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(54) Apparatus for producing plural streams of liquid droplets.

(57) An apparatus for producing a plurality of streams of liquid droplets comprises a first chamber (1) having an inlet (2). The apparatus also has a second chamber (4) having a plurality of outlets (5). The first chamber also has a channel (10) for conveying liquid from the inlet (2) to an acoustic device (11) for producing vibrations within the liquid. The acoustic device (11) is located within the first chamber (1). The second chamber (4) has a frustoconical internal wall narrowing towards the outlets (5). A generally conical protrusion (9) has a base adjacent the outlets (5) and an apex pointing towards the acoustic device (11).

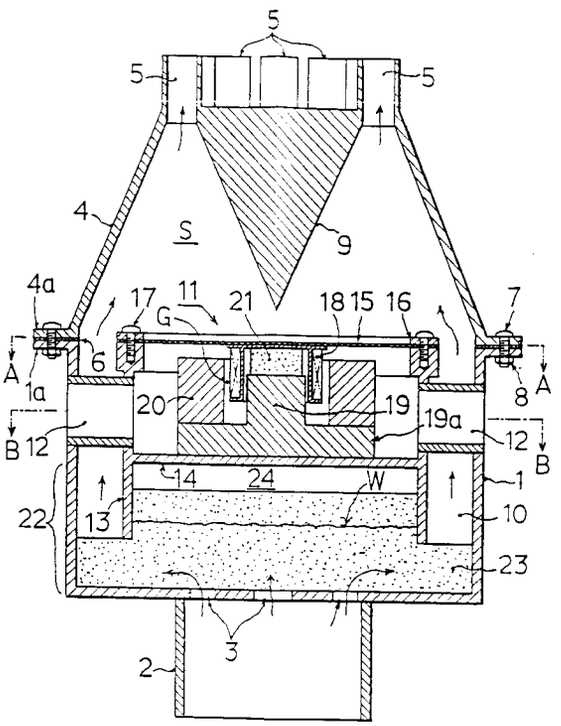

FIG 1

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The present invention relates to an apparatus for producing a plurality of streams of liquid droplets, eg streams of parabolic shape for producing a fountain. Such streams, when illuminated by multiple stroboscopic lights give the visual effect of visually distinguishing the droplets which produces a beautiful, aesthetically pleasing effect. The invention may also be employed in educational or industrial applications.

It is known to make acoustic vibrations (ie sound) in a stream of water or another liquid by impacting at regular intervals, under the control of a timer, a hose through which liquid is flowing. When the dense part of the resultant in-liquid sound wave arrives at the outlet aperture of the hose, the molecules of liquid in that area begin moving very rapidly. When these rapidly moving molecules emerge from the aperture, they cause a stream of liquid droplets to be formed. These droplets may be observed individually by illuminating the stream with a stroboscopic light source. This conventional technique is disclosed in laid-open Japanese Patent Specification No. 86-026068.

The subject of the aforementioned Japanese Patent Specification was designed as instructional device to explain the nature of parabola, using a single stream of water. It is an object of the present invention is to create several streams of water, for educational demonstration, for decorative effect or for other purposes. Although plural streams could be obtained using the conventional devices, the equipment would become extremely complex and impractical.

Thus, the present invention provides an apparatus for producing a plurality of streams of liquid droplets, the apparatus comprising a first chamber having an inlet and a second chamber provided with a plurality of outlets the first chamber being provided with a channel for conveying liquid from the inlet to an acoustic device for producing vibrations within the liquid, said acoustic device being located within the first chamber, said second chamber having an internal frustoconical wall which narrows towards the outlets and a generally conical protrusion having base which is adjacent said outlets and an apex which points towards said acoustic device.

The present invention enables acoustic vibrations to form droplets in several streams simultaneously, using a single device. Moreover, the conventional apparatus described above has a problem of generating undesirable reflected and diffracted waves which would interfere with the droplets and disturb the stream. The present invention is able to suppress the production of reflected and diffracted waves and to produce several well-ordered, branching streams.

The present invention also provides an apparatus for producing sound in a branching flow of water and which comprises a cylindrical lower body to which is attached a water supply pipe in the centre of the bottom thereof, and a topless-cone-shaped upper body from which an indefinite number of branching pipes lead off from the upper periphery thereof.

The upper and lower bodies are connected by a hollow area. Inside the upper body and extending down from the centre is an inverted cone. Inside the lower body and extending up from the bottom thereof is a cylinder containing a device for producing sound-in-water, with an annular water path surrounding the cylinder. This water path is penetrated by several support pipes which support the lower body. The device for producing sound-in-water comprises a round, elastic vibration membrane stretched over the top, and installed below the centre of this membrane, and a vibration coil surrounded by a ring-shaped permanent magnet, with a cylindrical projecting core fitting up into the centre of the coil within this magnet.

Also, towards the bottom of the above mentioned in water-sound-producing device inside the above mentioned lower body is a filter, the general construction of which is described in Japanese Patent Application 90-268213 "Filter for Eliminating Pulse and Turbulence in Water Flow". This filter comprises a flexible and porous, many-holed sponge-type member which is charged with water from the supply pipe, so that a residual air pocket forms in the top of the water-in-sound producing device, the air pocket being created when water is passed through the device.

The main purpose of this invention is to create a stream of multi-branching streams of distinct droplets produced by regular sound waves in the water or other liquid, without allowing any droplets of undesirable form to be apparent in the streams. Sources of undesirable droplets include:-

(a) Vibrations from outside the device

(b) Pulsed flow or turbulence

(c) Diffractions and reflections of the sound waves produced in the water

To eliminate the influence of (a) vibrations from outside the device, it is preferred that both the upper and lower bodies are made of vibration resistant rubber or plastic materials.

Pulsed flow and turbulence (b) in the water supply are inevitably generated by whatever pump is used to supply the water. These are preferably suppressed or eliminated by a filter.

A preferred embodiment of the present invention has been designed to avoid producing (c) reflected or diffracted waves. That is, the water coming in from the supply pipe passes first through the filter. The compound effect of the elasticity in the sponge-like member and in the air pocket, plus the bulk elasticity of the air trapped in the sponge serve to reduce or eliminate the pulse and turbulence in the water supply. Then, this water is fed into a circular water path through which it rises and fills the space in the upper body. The internal circumference of this space in the upper body. The internal circumference of this space is cone

shaped, and suspended at the very centre of this space is an inverted cone. Thus, all the internal surfaces are round, with no flat surfaces, protrusions, or indentations. The bottom is round, and, proceeding upward, the cross section is doughnut-shaped with gradually decreasing area until it flows into the branching pipes at the top.

At the bottom of the cone-shaped space is located the vibration membrane of the sound-producing device. This membrane, through the operation of the vibration coil, sends 50 or 60 vibrations per second into the water filling the space.

The vibration membrane is round and the operation of the vibration source at its centre emits a uniform wave.

This structure suppresses the generation of diffracted waves.

Also, the cone shaped walls and the suspended cone at the top of the space mean there are no surfaces perpendicular to the direction of the waves being produced. This structure suppresses the generation of reflected waves.

As a result, when the sound waves in the water arrive near the branching pipes, the water molecules move rapidly, and the streams emitted from the branching pipes become separate, distinct droplets.

These streams may be illuminated using a device described in Japanese Patent Application No. 90-253533 entitled "Method for Distinguishing Moving Granular Objects". Two or more coloured multi-strobe lights are used. The droplets created by the apparatus are thus caused shine both red or blue, and the resultant fountain can be appreciated as an object of aesthetic beauty.

The present invention will now be explained in more detail by the following description of a preferred embodiment and with reference to accompany drawings, in which:-

Figure 1 shows a mid-line cross section through a device according to the present invention;

Figure 2 shows a side view of the device shown in Figure 1;

Figure 3 shows a top view of the device shown in Figure 1;

Figure 4 shows a bottom view of the device shown in Figure 1;

Figure 5 shows a cross section view of the device shown in Figure 1, along the line A - A and seen in the direction of the arrows;

Figure 6 shows a cross section view of he device shown in Figure 1, along the line B - B and seen in the direction of the arrows;

Figure 7 shows a mid-line part cross section of an alternative embodiment of the present invention for producing diffracted waves;

Figure 8 shows a top view of the device shown in Figure 7; and

Figure 9 shows a cross section view of the device shown in Figure 8, along the line C - C and seen in the direction of the arrows.

As shown in Figures 1-6 a device according to the present invention comprises a lower body 1 comprising a cylindrical case having a bottom and made of a hard plastics material. A horizontal flange 1a surrounds the upper edge of the case and a water supply pipe 2 is connected to the centre of the case bottom. As seen most clearly in Figure 4, a plurality water inlet holes 3 are arranged in and around the case bottom, across the bore of the water supply pipe.

An upper body 4, comprises a hard frustoconical plastics shell with a horizontal flange (4a) formed around the lower circumference thereof, opposing flange 1a. Branching pipes 5 are arranged around the upper periphery of the upper body.

The flanges 1a of the lower body 1 and the upper body 4 respectively, are separated by an annular packing seal but are urged together to sandwich the seal by bolts 7 and nuts 8 to enclose a hollow interior of the device. From the centre of the uppermost port inside this hollow body is suspended an inverted cone 9. A cylindrical in-water sound generating device 11 is set within the lower body 1. The lower body 1 is supported by four supporting pipes 12 depending from the sides of the lower body, across a circular or annular channel 10.

The structure of the in-water sound generating device 11 is as follows. Extending across the top of a vertical cylindrical wall 13, which defines the inner wall of the channel 10, is a horizontal central base 14. Stretched over and blocking off the top of the cylinder is a circular disc-shaped rubber vibration membrane 15, held in place by a restraining ring 16, itself held in place by a plurality of screws 17. A vibration coil 18 is located under the centre of the vibration membrane 15. A toroidal permanent magnet 20 surrounds the coil. A small annular gap G separates the magnet from the coil. This magnet is mounted on a cylindrical seat 19a which forms the bottom of a narrower cylindrical protruding cores 19 which is fitted up into the centre of the vibration coil. This core is set on a central base which is of wider diameter than the core.

Between the core 19 and the vibration membrane 15 is a sponge cushion 21 inside the coil 18. The cushion prevents the vibration membrane 15 from undergoing excessive downward deformation under the pressure of water.

The supporting pipes 12 also serve as pathways for supplying air to the inside of the in-water-sound generating device 11. An electric power cord is introduced through one of these pipes for delivering power to the vibration coil 18.

A filter 22 is formed in the bottom of the lower body 1. The filter comprises an elastic and porous foam or sponge-like member 23 which blocks the bottom of the circular water path above the supply pipe 2. This member extends about half-way up into the in-

water sound generating device and is partially filled with water. In use, an air pocket 24 is formed between the upper surface of this foam sponge-like member and the central base 14.

Water introduced via the water supply pipe 2 passes through the water supply holes 3 into the bottom of the lower body 1. It passes through the foam or the sponge-like member 23, enters the annular channel 10 and continues to climb. However, the water level W inside the in-water sound generating device is located within the sponge-like member in the lower part of the cylinder. Air in the sponge-like member above this water level and in the air pocket is trapped and compressed.

In this way, when the water passes through the sponge-like member 23, the compound effect of the elasticity or the member itself, and the bulk elasticity of the air in the air pocket and the air in the sponge-like member above the water level filters out and smooths any pressure pulses or turbulence that may be in the water.

Therefore, the flow water that fills the space S in the upper body 4 is smooth and substantially streamline. However, at the bottom of the space S this water contacts the vibration membrane 15 of the in-water sound generating device. When, for example, a 60 Hz alternating current is supplied to the coil, the permanent magnet 20 is affected by the resulting alternating magnetic field and vibrates up and down. This in turn vibrates the membrane 15 which then generates sound waves in the water within the space S.

The shape of the in-water sound generating device 11 is designed to inhibit the production of diffracted waves. Figures 7, 8, and 9 show examples of shapes that do produce diffracted waves.

In figure 7, a water supply pipe 2′ enters the space S through the conical wall. Thus, the point t where the water pipe 2′ meats the conical wall reproduces diffracted waves k as indicated by the broken-line arrows. These diffracted waves result in the production of undesirable droplets. Therefore, the conclusion is that the walls of the frustoconical shell of the upper body 4 should generally be smooth and without deformities.

Figure 8 is a top view of a square in-water sound generating device 11′. Figure 9 is a mid-line cross sectional view of the device shown in Drawing 8. The four corners p, q, r, and s of the square vibrating membrane 15′ are difficult to vibrate, so that the sound generated at the centre of the membrane 15′ is diffracted at the four corners, leading to the production of undesirable droplets. Thus, the vibration membrane should not be square and preferably, is substantially circular.

Next, because reflected waves are easily produced by any surface perpendicular to the direction of the in-water sound waves, without the inverted cone 9 hanging down into the space S, the top of the upper body 4 would be flat. The in-water sound wave would reach that surface and reflect back. Again, these reflected waves could create undesirable droplets. Thus, it is greatly preferred that none of the surfaces in the space S is flat.

In the ways described above, the structure of this invention is designed to avoid producing reflected and diffracted waves. The sound waves produced in the water in the space S travel upwards and arrive near the branching pipes 5. The molecules begin to move with increasingly rapidity and the water ejected from the apertures of the branching pipes 5 forms distinct droplets.

The general hydrodynamic principles involved in producing droplets are described in the aforementioned Japanese Patent Specification No. 86-026068, so they will be omitted here.

The device described above may be used for purposes of demonstration (eg in the teaching of physics) or for decorative effect. Thus, when the emerging droplets are alternately illuminated by a two-colour (eg red and blue) multi-strobe light as described in Japanese Patent Specification No. 90-253533 "Method for Discriminating Moving Granular Objects," if the device is incorporated in a fountain, the resultant droplets shine in an aesthetically pleasing manner.

As described above, by means of a round vibration membrane with the vibration source in its centre, and by making the in-water sound chamber conical and such that no surfaces perpendicular to the in-water sound wave can produce diffracted or reflected waves, a branching flow of water composed only of the distinct droplets formed by the in-water sound waves can be obtained. Moreover, by illuminating this branching flow of droplets with two or more multiple strobe lights, an aesthetically pleasing fountain can be obtained.

Claims

1. An apparatus for producing a plurality of streams of liquid droplets, the apparatus comprising a first chamber (1) having an inlet (2) and a second chamber (4) provided with a plurality of outlets (5), the first chamber being provided with a channel (10) for conveying liquid from the inlet (2) to an acoustic device (11) for producing vibrations within the liquid, said acoustic device being located within the first chamber (1), said second chamber (4) having an internal frustoconical wall which narrows towards the outlets (5) and a generally conical protrusion (9) having base which is adjacent said outlets (5) and an apex which points towards said acoustic device (11).

2. An apparatus according to claim 1, wherein the channel (10) is generally annular.

3. An apparatus according to claim 1 or claim 2, wherein the internal wall of the second chamber (4) is substantially smooth.

4. An apparatus according to any preceding claim, wherein the acoustic device (11) comprises a substantially circular membrane (15).

5. An apparatus according to claim 2, wherein the first chamber (1) is provided with an approximately central base (14) surrounded by the generally annular channel (10), the acoustic device (11) being mounted on said base (14).

6. An apparatus according to claim 5, wherein the first chamber (1) is provided with a filter.

7. An apparatus according to claim 6, wherein the filter comprises spongy member (23) located within the first chamber on the side of the base (14) opposite to the acoustic device (11).

8. An apparatus according to claim 7, wherein the spongy member (23) is spaced apart from the base (14) to allow formation of an air pocket (24).

9. An apparatus according to claim 7 or claim 8, wherein part of the spongy member (23) extends across an inlet to the generally annular channel (10).

10. An apparatus for producing sound in a branching flow of water and which comprises a cylindrical lower body (1) to which is attached a water supply pipe (2) in the centre of the bottom thereof, and a topless-cone-shaped upper body (4) from which an indefinite number of branching pipes (5) lead off from the upper periphery thereof.

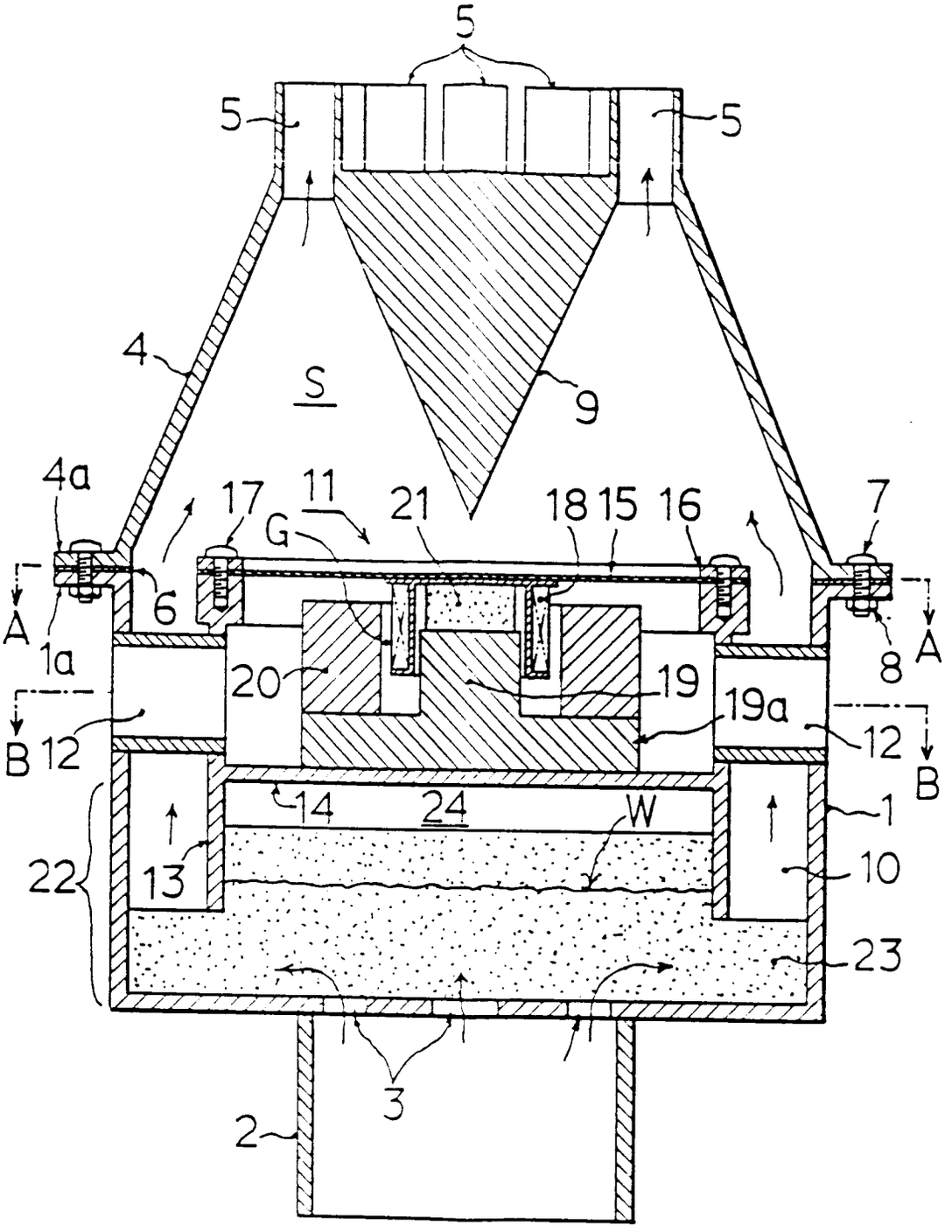
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FIG 1

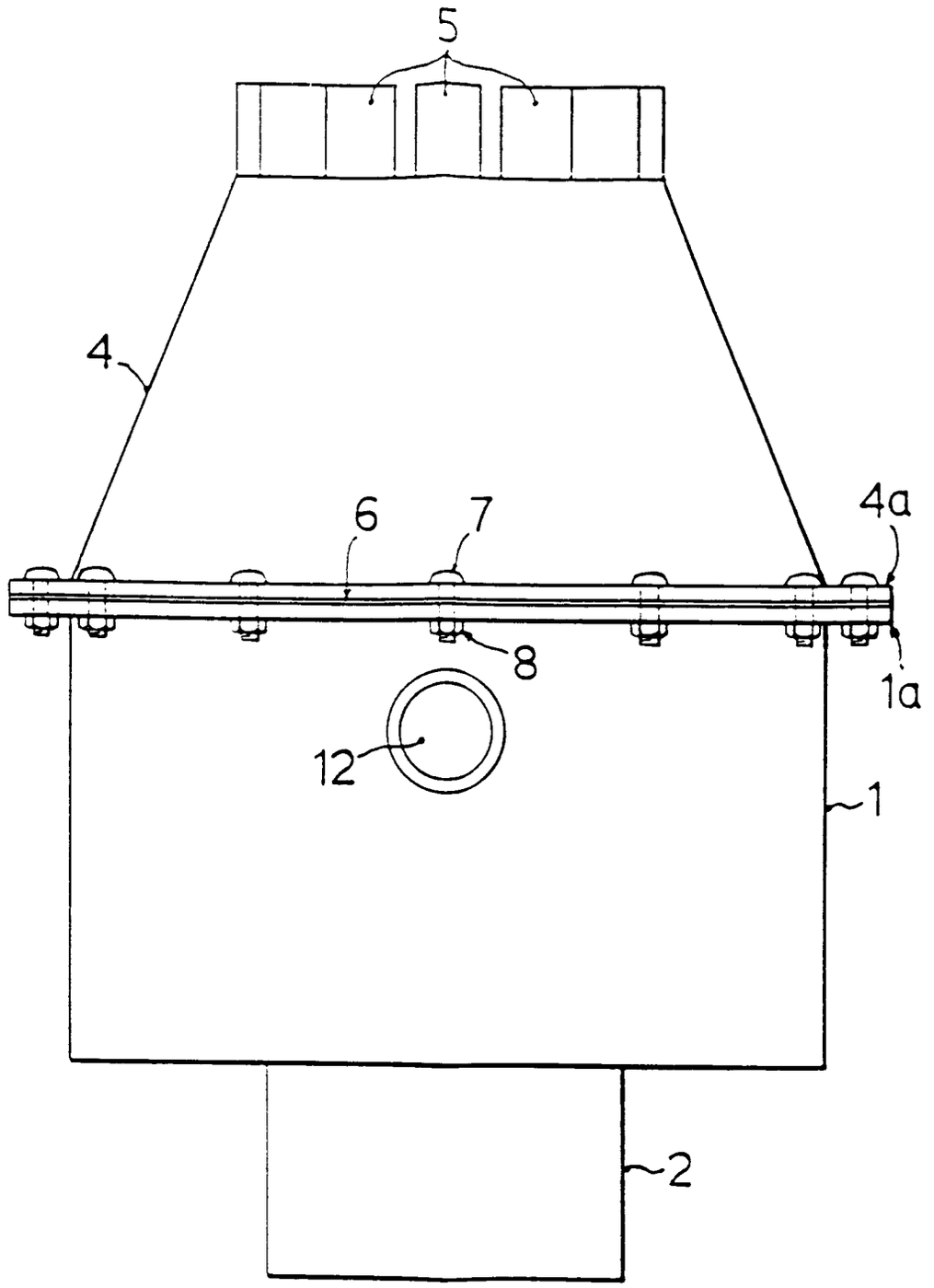

FIG 2

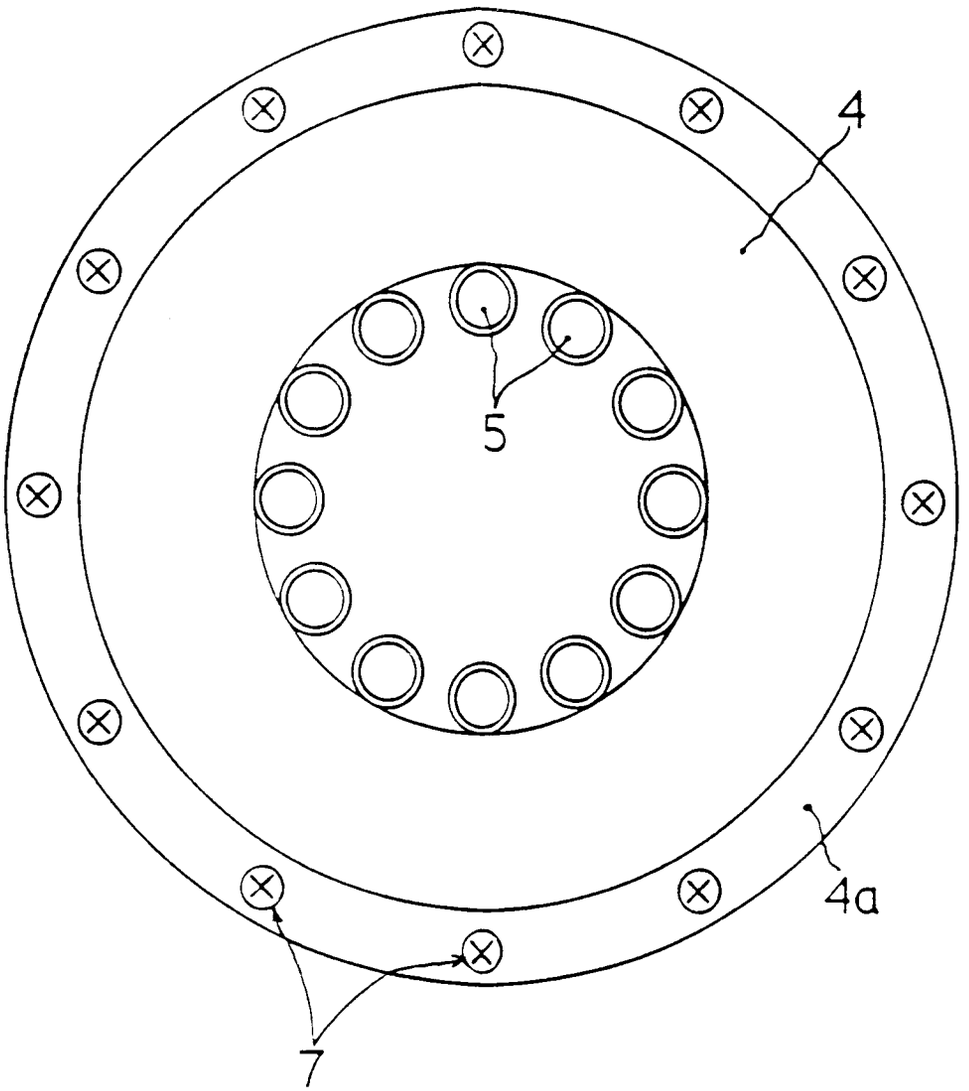

FIG 3

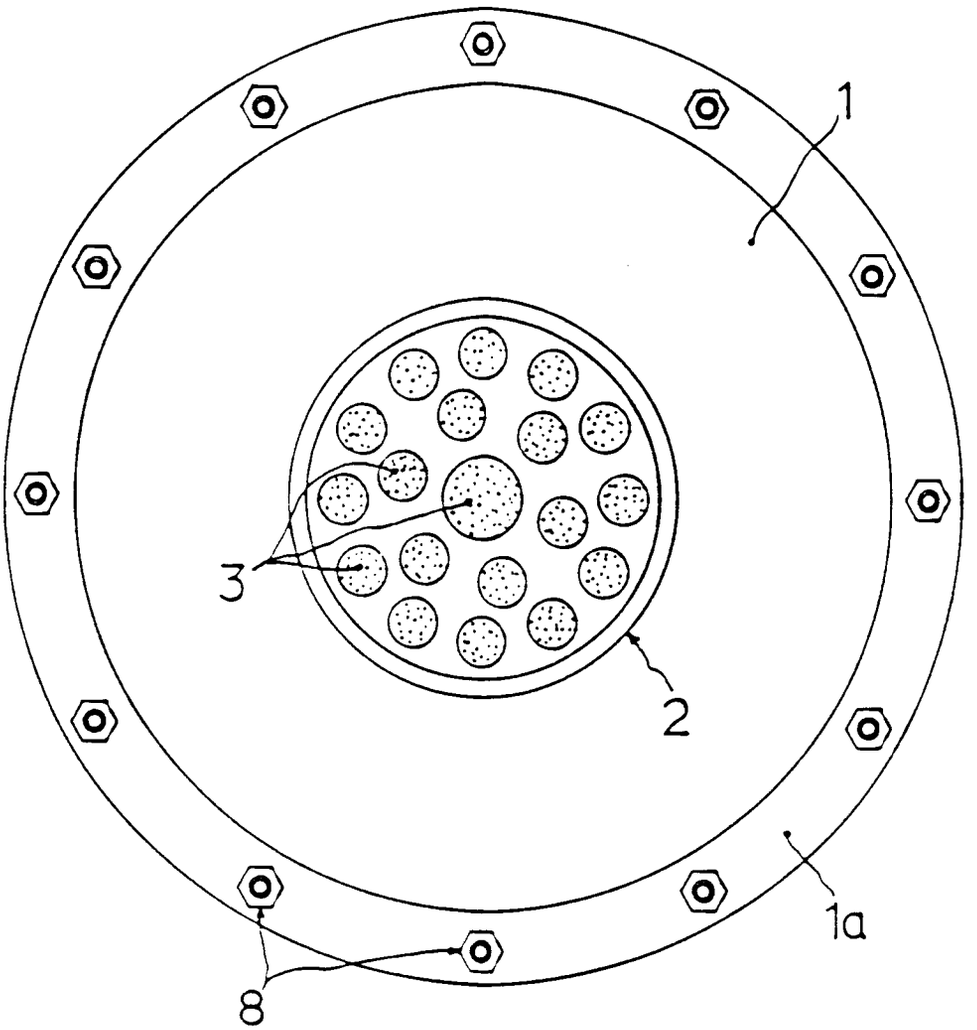

FIG 4

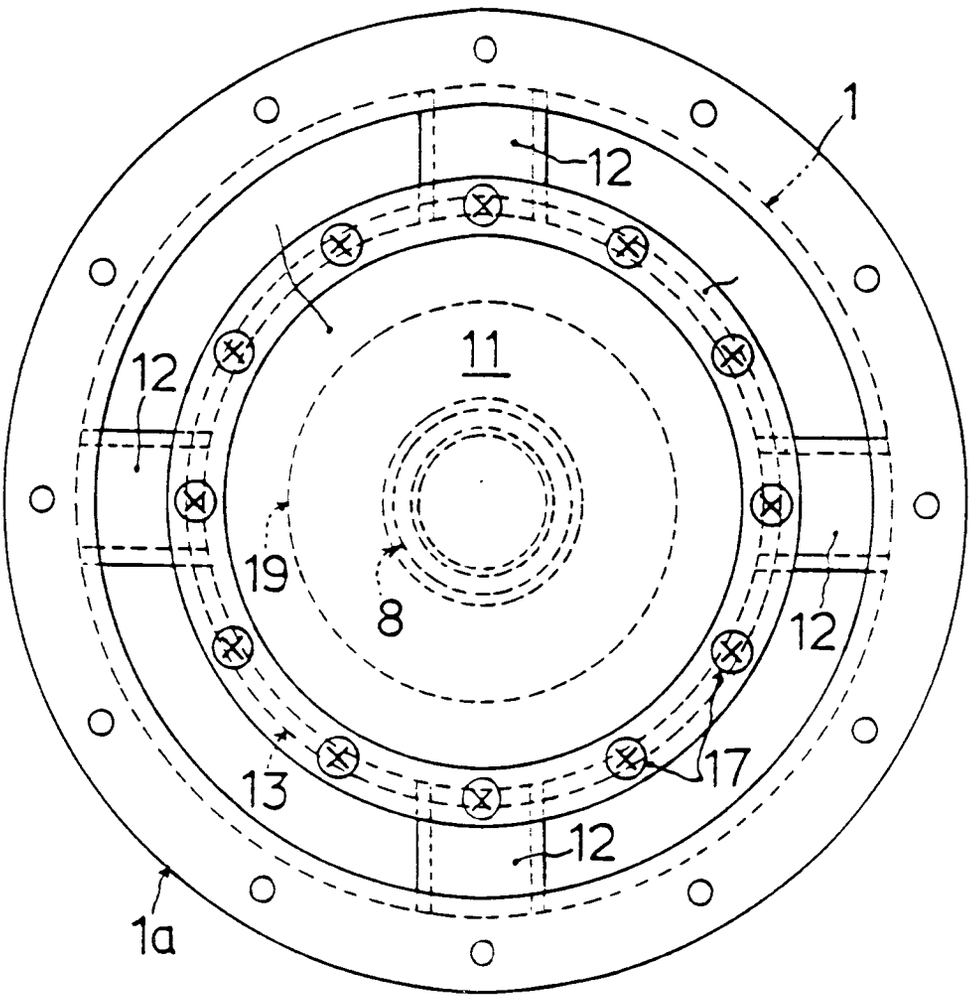

FIG 5

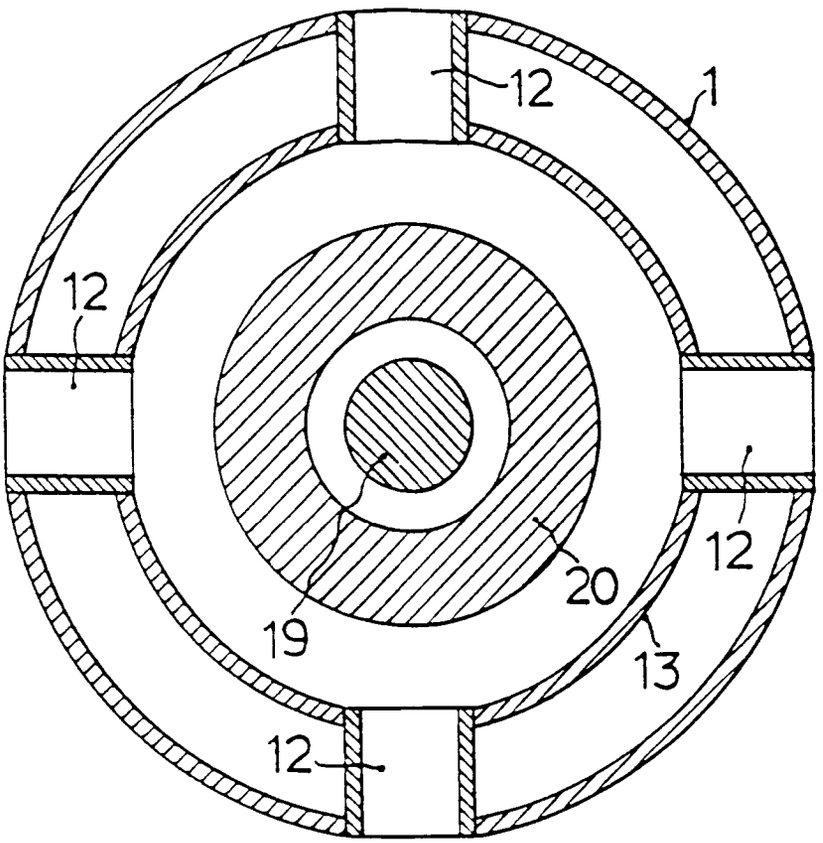

FIG 6

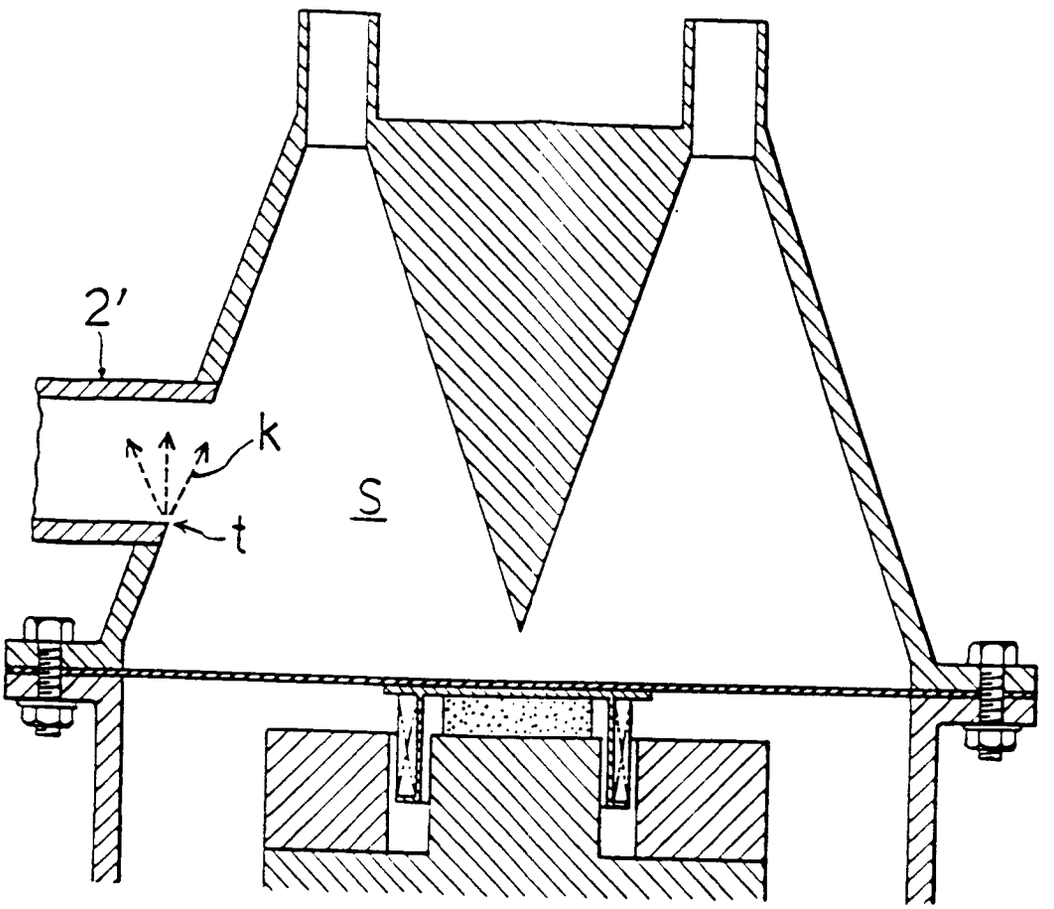

FIG 7

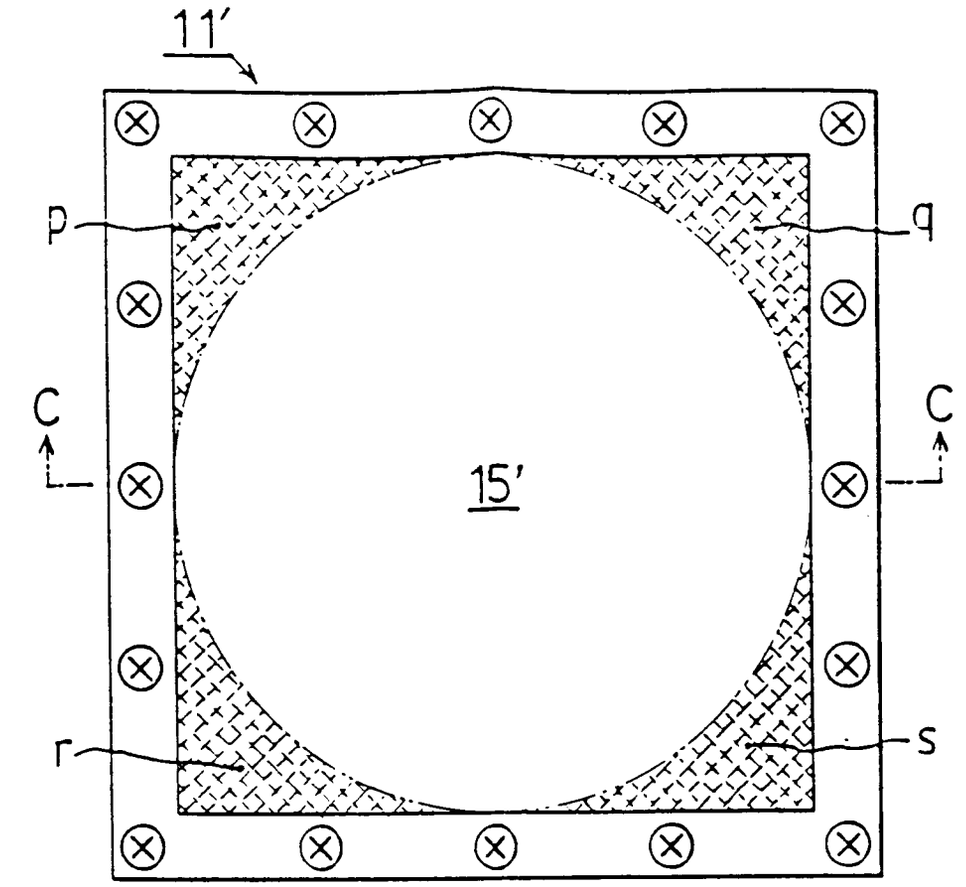

FIG 8

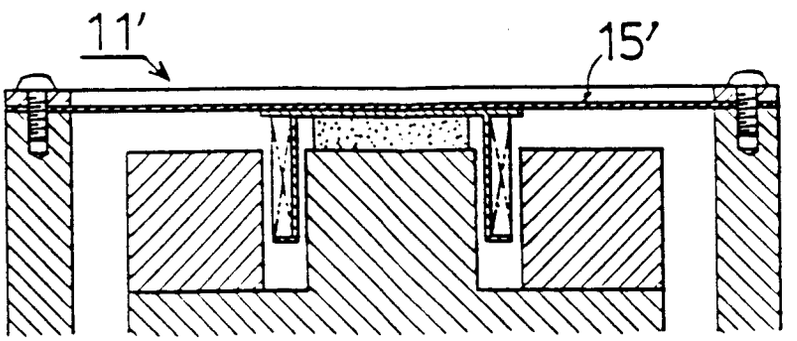

FIG 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0851

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-4 667 877 (YAO ET AL.) * abstract; figures *	1,10	B05B17/08 B05B17/06
A	US-A-3 640 472 (HRUBY JR. ET AL.) * abstract; figures 1,2,3 *	1,3,10	
A	US-A-3 782 629 (HRUBY JR.) * figure 1 *	1,3,10	
A	EP-A-0 021 996 (INSTRUMENTS SA) * page 2, line 17 - page 2, line 25; figure *	1,3,10	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 FEBRUARY 1992	GINO C.P.G.

CATEGORY OF CITED DOCUMENTS

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