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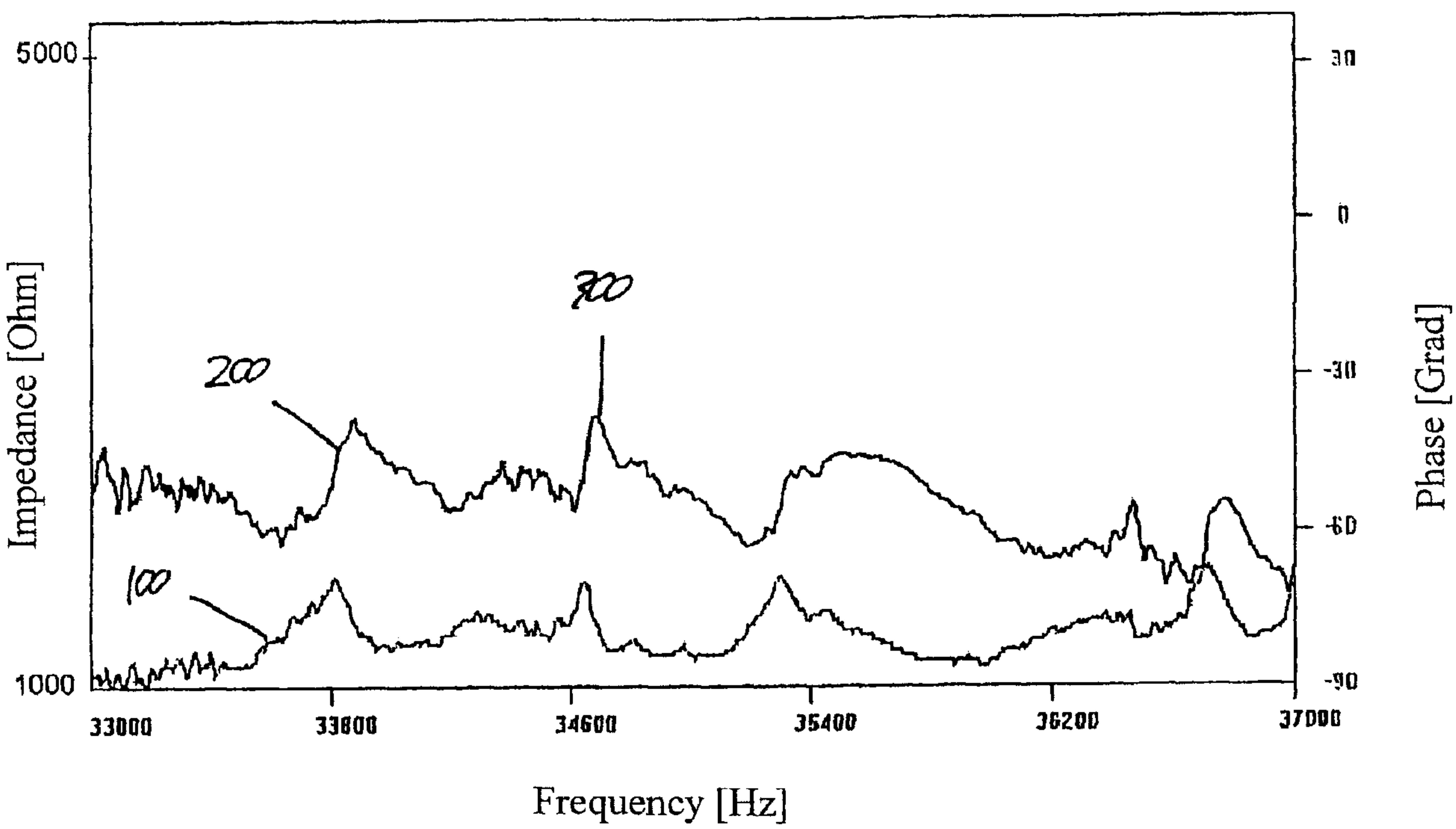
(54) Titre : PROCEDE ET DISPOSITIF D'ACTIVATION PAR ULTRASONS DE STRUCTURES DE GEOMETRIE QUELCONQUE EN VUE DE REDUIRE LE FROTTEMENT
(54) Title: METHOD AND DEVICE FOR ULTRASOUND EXCITATION OF STRUCTURES OF ANY GEOMETRY FOR THE PURPOSE OF REDUCING FRICTION



(57) Abrégé/Abstract:
Method for ultrasound excitation of structures of any geometry, comprising the steps of producing a connection between a generator, an ultrasound converter, and at least one mechanical system to be excited, passing through a frequency range for determining an operating point, wherein at each approached frequency the power consumption of the system to be excited determines a current, and/or a voltage emitted by the generator, which is measured using a sensor such that a measurement value of the sensor renders the power output to the system to be excited, and performing an ultrasound excitation at the determined operating point, or around an environment around the operating point, wherein the operating point, once determined, or the environment around the operating point, once selected, is not modified anymore, and device for the ultrasound excitation of

(57) Abrégé(suite)/Abstract(continued):
structures of any geometry by means of this method using a generator, an ultrasound converter, and at least one mechanical structure, wherein the generator has control means for the voltage, current, and frequency, by means of which these magnitudes can be varied across a certain range, and at least one sensor for determining a voltage reflecting the power supplied to the total system, and/or a current reflecting the power supplied to the total system at a given frequency, and a memory for storing target values for the power supplied to the total system input by a user on one hand, and of parameter values for voltage, current, and frequency on the other hand, in which the desired target values are achieved, or are achieved as closely as possible.

ABSTRACT

Method for ultrasound excitation of structures of any geometry, comprising the steps of producing a connection between a generator, an ultrasound converter, and at least one mechanical system to be excited, passing through a frequency range for determining an operating point, wherein at each approached frequency the power consumption of the system to be excited determines a current, and/or a voltage emitted by the generator, which is measured using a sensor such that a measurement value of the sensor renders the power output to the system to be excited, and performing an ultrasound excitation at the determined operating point, or around an environment around the operating point, wherein the operating point, once determined, or the environment around the operating point, once selected, is not modified anymore, and device for the ultrasound excitation of structures of any geometry by means of this method using a generator, an ultrasound converter, and at least one mechanical structure, wherein the generator has control means for the voltage, current, and frequency, by means of which these magnitudes can be varied across a certain range, and at least one sensor for determining a voltage reflecting the power supplied to the total system, and/or a current reflecting the power supplied to the total system at a given frequency, and a memory for storing target values for the power supplied to the total system input by a user on one hand, and of parameter values for voltage, current, and frequency on the other hand, in which the desired target values are achieved, or are achieved as closely as possible.

Method and Device for Ultrasound Excitation of Structures of any Geometry for the Purpose of Reducing Friction

The invention relates to a method and device for ultrasound excitation.

The industry has a number of uses for which it is desirable to reduce the friction between the particles and/or between the particles and a system, which is in contact therewith. Some examples for such uses are:

- The ultrasound screening, where the performance can be increased considerably by ultrasound excitation of the screening material. The performance in response to the ultrasound screening is a function of the clogging tendency of the screening materials. The material openings are kept free by means of the use of ultrasound because the static friction is transferred into the smaller dynamic friction due to the ultrasound motion and because powder bridges are broken.
- The transport of bulk goods and colored powder in tubes or on platforms. The friction between the bulk goods and the platform or the conduit reduced by the ultrasound excitation is reduced. The volume flow rate can thus be metered better and the performance can be increased.
- The excitation of interfaces between moving particles or between fixed and moved surfaces. Generally, the transition from the static friction to the dynamic friction caused by the use of ultrasound leads to a reduction of the mechanical resistance and can thus reduce the wear and the energy input, respectively, in mechanical motion processes.

According to the state of the art, it was normal until now to adapt the natural vibration frequency of the mechanical body, which is to be made to vibrate, to the converter frequency for the purpose of ultrasound excitation. Such a screening system can be found in DE 4418175, for example.

However, when using this approach, it is problematic that the tuning of the mechanical body, which is to be made to vibrate, to the converter frequency is difficult and is connected with much effort. Already common manufacturing tolerances, in particular at welding or other connecting points, or fluctuations of the acoustic parameters, such as e-module, speed of sound and density, lead to mechanical bodies with slightly different natural frequencies, which already differ from one another to the extent that the operation of a plurality of screens, for example, is impossible with an ultrasound converter according to the state of the art.

Upon transitioning to more complex mechanical bodies, the individual resonances thereof are no longer clearly developed for the most part and one attains a mountain of resonances, as is shown below. This vibration behavior generally does not oppose a performance-boosting ultrasound excitation. It is known from EP 0 567 551 B1, for example, to excite the frames of screening systems to a vibration outside of the resonance frequency.

If, nonetheless, problems oftentimes arise in response to the operation of ultrasound-excited systems, which are not tuned to the frequency of the ultrasound converter, this is the result of the presently used ultrasound generator technology, where the phase angle is used for controlling the generator.

This control principle works better, the clearer the zero crossing can be determined in response to the change of sign of the phase, that is, in particular with high-quality resonance systems, which, in turn, can be achieved only with exactly tuned resonators without high attenuation effect.

Vice versa, resonances, which do not identify a clear zero crossing of the phase, are not recognized and the control fails. If the quality or the phase information deteriorates during the operation, the phase control can fail completely and the generator goes into overload.

While a use of the phase control is indeed advantageous in very high-quality systems, as must be used in response to ultrasound welding, e.g., this approach becomes susceptible and instable when the quality of the vibrating system is not sufficient. Accordingly, it must thus be ensured that this is the case by means of extensive individual adaptation of the vibrating system to the desired resonance frequency.

A further problem in response to a resonance excitation is that the resulting resonance amplitude is determined so as not being capable of being controlled in particular in complex resonance systems. This is problematic because this variable determines the power loss, which in turn leads to the heating of the system. An uncontrolled heating as such is already disadvantageous in many cases, because a sintering of the powder or of the bulk goods is boosted. This problem increases in response to materials, which already become soft or start to melt at low temperatures.

Furthermore, the quality of the excited system is a function of the temperature. It is thus possible in response to resonance excitation for the heating of the system to improve the quality, which, in turn, leads to a higher resonance amplitude and thus to a further heating, which further improves the quality.

Based on this state of affairs, the problem of providing a method and a device for ultrasound excitation arises, with which the excitation of arbitrarily complex structures and, in particular, also of a plurality of screens are made possible in response to the lowest possible heating.

The problem is solved by means of a method and device for ultrasound excitation as disclosed hereinafter.

The invention is based on the knowledge that it is advantageous to adapt vibration frequencies and amplitudes of the ultrasound converter by means of the generator control to the vibration behavior of the total system instead of attempting to adapt the vibration behavior of resonating sound conductors to a natural frequency of the ultrasound converter.

According to the method as disclosed in the invention, after a first step of producing the connection between generator, ultrasound converter and the systems, which are to be excited by means of the ultrasound, the operating point of the system is accordingly searched and established in a second step by varying the (generator) parameter frequency of the generator via a specific range and by measuring the current and/or the voltage, which is determined by the power consumption at the current frequency value. The ultrasound excitation then takes place in a third method step at the operating point or in its environment, wherein the operating point, once determined, or the environment, once determined, is not controlled anymore, but the frequency can be varied within the determined environment of the operating point.

Even in the event that it is a fixed excitation at an operating point, this will typically not be a resonance excitation of a sound conductor belonging to the screening system, but an excitation of the dispersion amplitude. The excited sound conductor or screening frame thus transfers the vibration generated by means of the ultrasound converter to the screening frame or sound conductor, which is not directly excited by the ultrasound converter, by means of connecting elements. Neither the screening frame nor the sound conductor are thereby tuned; even the provision of supply resonators tuned to the ultrasound converter is no longer necessary, but they are replaced by simple supply pieces or supply sound conductors. The form of excitation thereby corresponds to the forced vibration of a harmonic oscillator comprising a force amplitude F_0. The general solution of the corresponding differential equation for a system comprising mass M, natural frequency ω_0 and attenuation constant Γ has the design

$$X(t) = A \sin(\omega t) + B \cos(\omega t)$$

wherein the dispersion amplitude B can be represented as:

$$B = \frac{F_0\ (\omega_0^2 - \omega^2)}{M(\omega_0^2 - \omega^2)2 + \Gamma^2 \omega^2}$$

and for the ratio between dispersion amplitude B and absorptive amplitude A the following applies:

$$\frac{B}{A} = \frac{\omega_0^2 - \omega^2}{\Gamma\gamma\omega}$$

For large frequency distances between natural frequency of the system and excitation frequency, the absorptive amplitude A becomes negligible and the following applies in a good approximation:

$$B = \frac{F_0}{M(\omega_0^2 - \omega^2)}$$

It thus becomes clear that the parameter excitation amplitude, which is highly relevant for the efficiency of the screening process, is proportional to the force amplitude F_0 in response to the excitation of a dispersion vibration and that it can thus be controlled in a highly systematic manner. However, this is not only the case across a specific range of the screen, because, due to the fact that a dispersion vibration of the system is excited, the corresponding components must no longer fulfill a resonance condition, which enables an optimization of the component geometry in view of the distribution of the sound amplitude via the screening material.

A frequency range from 33 to 37 kHz have notably proven themselves as parameters defining the search range in response to currents between 0 and 0.5 A and voltages between 0 and 600 V, wherein the preferred step size is 500 µsec.

Advantageously, the power (power loss), which correlates with the vibration amplitude of the excited system, which is supplied to the total system, which is a function of square of the vibration amplitude and of the contact surface is used as criterion for selecting the operating point. This context shows that it is not only important to maximize the amplitude of a single sound conductor, for instance by operating in its resonance, but that it is furthermore substantial to excite a large contact surface. The power supplied to the total system can be relevant in response to a single fixed frequency, but it often also proves to be advantageous to consider the power supplied to the system in response to a variation of the excitation frequency across the chosen environment of the operating point. Due to the fact that an excitation typically takes place by means of a dispersion amplitude, no problems are associated with local heating and, contrary to the situation in response to the resonance operation of a sound conductor, the thermal effects on the material to be moved or screened, can be controlled.

A preferred embodiment provides for the use of the operating point with the highest power supplied to the total system at a fixed frequency or via a frequency range. In this case, the current value of the power supplied to the total system is in each case determined in response to passing through the generator parameters of the search range, is compared to the stored currently highest value and is then stored together with the generator parameters leading to its attainability when the value is higher than the currently highest value.

However, a user-defined specification of another target value, which is to come as close as possible to the power supplied to the total system, which can be advantageous, in particular if the system is to operate with temperature-sensitive materials, is also possible.

In this case, the target value is deducted from the power supplied to the total system in response to passing through the frequency range prior to the comparison with the presently best value and the value is then stored together with the generator parameters, with which it is achieved, as a new best value when the difference between target value and the value determined for the given generator parameter set is less than the currently best value.

In an embodiment of the method, which is particularly preferred because of its high efficiency, a plurality of structures to be excited, are excited at the same time by means of a single generator and by means of a single or a plurality of ultrasound converters. According to the state of the art, this is typically not possible because manufacturing variations and variations of the acoustic parameters of the mechanical bodies to be excited, are sufficient for shifting the resonance frequencies thereof against one another, which, in turn, leads to a phase behavior of the total system, which leads to a malfunction of generators comprising phase control.

In a further advantageous development of this process, which can be of interest in particular when grave differences arise with reference to the efficiency of the excitation in response to the common excitation of a plurality of structures to be excited, the operating frequency is varied during operation in a certain range around the operating point. This approach can lead to a compensation of the efficiencies.

When defining the range of the frequency variation, different approached are possible. In the simplest embodiment of the method, a frequency interval, for example +/- 1000 Hz, which is then placed around the located operating point, is simply determined by the user.

The definition of the range of the frequency variation using threshold values, which are based on a certain power drainage and on a certain current, respectively, and/or on a certain voltage relative to a maximum power output, respectively, and on a certain current and/or a certain voltage, e.g. 50% of the maximum values of these variables, is more extensive. The frequency values are thereby established as boundaries of the variation range, at which the threshold values are undercut. In this embodiment, the supplied power is advantageously optimized by means of the delivery to the power spectrum; in screening systems comprising clearly defined resonances, a variation range, which is smaller than in screening systems comprising very flat resonances, will be available around the operating point. Another possibility for automatically defining the boundaries of the frequency variation is to automatically find the lowest and the highest frequency position, at which a predetermined value of the power supply and of the voltage or of the current, respectively, are reached and to then use these positions as boundary for the range variation. This is particularly advantageous when a high power consumption takes place in a plurality of ranges in the vibration spectrum.

In another embodiment of the method, which, for its executions, requires means for graphically illustrating the dependency between power consumption of the system and current respectively, and /or voltage values and excitation frequency determined by the generator, this dependency is illustrated graphically and the boundaries of the variation range are manually defined by the user. In this approach, screens comprising frequency groups located apart from one another can be controlled in an optimized manner. A used automated method is also possible in that a frequency range chosen once is controlled e.g. by comparing the integrals via the variable determined by means of the generator across the total examined frequency range and the frequency range comprising the boundaries, which were just chosen. If the latter falls below a certain fraction of the former, this is a sign that ranges, which are significant for the increase of the performance, are not yet covered by the frequency variations.

For high stability of the performance of the method it is advantageous to operate the generator below its capacity.

It has proven itself to be sensible to reduce the power supply of the generator during the search for the operating point so that the generator provides less power during the search for the operating point than in response to the subsequent operation at this operating point. Damages to the system, when a high-quality resonance is hit, are thus avoided.

As is the case with a conventional system for excitation by means of ultrasound, the device according to the invention encompasses a generator, an ultrasound converter and at least one mechanical structure to be exited. The generator encompasses means for varying the excitation frequency via a frequency range between 33 and 37 kHz as well as the provision of currents between 0 and 0.5 A and voltages between 0 and 600 V. Furthermore, provision is made according to the invention for at least one sensor for measuring the voltage and current values occurring in response to a given excitation frequency, from the measuring data of which the power supplied to the total system is determined.

Furthermore, the system according to the invention comprises a memory, in which, on the one hand, desired values for the power loss, which can be input by a user, can be stored and in which, on the other hand, parameter values, for which the desired values are reached or reached as closely as possible, can be stored. In particular, the memory can also be dimensioned in such a manner that the measuring values determined by the generator when passing through its total frequency range are stored as a function of the frequency at the respective measuring point. It is also possible, however, to transfer these data to a PC and to store them there.

The use of an ultrasound converter, which is designed for large amplitudes for compensating for the omission of the build-up of the resonance amplitude, which is typical for the operation in resonance frequency of the ultrasound converter, is thus necessary. A typical amplitude of 6 µm peak-peak has turned out here to be sufficient for many uses.

In a particularly advantageous embodiment, the ultrasound converter is thereby arranged outside of the powder flow.

It is also useful to provide for a supply sound conductor, which is arranged between the ultrasound converter and the directly excited sound conductor or screening frame. This supply sound conductor can be designed as a linear or curved line rod and can either be designed for exciting flexural or longitudinal vibrations.

With a corresponding embodiment of the supply sound conductor it is possible, in particular, to optimize the excitation amplitude in view of the used screening and sound conductor geometry as well as the used types of powder.

In particular with expanded sound conductors, it can furthermore be useful to excite the sound conductor at more than one location and to thus use a plurality of supply sound conductors for compensating for attenuation, which may be too large. Such an arrangement can also be operated when using only one ultrasound generator either in parallel, that is, with a simultaneous excitation via both sound conductors, or sequentially, that is, alternately. The last-mentioned solution is particularly cost-efficient, but reduces the performance. However, in addition to a more homogenous vibration amplitude, the use of a second ultrasound generator for exciting the second supply sound conductor, also has the advantage that the frequencies are not typically tuned exactly and that they are not identical but typically differ from one another by several 100 Hz. This leads to a low-frequency beat, which has an advantageous effect on the discharge behavior for certain types of powder.

In an advantageous embodiment, the sound conductor is molded so as to be L-shaped or as a square pipe, because this shape encompasses a high stiffness as compared to forces acting at right angles and because the short blade of the L or of the square pipe can serve as contact or adhesion surface to the screening material.

Another arrangement provides for a plurality of sound conductors to be arranged on the screening material. Said sound conductors are in contact with a first sound conductor, which is excited. In so doing, it is possible to achieve very homogenous distributions of the sound on very large screens in an advantageous manner.

Ring-shaped sound conductors, angled sound conductors and sound conductors in the shape of a segment of a circle represent yet other advantageous sound conductor geometries.

A further advantageous embodiment for the optimized distribution of the sound energy across the screening surface is to weld resonator plates to the sound conductor, via which the contact to the screening surface is then provided. Plate-shaped resonators comprising a diameter of from 40-60 mm and a thickness of approx. 1.5 mm, represent a preferred embodiment. However, rectangular or square resonators can also be used.

A particularly preferred embodiment provides for providing individual amplitude modulators or consecutive amplitude modulators connected in series at least partially as acoustical bridges between different sound conductors and/or as connecting piece to the screening frame. Rods, which encompass sections comprising a different radius can be used, for example, as amplitude modulators, wherein the length can be tuned to selectable frequencies, whereby a local modification of the vibration amplitude in certain frequency ranges is achieved selectively in individual sound conductors of the system. Likewise, it is possible to provide sections comprising rectangular cross sections, which encompass an improved stiffness. They are preferably used in screens, which require a high degree of stiffness for supporting the bearing weight of the powder. With these amplitude modulators, crossbars can also be installed within the sound conductor for counteracting the pressure of the screening product. The manufacturer can thus forego an additional mechanical bearing cross within the screening surface, for example.

Exemplary embodiments of the invention will be discussed in detail by means of the below figures.

Fig. 1 shows a screening arrangement comprising a circular sound conductor structure and curved supply sound conductor.

Fig. 2 shows a screening arrangement comprising a complex sound conductor structure.

Fig. 3 shows a screening arrangement, in which plate-shaped resonators are additionally arranged between sound conductor and screening surface.

Fig. 4 shows a screening device comprising two ring-shaped sound conductors, which are connected to one another and to the frame in each case via different strings of amplitude modulators.

Fig. 5 shows a result of a frequency analysis of a coupled system.

The course of action in response to the ultrasound screening is initially defined by means of Fig. 1 by means of an exemplary device. The sound conductor 2 is in close contact with the screening material 1, which is fastened to the screening frame 3. A supply sound conductor 6 is set into vibration by means of a ultrasound converter 4, which is operated at a given vibration frequency by means of a non-illustrated generator. The supply sound conductor 6 is embodied as being curved in the illustrated exemplary embodiment, but can also be embodied so as to be linear, for example. The supply sound conductor 6 excites the sound conductor 2, which is connected to the screening frame 3 by means of the connecting element 5. In this arrangement, it is not only possible to arrange the converter outside of the powder flow, but the vibrations excited in the sound conductor 2 are also transmitted to the screening frame by means of the connecting element 5. In the alternative, the screening frame 3 can also be excited via the supply sound conductor 6 and vibrations can be transmitted to the sound conductor 2 by means of the connecting elements 5.

In both cases, a more even distribution of the sound on the screening material is thus achieved. This can be further optimized because the excited system contrary to the situation with known screening systems, comprising sound conductors tuned to a resonance of the ultrasound converter, is operated so as not to be tuned to a resonance frequency, but the frequency operating point is adapted to the conditions of the system, whereby the flexibility is considerably increased with reference to the shape and size in response to the embodiment of the different frame/sound conductors. Figure 2 shows an example for such an improved arrangement, the analogon of which for the resonant operation would not be possible or would only be possible with considerable effort with the incorporation of four resonators, which are tuned to identical frequencies. Four ring-shaped sound conductor structures 2, which are connected to one another via acoustical bridges 7, are connected to the screening frame 3 and a bearing cross 8, respectively, via connecting elements 5. One of the sound conductor structures 2 is excited by means of an ultrasound converter 4. The vibration is transferred via the acoustical bridges 7 to the other sound conductors 4 and to screening frames and support cross via the connecting elements 5. In particular, the operation of angled sound conductor structures also becomes possible.

Fig. 3 introduces an embodiment, in which a plurality of resonator plates 9 are mounted between sound conductor 2 and screening material 1. Their typical number lies between 6 and 10, but a different number of resonator plates 9 can also be advantageous, depending on the screening and sound conductor geometry. The use of this measure achieves an additional homogenization of the transmission of the sound energy to the screening material.

The arrangement illustrated in Figure 4 points out advantages, which are involved with the embodiment of acoustical bridges 5 and/or connecting elements 7 in the form of amplitude modulators 10. A screening device, in which different series connections of amplitude modulators 10 are used, can be seen in Figure 4. Initially, an outer circular sound conductor 2, which is connected to an inner circular sound conductor 2 via two amplitude modulators 10 and which is connected to the frame via three amplitude modulators 10, which are arranged in reverse direction, is excited via a supply sound conductor 6.

The phase angle curve 100 shown on the bottom of Figure 5, shows a measurement of a phase angle as a function of an excitation frequency for an excited coupled mechanical system. According to the method for the excitation of vibrations known from the state of the art, a stable zero crossing of the phase angle in this curve would have to be identified so as to be able to perform the desired excitation in a natural frequency. A view onto the curve 100 shows the person of skill in the art that an excitation of the systems based on this control system is not possible.

The method according to the invention bypasses this problem by using another control criterion. To select the operating point, at which operation is to be carried out, the frequency is gradually varied between 33 kHz and 37 kHz. The total power received by the system thus leads to a current and/or a voltage of the generator for each frequency, which is chosen in such a manner. The value of this current and/or of this voltage measured by means of a sensor is used for determining the power supply at this frequency to the system to be excited, as power loss.

An approach for this can be that the voltage is initially held constant for all frequencies, while the current rises or falls with the power consumption of the system. However, it is also possible to change the voltage in response to constant current.

In so doing, the impedance curve 200 shown in Figure 1, which is correlated with the power loss supplied to the total system, can be determined as a function of the excitation frequency. The fact that the preferred operating point is that point, where the highest output power loss occurs, is used in the embodiment of the invention described herein, as criterion for selecting the operating point, at which the generator is then operated. This point 300 can be easily determined with the complex excited system. However, other selection criteria are also possible, which can be a function of the attainable integral power across a certain frequency range, for example.

The operation of the ultrasound-excited system then takes place at the operating point determined in such a manner. Advantageously, the frequency is continuously passed through (swept) around the steadied operating point in response to the excitation of a plurality of structures.

List of Reference Numerals

1	screening material
2	sound conductor
3	screening frame
4	ultrasound converter
5	connecting element
6	supply sound conductor
7	acoustical bridge
8	bearing cross
9	resonator plate
10	amplitude modulator
100	phase angle curve
200	impedance curve
300	operating point

Claims

1. A method for ultrasound excitation of structures with arbitrary geometry, comprising the steps:
a) providing a connection between a generator, an ultrasound converter (4) and at least one mechanical system that is to be excited;
b) going through a frequency range in order to determine a working point, wherein at each frequency the power accepted by the system to be excited determines a current or a voltage output of the generator that is measured by a sensor, so that a measurement of the sensor represents the power provided by the generator to the system to be excited; and
c) performing the ultrasound excitation at the determined working point or in a region around the determined working point, wherein the chosen working point or the chosen region around the working point are not changed any more after choosing.

2. The method according to claim 1, characterized in that the power provided to the system to be exited is used as criterion for the choice of the working point in step b) of the method.

3. The method according to claim 1 or 2, characterized in that the working point determined in step b) is the one at which the highest amount of power provided to the system to be excited is reached.

4. The method according to claim 3, characterized in that in step b) while going through the frequency range each time an actual value of the power provided to the system to be excited is determined, compared to a saved value that is the highest value so far and saved together with the voltage- or current- and frequency-values that determined it.

5. The method according to claim 2, characterized in that the working point determined in step b) is the one at which a value of power provided to the system to be excited is the one that is closest to a predetermined specified value.

6. The method according to claim 5, characterized in that while going through the frequency region the specified value is subtracted from the power provided to the system to be excited and the thus obtained value is stored along with the value of the voltage or the current and the frequency at which it is obtained as new best value if the value obtained by the subtraction is smaller than the previously stored best value.

7. The method according to any one of the claims 1 to 6, characterized in that in method step c) several mechanical systems are excited simultaneously.

8. The method according to claim 7, characterized in that during step c) of the method the frequency of the generator is varied in a predetermined region around fixed working point.

9. The method according to claim 8, characterized in that the region of the frequency variation is predetermined using threshold values that are related to a defined power outflow, to a defined current or to a defined voltage relative to a maximum power outflow, a defined current or a defined voltage, respectively, by defining the frequency values as borders of the region of variation that are closest to the working point and at which the threshold values are undercut or by the lowest and the highest frequency position, at which a predetermined value of power outflow, voltage or current, respectively, is reached, at which the frequency thresholds are undercut.

10. The method according to claim 9, characterized in that the dependence between power acceptance of the system or at least one of current and voltage values, respectively, is displayed graphically and the borders of the variation region are defined manually by a user.

11. The method according to any one of claims 1 to 10, characterized in that the generator is operated below its maximum output.

12. The method according to any one of claims 1 to 11, characterized in that the generator is operated during step b) at each point with a smaller power output as during step c).

13. The method according to claim 12, characterized in that the generator is operated during step b) also at the working point, with a smaller power output as during step c).

14. A device for ultrasonic excitation of structures with arbitrary geometry using a method according to any one of claims 1 to 13 with a generator, at least one ultrasound converter (4) and at least one mechanical structure, characterized in that the generator comprises controlling means for voltage, current and frequency, by which these values can be varied over a given region to determine a working point and at least one sensor for determining a current or a voltage outputted by the generator, so that a measurement value of the sensor represents at each accessed frequency value the power outputted to the system, and a memory for storing on the one hand specified values entered by a user and on the other hand parameter values for voltage, current and frequency at which the specified value is reached or approximated in the best possible way.

15. The device according to claim 14, characterized in that at least one supply sound conductor (6) is arranged between the ultrasound converter (4) and a sound conductor (2) or a screening frame (3).

16. The device according to claim 15, characterized in that the arrangement of the supply sound conductor (6) is suitable for exciting flexural vibrations or suitable for exciting longitudinal vibrations.

17. The device according to claim 16, characterized in that a supply sound conductor (6) is provided that is suitable for scaling the excitation amplitude.

18. The device according to claim 17, characterized in that several supply sound conductors (6) are provided.

19. The device according to any one of claims 15 to 18, characterized in that several sound conductors (2) that are interconnected in a sound conducting way are provided, only one of which is prepared for excitation.

20. The device according to any one of claims 15 to 19, characterized in that in a circular screening frame (3) that is divided into four partial segments by a bearing cross (8) a circular sound conductor (2) is provided in each partial segment, one of which is excited directly, wherein each sound conductor (2) is connected via sound bridges (7) to the sound conductors (2) arranged in neighboring partial segments, wherein each sound conductor (2) is connected to the bearing cross (8) and the screening frame (3) via connector elements.

21. The device according to any one of claims 15 to 20, characterized in that a plurality of resonator plates (9) are fixedly installed on the sound conductor (2) between a screening surface (1) and the sound conductor (2).

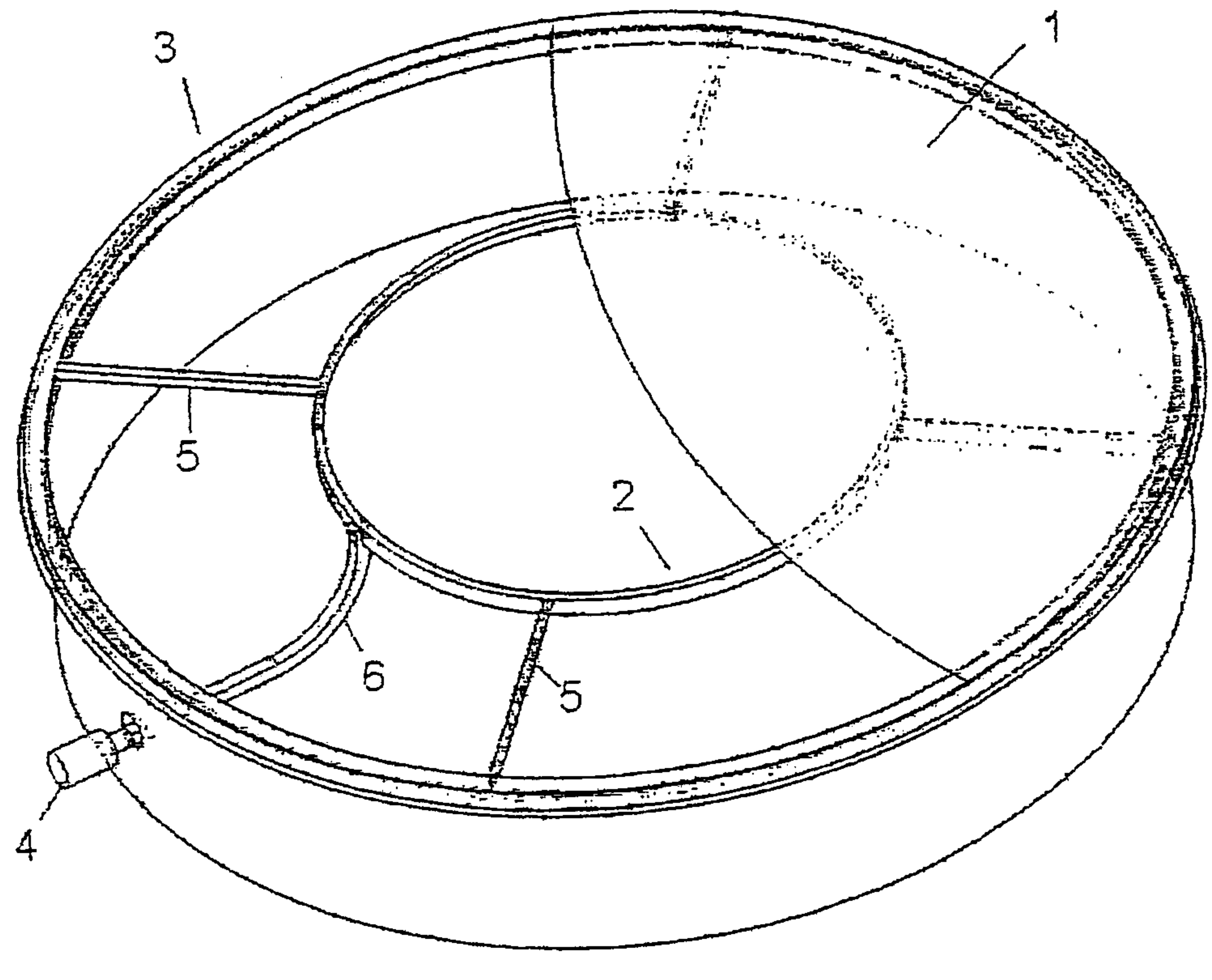


Fig. 1

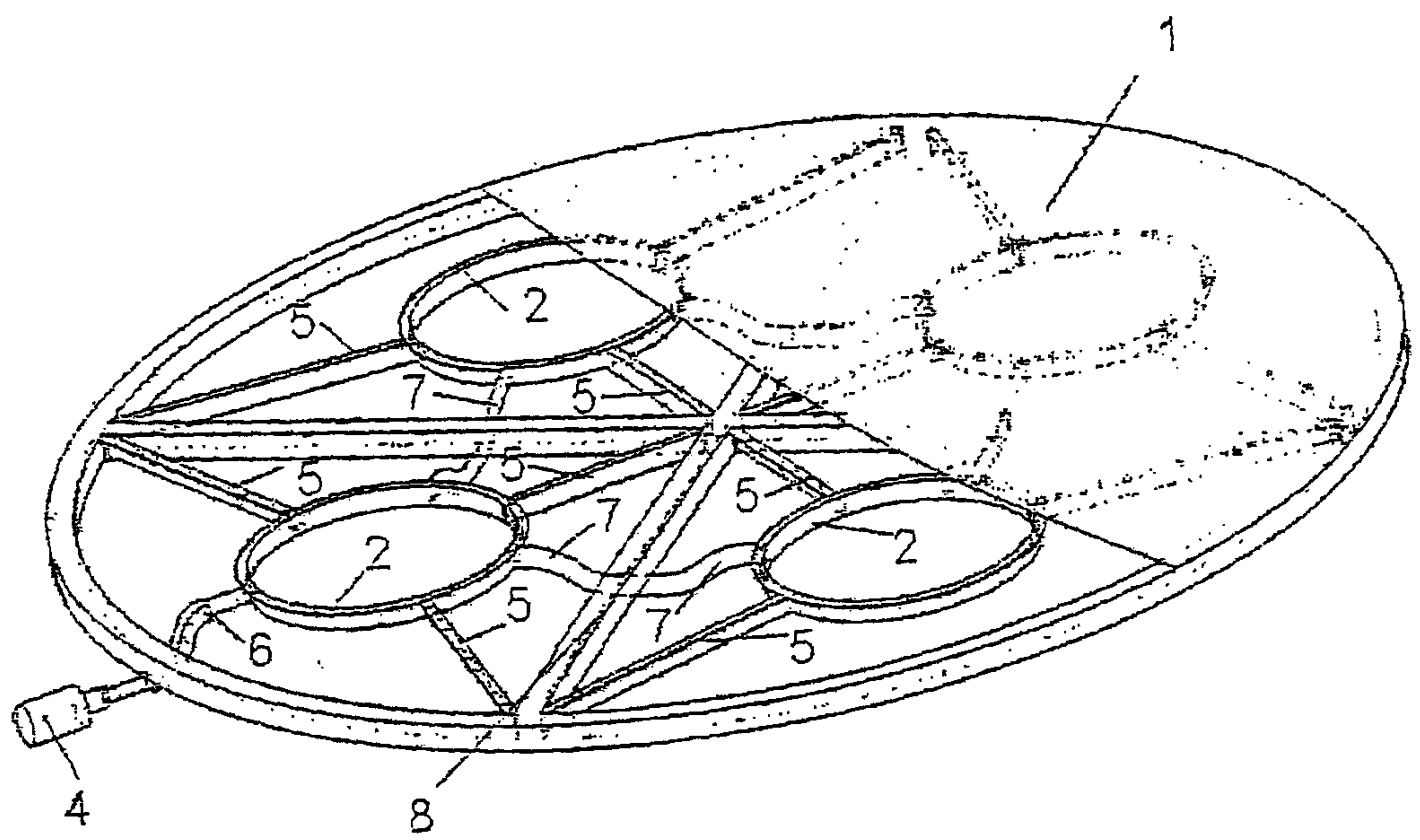


FIG..2

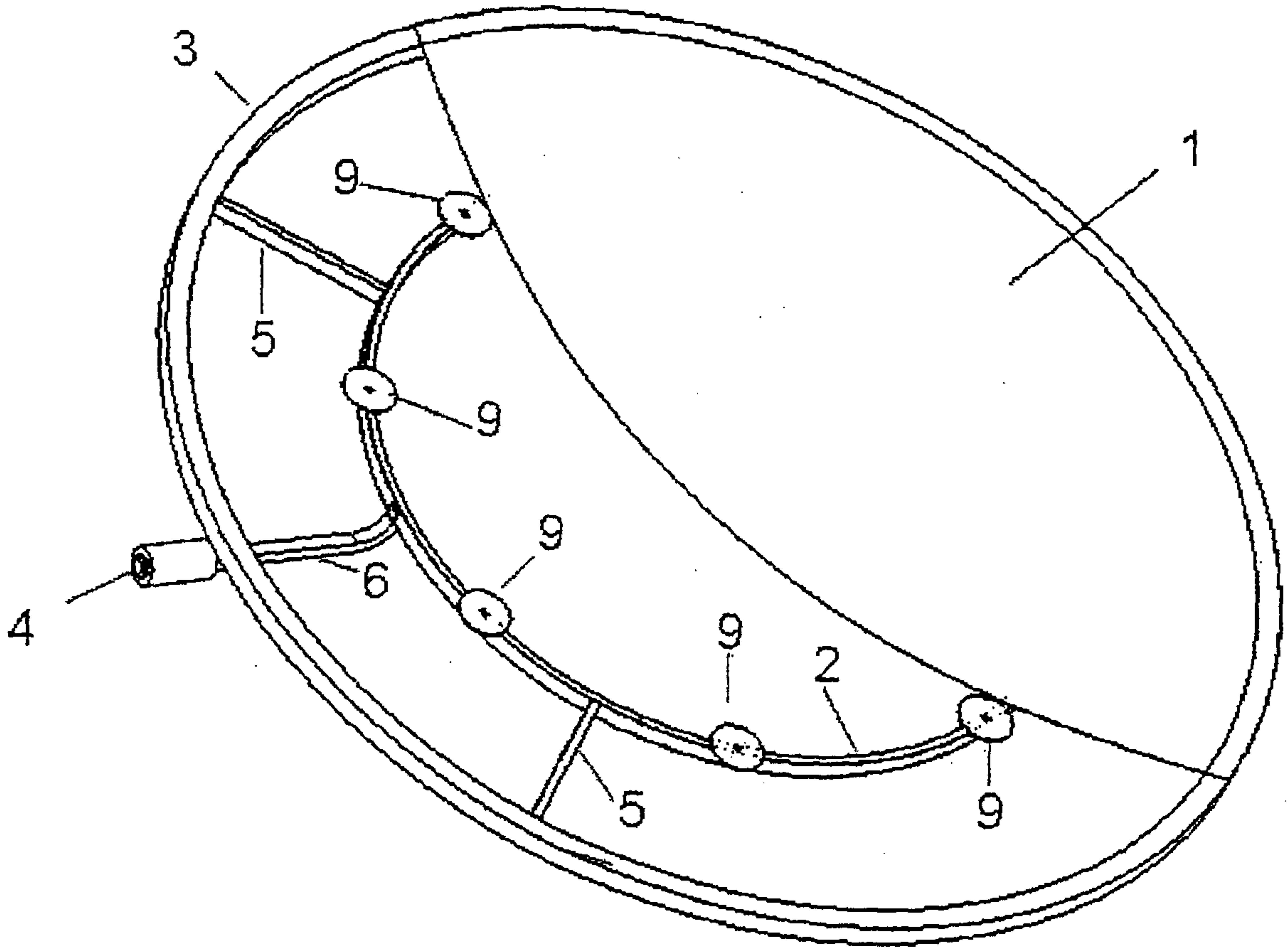


FIG..3

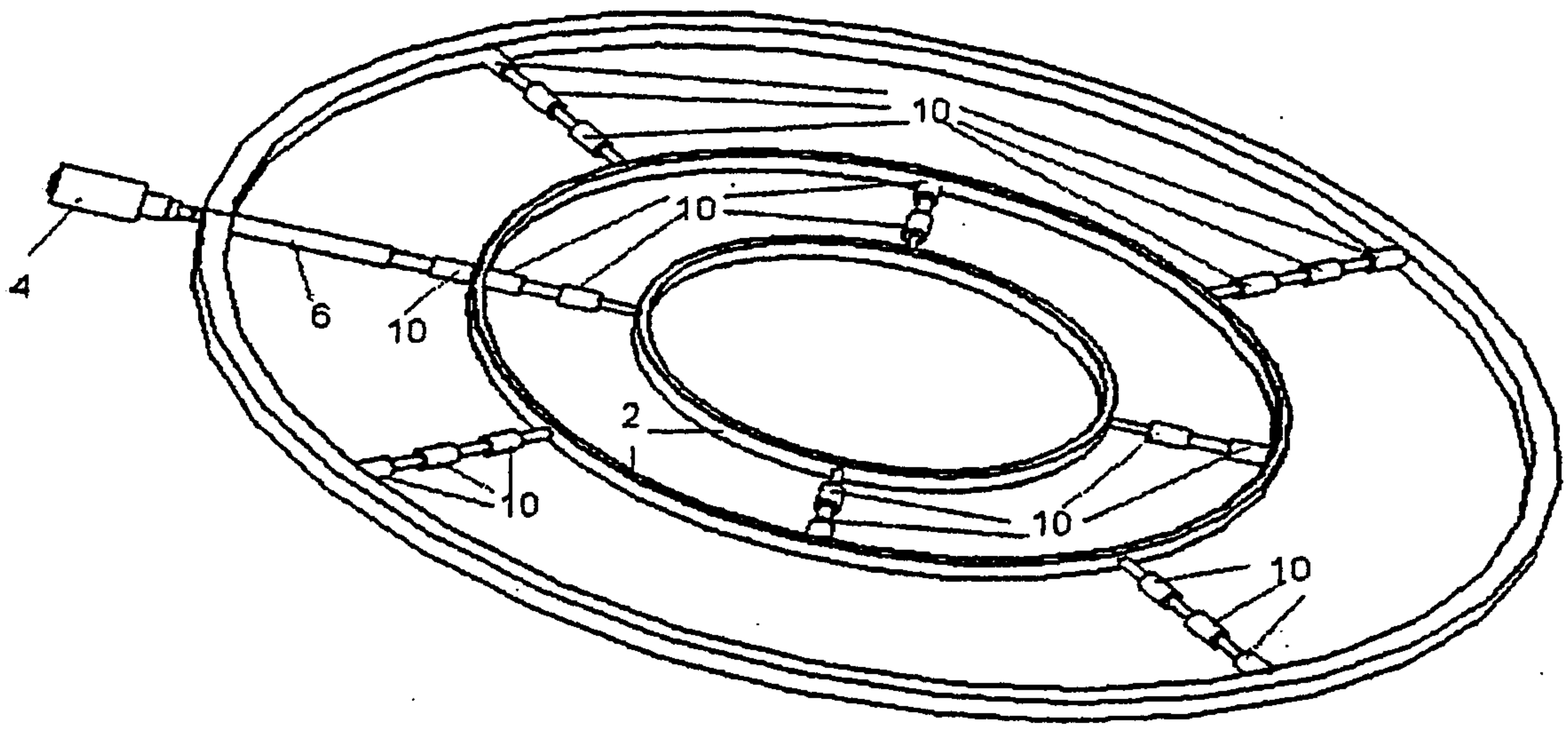


FIG..4

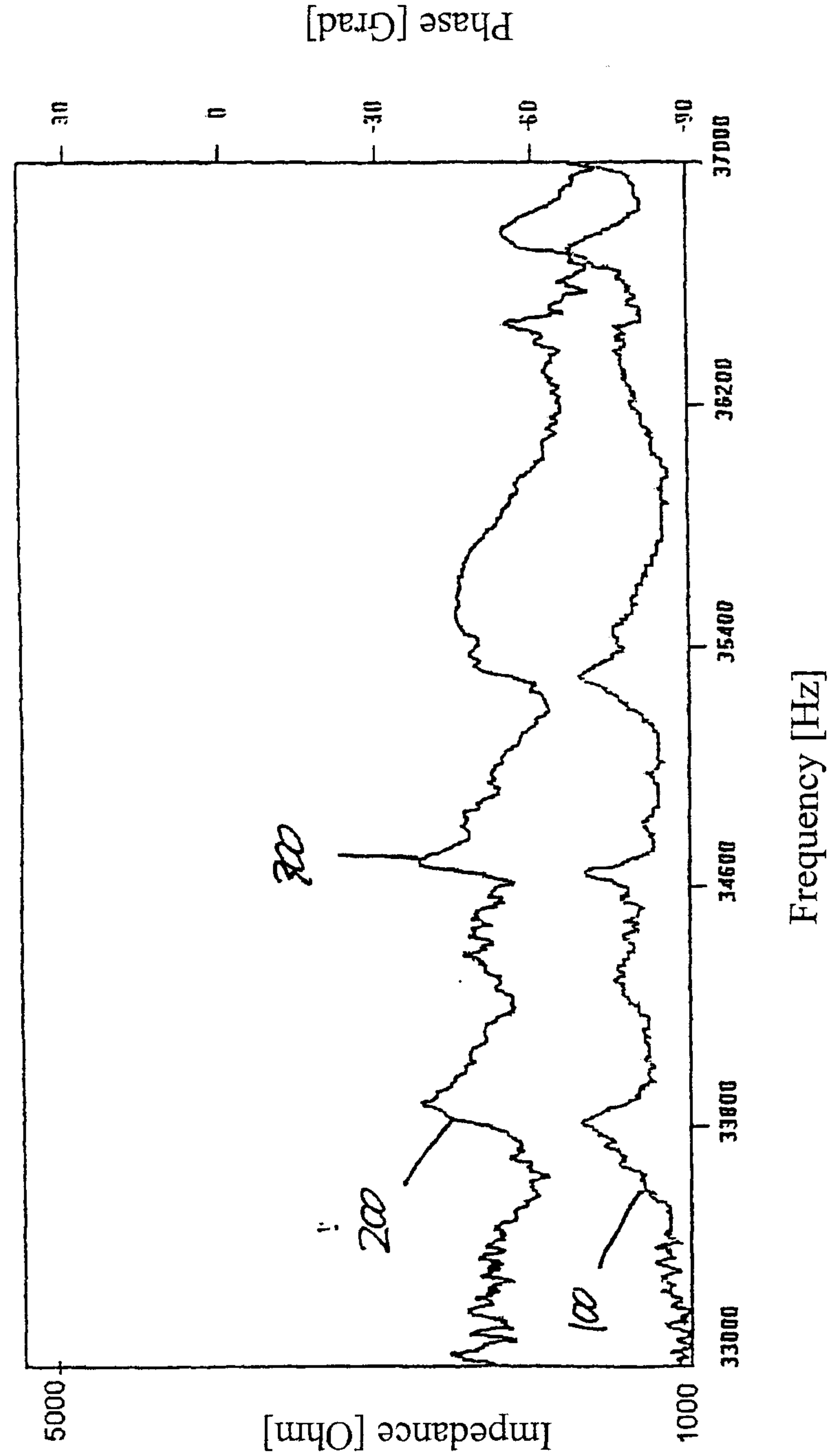

Phase [Grad]
30
0
-30
-60
-90
Impedance [Ohm]
5000
1000
Frequency [Hz]
33000
33800
34600
35400
36200
37000
100
200
300

FIG..5


5000
1000
Impedance [Ohm]
30
0
-30
-60
-90
Phase [Grad]
300
200
100
33000
33800
34600
35400
36200
37000
Frequency [Hz]