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(54) Metal vapor discharge lamp.

(57) A metal vapor discharge lamp including a hermetically sealed bent-shape bulb (16) made of translucent ceramic material, a pair of electrodes (20, 20) mounted in the bulb (16) through both ends of the bulb (16) end metal vapor filled in the bulb, wherein the bulb (16) has a wall load A W/cm^2 and an inner bulb diameter Di mm which satisfy the following two relations ;

$$12 \leq A \leq 30, \text{ and}$$

$$Di \leq -0{,}5 \times A + 18.5.$$

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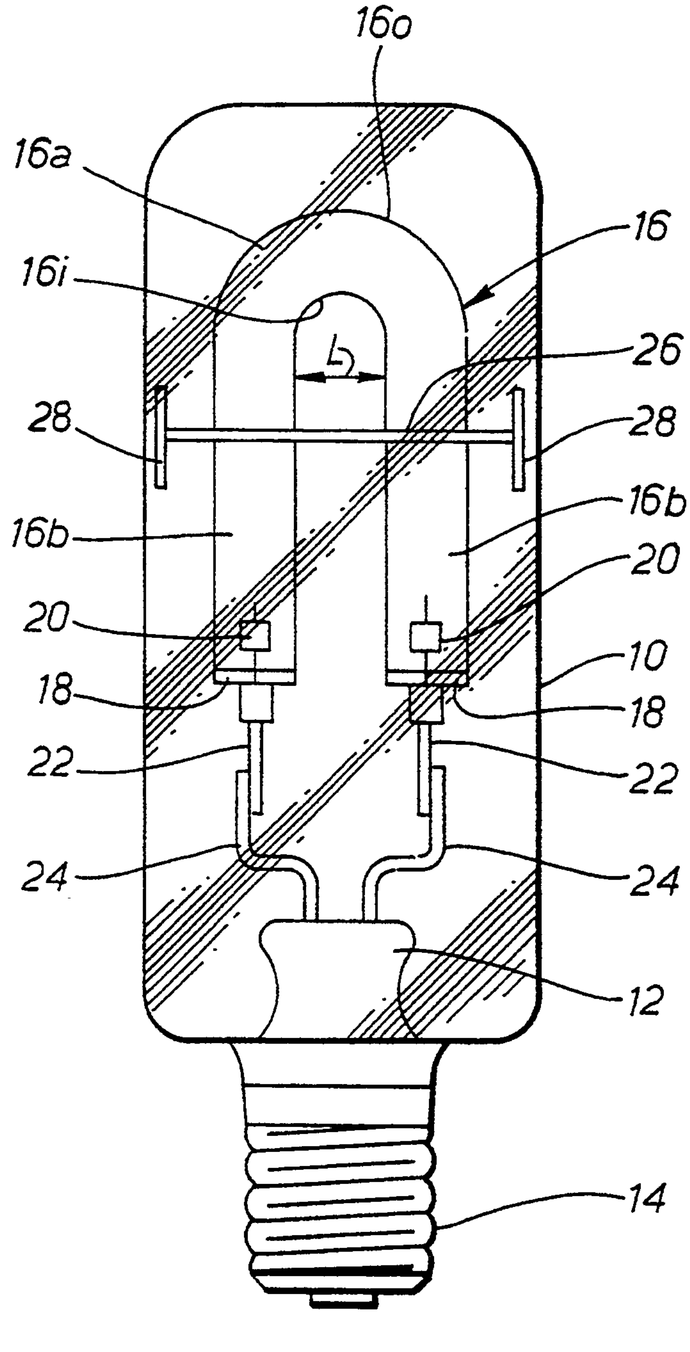
FIG.1



The present invention relates generally to a metal vapor discharge lamp, and more particularly, to a metal vapor discharge lamp having a bent-shape ceramic bulb.

A metal vapor discharge lamp such as a sodium discharge lamp generally comprises a hermetically sealed light source bulb made of translucent material, e.g., a glass tube, a pair of electrodes mounted in the light source bulb through both ends of the bulb, sodium vapor and mercury vapor filled in the bulb as a luminous material and a buffer material, respectively, and rare gas for a lighting starter filled in the light source bulb.

Recently, a metal vapor discharge lamp having a translucent ceramic bulb such as an alumina glass bulb has been developed. Alumina glass has an excellent corrosion-resistancy to sodium and an excellent heat-resistancy in comparison to silica glass.

Thus, this kind of discharge lamp (referred to as a ceramic discharge lamp hereinafter) may present a higher lamp efficiency in comparison to a conventional discharge lamp having the silica glass bulb.

The ceramic bulb, such as the alumina glass bulb, however, is hard to be formed into a bent-shape bulb, due to its higher heat-resistancy. That is, the ceramic bulb needs a very high temperature to be softened enough for a hot shaping. Thus, conventionally the ceramic discharge lamp had a straight ceramic bulb.

Recently, metal vapor discharge lamps have been studied for use as interior lighting sources. The interior lighting sources are generally demanded to be as small in size as possible.

In miniaturizing such discharge lamps as described above, it is an important point to reduce the size of the light source bulb.

A good approach for reducing the size of the light source bulb is to form the bulb into a bent-shape bulb, e.g., a U-shape bulb. Because the light source bulb is formed in a curved shape, it becomes possible to form the light source bulb into the bent-shape bulb while a distance between electrodes is kept at a required value. Thus, it was highly typical to use a metal vapor discharge lamp having a bent-shape silica glass bulb for the interior lighting sources.

In case of conventional sodium discharge lamps having a straight alumina glass bulb with a rating power, 70 W through 1000 W, the alumina glass bulb has been designed to have a thickness, 0.5 through 1.2 mm, and the discharge lamps were operated at a wall load about 12 through 30 W/cm^2.

If the wall load is quite low, the bulb wall temperature does not rise sufficiently for obtaining a desired lamp efficiency. On the other hand, if the wall load is excessively high, the bulb wall temperature rises to excessively high to cause a sublimation of the alumina glass bulb. The sublimation of the alumina glass bulb results a blackening of an outer envelope encompassing the light source bulb.

In case of conventional sodium discharge lamps having a bent-shape alumina glass bulb which is designed in similar to the above-mentioned case, i.e., the straight bulb ones, an arc discharge occurs at an abnormal position close to the inner radius wall of the bent section so that a large temperature difference results between the outer radius wall and the inner radius wall of the bent section. When the temperature difference becomes excessive, it causes a breakage of the light source bulb.

Such a breakage can be avoided by reducing the wall load, but it leads to a deterioration ofthe lamp efficiency.

The present invention seeks to provide a ceramic discharge lamp, i.e., a metal vapor discharge lamp having a bent-shape ceramic bulb which is not easily broken, without deteriorating the lamp efficiency.

The present invention also seeks to provide a ceramic discharge lamp which is able to reduce a temperature difference a temperature imbalance between the outer radius wall and the inner radius wall of the bent section of the bulb.

The ceramic discharge lamp according to one aspect of the present invention includes a hermetically sealed bent-shape bulb made of translucent ceramic material, a pair of electrodes mounted in the light source bulb through both ends of the bulb and metal vapor filled in the bulb, wherein the bent-shape ceramic bulb has a wall load A W/cm^2 and an inner bulb diameter Di mm which satisfy the following two relations;

$$12 \leq A \leq 30, \text{ and}$$
$$Di \leq -0.5 \times A + 18.5.$$

A more complete appreciation of the present invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIGURE 1 is a section showing a metal vapor discharge lamp according to an embodiment of the present invention; and

FIGURE 2 is a graph showing a result of breakage examining test implemented on different samples of the metal vapor discharge lamp having bent-shape ceramic bulb.

The present invention mill be described in detail with reference to the FIGURES 1 and 2.

Referring now to FIGURE 1, a first embodiment of the ceramic discharge lamp having a bent-shape ceramic bulb according to the present invention will be described in detail. In FIGURE 1, an outer envelope 10 made of, e.g., quartz glass, is evacuated and sealed its one end by a stem 12. The stem 12 is coupled to the Edison socket 14.

The outer envelope 10 houses a U-shape light source bulb 16 made of a translucent ceramic, e.g., an alumina glass. The light source bulb 16 thus includes a U-shape section 16a and a pair of straight sections 16b, 16b which are separated by a gap L.

Both ends of the light source bulb 16 are hermetically sealed with, for instance, ceramic disks 18, 18 through a solder (not shown) such as metallic oxide. These ceramic disks 18, 18 support electrodes 20 and 20, respectively.

For example, the light source bulb 16 had following dimensions:

A) Inner diameter Di of about 7.25 mm;

B) Outer diameter Do of about 8.75 mm;

C) Gap L of about 90 mm;

D) Center radius of curvature R of the U-shape section 16a of about 7.5 mm; and

E) Height H of light source bulb 16 of about 40 mm.

Further, the light source bulb 16 is filled with a sodium amalgam (not shown) including sodium at the ratio of 10 through 25 weight percentage and xenon gas at the pressure of 20 through 700 Torr.

The electrodes 20, 20 are coupled to lead wires 22, 22 which extend from the straight sections 16b, 16b of the light source bulb 16 through the ceramic disks 18, 18, respectively.

The lead wires 22, 22 are coupled to support wires 24, 24 which extend in the the outer envelope 10 through the stem 12. Thus the light source bulb 16 is held in the space of the outer envelope 10. Other ends of the support wires 24, 24 are coupled to the Edison socket 14 as usual.

Further the straight sections 16b, 16b of the light source bulb 16 are fastened by a bulb holder 26 which is suspended between opposite walls of the outer envelope 10. Both ends of the bulb holder 26 are elastically fixed on the walls through elastic plates 28, 28, respectively. Thus, the light source bulb 16 is securely held in the outer envelope 10.

As a result of the above construction, the straight sections 16b, 16b of the light source bulb 16 are aligned to the longitudinal direction of the outer envelope 10, while the U-shape section 16a of the light source bulb 16 faces a top end of the outer envelope 10 which is opposite to the stem 12.

Now, a breakage examining teat implemented on different samples of the metal vapor discharge lamp having the U-shape ceramic bulb, will be described below. The test was performed by varying the wall load A and the inner diameter Di of the light source bulb 16. The wall load A was varied from 10 to 33 W/cm^2, while the inner diameter Di was varied from 2.0 to 9.5 mm. The result of the test is shown in the following table 1.

Table 1 (Part 1)

Inner Diameter Di (mm)	Wall Load A (W/cm^2)	Breakage Presence (×) None (o)
9.5	12	×
9.5	21	×
8.0	10	o
8.0	12	o
8.0	16	o
8.0	21	o
8.0	24	×
6.5	12	o
6.5	16	o
6.5	21	o
6.5	24	o
6.5	27	×
5.0	12	o
5.0	16	o
5.0	24	o
5.0	27	o
5.0	30	×

Table 1 (Part 2)

Inner Diameter Di (mm)	Wall Load A (W/cm^2)	Breakage Presence (x) None (o)
3.5	12	o
3.5	16	o
3.5	24	o
3.5	30	o
3.5	33	x
2.0	12	x
2.0	16	x
2.0	21	x
2.0	24	x
2.0	27	x
2.0	30	x

The results of the breakage examining test, i.e., the presence (x) or absence (o) of the breakage shown in Table 1 are also shown in FIGURE 2. As seen from FIGURE 2, it is revealed that when the inner diameter Di exceeds 8 mm the light source bulb 16 is damaged regardless of the wall load A, and when the inner diameter Di is outside a border given by the function; Di = - 0.5 x A + 18.5 the light source bulb 16 is broken.

The inventors of the present invention have investigated a cause of the breakage so that it is estimated that the breakage has a close relation to the position of an arc of discharge occurring between the electrodes 20, 20. When the diameter of the light source bulb 16 is reduced, the discharge arc comes close to the bulb wall of the light source bulb 16. By the way, the heat of the inner radius wall 16i is hardly dissipated in comparison to the outer radius wall 16o. It causes a temperature difference between the inner radius wall 16i and the outer radius wall 16o. Thus, when the inner diameter Di of the light source bulb 16 is reduced to less than 3.5 mm, the breakage of the light source bulb 16 occurs.

On the other hand, it is estimated that when the diameter of the light source bulb 16 is increased, the discharge arc becomes close to the inner radius wall 16i of the light source bulb 16. This is because the discharge arc tends to take its shortest route at the position near the inner radius wall 16i in the U-shape section 16a. This also causes a large temperature difference between the inner radius wall 16i and the outer radius wall 16o. Thus, when the inner diameter Di of the light source bulb 16 exceeds 8.0 mm, the breakage of the light source bulb 16 again occurs.

Further, it is estimated that when the diameter of the light source bulb 16, i.e., the inner diameter Di is within the range from 3.5 mm to 8.0 mm, the breakage occurs in relation to both the inner diameter Di and the wall load A of the light source bulb 16. The above function; Di = - 0.5 x A + 18.5 gives the border.

It was revealed by the test that the wall load A must be set at 12 w/cm^2 or above, otherwise a lamp efficiency remarkably drops.

Further, another breakage examining test was implemented in regard to the gap L between the straight sections 16b, 16b of the light source bulb 16. Because it was estimated that the gap L would also affect the position of the discharge arc. The test was performed by varying the gap L from 2.7 mm to 14.5 mm. The result of the test is shown in the following table 2.

Table 2 (Part 1)

Wall Load A (W/cm^2)	Inner Diameter Di (mm)	Outer Diameter Do (mm)	Gap L (mm)	Breakage Presence (x) None (o)
12	3.5	5.0	2.7	x
12	3.5	5.0	3.0	o
12	3.5	5.0	3.2	o
12	6.0	7.5	4.2	x
12	6.0	7.5	4.5	o
12	6.0	7.5	4.7	o
12	8.0	9.5	5.5	x
12	8.0	9.5	5.7	o
12	8.0	9.5	6.0	o

Table 2 (Part 2)

Wall Load A (W/cm^2)	Inner Diameter Di (mm)	Outer Diameter Do (mm)	Gap L (mm)	Breakage Presence (x) None (o)
21	12.0	13.5	13.7	x
21	12.0	13.5	14.1	o
21	12.0	13.5	14.5	o
25	6.0	7.5	9.0	x
25	6.0	7.5	9.3	o
25	6.0	7.5	9.5	o
30	3.0	5.0	7.2	x
30	3.0	5.0	7.5	o
30	3.0	5.0	7.7	o

As a result of investigation of the later test as shown in Table 2, it is revealed that the relation as shown below exists among the outer diameter Do, the wall load A and the gap L, in connection with the occurrence of the breakage of the light source bulb 16. That is, when the condition; $L \geq Do \times A/20$ is satisfied, the light source bulb 16 will not be broken.

This is because that if the gap L is too small the curvature of the U-shape section 16a becomes very sharp. This also causes the position of the discharge arc to come close to the inner radius wall 16i of the U-shape section 16a. This causes the temperature at the inner radius wall 16i to rise strongly in comparison to the outer radius wall 16o. Thus, when the wall load A is set at a relatively high, the temperature difference between the inner radius wall 16i and the outer radius wall 16o becomes large to make the light source bulb 16 be broken.

As described above, it is revealed that the light source bulb with the U-shape section will not be broken when at least the following two relations are satisfied;

$$12 \leq A \leq 30$$

$$Di \leq -0.5A + 18.5$$

Further the safety of the light source bulb is increased by the following relation;

$$L \geq Do \times A/20$$

In the above embodiment, although the light source bulb is formed in the U-shape has been explained in the above embodiment, the present invention is applicable to any bent-shape such as a W letter shape, a V letter shape, a rectangularly bent shape etc.

As described above, the present invention can provide an extremely preferable ceramic discharge lamp.

While there have been illustrated and described what are at present considered to be preferred embodiments of the present invention, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof without departing from the true scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the present invention without departing from the central scope thereof. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed as the beat mode contemplated for carrying out the present invention, but that the present invention include all embodiments falling within the scope of the appended claims.

The foregoing description and the drawings are regarded by the applicant as including a variety of individually inventive concepts, some of which may lie partially or wholly outside the scope of some or all of the following claims. The fact that the applicant has chosen at the time of filing of the present application to restrict the claimed scope of protection in accordance with the following claims is not to be taken as a disclaimer or alternative inventive concepts that are included in the contents of the application and could be defined by claims differing in scope from the following claims, which different claims may be adopted subsequently during prosecution, for example for the purposes of a divisional application.

Claims

1. A metal vapor discharge lamp comprising a hermetically sealed bent-shape light source bulb (16) made of translucent ceramic material, a pair of electrodes (20, 20) mounted in the light source bulb (16) through both ends of the bulb (16) and metal vapor filled in the bulb (16), characterized in that the light source bulb (16) has a wall load A (W/cm^2) and an inner bulb diameter Di (mm) which satisfy the following two relations;

$$12 \leq A \leq 30, \text{ and}$$

$$Di \leq -0.5 \times A + 18.5.$$

2. A metal vapor discharge lamp of claim 1, wherein the light source bulb (16) has a gap L (mm) between two straight sections (16b, 16b) of the bulb (16) end an outer bulb diameter Do (mm) which satisfy the following relation in connection with the wall load A;

$$L \geq Do \times A/20.$$

FIG.1

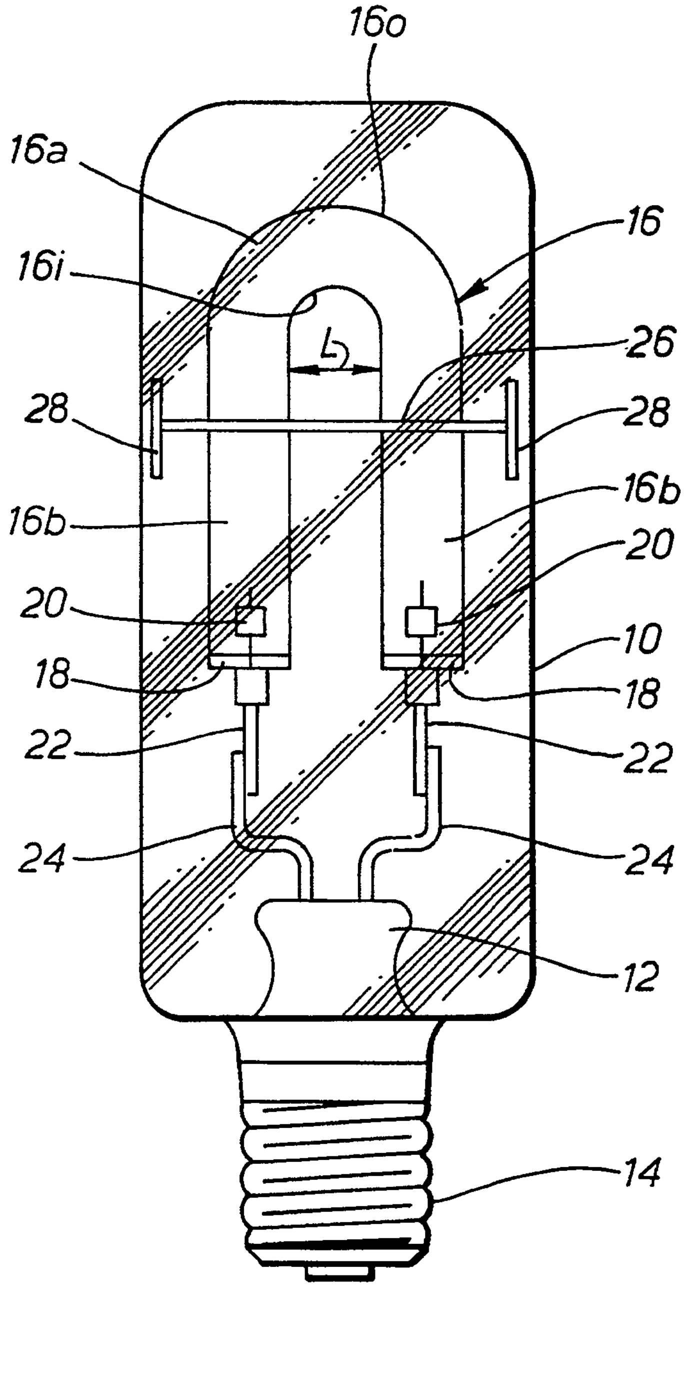
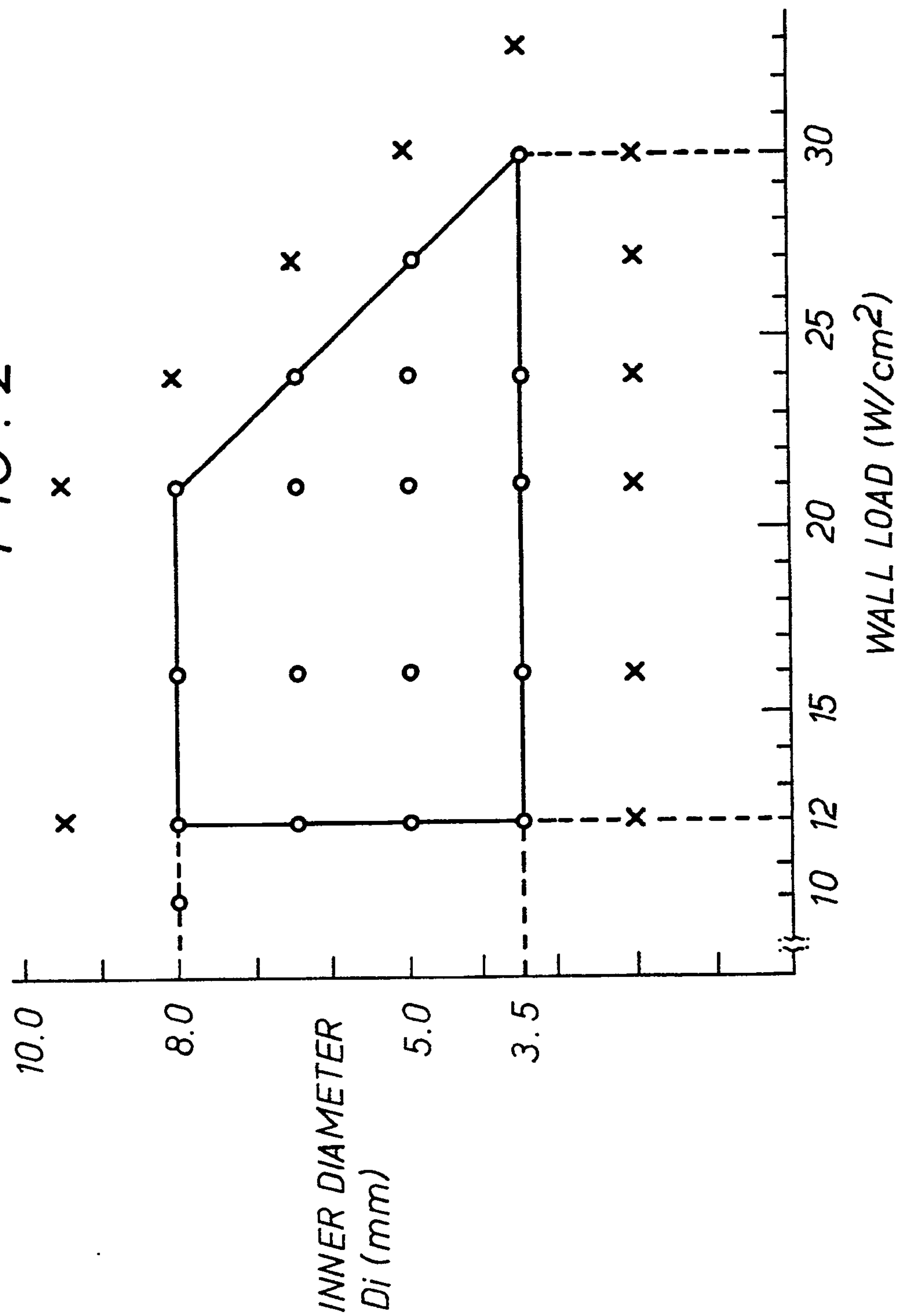


FIG. 2


INNER DIAMETER
Di (mm)
10.0
8.0
5.0
3.5
WALL LOAD (W/cm²)
10
12
15
20
25
30