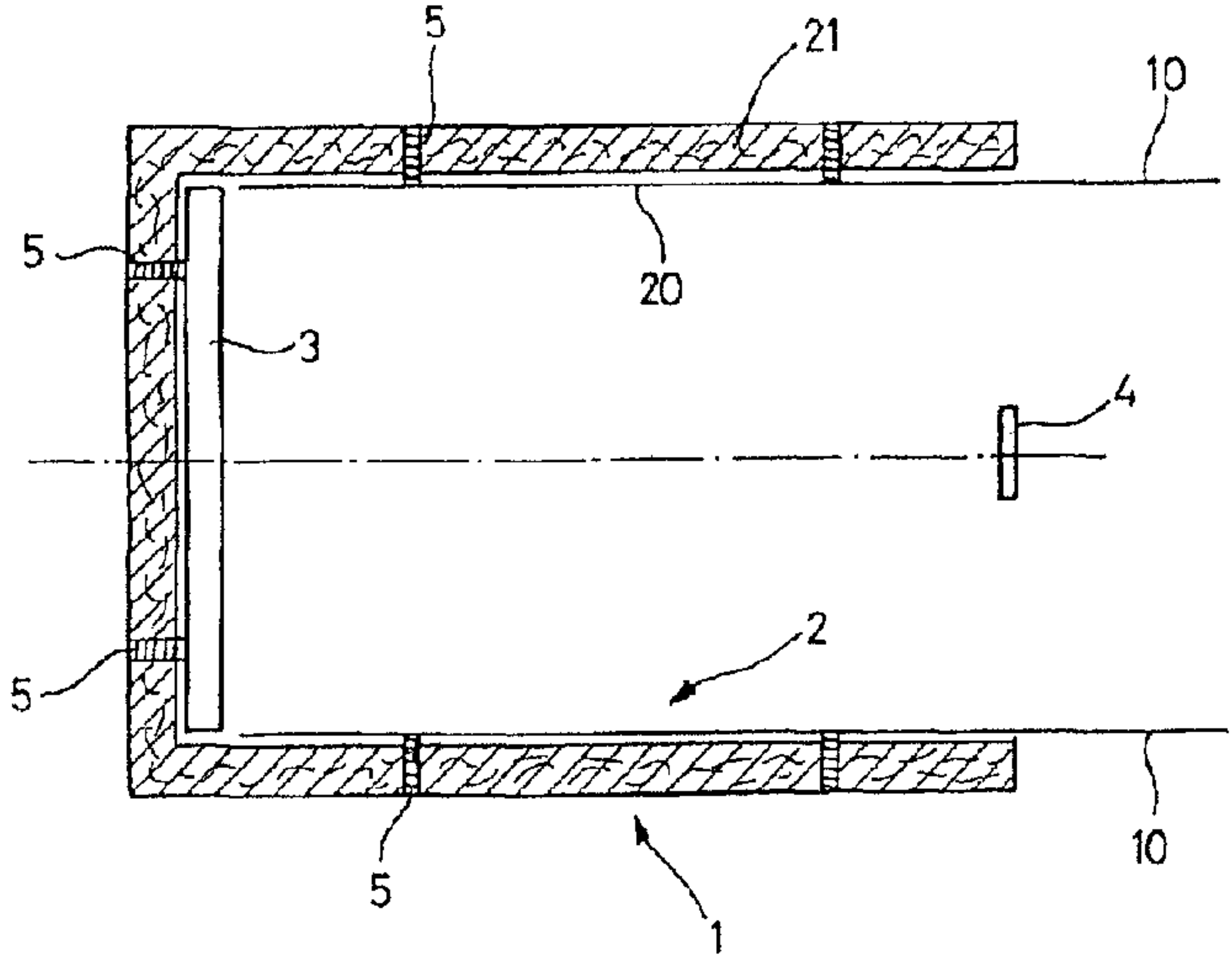


FIG_2

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