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(72) Inventeurs/Inventors:
UMLAUFT, HELMUT, AT;
LAMMER, HERFRIED, AT
(73) Propriétaire/Owner:
HEAD SPORT AKTIENGESELLSCHAFT, AT
(74) Agent: OGILVY RENAULT LLP/S.E.N.C.R.L.,S.R.L.

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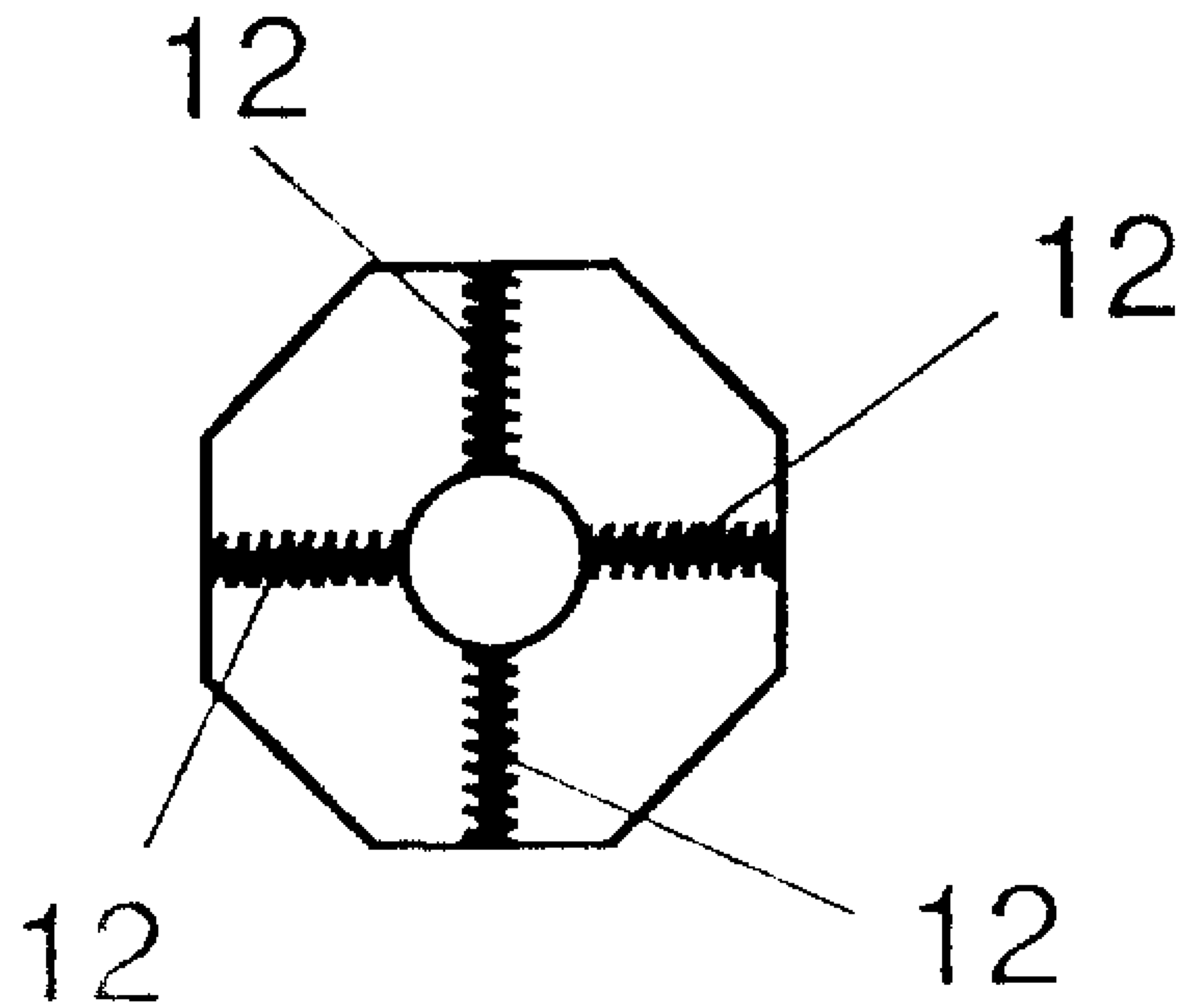
(54) Title: DEVICE FOR DAMPING THE VIBRATIONS OF A BALL RACKET



(57) Abrégé/Abstract:
In a device for damping the vibrations of a ball racket (1) and, in particular, a tennis racket, squash racket or racketball racket, a damper weight is mounted on or in the grip-side end of the ball racket so as to be able to elastically excurse from the axis of the handle grip, its weight being selected between 0.6 to 3.5 % of the weight of the strung racket (1) and the elastic mounting being designed or dimensioned with a view to an at least monoaxial excursion at an eigenfrequency of between 100 and 300 Hz.

Abstract:

Device for Damping the Vibrations of a Ball Racket

In a device for damping the vibrations of a ball racket (1) and, in particular, a tennis racket, squash racket or racket-ball racket, a damper weight is mounted on or in the grip-side end of the ball racket so as to be able to elastically excurse from the axis of the handle grip, its weight being selected between 0.6 to 3.5 % of the weight of the strung racket (1) and the elastic mounting being designed or dimensioned with a view to an at least monoaxial excursion at an eigenfrequency of between 100 and 300 Hz. (Fig. 1)

The invention relates to a device for damping the vibrations of a ball racket and, in particular, a tennis racket, squash racket or racketball racket.

Conventional devices for damping the vibrations of a tennis racket are based on the absorption of energy by friction or internal friction of materials arranged between the grip shell of a racket handle and the frame members of the racket frame. In order to be able to absorb an appreciable amount of energy, relatively heavy structural parts are usually required. This holds all the more if the weight of the racket is relatively low such that the damping elements to be provided for the absorption of energy will attain a considerable portion of the overall weight of the racket. Since such damping structural parts, moreover, usually are arranged in the region of the handle grip, this will result in a grip-heaviness of the racket. In order to produce head-heavy rackets, compensation weights, therefore, have to be arranged in the head region, which again leads to an increase in the overall weight of the racket.

Other conventional damping elements are arranged between the strings of a stringing. In this connection, a damper has become known from US-A 5,651,545, in which a viscoelastic carrier for a movable element is mounted between strings of a stringing. As the racket gets into contact with a ball, what constitutes a transient procedure, the racket vibrates at its eigenfrequency, wherein the racket, if exhibiting a relatively low mass, is excited to vibrate at its eigenfrequency, being damped to a lesser degree. The eigenfrequency of modern rackets having relatively low weights and, in particular, weights ranging between 200 and 250 g varies between frequencies of about 180 to 280 Hz depending on the racket frame material chosen, that eigenfrequency corresponding to the first mode of bending under free-free constraint. Typical of such a free-free vibration is the fact that a maximum vibration amplitude is each present on the head-side and grip-side ends as well as in a central region. The area of the strung surface, like the end region of the grip facing the strung surface, is located in a node of vibration. The arrangement of damping elements in the stringing area always will bring about relatively little effect and hence relatively slight damping if such an element is arranged near a node of vibration. Moreover, additional superpositions will be caused in the stringing area. Besides, the effect of a damping means provided in the stringing area also is a function of the hardness of the stringing and of the strings chosen for the stringing. The effects of damping, therefore, cannot be precisely predicted in such cases. Due to the mass vibrating between the strings in a viscoelastic element, a two-mass system having an equal number of degrees of freedom is involved, ratios changing to a high degree as a function of the weight of the strings and the material of the strings.

The invention aims at providing effective damping for rackets having low dead weights, by as low an additional weight as possible and appropriate tuning of damping irrespective of the strings chosen for the stringing and of the weight of the stringing selected.

To solve this object, the configuration according to the invention essentially consists in that a damper weight is mounted on or in the grip-side end of the ball racket so as to be able to elastically excurse from the axis of the handle grip, its weight being selected between 0.6 to 3.5 % of the weight of the strung racket and the elastic mounting being designed or dimensioned with a view to an at least monoaxial excursion at an eigenfrequency of between 100 and 300 Hz. By providing but an extremely low weight, the dimensioning of which is to be selected between 0.6 and 3.5 % of the weight of the strung racket, the characteristics of the racket will hardly change and it will be ensured, in particular, that a head-heavy racket can be produced without any additional weights in the head region at an extremely low overall weight.

By mounting that relatively low damper weight elastically in a manner so as to obtain an at least monoaxial excursion at an eigenfrequency of between 100 and 300 Hz and by arranging the relatively low damper weight on the grip-side end of the ball racket, it is feasible to almost cancel vibrations by interference without having to markedly increase the overall weight of the ball racket for that purpose. The relatively light racket, after excitation by the ball contact, reacts nearly undamped with its eigenfrequency, the damper reacting to the same impact with its eigenfrequency. The extent of damping of the vibration of the damper weight in the elastic mounting has hardly any influence on the effect of damping, since the two vibrations, i.e., the vibration of the racket and the vibration of the damper weight are linked with each other. To the player only the vibrations of the racket will be decisive, and, if the eigenfrequency of the damper is tuned to the eigenfrequency of the racket with a view to safeguarding an appropriate amplitude of the damper weight, effective damping with the slightest masses on the smallest space will be feasible. The arrangement in the grip-side end of the ball racket ensures that the damper weight will always be located in the antinode of the eigenfrequency of the racket.

Advantageously, the configuration according to the invention is devised such that the grip-side damper weight is mounted so as to be capable of excursing in a biaxially elastic manner and elastically pivotable about the axis of the handle grip, such a biaxial elastic excursion, as a rule, also enabling damping of vibrations about the axis of the handle grip on account of the inertia of the mass of the damper weight. With an eccentric excitation of the racket frame, the damper weight at first remains in its original position on grounds of the inertia of the mass and subsequently is excited to rotational vibration by the elastic deformation of the mounting, said rotational vibration acting against the vibration of the racket frame about the longitudinal axis of the handle grip.

Advantageously, the damper weight amounts to about 3 and 10 g and, preferably, about 5 g. Taking into account the initially mentioned racket weights of between 180 and 250 g of modern tennis rackets and the slightly lower weights of squash rackets, an extremely small damper weight mass will, therefore, suffice.

In a preferred manner, the arrangement of the damper weight is realized in a hollow space on the end of the grip, the damper weight preferably being arranged in an elastic carrier which is supported on the wall of the hollow space in at least two points located diametrically opposite each other with respect to the axis of the handle grip. Such an elastic carrier simply may be made of an elastomer material such as, in particular, silicone rubber, wherein the carrier, in the manner of a carrier of uniform strength, has a cross section increasing from the damper weight towards the walls of the hollow space, viewed in the axial direction of the handle grip. Thus, an extremely small structural component is required also for the elastic carrier, which structural component, in turn, contributes to the overall mass of the racket to as slight an extent as possible. In order to ensure that any vibration will actually be compensated for in the region of the antinode of the free-free vibration of the racket, the configuration advantageously is devised such that the carrier and the damper weight extend in the axial direction of the handle grip over less than 1/10 of the length of the handle grip, whereby further substantial weight reduction is feasible as compared to conventional constructions.

Appropriate tuning of the amplitudes of the damper relative to the amplitude of the racket is advantageous with a view to a most effective absorption of vibrations and the pertinent reduction of the same. The eigenfrequency of the vibration of the damper weight is a function of its stiffness and mass. The respective physical formula for that eigenfrequency $f = \sqrt{c/m}$ is applicable universally, $\underline{c}$ being a measure for the stiffness, and m denoting the mass, of the damper weight. The stiffness of the elastic carrier may be influenced by compression as well as the mode of constraint of the carrier and its shape. As a rule, the stiffness of the damper is decisively influenced by the flexural strength of the elastomer. Measurement of the eigenfrequency of the damper is relatively difficult from a measuring engineering point of view, since measurements must be carried out by means of extremely small acceleration probes. Good approximation, however, results from the determination of the eigenfrequency by calculation knowing the material for the elastomer and the shape of the carrier as well as the mass of the vibration damper.

In an advantageous manner, the invention thus contemplates that the eigenfrequency of the vibration of the damper weight, by selecting the stiffness and/or compression of the carrier and by selecting the mass of the weight, is adjusted to a frequency corresponding to the frequency of the free-free vibration of the first mode of the ball racket. Dimensioning of the eigenfrequency of the vibration of the damper weight in such a manner results in a nearly immediate extinction of the vibrations of the racket, slight differences in the frequencies still causing extremely rapid damping. In order to provide for optimum damping at a low weight, the arrangement according to the invention in that case is devised such that the damper weight and, in particular, the center of gravity of the damper weight is arranged on the grip end in the region of the antinode and, in particular, of the plane which extends normal to the axis of the handle grip and through which the antinode of the free-free vibration of the first mode of the ball racket passes.

In order to cancel vibrations effectively, appropriate tuning and, in particular, enlargement of the amplitude is particularly advantageous in addition to the measure of tuning the eigenfrequency of the damper to the eigenfrequency of the racket. The damper amplitude that is required for damping is proportional to the ratio of the stiffness of the racket to the stiffness of the damper. The lighter the racket the larger the amplitudes that must be admitted for the damper, the design advantageously being devised such that the vibration amplitude of the damper weight proportional to the ratio of the stiffness of the racket to the stiffness of the carrier with a lower racket weight is chosen to be larger than with a higher racket weight.

A further measure characteristic of the effect of the damper is the socalled enlargement function. This enlargement function is defined as the amplitude of the racket divided by the excitation amplitude. If that ratio between the eigen-frequency of the damper and the eigenfrequency of the racket assumes values smaller than 1, particularly intensive damping of the overall system is reached. Consequently, the configuration advantageously is devised such that the ratio between the amplitude of the ball racket and the excitation amplitude in the range between the eigenfrequency of the damper weight and the eigenfrequency of the ball racket is chosen to be smaller than 1.

Particularly effective damping at low weights may be achieved in that the weight of the mounting of the damping element amounts to a maximum of 30 % and, preferably, 25 % of the damper weight. In this manner, the influence of the mounting on the vibration behavior of the damper weight may be minimized and particularly weight-saving and effective damping by interference may be realized.

In the following, the invention will be explained in more detail by way of exemplary embodiments schematically illustrated in the drawing. Therein, Fig. 1 is a top view on a racket; Fig. 2 is a side view in the direction of arrow II of Fig. 1 with the schematic illustration of the free-free vibration in the first mode; Fig. 3 is a view in the direction of arrow III of Fig. 1, on the bottom grip end; and Fig. 4 is a view analogous to Fig. 3, illustrating the schematic arrangement of a damper weight suspended in a biaxially elastic manner.

Fig. 1 depicts a tennis racket 1 whose stringing oval is denoted by 2. The tennis racket 1 has a handle grip 3 whose axial height is denoted by a. The axis of the handle grip or tennis racket is denoted by 4.

On the lower end of the grip 3 a damper 5 is arranged, whose axial height b extends over less than 1/10 of the axial length a of the grip portion 3.

In the illustration according to Fig. 2, the free-free vibration of the first mode is indicated by 6. The nodes of vibration 7 of that free-free vibration of the first mode pass throught the stringing oval 2 and the grip portion 3, whereas the maximum amplitudes c in the region of the antinode are each present on the head-side end and on the grip-side end of the ball racket 1 as well as closely below the stringing oval 2 in the chosen illustration.

From Fig. 3, the damping device 5 is apparent in a view according to arrow III of Fig. 1. The damping device 5 is comprised of a carrier and a damper weight 8, the damper weight 8 being retained between carriers 9 for elastic excursion. Excitation of the racket frame by a ball contact causes the damper weight 8 to make an elastic excursion, the way of clamping represented in Fig. 3 allowing for a multiaxial excursion. An excursion may, thus, take place both in the direction of double arrow 10 and also transverse thereto in the direction of double arrow 11, the respective elastic torsional vibration of the mass of the damper weight 8 being likewise admitted whenever eccentric impacts on the stringing oval stimulate the racket frame to torsionally vibrate.

The type of elastic suspension is schematically illustrated in Fig. 4, wherein a biaxial suspension via springs 12 is provided. By selecting suitable materials for the carrier 9 and the springs 12, respectively, and selecting suitable biassing, the eigenfrequency of the damping device 5 may be tuned to the free-free eigenfrequency of the vibration of the racket frame after a ball contact, thereby obtaining effective damping.

I/WE CLAIM:

1. A device for damping vibrations of a ball racket and, in particular, a tennis racket, squash racket or racket ball racket, in which a damper weight (8) is fixed on or in the grip-side end of the ball racket (1) in a manner capable of elastically excursing from the grip axis (4), characterized in that the damper weight (8) is selected at 0.6 to 3.5% of the weight of the strung racket (1) and an elastic fixation is designed for an at least monoaxial excursion at an eigenfrequency of between 100 and 300 Hz, and that the damper weight (8) is arranged in a hollow space on the end of the grip (3) in an elastic carrier (9) which is supported on the wall of the hollow space in at least two points located diametrically opposite each other relative to the grip axis (4).

2. A device according to claim 1, characterized in that the grip-side damper weight (8) is capable of elastically excursing biaxially and fixed to be elastically pivotable about the grip axis (4).

3. A device according to claim 1 or 2, characterized in that the damper weight (8) amounts to between 3 and 10 grams, preferably about 5 grams.

4. A device according to any one of claims 1 to 3, characterized in that the elastic carrier (9) is made of an elastomer material, in particular silicone rubber, wherein the carrier (9) in the manner of a carrier of equal strength has a cross section that increases from the damper weight towards the walls of

the hollow space, seen in the cross sectional view of the grip.

5. A device according to any one of claims 1 to 4, characterized in that the carrier (9) and the damper weight (8) in the axial direction of the grip (3) extend over less than 1/10 of the length of the grip (3).

6. A device according to any one of claims 1 to 5, characterized in that the eigenfrequency of the vibration of the damper weight (8) by selection of the stiffness and compression of the carrier (9) and by selection of the mass of the weight (8) is adjusted to a frequency corresponding to the frequency of the free-free vibration of the first mode (6) of the ball racket (1).

7. A device according to any one of claims 1 to 6, characterized in that the damper weight (8) and, in particular, the center of gravity of the damper weight (8) are arranged on the grip end in the region of an antinode and, in particular, the plane extending normal to the axis (4) of the grip (3), through which plane the antinode of the free-free vibration of the first mode (6) of the ball racket (1) passes.

8. A device according to any one of claims 1 to 7, characterized in that the ratio between the amplitude of the ball racket (1) and the excitation amplitude in the range between the eigenfrequency of the damper weight (8) and the eigenfrequency of the ball racket (1) is selected to be smaller than 1.

9. A device according to any one of claims 1 to 8, characterized in that the weight of the bearing of the damper element amounts to 30% at most, preferably 25% at most, of the damper weight (8).

10. A series of ball rackets of different weights, provided with a device according to any one of claims 1 to 9, characterized in that the vibration amplitude of the damper weight (8) proportional to the ratio of the stiffness of the racket (1) to the stiffness of the carrier (9) is selected to be larger at a lower racket weight than at a higher racket weight.

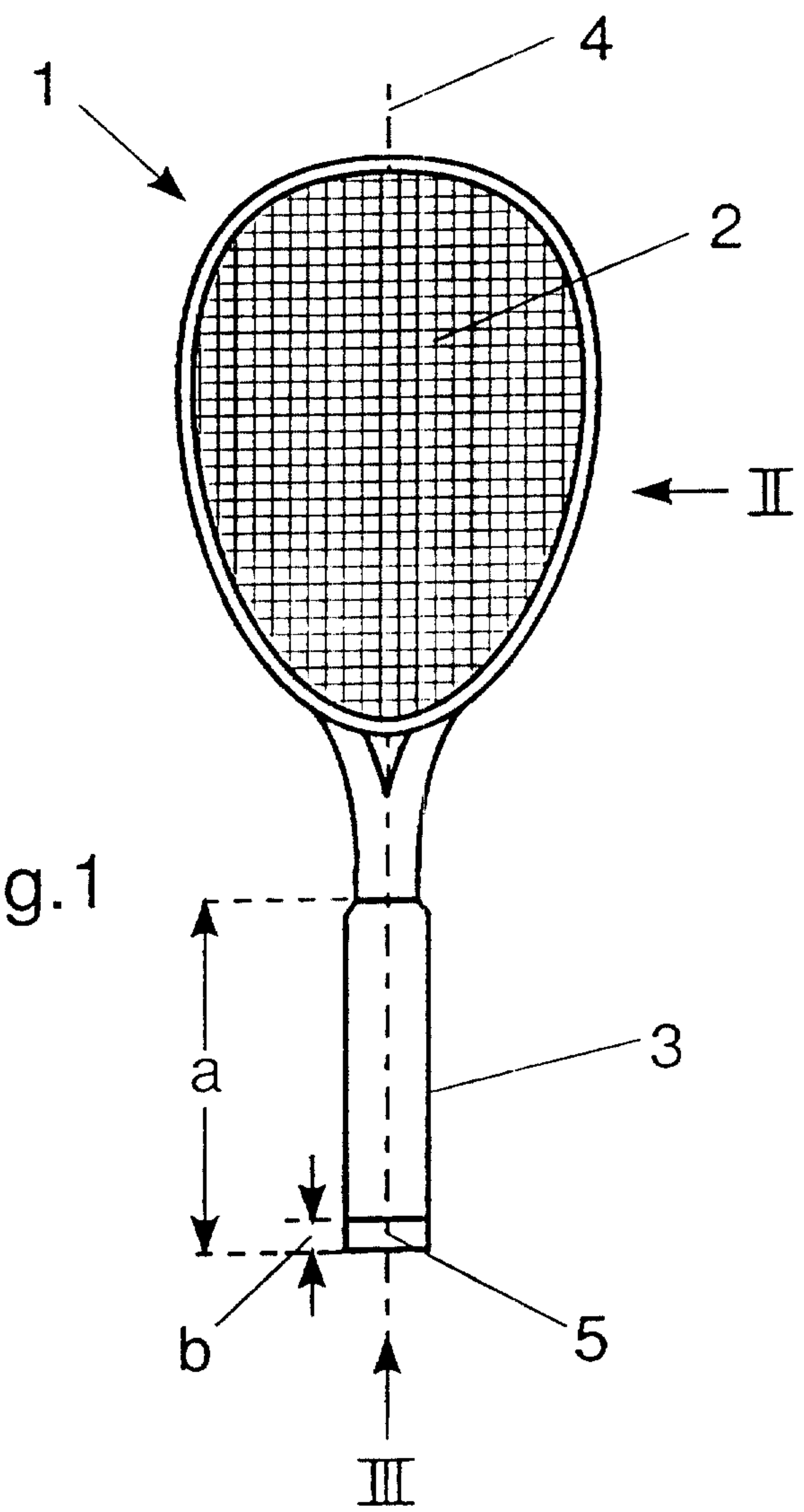


Fig.1

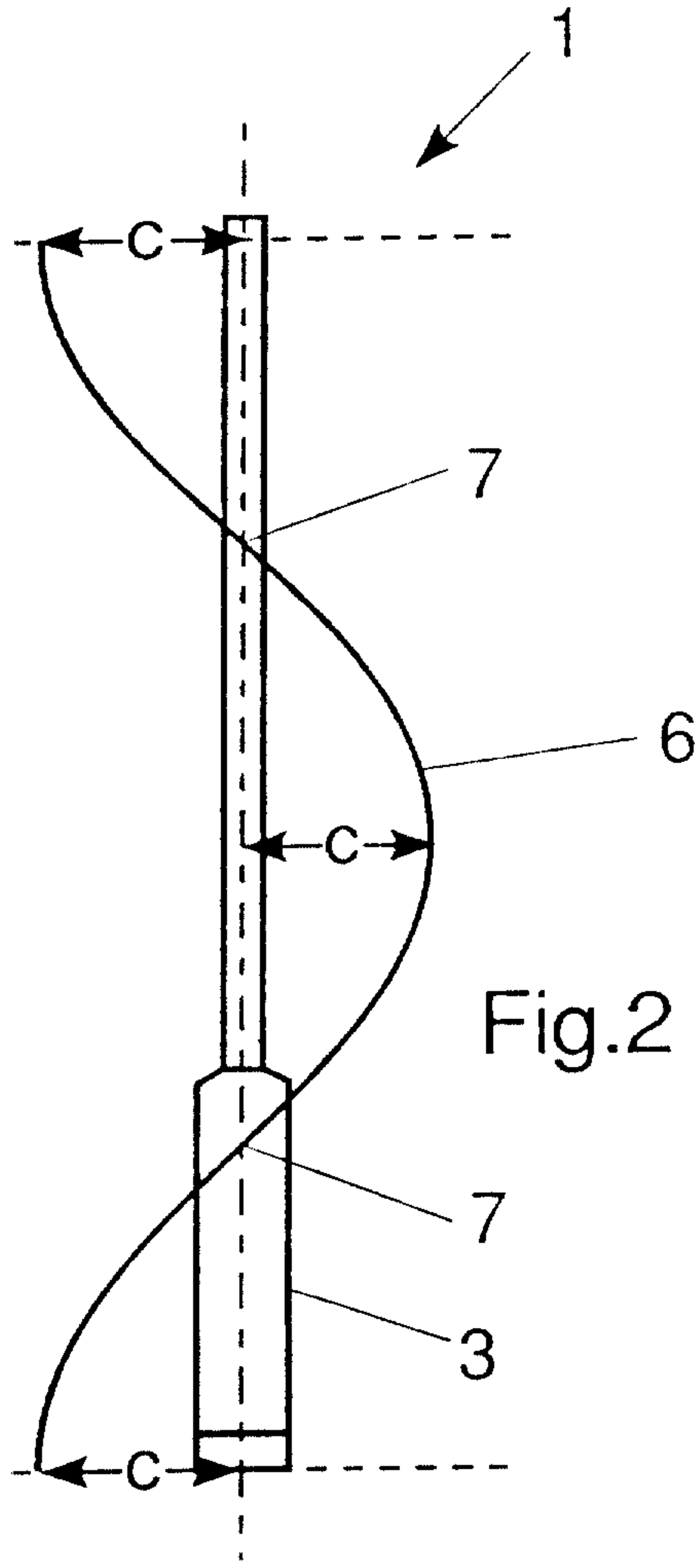


Fig.2

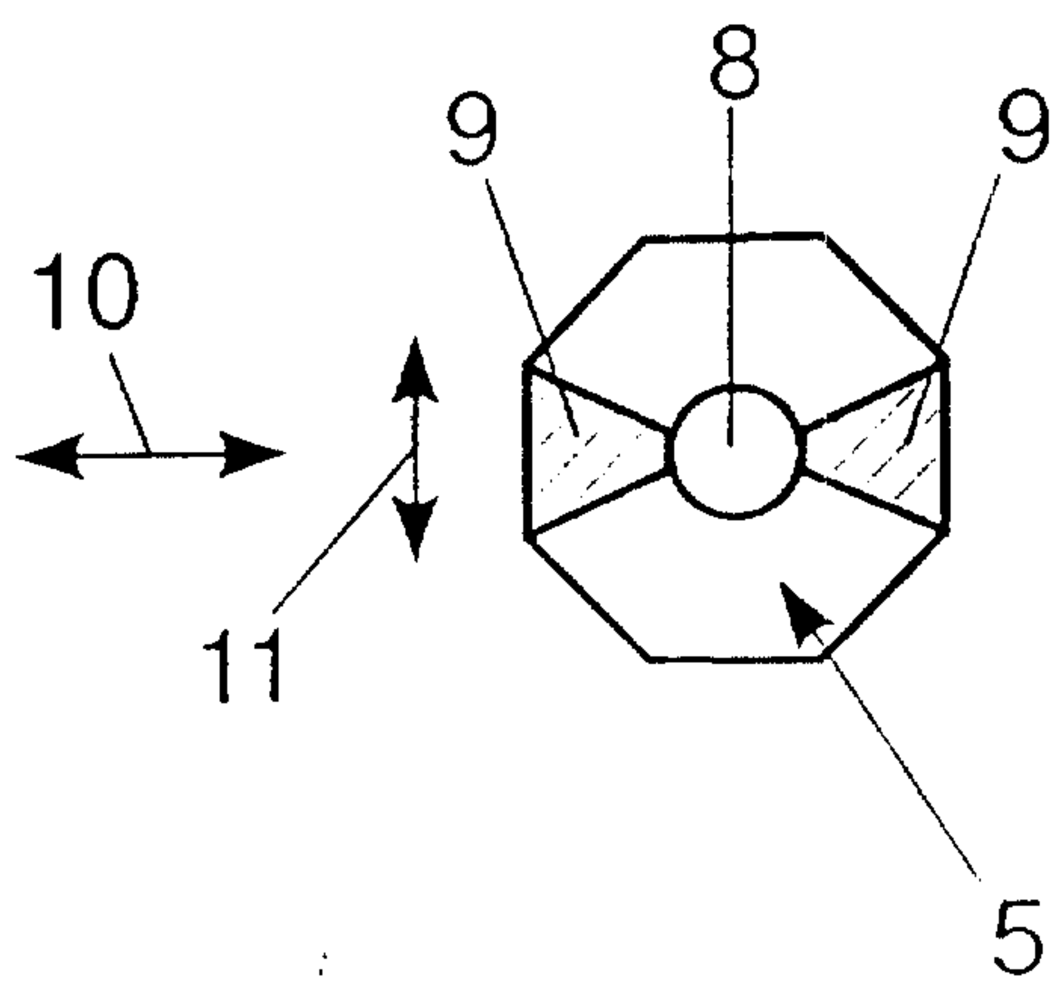


Fig.3

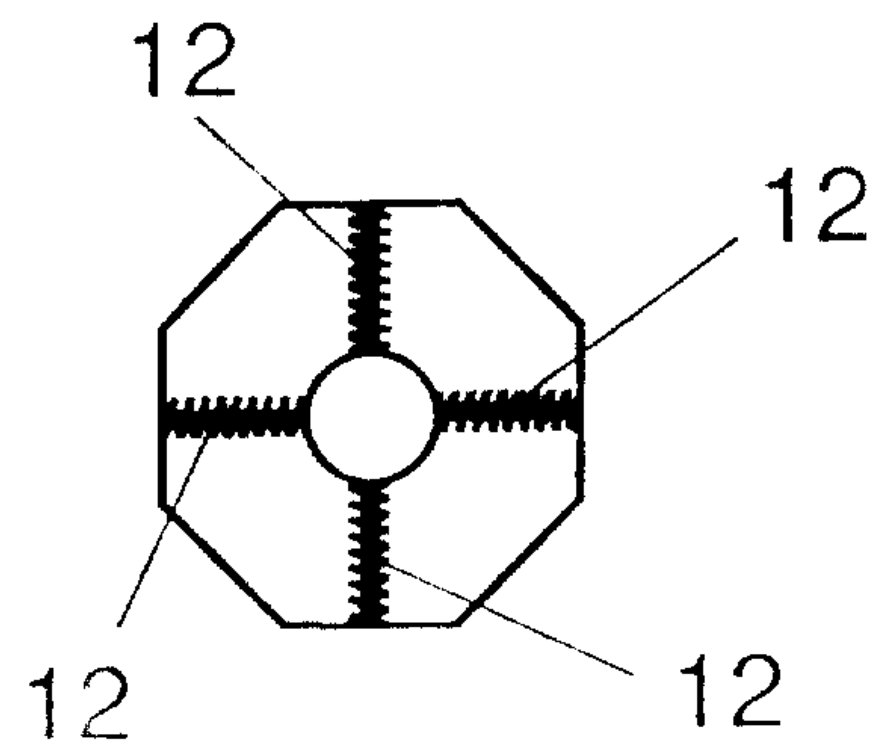
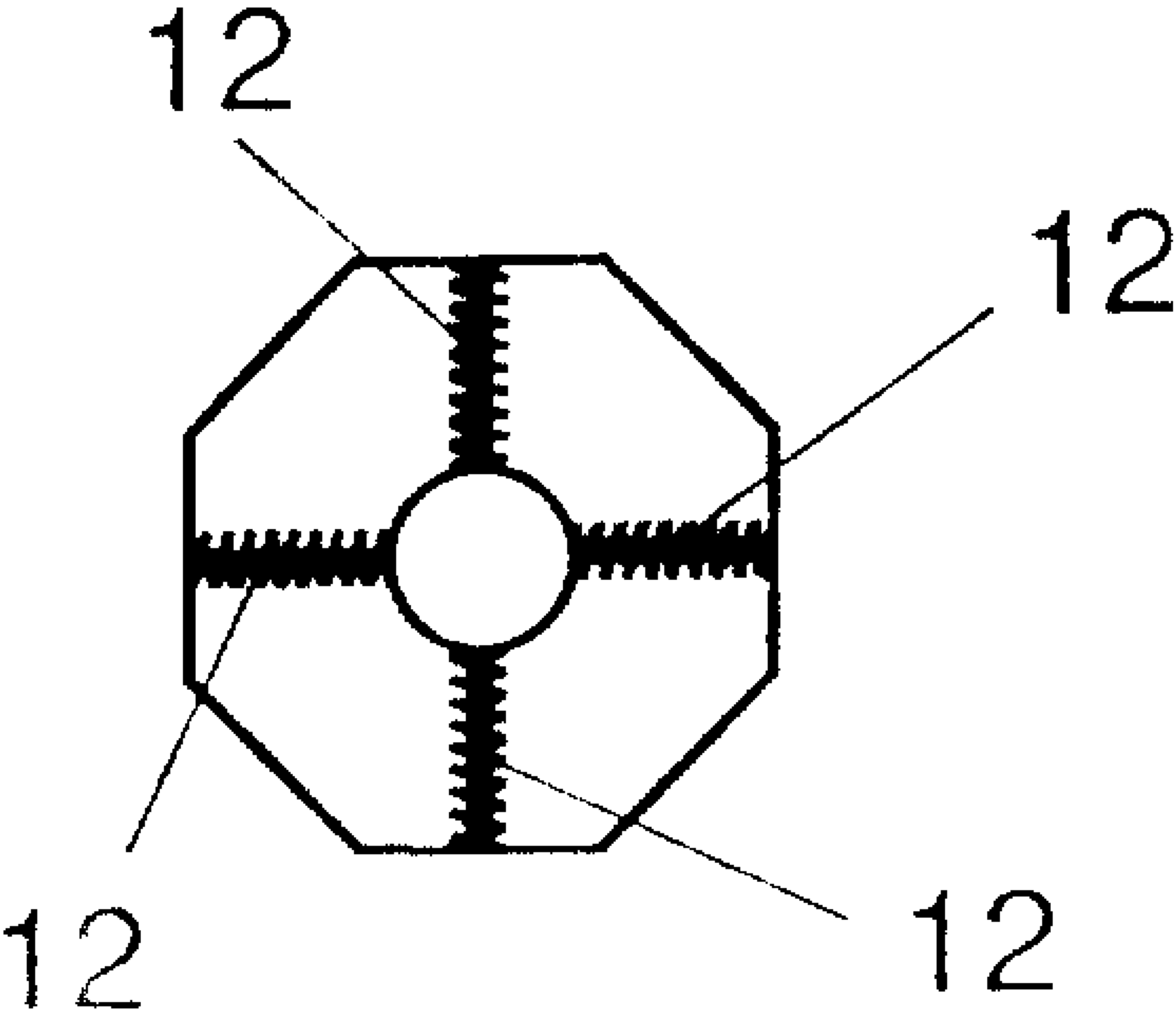


Fig.4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