

(86) **Date de dépôt PCT/PCT Filing Date:** 2007/07/13
(87) **Date publication PCT/PCT Publication Date:** 2009/01/22
(45) **Date de délivrance/Issue Date:** 2018/04/03
(85) **Entrée phase nationale/National Entry:** 2009/03/06
(86) **N° demande PCT/PCT Application No.:** TT 2007/000001
(87) **N° publication PCT/PCT Publication No.:** 2009/011669
(30) **Priorité/Priority:** 2007/07/13 (TT TT/A/2007/000172)

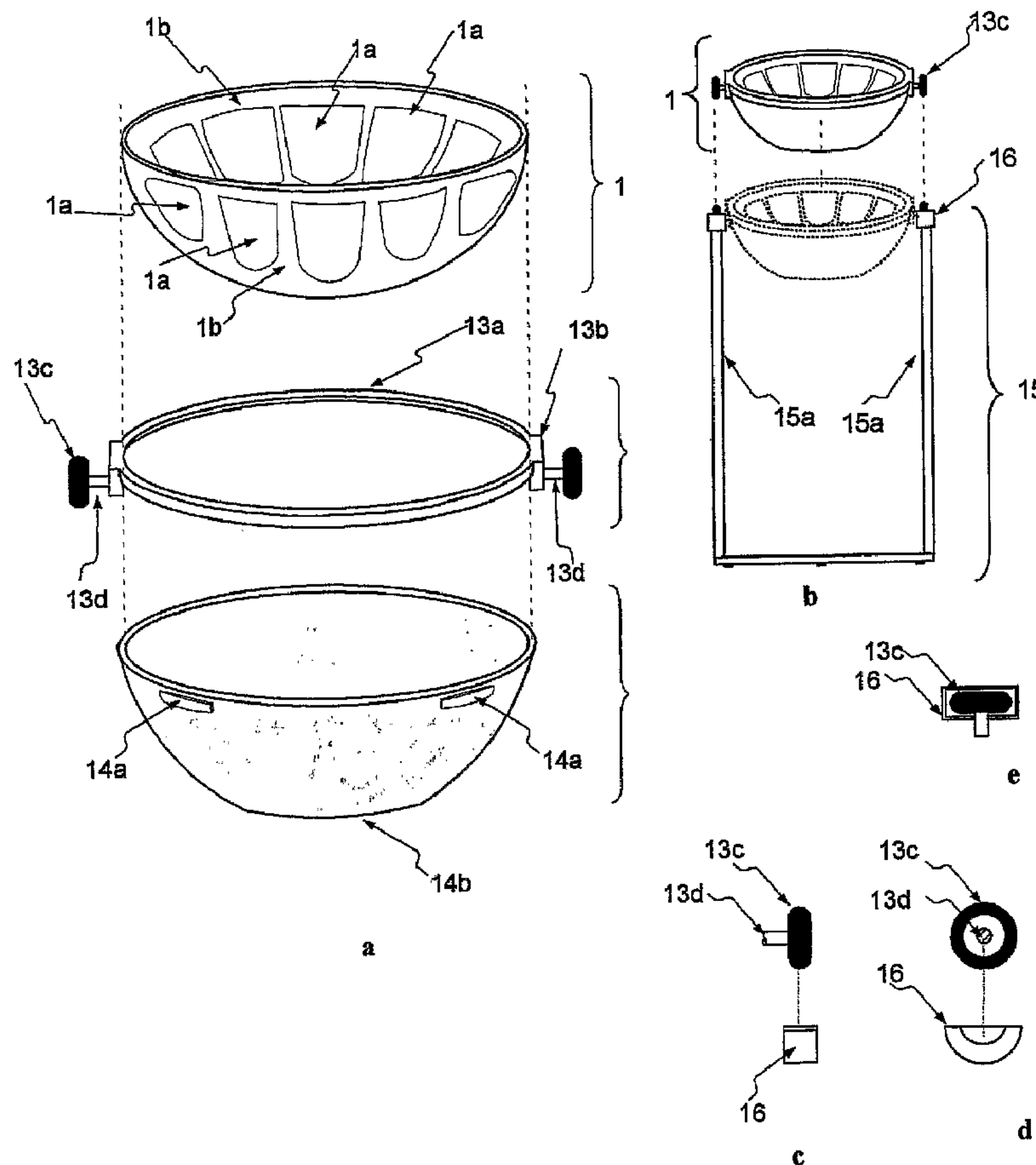
(51) **Cl.Int./Int.Cl. G10D 13/08** (2006.01)

(72) **Inventeur/Inventor:**
COPELAND, BRIAN R., TT

(73) **Propriétaire/Owner:**
THE GOVERNMENT OF TRINIDAD AND TOBAGO THE
PERMANENT SECRETARY MINISTRY OF THE
ATTORNEY GENERAL, TT

(74) **Agent:** ANDREWS ROBICHAUD

(54) Titre : INSTRUMENT DE MUSIQUE DE TAMBOUR G
(54) Title: THE G-PAN MUSICAL INSTRUMENT



(57) Abrégé/Abstract:

An ensemble of acoustic steelpan musical instruments, being an innovation which significantly improves upon traditional acoustic steelpan prior art. Said improvements include an extension of note range across the assemblage of G-Pans, a substantial

(57) Abrégé(suite)/Abstract(continued):

reduction in the number of steelpans required to effectively cover the steelpan musical range, the use of a compound design whereby individual component parts of the instrument, specifically the playing surface, chime, rear attachment, or skirt and the playing stick or mallet, are optimized for thier specific function, the application of a variety of techniques for eliminating or reducing, non-musical sympathetic vibrations and the inclusion of a variety of mechanical and acoustic resonator designs, to enhance optimally, the sound projection of the aforementioned instrument.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 January 2009 (22.01.2009)

PCT

(10) International Publication Number
WO 2009/011669 A1

(51) International Patent Classification:
G10D 13/08 (2006.01)

(74) Agent: EVERARD BYER & CO; 60-62 Frederick Street,
Port Of Spain,, Trinidad, West Indies (TT).

(21) International Application Number:
PCT/TT2007/000001

(22) International Filing Date: 13 July 2007 (13.07.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
TT/A/2007/000172 13 July 2007 (13.07.2007) TT

(71) Applicant (for all designated States except US): **THE GOVERNMENT OF TRINIDAD AND TOBAGO** [TT/TT]; The Permanent Secretary, Ministry of the Attorney General, Cabildo Chambers, 23-27 St. Vincent Street,, Port Of Spain,, Trinidad, West Indies (TT).

(71) Applicant and

(72) Inventor: **COPELAND, Brian R.** [TT/TT]; 14 Birchwood Boulevard, Cocoyea, San Fernando,, Trinidad, West Indies (TT).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL,

[Continued on next page]

(54) Title: THE G-PAN MUSICAL INSTRUMENT

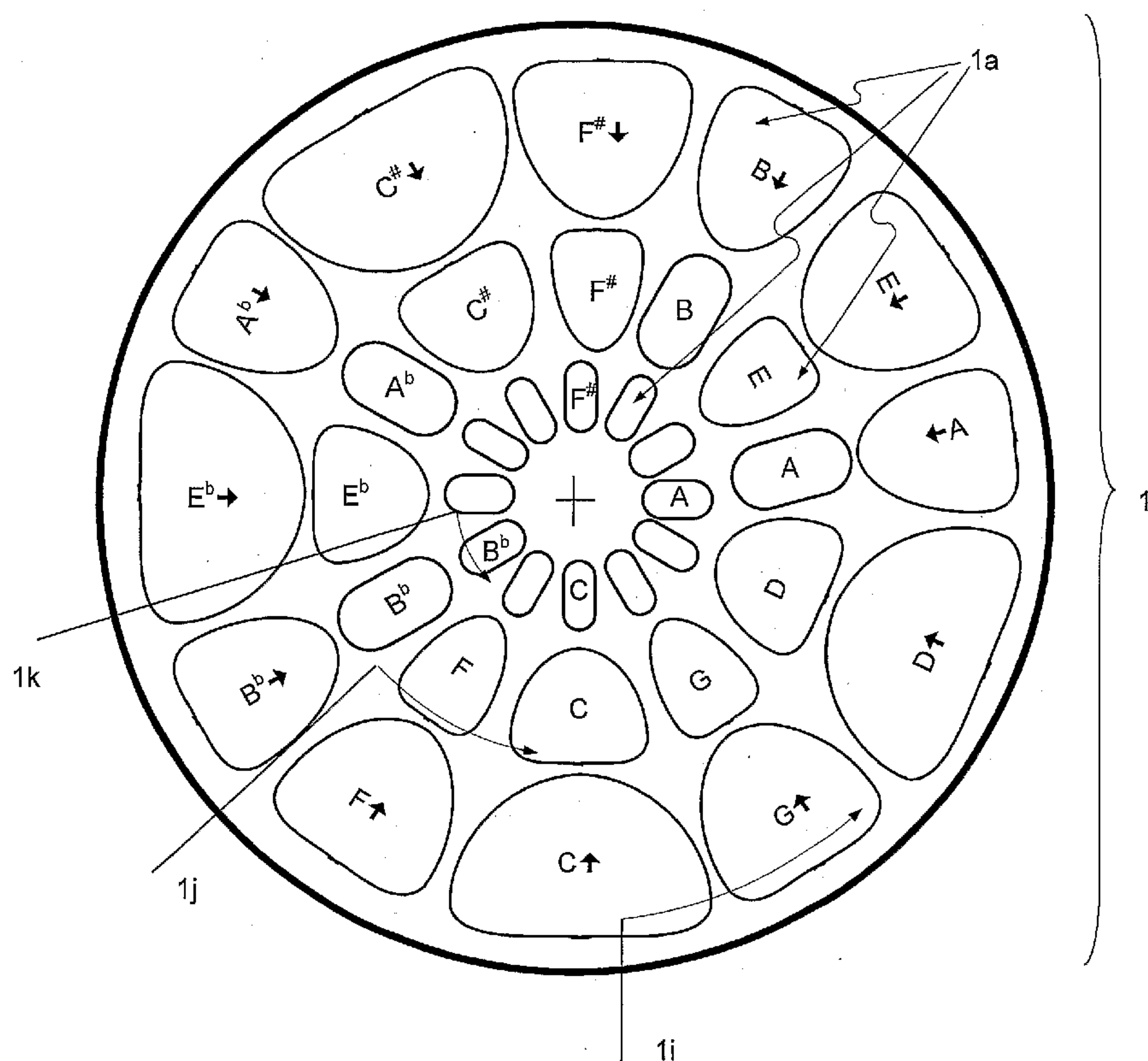


Fig. 1

(57) Abstract: An ensemble of acoustic steelpan musical instruments, being an innovation which significantly improves upon traditional acoustic steelpan prior art. Said improvements include an extension of note range across the assemblage of G-Pans, a substantial reduction in the number of steelpans required to effectively cover the steelpan musical range, the use of a compound design whereby individual component parts of the instrument, specifically the playing surface, chime, rear attachment, or skirt and the playing stick or mallet, are optimized for their specific function, the application of a variety of techniques for eliminating or reducing, non-musical sympathetic vibrations and the inclusion of a variety of mechanical and acoustic resonator designs, to enhance optimally, the sound projection of the aforementioned instrument.

WO 2009/011669 A1



PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report*
- *with amended claims*

Declaration under Rule 4.17:

- *of inventorship (Rule 4.17(iv))*

5

THE G-PAN MUSICAL INSTRUMENT

Background of the invention

1. Field of the invention

10 The present invention in ensemble, relates to a novel acoustic musical instrument which significantly innovates and improves upon the conventional metallurgical technology of traditional acoustic steelpan musical drum instruments. The present invention is played in the percussive mode, in which melodic sound is generated by striking physically defined note playing areas, on a metallic note bearing surface, in
15 like fashion to the traditional acoustic steelpan musical drum instrument.

2. Description of the Prior Art

20 The steelpan is considered as a traditional art form in the country where it has originated, namely the Republic of Trinidad and Tobago, where it has been proclaimed as the National Instrument. In its bearing on the evolution of the present invention, the prior art is completely defined by the conventional traditional acoustic steelpan musical drum instrument. The acoustic steelpan or traditional steelpan is an instrument which presents well-defined note playing areas of definite pitch, on one or
25 more continuous metal note bearing surfaces, hereinafter also referred to as playing surfaces.

The heretofore mentioned instrument is played in percussive mode and was first invented in the island of Trinidad in the Republic of Trinidad and Tobago, some time
30 in the late 1930s. The exact date of invention is unknown as the origins of the instrument are steeped in folklore, having been first fashioned by individuals who were mostly working class and generally technically illiterate. However, the first published report of the instrument was printed in the Trinidad Guardian newspaper on February 6th 1940.

35 As forerunners of the present invention, the first steelpanns were fashioned from the empty oil drums abandoned by the US army¹ and are still largely made from what is known to those skilled in the art of steel container manufacture, as tight head cylindrical steel barrels or drums. Said drums are manufactured by cold rolling the top and bottom heads to the cylindrical body of the drum or barrel. The joint thus formed
40 is known by those skilled in the art of steel container manufacture as a chime.

In its relation to the present invention, the playing surface is fabricated by first manually sinking and forming one of the drum heads with a hammer or impact tool

¹ *The steel drums of Kim Loy Wong: an instruction manual to accompany the Folkways records FI-8367 and FS-3834 and the movie, "Music from oil drums".* Seeger, P. and Loy Wong, K., New York: Oak Publications, 1961.

18 August 2008

45 and or press forming equipment. Musical note playing areas are then clearly defined
on the note bearing surface by the formation of grooves. The aforementioned note
bearing surface is then heat treated and cooled. Subsequently, the said note areas are
tuned by carefully and skillfully hammering them into the required shape by a Pan
Tuner, to create areas that produce musical notes of definite pitch when struck.

50 The cylindrical body of the original drum is retained to form what is known as the
skirt of the steelpan but is cut to various lengths primarily to perform the role of an
acoustic resonator. The circular playing surface typically ranges from 55.88 cm/22 in
to 68.58 cm/27 in in diameter and the length of the skirt ranges from about
55 15.24 cm/6 in to 91.44 /36 in. Larger and smaller sizes have been used but the
implementations that have been adopted utilize the stated ranges presumably for
reasons of ergonomics and performance facilitation.

60 In their influence on the development of the present invention, drums which are
formed as described above, are grouped to form a variety of steelpan instruments to
cover different parts of the musical range. As such, a steelpan instrument is a musical
instrument in which the notes are distributed over a number of drums. The number of
drums in a steelpan instrument is dictated by the limitations of the applicable laws of
science that determine the size of note area required to resonate at desired musical
65 note frequencies.

There are at least eleven steelpan instruments in the traditional steelpan family. The
nine-bass steelpan consists of nine drums with three notes each for a total of 27 notes
typically ranging from A₁ to B₃. The more common six-bass steelpan consists of six
70 drums with three notes each for a total of 18 notes typically ranging from A₁ to D₃.
Tenor bass steelpans consist of four drums to typically cover the range G₂ to D₄. Cello
steelpan covers the baritone range and come in two varieties. The 3-cello steelpan
typically covers the range B₂ to G₄ over three drums while the 4-cello steelpan
typically covers the range B₂ to D₅ over 4 drums.

75 The quadraphonic steelpan is a recent innovation that uses 4 drums to cover the range
B₂ to B₅^b. The double guitar steelpan uses two drums to cover the range C₃[#] to G₄[#].
The double second steelpan uses two drums to cover the range F₃ to B₅^b. The double
tenor steelpan uses two drums to cover the range A₃ to C₆[#]. The Low tenor uses a
80 single drum to cover the range C₄ to E₆^b. The high tenor uses a single drum to cover
the range D₄ to F₆. For historical reasons, an anomaly exists in the naming of the tenor
pan which actually carries notes in the soprano range.

85 In order that the pan player may obtain good musical quality, the end of the stick or
mallet that is used to contact the note bearing surfaces is covered, wrapped, or coated
with a soft material, usually of the consistency of rubber. If the material used is too
hard, the sound produced tends to become dissonant and harsh. If the material used is
too soft, the sound produced becomes muffled. Thus the design of the stick
determines the time that the stick remains on the note at the point of impact, defined
90 in the literature² as the *contact time*. Note partials that have frequencies with cycle

² *Steelpan Tuning*, Kronman, U., Musikmuseet, Stockholm, 1991.

18 August 2008

periods shorter than the contact time are suppressed while those possessing frequencies with cycle periods longer than the contact time are not.

95 The playing surface of the very first steelpan was of a convex shape. However, this provided some difficulty in performance. As the instrument evolved, pannists and steelpan tuners showed strong preference for the concave shape which has now been adopted universally as the norm.

100 As it relates to the background art, in current steelpan designs, the playing surface is fashioned by hammering one flat end of the drum into a concave bowl, thus stretching the metal to the required depth and thickness. This said process is called "sinking." The sinking process reduces the thickness of the playing surface and adjusts the material elasticity to levels required to support the desired note range. The sunken surface is then separated from the rest of the drum by cutting the skirt at an
105 appropriate distance beneath the rim of the sunken end. The other half of the drum is either discarded or used to make a separate steelpan.

Note bearing areas may now be demarcated, often by engraving grooves or channels between note areas with a punch. This step is not absolutely necessary and serves only
110 as a means for pannists to easily identify note areas. What is more important is the degree of separation and isolation between the notes; this is essential to a good sounding instrument as it provides an acoustic barrier which reduces the transmission of vibration energy between notes thus improving the accuracy of the instrument. For the purpose of clarification, accuracy refers to the characteristic of the instrument
115 which facilitates the production of the intended musical note and only the intended notes, when the pertinent note bearing area is excited.

Trinidad and Tobago patent No. 33A of 1976(expired) to Fernandez, the "magno pan" was the result of magnetic tuning of steel drums by magnets contacted to each note in
120 a particular way, so that when the magnets of different magnitudes are regulated to specific areas of the notes, the pans can be altered from one key to another key, by as much as two tones apart i.e. C to E, or E to C. The quality of tone can also be altered by regulation of the magnets. Trinidad and Tobago patent No.32 of 1983(expired) also to Fernandez, the "bore pan", enhances the barrier by boring holes along the note
125 area perimeter and heat treating the area around the note.

On the note bearing surfaces of the steelpan, note separation refers to the degree of isolation of one note from another; in poorly separated notes, a significantly large percentage of the energy imparted by a strike to one note is transmitted to another, so
130 much so that the sound generated by the second note is discernible. Poor separation can result in unwanted excitation of groups of notes.

Consonance and dissonance are terms used to describe the harmoniousness and pleasantness of the composite sound produced when two or more notes are
135 simultaneously excited, a distinct possibility on the steelpan on which multiple notes share the same surface and multiple notes can be accidentally excited through energy coupling as described above. Consonant tones sound pleasant while dissonant tones sound unpleasant. As such, the concept of consonance and dissonance is a bit subjective.

18 August 2008

140 In the prior art, it is generally accepted that dissonance results when partials from two
notes fall within a critical band of frequencies. Although the range of this band varies
along the musical scale, it typically ranges from about 30 Hz to 40 Hz. Thus
consonance and dissonance are directly related to musical intervals and, as such, there
are levels of consonance that arises in any musical scale. In particular, in Western
145 music, the consonance of musical intervals is graded in decreasing consonance or
increasing dissonance.

Intervals corresponding to octave (most consonant), perfect fifth, perfect fourth are
said to be in perfect consonance, while intervals corresponding to major sixth, major
150 third, minor sixth and minor third are said to be in imperfect consonance. The most
dissonant intervals, in decreasing levels of dissonance, are generally considered to be
the minor second (most dissonant), major seventh, major second, minor seventh, and
the tritone (augmented 4ths or diminished 5ths).

155 Dissonant sounds can be produced if some energy from a note that is struck is
transmitted to another note that has overtones that are not in consonance with the
struck note. It is for this reason that chromatic arrangements of notes on the playing
surface are generally avoided as all notes will then be a minor second apart.

160 As it relates to the present invention, it must be emphasized that tuners capitalize on
inter-note coupling to vary the overtones produced by each note. This is done by
selective adjustment of tensions in the area between the notes and by judicious
arrangement or layout of notes on the playing surface of the instrument to ensure that
most of the coupling occurs between consonant groups of notes.

165 For the present invention, the note separation problem lies at the heart of the
challenge of devising a note layout schema that determines the value and location of
notes on a steelpan drum. A plurality of note layout schemas has been used over the
years. The key considerations in adopting any of these note layout configurations are
170 ease in musical performance and the control of dissonance to acceptable levels.

As it has affected the evolution of the prior art over the years, pannists have
demonstrated preference for particular given physical note arrangements. The
preferred arrangements are listed in standards published by the Trinidad and Tobago
175 Bureau of Standards³. Most notable of these is the fourths and fifths arrangement for
use on the tenor steelpan which has been found to facilitate musical performance
while minimizing dissonance on that said instrument. Adjacent notes on said layout,
being generally the notes that will experience the greatest degree of energy coupling,
are set to musical intervals of the octave, fourths or fifths, these being the four most
180 consonant musical intervals.

After note demarcation, the drum is heated to about 300°C to relieve the mechanical
stresses developed in the sinking process. The steelpan is then cooled either quickly
by quenching or more slowly in air. Variations in the heating process vary from one
185 manufacturer to another. Next, individual notes are formed by careful hammering of

³ *Ad Hoc Specification Committee on Steel Pan (1989): Proposal for a Trinidad and Tobago Standard - Glossary of Terms Relating to the Steel Pan*. TTS 1 45 000, Trinidad and Tobago Bureau of Standards.

the selected areas. Finer adjustments are made in the size and shape of the note areas to define the note pitch and partials. Tuning of the steelpan is an iterative process and is accomplished either by ear or with the aid of mechanical or electronic tuning devices.

190

The steelpan musical instrument of the prior art allows for some variation of timbre or voice because a tuner can individually tune the partials of any given note. This process is known as "harmonic tuning". In essence, then, the steelpan is a mechanical means of implementing sound synthesis. Harmonic tuning also benefits the player

195

who can thereby create further subtle variations in note timbre by striking of the note bearing surfaces in different locations.

200

For the prior art, the skirt of the said traditional acoustic steelpan takes the form of a tube or pipe, of diameter equal to the playing surface. Its role in effecting acoustic coupling and projection of the sound created by vibration of notes on the playing surface can be described by rigorous application of well known principles of acoustics. The required analysis is quite complex but can be simplified for the purpose of this document through consideration of two primary mechanisms.

205

Firstly, the steelpan drum can be modeled as a tube that is closed only on one end. This is known to those skilled in the discipline of acoustics as a closed-open tube and displays resonances characteristic of the air enclosed in the barrel. An ideal closed-open tube has a fundamental resonance at

$$f_1 = \frac{v}{4(L + 0.3d)}$$

210

where d is the tube diameter, L the tube length and v the velocity of sound in air. The factor $0.3d$ is an end correction factor used to compensate for dispersion of the sound at the end of the tube. The factor $L + 0.3d$ therefore corresponds to a $\frac{1}{4}$ wavelength of the fundamental resonance frequency.

215

In its bearing on the prior art, what is of significance to the steelpan, is the fact that the ideal closed-open tube also displays resonance peaks at odd multiples of the fundamental resonance frequency and resonance nulls at even multiples of the fundamental resonance frequency. In practice, the frequency response of a tube will display maxima at odd multiples of the fundamental resonance frequency and minima

220

at even multiples of the fundamental resonance frequency.

225

The strength of the displayed resonances and correspondingly, the difference between frequency response maxima and minima, become more pronounced as the ratio of radius to skirt length decreases. As such, the contribution of the resonance effect increases for steelpan of lower pitch that typically carry long skirts.

230

In addition, sound is propagated from the walls of the skirt itself in response to acoustic energy transferred from the playing surface through the rim to the skirt. Whereas the skirt is naturally characterized by its own modal behaviour defined by characteristic modal frequencies at which it resonates, it would also vibrate at the frequencies produced by the note bearing areas on the playing surface as well. The strength of these vibrations would depend on the how hard the notes are struck and

18 August 2008

how close the component frequencies of the resultant vibrations on the playing surface are to the resonant frequencies of the skirt.

235

Frequency components that are closest to a skirt resonant frequency will tend to experience greater amplification in vibration level than those that are not. The net contribution to the sound field by the skirt would be as a result of the composite effect of these vibrations over the entire area of the skirt. In particular, although vibration levels at any given point of the skirt would generally be small, the resultant contribution over the large surface area of the skirt would lead to a level of sound that is quite discernible.

240

For the high tenor steelpan, the skirt of the drum from which the pan is made is cut to a length of 11.60 cm/4 in to 15.24 cm/6 in. The length of this aforementioned skirt increases as one goes down the musical range, reaching a typical length of 86.36 cm/34 in for the six-bass. In the final stage of the process the said instrument is given a protective coat. This may include paint, an electroplating finish, usually nickel or chrome, or sprayed and baked plastic finish. Minor adjustments in tuning are often required after this process.

250

The perimeter of the said playing surface of the steelpan, which is called the rim in the steelpan fraternity on the traditional acoustic steelpan, corresponds to what is known as the chime by those skilled in drum and barrel container manufacture and is made by crimping or rolling the materials comprising the playing surface and skirt. When the playing surface of a traditional steelpan is struck during a performance, some of the impact energy excites one or more torsion modes of the drum. For the 55.88 cm/22 in diameter drums used on most traditional steelpans, with the rim as described above, said torsional vibration has a subsonic frequency component of about 15 Hz. Said vibration is significant for normal performance impacts and can actually be felt when one touches the rim of the instrument.

255

260

The consequent fluctuating shape distortion of the playing surface on the traditional steelpan drum due to the torsion mode of vibration is largely responsible for the changes in note pitch frequency at times occur, particularly on the notes closest to the edge of the playing surface, and therefore negatively affects note clarity and accuracy. Moreover, traditional steelpans go out of tune if the rim of the instrument is distorted due to stress caused by an externally applied force or temperature changes.

265

By dint of a paradigm shift, the invention and ongoing development of the steelpan musical instrument, apart from fostering the export of the steelpan instrument from a developing country to many first world countries has ushered in a new era of metallurgical technology globally. Until its invention in Trinidad and Tobago in the 1940s, musical instruments made from steel shells and steel plates were relegated for use only as rhythmic instruments such as gongs, cymbals and bells.

270

275

Dynamically however, the advent of the steelpan musical instrument has added to the global repository of metallurgical technological knowledge, by demonstrating convincingly that it is possible to produce high quality melodic tones, through controlled deformation and treatment of steel sheets and meticulously careful design of the sticks or mallets used for performance, in the striking of respective note bearing

280

surfaces. The term "steelpan technology" has been coined in Trinidad and Tobago out of the dire need to codify and encapsulate the complex metallurgical processes involved.

285

There are many easy and obvious extensions to the traditional practice of steelpan fabrication. The instrument needs not be fashioned from an oil drum as was done traditionally. Indeed the entire instrument can be made from sheets of metal by fashioning and attaching a metal top, which will ultimately form the playing surface, to an appropriately shaped support. Attachment can be achieved by welding or crimping, for example. Sinking can and has been achieved by a variety of standard industrial processes such as hydro-forming or spin-forming.

290

Despite its novelty and appeal, the traditional acoustic steelpan instrument suffers from several disadvantages. Firstly, the musical range of each steelpan in the traditional family of steelpans is typically less than three octaves. This is a limitation, particularly for soloist performances that is often compensated for by transposition of portions of a composition, the required notes of which fall outside the range of the instrument being played. In addition, some performers make up for this deficiency by simultaneously performing with two different steelpan ranges.

295

300

Furthermore, as existing steelpans evolved in a generally ad hoc manner, dependent upon need, there is an apparent clutter due to the fact that at least eleven instruments were required, until now, to cover the entire musical range. This clutter is further compounded when one considers the plethora of variations in note layout styles.

305

Said variations in note layout styles also contribute to the difficulty experienced by individuals, who may wish to play a wide range of steelpan instruments in an orchestra. Moreover, it works against player mobility, said mobility being the ability of a player to play in different steelpan orchestras which have steelpans with differing note layouts.

310

The traditional method for acoustic steelpan manufacture, relies on the steel container manufacturing industry for its primary raw material, said raw material being a finished used or unused steel drum, usually of the 55 gallon variety. However, drums made by said steel container manufacturers are designed strictly for the container market for which the primary concern is the ability of a drum to resist bursting when subjected to impact stress. As such, said manufacturers are less concerned with the metallurgical properties of the steel used to manufacture drums, than they are with its tensile strength. As such, the steel used in traditional manufacture can have widely varying metallurgical characteristics, such as Carbon content, grain size and purity, required to make a high quality steelpan musical instrument. This clearly impacts on the variation of musical quality of the steelpan instrument made from such drums.

315

320

In addition, as traditional drums are largely manufactured from barrels made for the container industry, traditional steelpans are not of optimum design, said design being characterized by consideration of the required characteristics of the major parts of the steelpan for the creation of an instrument of the highest musical accuracy and rendition. Said major parts are the playing surface, the chime and the skirt.

325

18 August 2008

330 In the manufacture of the traditional acoustic instrument, little or no attention is paid to the need to modify or adapt the chime and skirt to optimize performance. Moreover, the playing surface is only shaped with the sole intent of defining musical note areas. These said three components can detract from the musical accuracy of the instrument as they resonate at their own natural structural modal frequencies when the instrument is struck during a performance. Said modal frequencies have been measured at as low as 15Hz. As these natural modes of vibration are associated with modal deformations of the playing surface, the geometry of the notes defined therein is distorted resulting in low frequency modulation of the note frequencies.

340 In addition to the modulation effect, the non-musical vibrations of the skirt, in particular, contribute to noise that detracts from musical quality. In particular, high frequency resonances can often be discerned when a note is struck and very often even after the musical components of the generated sound have substantially decayed. These resonances are generated primarily from the parts of the playing surface that are not tuned as note areas, from the chime and from the skirt. This is a pertinent issue with the traditional steelpan which requires resolution and has been readily identified by varied experts with keen musical ears.

As well, the frequency response of the closed-open tube that forms the skirt has maxima at odd multiples of the first resonance and minima at even multiples of the first resonance. Moreover, the difference between maxima and minima increases as the ratio of barrel radius and length decreases. Said radius/length ratio typically varies from 0.32:1 for the bass to 1.83:1 for the tenor steelpan. Thus, although a stronger resonance exists for the bass instruments, the frequency response of the closed-open tube of which it is formed is much more uneven than for the higher pitched instruments that use shorter skirts. This can have deleterious effects on tonal structure. By comparison, the resonance effect that arises from the characteristic uneven frequency response of the closed-open tube design used in wind instruments such as the clarinet or flute is absolutely essential for the generation of notes and their corresponding harmonic overtones. Said instruments have radius/length ratios of the order of 0.04:1.

365 However, when applied to the traditional steelpan the tube which forms the skirt is not, by virtue of the same characteristic uneven frequency response, an optimum acoustic resonator for the simultaneous spectrum of overtones that typically exists for notes on the playing surface. For example, if the length of the skirt is adjusted so that its first resonance corresponds to the pitch of the lowest note on a given drum, then the octave of said note would be suppressed as a consequence of the frequency response minimum. This problem is compounded when one considers the effect of the fifth, which would normally be the other note on the playing surface of a bass, and its partials.

375 In consequence therefore, all of the above suggests that traditional steelpan construction techniques do not adequately focus on the acoustic design of the instrument and that more effective skirt designs are required.

18 August 2008

380 Regrettably, traditional acoustic steelpanns do not allow for the easy removal and replacement of the skirt to facilitate maintenance, transportation, or change in instrument sound radiation characteristics.

385 Traditional acoustic steelpanns are usually suspended from a specially designed stand by a string, cord, or wire. Apart from the need for improvement in terms of aesthetics, this arrangement facilitates undesirable coupling of vibration energy between the steelpan, the support stand and the floor on which it is placed. This unwanted coupling can further detract from musical quality through the additional noise component added, particularly from the support stand, or other such structure.

390 In addition, as the string, cord, or wire by which the steelpan is suspended is usually affixed to the rim of the instrument, the top of the support stand to which the string is attached must project above the rim and therefore impedes somewhat the performance of the player. As well, although support stands with mechanisms for height adjustments do exist, said traditional method of suspension does not facilitate easy adjustment of the attitude of the instrument. This works against the ergonomic use of
395 the instrument.

US patent No. 4,214,404 to Rex is among numerous innovations which describe percussive devices which produce musical sound using acoustic or mechanical means and is a drum comprised of a multiplicity of resonant chambers within a single enclosure and excited by a drum head that effectively forms a compound membrane, when pinched against the opening of said resonant chambers. The said invention thus
400 disclosed, uses acoustic resonance of tubes, as its sound generation mechanism and is therefore different in design from the steelpanns that exist in the prior art, or as described, such as that of the present invention, that use the modal characteristics of
405 shell indentations on a continuous surface to produce sound.

Canadian patent No.1209831 (expired) to Salvador and Peters, provided a drum which was adapted to mitigate the drawbacks found in the prior art structure. More specifically, the said invention provided a drum having a musical note bearing
410 surface, which included rectangular notes which were tuneable, to have the harmonic modes of each individual note dominate the inharmonic modes.

German patent No.DE20013648U to Schulz and Weidensdorfer outlines a steel drum which has an outer ring of eight tone fields (1-8) representing an octave (diatonic)
415 from middle C to upper C .It also has an inner so-called centre area containing five tone fields, viz. containing upper D, E and F (9-11) and two areas covering B flat or A sharp and G flat or F sharp. Thus the musical range is a tenth from middle C to E above upper C plus two accidentals i.e. B flat or A sharp and G flat or F sharp.

420 US patent No. 5,814,747 to Ramsell the "Percussion Instrument capable of producing Musical Tone" is a device that is comprised of a multiplicity of synthetic tubes of varying lengths that resonate at different frequencies when struck with a mallet. The invention thus disclosed is a percussive device that produces musical tones, but uses acoustic resonance of tubes as its sound generation mechanism and is therefore
425 different in design from the steelpanns which comprise the prior art, or as described

18 August 2008

such as that of the present invention, which use the modal characteristics of shell indentations on a continuous surface to produce sound.

430 US Patent No. 5,973,247 to Matthews, describes The "Portable Steel Drums and Carrier" a device that is comprised of two steelpan drums with eighteen notes on a harness and mount, designed for the carrying of two steelpan drums mounted upon the human body. The invention thus disclosed does not cover the entire musical range, nor does it extend the range of the traditional steelpan, nor does it give consideration to the optimum design of the playing surface, rim and skirt of the steelpan drums
435 used, nor does it consider the design of the skirt to effect sound propagation.

US Patent No. 6,750,386 to King [Inter Partes Reexamination Certificate(0026th) US 6,750,386 C1 issued under 35 U.S.C. 316], describes The "Cycle of Fifths Steelpan," a steelpan which uses a note layout based on the cycle of fourths and fifths. The
440 invention thus disclosed, differs from the prior art only by way of the layout of notes, such that they progress in musical fifths intervals in a counter-clockwise direction, whereas the traditional tenor steelpan as well as the invention described in this document places notes progressing in musical fifths intervals in a counter-clockwise direction. The invention thus disclosed does not cover the entire musical range, nor
445 does it extend the range of the traditional steelpan, nor does it give consideration to the optimum design of the playing surface, rim and skirt of the steelpan drums used, nor does it consider the design of the skirt to effect sound propagation.

US Patent No. 6,212,772 to Whitmyre and Price, the "Production of a Caribbean
450 Steelpan" describes a manufacturing process to facilitate mass production of the steelpan musical instrument by hydroforming the playing surface. The process also allows for providing the instrument with a means to easily detach the skirt to facilitate maintenance, portability and changes in tonal characteristics. However, the description in said aforementioned patent, does not disclose an instrument that
455 extends the range of the traditional steelpan, nor does it reduce the number of steelpans required in an orchestra, nor does it give consideration to the optimum design of the playing surface, rim and skirt of the steelpan drums used for the reduction of non-musical resonances, nor does it consider the design of the skirt to effect sound propagation, nor does it treat with the issue of how the steelpans are to be
460 suspended.

In particular, whereas in the prior art, steelpan quality was subject to the inconsistencies of drums and barrels that could be accessed by tuners, but which were fabricated for the express purpose of packaging, the ensemble of the present invention
465 features a playing surface that is significantly improved through use of certified high quality steels, specifically selected for its manufacture.

In addition, the playing surface is of a compound design to support the creation of notes in the upper musical ranges. The present invention noticeably breaks with the
470 traditional consideration of a drum as an integral entity, treating with said drum, instead, as an item that is constructed from three separate components after deliberate and careful design of said components of the instrument, for optimization of function and in so doing, overcomes the heretofore mentioned disadvantages of the prior art.

475 Summary of the Invention

The present invention improves upon the traditional acoustic steelpan instrument, primarily through deliberate application of music, appropriate metallurgical and acoustic technology, as well as engineering construction.

480 The design philosophy of the present invention differs from the prior art in that the latter is made from pre-manufactured barrels that are often made, through material selection and construction, for the sole purpose of packaging. As such the materials used are often not the best suited for the steelpan and are often of unknown and variable quality and metallurgical composition.

485 The ensemble of acoustic steelpan drums of the present invention, on the other hand, are of a compound design and construction, being fabricated from parts consisting of a playing surface bonded by a rigid chime that is itself fastened to a rear attachment. The playing surface is itself of compound design to better facilitate the wide range of
490 notes on each such steelpan drum. In particular, the playing surface incorporates an insert that is specially machined and formed to support notes in the highest ranges of any given instrument of the ensemble of the present invention. The present invention features an option of three types of rear attachments and employs scientific principles to fashion resonators and acoustic radiators to enhance the musical performance by
495 increasing the acoustic radiation levels from each instrument. The materials used in construction, particularly of the playing surface, are specially selected for optimum application.

At the same time, the rear attachments of the present invention use damping methods
500 known to those skilled in the art, to reduce or minimize undesirable rear attachment resonances while significantly reducing the level of non-musical resonances that are typical in the prior art. Said resonances often arise from the skirt of the traditional instrument which is neither treated nor modified in any way in the prior art to subdue such resonances. Thus it may be said that the rear attachment design of the present
505 invention, therefore significantly improves on the prior art whereby players are constrained to rear attachments that are a single barrel, or tube.

For the present invention, the playing surface is supported by a rigid chime that reduces coupling across the playing surface and between playing surface and skirt, a
510 vibration mechanism that often detracts from musical quality in the prior art. The rigid chime also reduces the need for retuning due to temperature variations that tend to undo the mechanical crimp chime design used in the prior art.

Utility is further enhanced by consideration of portability and assembly for
515 performance. In particular, whereas the traditional instrument is suspended by a string, cord, twine or similar contrivance to a support stand, the present invention offers a built in suspension mechanism in the form of a wheel that is inserted into a receptacle mounted upon the arms of the support stand thus facilitating the process of rapid one-step assembly of the present invention for a performance. One only has to
520 insert the wheels into the receptacle for the present invention to be performance ready. Said wheel and receptacle arrangement is unique to instruments of any nature and facilitates the free swinging motion traditionally required by performers.

18 August 2008

525 The current invention utilizes a new design methodology based on a set of design equations that facilitate the determination of the size of drum, as measured by the radius of the playing surface, required to support a chromatic sequence notes in a predetermined range. In addition, these equations, called steelpan design equations, can be used to determine, a priori, the number of drums of pre-determined size required to support a chromatic sequence notes in a predetermined range.

530 The new design technologies as embodied in the present invention are applied with the aid of the generator equations to produce an ensemble of steelpan instruments which adequately extend the upper and lower musical ranges of the steelpan assemblage. Moreover, the range of each instrument of the ensemble of the present invention effectively covers a large number of notes, typically 3 octaves or 36 notes. 535 As a result, only four instruments are now required to cover the entire music spectrum whereas, for the traditional acoustic instrument, as many as eleven instruments or more are required.

540 In addition, there is a consequent extension of the musical range of the entire ensemble of instruments beyond the upper and lower musical ranges of the existing steelpan assemblage of the prior art. By application of the generator equations to facilitate the wide range of notes of the present invention, drums are designed with a 67.31 cm/26.50 in diameter, the approximate maximum size for a single drum based 545 on ergonomic considerations and utility in performance.

The preferred embodiment of an orchestra that strictly utilizes the present invention uses instruments that support two complementary physical note layout philosophies. This reduces the number of layout styles with which a player must become familiar on 550 different steelpan instruments in said orchestra, a problem that commonly affects traditional steelpan orchestra. The primary note layout philosophy is motivated by the musical cycle of fourths and fifths on a single drum, as obtains for the traditional tenor steelpan, or the two whole note scales as exists on the traditional double second steelpan which utilizes two drums. These layout styles complement each other as the 555 fourths and fifths produces the least dissonant coupling between adjacent notes when applied in a uniform fashion to steelpan with one, three, or six drums, whereas the whole tone scale layout, produces the least dissonant coupling between adjacent notes, when applied in a uniform fashion to a steelpan assemblage comprising of two or four drums.

560 These note layout patterns are replicated and extended to steelpan with a higher multiplicity of drums in such a manner as to preserve, as far as is possible, the relative position of notes. In both layout styles, notes are laid out in circles which are repeated to create a "spider web" effect, whereby the cycle of notes are arranged in concentric 565 rings with note pitches increasing by an octave per ring as one moves towards the centre of the playing surface.

570 **Brief Description of the Drawings**

FIG. 1 shows an exploded view of the preferred embodiment of a single acoustic steelpan drum of the ensemble of the present invention and includes an illustration of how the said drum is to be suspended utilizing the wheel and receptacle attachments.

575

FIG. 1a provides an exploded view of a typical drum of the G-Pan family showing the component parts.

580

FIG. 1b provides an illustration of how a typical drum of the G-Pan family can be suspended in the case of the G-Soprano, G-Seconds and G-3Mid instruments

FIG. 1c shows an exploded view of the front of the system used for suspension of the G-Pans

585

FIG. 1d shows an exploded side view of the system used for suspension of the G-Pans

FIG. 1e shows a plan view of the system used for suspension of the G-Pans.

590

FIG. 2 is an exploded view showing the detailed construction of the preferred embodiment of the playing surface, of a single drum of the ensemble of the present invention

FIG. 3 shows a preferred embodiment of the present invention using Type 1 rear attachments.

595

FIG. 4 shows a preferred embodiment of the present invention using a rear attachment made of a cluster of tubes.

600

FIG. 4a shows the side view of a preferred embodiment of the present invention using a rear attachment made of a cluster of tubes with the outer shell of the rear attachment cut away to expose the cluster of tubes within

FIG. 4b shows the rear view of a preferred embodiment of the present invention using a rear attachment made of a cluster of tubes.

605

FIG. 4c shows the frame and tube clusters that form the Type 2a rear attachment.

FIG. 5 shows a preferred embodiment of the present invention using tuned rear attachment components or sections.

610

FIG. 6 shows a preferred embodiment of the present invention with a ported rear attachment design.

615

FIG. 6a is a top view of a preferred embodiment of the present invention with a ported rear attachment design showing the section line I-I.

FIG. 6b shows a cutaway view of the side perspective of a preferred embodiment of the present invention with a ported rear attachment design.

620

FIG. 6c shows the bottom view of a preferred embodiment of the present invention with a ported rear attachment design.

625

FIG. 7 shows a side view of a preferred embodiment of the present invention with ported rear attachment and illustrates the variable nomenclature used in the required calculations.

630

FIG. 8 shows the note layout for the preferred embodiment of the G-Soprano steelpan of the ensemble of the present invention.

635

FIG. 9 shows the note layout for the preferred embodiment of the G-Second steelpan of the ensemble of the present invention.

FIG. 10 shows the note layout for the preferred embodiment of the G-3Mid steelpan of the ensemble of the present invention.

FIG. 11 shows the note layout for the preferred embodiment of the G-6Bass steelpan of the present invention.

640

Description of the preferred Embodiments

Following is a description of the G-Pan and its preferred embodiment.

645

The G-Pan instrument is defined by the physical structure and design of the drums of which it is comprised. Said drums provide for a wider range of notes of high musical quality on each instrument. Specifically, each instrument using the G-Pan design concept targets a musical range of at least three musically contiguous octaves or 36 chromatically sequenced notes. In addition, all notes on each instrument must be of high musical clarity. In this regard, musical clarity implies that the spectral composition of all notes contains the musical fundamental and up to two harmonically related partial frequencies that are significantly above non-musical resonances when compared with the prior art.

650

655

Whereas the traditional steelpan drum typically has a diameter of 55.88 cm/22 in as measured across the top of the bowl, the diameter of the playing surface of drums that are utilized for the preferred embodiment of the G-pan is nominally 67.31 cm/26.50 in. The increased diameter provides more flexibility in obtaining greater bowl depth and, consequently, surface area on the playing surface, hence accommodating a larger number of notes.

660

For the traditional acoustic tenor pan, tuners would typically create a bowl depth of 20.32 cm/8 in. Assuming a spheroid bowl and using the corresponding formula:

$$S_a = \pi(r^2 + d^2)$$

665 where S_a is the spheroid bowl surface area, r the radius of the top of the bowl, and d
the depth of the bowl, the bowl surface area for the traditional tenor steelpan, prior to
note demarcation, would be $3749.2 \text{ cm}^2/581.2 \text{ in}^2$. For the preferred embodiment of
the G-Soprano, a depth of 25.4 cm/10 in can easily be achieved resulting in a surface
area of $5585.2 \text{ cm}^2/865.7 \text{ in}^2$ or an increase in surface area of roughly 49%. This
670 allows more flexibility over the traditional instrument in the number and range of
notes that can be accommodated.

The need to allocate notes to the multiplicity of drums that comprise a specific
instrument is determined by the laws of physics that dictate that notes must be of a
minimum size to support vibration at a given fundamental frequency and that, as a
675 consequence, on the lower register must be larger in size than notes in the higher
register. The design of G-Pan drums and instruments can be simplified by a method
that specifies the playing surface geometry required for a specified note range.

680 Following are two equations, called steelpan design equations, that facilitate the
estimation of the radius and depth of drums required to produce a specified musical
range as well as the number of drums required for an instrument comprised of an
ensemble of drums to support a pre-specified range of notes. The equations assume,
as is the case for the traditional instrument, that all instruments in the orchestra utilize
drums of the same size as the single drum used for the G-Soprano.

685

The first equation specifies the number of drums required to make up a single
instrument. This is given by the integer n_{drums} that satisfies the inequality

$$n_{drums} \geq S_{instrument}/S_{soprano}$$

where

690 $S_{instrument}$ is the total surface area required to support all the notes desired on
any instrument and,
 $S_{soprano}$ is the surface area required to support all the notes desired on the G-
Soprano.

695 The second equation specifies the playing surface area, $S_{instrument}$, that is required to
support a given range of musical notes and is determined from the general equation, a
geometric sum given by

$$S_{instrument} = kA_{B1} \alpha^J \left(\frac{1 - \alpha^n}{1 - \alpha} \right)$$

where

700 A_{B1} is the area of a B_1 note, drawing reference to Kronman⁴ this typically of
the order of 1575 cm^2
 α is the factor by which note area decreases for each semitone increase in
pitch. From observation of the average size of notes in the range B_1 to B_5 ,
 $\alpha=0.93$ gives a better fit than $\alpha=0.94$ as estimated by Kronman⁴. Note that
705 the value of $S_{instrument}$ is very sensitive to the value of α .
 J is the semitone interval from B_1 corresponding to the lowest note on the
drum.

⁴ *Steelpan Tuning*, Kronman, U., Musikmuseet, Stockholm, 1991.

$S_{instrument}$ is the playing surface area of a drum of radius r and depth d , assumed to be a spherical cap.

710 n is the number of contiguous notes on the instrument

k is a factor that compensates for the area between the notes on the playing surface, i.e. the support web. For all but bass instruments $k=1.1$. For bass instruments such as the G-6Bass, $k=1.05$ as the defined note areas often tend to be more closely spaced.

715

For a G-Soprano, it is known that the largest comfortable depth is about 10 in or 25.4 cm. For example, a lowest note of A_3 requires $J=22$ and for a 3-octave range,

$S_{soprano} = S_{instrument}$ is at least 4646.4 cm^2 and the required radius is $r = \sqrt{\frac{S_{soprano}}{\pi} - d^2}$

720

i.e., 32.7 cm/12.9 in. Here it is assumed that the playing surface is modeled as a spherical cap of base radius, r , and depth d and therefore has surface area $S = \pi(r^2 + d^2)$. This will also accommodate any layout for which the lowest note is higher than A_3 . In particular, it will accommodate the range C_4 to B_6 , the range specified in Table 1 for the preferred embodiment of the G-Soprano steelpan.

725

If the next lower range instrument has lowest note A_2 it will have a 3-octave range A_2 to A_5^b . The total area should be $S_{instrument} = 11100 \text{ cm}^2$ so that the required number of drums is $n_{drums} = 3$. This gives rise to the G-3Mid.

730

If the next lower range instrument has lowest note G_1 it will have a 3-octave range from G_1 to $F_4^\#$. The total area should be $S_{instrument} = 29265.56 \text{ cm}^2$ so that the required number of drums is $n_{drums} = 7$. While this is realizable, in the interest of portability and in consideration of the increasing difficulty in performance of an instrument with a large number of drums, we may select to reduce the musical range so as to reduce the number of drums to 6. If the range is reduced to 2.5 octaves from G_1 to $C_4^\#$ the

735

total area required is now $S_{instrument} = 27535 \text{ cm}^2$ so that the required number of drums is $n_{drums} = 6$. This gives rise to the G-6Bass.

740

By rearranging these steelpan design equations, one can also specify the number of drums, n_T , and then determine the lowest note that can be supported. This note is J semitones from B_1 , where

$$J = 22 + \frac{\log n_T}{\log \alpha}$$

745

The three instruments G-Soprano, G-3Mid and G-6Bass together span the range G_1 to B_6 . However a two-drum instrument may now be added to provide increased musical performance dexterity in support for the soprano range. Using $n_T=2$ in the aforementioned equation, such an instrument would support a lowest possible note that is $J=12$ semitones from B_1 , i.e. B_2 . This gives rise to the G-Second.

750

The G-Pan ensemble of steelpan of the present invention provides a wider range of notes on each said instrument through the use of larger drums. Whereas the traditional instrument typically has a diameter of 55.88 cm/22 in as measured across the top of the bowl, the diameter of the playing surface of the preferred embodiment of drums used for the G-pan is 67.31 cm/26.5 in which is slightly larger than the 65.4 cm/25.8 in diameter previously calculated. The increased diameter has been

18 August 2008

found to facilitate better quality in the fashioning of the outer notes and through the provision of greater inter-note spacing on the G-Soprano.

755

The sheet metal blank from which the bowl is formed has a thickness in the range 1.2 mm to 1.5 mm and has carbon content rating of 0.04% to 0.15%. The actual thickness of the sheet metal blank used depends on the tonal range and timbre required.

760

Thinner blanks facilitate the creation of notes in the higher register and are therefore preferred for the G-Soprano and G-Second steelpan. Thicker blanks facilitate the suppression of high pitched overtones due to the higher mass per unit area. The latter also tends to minimize note frequency modulation incurred by structural flexure of the entire drum. In the preferred embodiment of the ensemble of the present invention, the G-Soprano and G-Second steelpan are made from 1.2 mm blanks, the G-3Mid steelpan from 1.4 mm blanks and the G-6Bass steelpan from 1.5 mm blanks.

765

770

As a consequence of note geometry, placement and tuning, each G-pan steelpan instrument of the present invention has its own unique harmonic characteristic thus resulting in a variation of voicing in the common musical ranges. Further variations in voicing are possible through the choice of the mallet or stick used to play the instrument and by more selective shaping, relative positioning, separation and tuning of notes.

775

780

Figure 1 shows construction and application aspects of a typical drum in the G-Pan family. Figure 1a provides an exploded view of said typical drum showing the component parts. Figure 1b provides an illustration of how said drum can be supported in the case of the G-Soprano, G-Seconds and G-3Mid instruments. Figure 1c, Fig. 1d and Fig. 1e show detail perspectives of the support wheel and support cup used in the preferred method for attaching the steelpan to a support stand.

785

Reference is drawn to Figure 1a. The drum consists of a playing surface 1 upon which are placed the notes 1a that are the tuned sections of said playing surface 1 a chime 13 that provides support and a rigid boundary for the playing surface and a rear attachment 14 that replaces the skirt in the traditional steelpan. The rear attachment 14 shown in Figure 1a is but one of several optional designs.

790

Said notes on the playing surface 1 produce musical sound when struck with an appropriate implement such as a stick or mallet specially made for this purpose. The playing surface is made from sheet metal that is formed to create the bowl shape shown in Figure 1. The preferred embodiment utilises steel sheet metal with carbon content rating of 0.04% to 0.15%.

795

The region of the playing surface 1 that exists between the notes and is therefore that part of the playing surface 1 that is not tuned is defined in this document as the support web 1b. The support web 1b bears no distinct musical pitch when struck but serves to physically separate and support the notes 1a on the playing surface 1 while connecting the entire structure to the chime 13.

800

The sinking method used to shape the playing surface 1 should result in an ultimate thickness profile that ensures that the thinnest cross-section is at the centre of the playing surface 1 where notes with the highest pitch are to be located.

805 The bowl shape of the playing surface 1 facilitates the formation of a rigid shell upon which the playing surface 1 is established; the rigidity of the shell is further enhanced by the natural hardening that takes place as the sheet metal is worked into the ultimate shape.

810 The bowl shape of the playing surface 1 also facilitates the establishment of an ergonomic form for said playing surface 1, allowing the average pannist, with an arm reach of some 76.2 cm/30 in, to access all notes within the natural extension capabilities of their arms and wrists.

815 The shaping process applied to the fabrication of the playing surface 1 should not allow for the achievement of the maximum strain, inter-granular separation or excessive work hardening in the material. Intermediate heat treatment to stress relieve the material may be necessary as shaping takes place depending on the depth and thickness required in the finished form.

820 Milling or grinding is used to attain the required shape profile and thickness, particularly in the inner section of the playing surface 1 where notes in the higher register are to be placed. This is particularly crucial for notes in the sixth octave on the G-Soprano pan as traditional sinking methods result in a thickness at the bowl center of half the original metal sheet blank thickness or 0.60 mm/0.024 in whereas
825 for the G-Soprano pan it has been determined that a uniform thickness of 0.30 mm to 0.45 mm is required to obtain notes of high clarity with limited modulation of tone and good musical quality.

830 In order to minimize coupling and reduction in the tension afforded by the material interconnecting said notes, grinding and milling is restricted to the note areas themselves. Additionally, the hardness of the thinned sections is increased by chemical or heat treatment to improve their robustness and to increase the modal frequencies that can be attained by traditional tuning.

835 Again in reference to Figure 1a, the chime 13 functions to:
(a) minimize static shape distortion due to external forces and temperature variations and, most significantly, transient shape distortion generated by the torsion modes that are excited by the impact of the playing stick and contribute significantly to
840 note modulation, and, in addition,
(b) provide a support structure for connection of the rear attachment 14.

845 Said chime 13 is comprised of a support ring 13a of solid or hollow round, square, rectangular or ellipsoidal cross-section and a pair of abutments 13b that provide structural extension of the support ring 13a to facilitate attachment of suspension wheels 13c. The chime should be made of the same steel composition as the playing surface so as to eliminate the risk of corrosion due to galvanic action. However, other materials, such as aluminum, can be used so long as the result is a rigid frame that significantly reduces the level of flexural vibration that occurs in the traditional

18 August 2008

850 instrument as the instrument is played and adequate anti-corrosive preventative measures, known to those skilled in the art, are utilized.

The chime 13 may be attached to the playing surface by welding, crimping, seaming, gluing, the use of mechanical fasteners or any combination of the foregoing and any
855 method that prevents relative movement and vibration of the ring and the playing surface.

In the preferred embodiment of the present invention the chime 13 is fabricated from 2.54 cm/1.00 in wide mild steel of 0.64 cm/0.25 in thickness formed into a circle of
860 inner diameter 67.31 cm/26.5 in. Abutments 13b are added along at the intersection of the perimeter support ring 13a and the diametric line of the support ring 13a that defines the points at which the drum is to be suspended. Suspension wheels 13c are affixed to the abutments with axles 13d that allow free rotation of said suspension wheels 13c. Suspension wheel 13c diameter is between 5.04 cm/2.00 in to
865 7.62 cm/3 in.

The abutment 13b and suspension wheel 13c are so positioned that the top of the suspension wheel 13c is at, or beneath the top of the chime 13. The latter requirement eliminates any possible obstruction from the support stand 15 on which the steelpan
870 drum is to be placed when notes in the vicinity of the abutment are played, an improvement on what currently obtains in the prior art whereby the upright 15a of the stand protrudes above the top of the chime 13.

The chime 13 is so designed and fitted to allow for its connection to a rear attachment
875 14 that serves the dual purpose of (a) protecting the bowl of the pan from physical shock and (b) providing a means of enhancing the acoustic radiation of the sound emanating from the playing surface 1 either directly by way of vibration of the rear attachment 14 itself or by way of its acoustic design.

880 The rear attachment 14 must be rigid enough to reduce or eliminate any sympathetic vibrations that would contribute negatively to the sound of the instrument. Such vibrations would typically occur at non-musical frequencies corresponding to resonance modes of the rear attachment 14. This is one problem which plagues the traditional acoustic steelpan instrument, whereby the energy imparted by the striking
885 action of the player, excites non musical modes on the skirt of the instrument.

Virtually any rear attachment 14 of rigid design that adequately covers a significant part of the playing surface 1 will serve the purpose of protecting said playing surface 1 of the pan from physical shock. In particular, the traditional cylindrical tube design
890 suffices in regard to protect the playing surface 1. However, the preferred embodiment of the present invention incorporates a rear attachment 14 as shown in Fig. 1a is bowl shaped, with a hole or port 14b, cut into the bottom of the bowl thus forming a ported acoustic enclosure, the details of which are described later in the document.

895 The curved surface of the rear attachment 14 of the preferred embodiment of the present invention is an improvement over the prior art, as it is inherently stronger than the cylindrical tube design used on the traditional steelpan. The improved strength of

18 August 2008

900 dome or bowl structures over cylindrical or tube structures, is well known to those who are versed in the area of structural vibration control. The higher strength of the rear attachment used on the preferred embodiment of the present invention therefore results in increased resistance to deformation from external forces and produces resonances with lower vibration intensity levels for the same impact.

905 In the preferred embodiment of the present invention, the resistance of the rear attachment to vibration is further enhanced through a variety of physical means known to those skilled in the art of vibration control. These include fabrication from vibration resistant materials such as wood, fiberglass, composites or synthetics or metal of appropriate thickness and other material appropriately reinforced to reduce or
910 eliminate the natural vibration modes associated with such a structure. In addition, the rear attachment 14 may be covered with vibration absorbing panels, sheets or compound such as those commercially available from Dynamat.

The rear attachment 14 is affixed to the chime 13 by welding, crimping, seaming,
915 gluing, the use of mechanical fasteners or any combination of the foregoing and any method that prevents relative movement and vibration of the ring and the playing surface. The preferred embodiment of the present invention incorporates the use of mechanical fasteners onto a solid chime 13 to facilitate G-Pans with removable and interchangeable rear attachments 14.

920 Attention is now drawn to Fig. 1b, Fig. 1c, Fig. 1d and Fig. 1e that illustrate a preferred method for suspension of G-Pans that facilitates the free swinging motion as obtains in the prior art. G-Pans provide this feature through the use of suspension wheels 13c as described and support cups 16 that are affixed to the top of the uprights
925 15a of the support stand 15. Figure 1c shows an exploded view of the front of the suspension wheel 13c and support cup 16 as seen from the perspective shown in Fig. 1b. Fig 1d shows an exploded view of the side of the assembly as seen from the perspective closest to the steelpan with a section through the axle 13d of the suspension wheel 13c. Fig 1e shows a plan view of the assembly.

930 The support cups 16 are of a simple semicircular design that facilitates a snug fit to the shape of the suspension wheel 13c. The functionality of the arrangement can be further enhanced by lining the support cup 16 and using suspension wheels 13c with vibration absorbing material such as foam. This would attenuate the vibration energy
935 transmitted between the steelpan and support stand 15 thus reducing sympathetic vibration of the stand, a potential source of noise in the traditional steelpan.

In operation, the support cups 16 hold the suspension wheels 13c in place facilitating a full 360° of movement of the G-pan drum about the axis of rotation established by
940 the line joining the axles 13d of the suspension wheels 13c. This design also facilitates rapid one-step set up of G-Pans as one only has to place the suspension wheels 13c in the support cups 16 for the G-Pan to be performance ready. To the knowledge of the inventor said wheel and cup arrangement is unique to instruments of any nature.

945 Theoretically, the symmetrical positioning of the abutments 13b and suspension wheels 13c results in a G-Pan suspension with an average attitude of 0°. In actuality,

18 August 2008

there will always be somewhat of an imbalance due to the non-uniform distribution in mass over the playing surface 1 and chime 13 on the two sections of the G-Pan drum on either side of the axis of rotation as a result of the non-symmetrical shape formed on the playing surface 1 to create the note areas 1a and the normal variations in characteristics of the various materials used on the instrument.

Said non-uniform mass distribution allows for the application of additional masses to change the angle at which balance is achieved, thus facilitating a means for adjustment of the attitude of the G-Pan. The preferred embodiment of the rear attachment 14 on the present invention therefore provides a simple means of adjusting the attitude of the instrument during a performance through the use of attitude offset weights 14a that are attached to the rear attachment 14 by means of magnetic strips or double-sided tape. This represents an improvement over the prior art where the attitude of the traditional pan is fixed at the time of manufacture.

Magnetic strips allow for quick and easy adjustment but can only be used on rear attachments 14 made of magnetic material. On the other hand, double-sided tape cannot be as easily moved once affixed but can be applied to rear attachments 14 made of non-magnetic material.

The preferred embodiment of the present invention uses attitude offset weights 14a of no more than 0.11 kg/0.25 lb for the smallest instrument, the G-Soprano, affixed to the rear attachment 14 just under the chime 13. The positioning of the attitude offset weights 14a just under the chime 13 reduces their visibility and conspicuousness. The greatest attitudinal angle will be achieved if all attitude offset weights 14a are placed midway between the suspension wheels 13c. Weight selection of the attitude offset weights 14a depends on the actual weight distribution on the G-Pan and the range of attitude adjustment required.

The traditional instrument is suspended by a string, cord, twine or similar contrivance to a support stand and is allowed to swing freely as notes on the playing surface are struck. This free swinging motion has become a norm in steelpan performances as it allows a great degree of freedom of expression. The use of a suspension wheel 13c to support the G-Pan and provide the free swinging motion during a performance is, to the author's knowledge, a novel idea and therefore a significant improvement to the prior art.

Attention is now drawn to Fig. 2 which shows a cutaway side view of the preferred embodiment of the playing surface 1 of the G-Pan. Unlike the prior art, the preferred embodiment of the playing surface 1 is compound in nature having four separate parts. These are the primary bowl 1d, an isolation gasket 1f, a secondary bowl 1g and note covers 1c.

The secondary bowl 1g is attached to the primary bowl 1d by the isolation gasket 1f which is made of industrial grade double sided tape such as commercially available 3M VHB. In the preferred embodiment of the present invention, the secondary bowl 1g is inserted on an appropriately sized countersunk ring on the inner side of the bowl that forms the playing surface 1 so as to preserve the continuity of the playing surface 1.

18 August 2008

Following shows how the concept of a secondary bowl is applied to a G-Soprano for which a 3-octave range starting from A₃ is desired. As such, the secondary bowl on said G-Soprano must support 12 notes starting from A₅ corresponding to the third octave of notes. It has already been determined that said G-Soprano has a minimum playing surface area of 4646.4 cm², a radius of 32.7 cm/12.9 in and a depth of 25.4 cm/10 in. The steelpan design equations suggest that the minimum area required for the inner bowl is 510.8 cm² which is obtained on a surface of diameter 20.00 cm/8.00 in and a depth of 8 cm/3.1 in.

The primary bowl 1d is created by first forming the playing surface for the drum required to support all notes in the range specified. For the preferred embodiment of the G-Pan, this requires sinking sheet metal of circular form with a diameter of 67.31 cm/26.5 in to the necessary depth as determined from the steelpan design equations. After sinking, a hole of diameter of 20.00 cm/8.00 in is cut at the middle of the playing surface 1. The perimeter of said invention 6 in. A 0.32 cm/0.125 in thick circular flange 1e of inner diameter 20.00 cm/8.00 in and width 0.64 cm/0.25 in is then welded into the sunken perimeter of the hole.

The secondary bowl 1g is formed with a similar matching flange 1h. Depending on the musical range of the drum, the secondary bowl 1g thickness ranges from 0.35 mm/0.13 in for the G-Soprano to 0.7 mm/0.26 in thick for the G-6Bass. The secondary bowl 1g is fabricated by first precision welding a 0.64 cm/0.25 in thick circular flange 1h of inner diameter 20.00 cm/8.00 in and width 0.64 cm/0.25 in to a 1.00 mm/0.04 in thick circular sheet metal blank of diameter 21.59 cm/8.5 in. The portion of the sheet metal blank that is not attached to the flange 1h is then sunken to create the required shape profile on the secondary bowl 1g. The secondary bowl 1g is then precision milled or ground to attain the desired thickness profile.

The secondary bowl 1g can be thought of as a miniature drum that is tuned to the pitches of the highest notes that are normally placed in the innermost concentric ring of notes of the original composite drum. For the preferred embodiment of the G-Soprano pan, this would correspond to the sixth octave, for example. The use of material that is thinner than that used for the primary bowl 1d and hardened by heat and chemical treatment provides an improved medium for creation of notes on the higher register of each drum. Said heat and chemical treatment are processes known to those skilled in the art of metallurgy. Hardening of the material increases the residual tension in the steel and thus allows for higher vibration frequencies just as tightening a string on a guitar increases the generated pitch.

The flanges 1e, 1h serve as stiffeners for the primary bowl 1d and secondary bowl 1g.

The isolation gasket 1f serves the very important function of decoupling the vibrations of primary bowl 1d from the secondary bowl 1g while acting as an effective mechanical fastener. This decoupling function is vital as experience has shown that the innermost notes of the traditional steelpan are difficult to fabricate to a high level of musical clarity due to the strong degree of coupling that exists between these notes and the entire structure. The high degree of coupling arises from the fact that these

1045 notes tend to be quite stiff as a result of the residual tensions required to generate the higher pitches.

1050 The attenuation of the level of vibration transferred between the secondary and primary surfaces due to the isolation gasket can be modeled by a mass supported on a parallel connected spring and dashpot. The major part of the mass, m , is that of the secondary bowl whereas the isolation gasket contributes the spring constant, k , and dashpot coefficient of friction, b . The attenuation of the applied velocity, V_0 , from the primary bowl to the resulting velocity, V_1 , at any given sinusoidal frequency ω rad/s is then

1055

$$\frac{V_1}{V_0} = \sqrt{\frac{b^2 \omega^2 + k^2}{(k - m\omega^2)^2 + b^2 \omega^2}}$$

1060 The attenuation is unity at $\omega = 0$ and goes to zero as ω increases to ∞ . If the lowest desirable frequency of interest on the secondary surface is ω_0 , corresponding to the lowest note on the primary surface or the lowest structural resonance frequency of the primary surface, then $b = m\omega_0$ and $k = m\omega_0^2/4$ gives an attenuation of 0.47 or 6.5dB or better when the primary surface is vibrating at frequency of at least ω_0 rad/s.

The isolation gasket can be replaced by commercially available bolt-on anti-vibration mounts such as those available from Vibrostop.

1065

The fact that the innermost, higher pitched notes tend to be small, typically ranging from an average diameter of 5.08 cm/2.00 in to as small 3.81 cm/1.50 in for the traditional tenor steelpan, creates difficulties in tuning as well as in performance as great skill is required to shape these notes with the same level of attention and detail as for larger notes and to accurately hit these small notes in fast musical passages.

1070

Moreover, acoustic wave reflections on the playing surface, quite apart from triggering other resonators on the playing surface 1, can result in noticeable echoing due to the size of the playing surface and the corresponding distance said acoustic waves must travel before impacting on the hard boundary established by the chime 13. Indeed, laser interferometry measurements of vibration levels often reveal other parts of the playing surface 1 that vibrate at the modal frequencies of some innermost notes, sometimes at higher vibration levels than the notes themselves.

1075

1080 The use of a secondary bowl 1g overcomes these problems by creating a surface for which the relevant geometries can be more tightly controlled. The surface of the secondary bowl 1g also acts to reduce the effect of acoustic reflections within the secondary bowl 1g material as the distance traveled by acoustic waves to the perimeter of the secondary bowl is far less than is the case in the prior art.

1085 The use of thinner material to form the secondary bowl 1g facilitates a modest increase in note size as the mass of the note on the traditional instrument can now be distributed over a larger area. On this basis of mass conservation, a reduction in thickness by a factor, k , would require an increase in area on the secondary bowl 1g by the same factor k and a corresponding increase of $\sqrt{k}$ in any note dimension.

1090

18 August 2008

Given that the typical thickness of the center portion of a traditional tenor is 0.6 mm/0.024 in, and assuming that notes on the secondary bowl are of thickness of the order of 0.35 mm/0.015 in, the corresponding increase in note dimension should be of the order of 30%.

1095

The compound design of the playing surface is therefore seen to facilitate the creation of a full octave of notes on the G-Soprano that extend the upper musical range of what obtains in the prior art. In addition, as said notes are as much as 30% larger than what obtains on a traditional tenor pan, musical performance is improved as the notes are easier to strike and the sound produced of these larger notes will be louder.

1100

Fig. 2 shows the secondary bowl oriented in a similar concave fashion as the primary bowl. However, the secondary bowl can also be inverted in a convex fashion for attachment to the primary bowl. This convex orientation has a dual advantage. First, the notes on the secondary bowl are now located closer to the pannist than for secondary bowls with a concave orientation as shown in Figure 2. Secondly, it is not absolutely necessary to create an opening on the primary playing surface to accommodate the secondary bowl, although it is advisable to do so to limit acoustic transmission across the centre of the playing surface as described below. Said secondary bowl can simply be affixed to the primary bowl after adequate preparation of the centre portion of the primary bowl to accommodate attachment of the secondary bowl, flange and isolation gasket.

1105

1110

On the G-Mid and G-Soprano pans note clusters that are radially opposite can result in a level of dissonance as a consequence of energy transmission between said notes. As such, there is a need to implement mechanisms to acoustically separate the notes and so reduce the sound energy transfer across the center of these instruments.

1115

While this mode of acoustic coupling will be significantly reduced by virtue of the flange formed to fit the secondary bowl, it can be even further reduced by selective mass loading of the web support on the playing surface or by the addition of artifacts on the playing surface to impede the transmission of acoustic energy.

1120

In the latter case, and as obtains in the prior art, notes may be separated by rigid areas that are not tuned, grooves, holes, slots, selective localized heat treatment of the areas between the notes and rigid attachments on areas of the support web 1b in the vicinity of the notes.

1125

By Newton's first law of motion,

1130

$$F = ma$$

where F is the applied force, m is the mass to which the force is applied and a the resulting acceleration. Thus the addition of mass by a given factor, x , results in a reduction in acceleration by the same factor, x , for the same applied force. This results in lower levels of vibration, the amount of which can be estimated by the factor to which the mass in a particular section of the support web 1b has been increased.

1135

For a spring with stiffness k and a given mass, m , it is known that the resonant frequency of the motion of the mass when hung from the spring is given by

1140

$$f_r = \sqrt{\frac{k}{m}}$$

Thus the addition of mass also reduces the resonance frequencies attributed to non-musical modes.

1145 The current invention therefore provides higher levels of inter-note isolation and separation by the selective addition of mass, termed mass loading by those skilled in the art of vibration control, as a means of vibration absorption treatments in the support web **1b** of the playing surface **1**. Masses used for this purpose may be concentrated at certain points of the support web **1b** or distributed across said support
1150 web **1b**. Said treatment also gives the benefit of suppressing unwanted high pitch non-musical resonances that are typical on the traditional instrument.

The use of commercial vibration absorbing treatments such as Dynamat and Dynamat Xtreme further enhances vibration damping properties of increased mass through the
1155 use of materials that employ friction to convert vibration energy into heat. Said energy would have otherwise been converted to sound.

In the preferred embodiment of the present invention, notes on the primary bowl **1d** secondary bowl **1g** are separated in the traditional manner by the support web **1b**.
1160 Said support web **1b** is enhanced for this purpose by localized heat or chemical treatment to increase the rigidity of the structure, said treatment being well known to those skilled in the area of metallurgy. Furthermore, vibration absorption treatments are also applied to the support web **1b**. The amount of mass and vibration absorption treatment required is determined from the degree of note coupling as measured using
1165 laser interferometry or other techniques known to those who are skilled in the art of vibration measurement.

A wide range of materials can be used for the playing surface **1**. The essential properties of the materials are (a) high fatigue performance (b) an acceptable
1170 resonance plateau (c) a linear relationship between stress amplitude and specific damping energy (d) heat treatable materials where the metallurgical condition can be altered to reduce the internal damping (energy dissipated per unit volume per cycle) (e) isotropic materials where homogeneous damping properties exist.

1175 Possible materials include non-ferrous metals such as (a) Aluminum and its alloys: Aluminum containing up to 2% magnesium, and cold rolled, (b) Copper and Copper Alloys: 99.95 % copper, 70% copper 30% zinc, 65% copper 35% zinc (c) Manganese alloys: 88% magnesium, 10% aluminium, greater than 2% manganese, zirconium, zinc, (d) Nickel, Titanium

1180 Possible materials also include ferrous metals such as Carbon steels containing 0.04% to 0.15% Carbon with low sulphur (<0.001%) and of drawing quality, carburized steels with up to 0.3% carbon, stainless steels which are Austenitic stainless steels stabilized by niobium or titanium that is non work hardened.

1185

18 August 2008

The primary bowl **1d** and secondary bowl **1g** need not be fabricated from the same material. Indeed, the metals used for each bowl could be selected on the basis of musical range and cost.

- 1190 The preferred embodiment utilizes Carbon steels containing 0.04% to 0.15% Carbon with low sulphur (< 0.001%) and drawing quality for both bowls.

- 1195 As the current invention features instruments which offer a wider range of notes than obtained for the prior art there is a corresponding difficulty in the design of the playing stick or mallet which has to be selected so as to excite only the two or three overtones that are traditionally tuned into each note and not to excite the higher partials that will naturally exist on said notes. Said higher partials are usually non-musical in character and lend to an often undesirable metallic sound.

- 1200 It is recognized that the response of a note to a strike depends on the forcing function, being the profile of force versus time that is applied to the note when struck. Said forcing function is a consequence of the manner in which the player executes the strike as well as the selection of playing stick. It is known that the critical stick properties are its mass and its compliance. These affect the contact time, the time the stick is in contact with the note during a strike and the maximum contact area during the strike.

- 1210 Low percentages of the impact energy from a strike are imparted to modal frequencies with periods that are shorter than the contact time. Higher fractions are imparted to modal frequencies with periods longer than the contact time.

- 1215 On the G-Soprano, for example, fundamental note periods differ by a ratio of 8 to 1 making it difficult for a single stick to effectively excite all the notes on the pan. The inner notes, i.e. those with higher pitches, require a stick with low contact times which would result from having a high compliance, i.e. a "hard" stick. However for a stick of the same mass, the outer notes, i.e. those with the lower pitches, require a stick with longer contact times which would result from having a stick with low compliance heads, i.e. a softer stick.

- 1220 In the current invention, these requirements are met by (a) utilizing a stick that has the required compliance for the highest pitch notes on the relevant drum and (b) utilizing note covers **1c** made of a material of appropriate compliance and thickness to cover the lower pitch notes. In essence, this approach removes some of the compliant material from the head of the playing stick and places it on the note. The note covers **1c** must not be so heavy as to affect the note pitch. They must also be thin enough to ensure adequate contact time when struck with the stick. On the G-Soprano steelpan, for example, note covers **1c** are applied only to notes on the outermost ring, Ring 0 **1i** and the middle ring, Ring 1 **1j**. These can now be satisfactorily played with a stick or mallet designed for optimum use on the innermost ring, Ring 2 **1k**. This approach can be used even if the specific G-Pan implementation does not utilize the compound design incorporating a secondary bowl **1g**.

The note covers **1c** are made of compliant material such as felt, rubber, silicone or other similar synthetic material. However, tests have shown that the note covers **1c** are most

18 August 2008

1235 effective when the compliant material of which they are made is of the consistency of felt and not the rubber material or other similar synthetic material used on most sticks. The thickness of felt so applied should be no more than 1 mm/0.025 in.

1240 In addition, the note covers 1c should not be bonded to the note as this would affect note flexure and vibration. Instead, the note covers 1c are close fitted to the note and held in place only at the sections of the support web 1b that form the boundaries of said note. Best results are attained if the material is form fitted to the note so that there are no air spaces between the covering and the note itself.

1245 The preferred embodiment of the playing surface 1 uses felt of thickness between 0.5 mm/0.013 in to 1 mm/0.025 in bonded to the playing surface at the note boundaries using double-sided tape.

1250 Reference is again made to Fig. 1. The skirt of the traditional steelpan is a consequence of the manufacture of the traditional instrument from barrels. However the preferred embodiment of the present invention provides an improvement to the traditional tube design for G-Soprano, G-Second and G-3Mid steelpan through the use of a rear attachment 14 that actually partially covers the rear part of the playing surface.

1255

The use of dome or bowl structures for this purpose provides the required strength and rigidity. The dome attachment could be of solid construction, of rigid meshed or a combination of the two. Careful acoustic design is required to ensure that the musical accuracy and performance characteristics of the instrument are not compromised by the change in acoustic impedance loading presented to the playing surface. For example, inclusion of a carefully designed opening or port on a solid rear attachment 14 on the G-Mid, G-Second and G-Soprano steelpan would serve to minimize the acoustic impedance loading while enhancing the sound projection in a chosen direction.

1265

The G-Pan design of the present invention facilitates other rear attachment 14 designs that enhance the acoustic projection of the instrument. Research has shown that the radiation patterns of the traditional steelpan instruments do not favour maximum sound projection to where an audience will typically be located. In particular, on instruments that cover the middle and upper ranges, the radiation patterns tend to be concentrated along the major axis of the drum i.e., towards the top and back of the playing surface. This means that the maximum sound energy is either projected back to the musician or due to the attitude of the instrument in a typical performance, projected to the floor. In the latter case, the sound is either reflected or absorbed depending on the material from which the floor is constructed.

1275

1280 Careful acoustic design of the rear attachment 14 would lead to substantial improvement in the acoustic directivity of the instrument. The major design constraint is that the acoustic impedance loading on the playing surface 1 should not differ significantly from that which obtains for the unloaded playing surface 1. In addition, the rear attachment 14 should provide easy access to the playing surface 1 so as to facilitate re-tuning of the instrument. In practice, variation in acoustic impedance

loading can be compensated for to some extent by final tuning of the instrument when the rear attachment is in place.

1285

The G-Pan design philosophy actually therefore allows for three categories of rear attachments 14.

1290

Type 1 attachments are designed solely to protect the rear of the playing surface 1 using a rigid rear attachment 14 design that is characterized by maximum possible damping of the physical structure over the entire audible range of 20 Hz to 20 kHz.

1295

The traditional cylindrical tube design that remains after the body of the original drum is cut, if properly reinforced to minimize or eliminate sympathetic vibration of the rear attachment 14 structure, is an example of a Type 1 rear attachment 14.

1300

For said cylindrical tube design, the required rigidity for suppression of unwanted vibrations can be obtained by a variety of physical means. These include use of vibration resistant materials such as wood, fiberglass, composites or synthetics or metal of appropriate thickness, treatment and material appropriately reinforced to reduce or eliminate the natural vibration modes associated with such a structure. In particular, the open end of the tube must be strengthened so as to reduce or eliminate the natural vibration modes that have antinodes at said open end. Strengthening could be achieved by affixing a reinforcement brace of various designs to the end of the tube. In all cases, said brace should be such as to not restrict access to the rear of the playing surface and so as to facilitate maintenance and re-tuning as the need arises.

1305

1310

1315

Fig. 3 shows a preferred embodiment of a Type 1 rear attachment 14 uses a cylindrical tube design that is fabricated from 1.5 mm mild steel. The steel sheet from which the tube is fabricated is rolled to the appropriate diameter for attachment to the chime 13 and then cut to the desired length. As the Type 1 rear attachment is designed more for protection of the playing surface 1 than for acoustic reasons, lengths should be chosen first to correspond to the depths of the bowl of the playing surface 1 but could otherwise follow the traditional lengths. For the G-Soprano this should be typically 20.3 cm/8 in but no more than 25.4 cm/10 in. For the G-Second steelpan this should be 25.4 cm/10 in but no more than 35.6 cm/14 in. For the G-3Mid this should be typically 35.6 cm/14 in but no more than 45.8 cm/18 in. For the G-6Bass this should be typically 86.36 cm/34 in.

1320

1325

A flange 14c to the end of the tube that is to be affixed to the chime 13 is used to facilitate attachment to the chime 13. The tube assembly, comprising the tube and flange, is then heat treated to relieve the internal stresses created by the rolling process. The reduction in internal stresses will also tend to reduce the modal frequencies set up by said stresses, in like fashion to the reduction of pitch that occurs with the reduction in string tension in pianos or guitars. The material should have a coarse grain size so as to further enhance the vibration absorption properties of the rear attachment 14.

1330

Attachment of the flange to the chime 13 is effected with nuts and bolts. To eliminate contact noise nuts and bolts are applied every 5 cm/2 in along the flange

circumference; in addition a gasket made of cork, rubber, felt or other vibration damping material is used between the flange and chime 13.

1335 Resistance to vibration is further enhanced by corrugating the surface of the steel used thereof. It is known by experts in vibration analysis and control that said corrugation rings perform the role of a brace that provides resistance to flexure in sheet metals. The ridges forming the corrugation thus formed should be 2.54 cm/1.00 in high with a maximum width of 2.54 cm/1.00 in and spaced no more than 7.62 cm/3 in apart. The inner surface of the Type 1 rear attachment should be coated with commercially available vibration absorbing mats or coatings such as Dynamat Extreme.

1340 The end of the tube opposite to the playing surface is left open and is reinforced with a ring 14d fitted onto the circumference. Said ring 14d is made of 1.25 cm/0.50 in hollow circular section mild steel. The minimum thickness of steel used for the ring and is ANSI Schedule 40.

1350 Type 2 rear attachments 14 are designed to protect the rear of the playing surface 1 while at the same time enhancing the sound radiation characteristics of the G-Pan through appropriate design of said rear attachment 14 to act as an effective radiator of sound energy over the musical range of the instrument to which it is attached. This category is divided into two sub-categories.

1355 Type 2a rear attachments 14 use resonators of various designs tuned to some or all of the notes that are present on the relevant instrument. An ideal frequency response of a Type 2a rear attachment 14 would therefore consist of resonance peaks solely at the various note frequencies present on the relevant instrument. Said resonators used in Type 2a rear attachments 14 would noticeably change the timbre of the instrument and result in increased loudness levels.

1360 Type 2b rear attachments 14 employ a rear attachment 14 structure that ensures uniform sound level intensity radiation from said rear attachment 14 across the audible spectrum. The ideal frequency response of a Type 2a rear attachment 14 would therefore avoid any significant resonance characteristics but be band pass in nature, having a flat response across the musical range of the instrument and rolling off below and above the lower and upper frequency limits. Said Type 2b rear attachments 14 would not employ as extreme a damping as Type 1 rear attachments 14 but would still exhibit relatively low levels of vibration at all frequencies of excitation, compared to Type 2a rear attachments 14 for which vibration levels peak at the designed resonant frequencies. Effective sound radiation would be as a consequence of the large surface area of the rear attachment.

1375 The preferred embodiment of a G-Soprano steelpan with a Type 2a rear attachment 14 uses a cluster of tubes 17 as shown in Fig. 4. Figure 4a shows the side view with the outer shell 18 of the attachment cut away to expose the cluster of tubes 17 within. The outer shell is exactly like the traditional single tube Type 1 rear attachment 14 already described. The tube cluster comprises a group of open ended tubes 17 of small diameter, typically 5.08 cm/2 in to 10.16 cm/8 in. The length of each tube 17 is set so as to ensure that the tube resonance corresponds to the fundamental note frequency.

1380 Fig. 4b shows the rear view of the G-Soprano steelpan with a rear attachment 14
containing a cluster of tubes 17. The Figure illustrates the inclusion of a frame 19 to
which the tubes are bolted. The frame 19 comprises concentric circular braces 19a
held together by radial braces 19b. Both circular braces 19a and radial braces 19b are
1385 made of aluminum or steel of hollow square or hollow circular cross section of
1.25 cm/0.5 in cross sectional diameter. The frame is itself bolted to the outer shell
18.

The formula relating resonant frequencies and tube geometry for an open tube is
known to be

$$1390 \quad f_n = \frac{nv}{2(L + 0.3d)}$$

where f_n is the n th resonant frequency, n is a positive integer, d is the tube diameter,
 L the tube length and v the velocity of sound in air. The factor $0.3d$ is an end
correction factor used to compensate for dispersion of the sound at the end of the tube.

1395 The factor $L + 0.3d$ therefore corresponds to a $\frac{1}{2}$ wavelength of the note frequency.

The formula applies for tube diameters that are smaller than $\frac{1}{4}$ wavelength of the
frequency applied. For the G-Soprano pan this varies from 33.02 cm/13 in to
4.06 cm/1.6 in. The preferred embodiment of the Type 2a rear attachment 14 as
1400 applied to the G-Soprano steelpan uses 5.08 cm/2.00 in diameter tubes for Ring 0 1i,
2.54 cm/ 1.00 in tubes for ring 1 1j and 1.27 cm/0.5 in tubes for Ring 2 1k. This
selection results in tubes of length varying from 71.48 cm/28.14 in to 8.93 cm/3.52 in
for the G-Soprano pan.

1405 Each tube in the cluster is placed beneath a single note. The diameter of the tube is
chosen to cover $\frac{1}{4}$ of the surface area of the corresponding note and placement is over
one quadrant of the note, avoiding any nodal lines. This is so as to minimize the
possibility of cancellation of the second and third partials thus maximizing the sound
intensity levels at the mouth of the tube.

1410 One major benefit of the tube cluster design is that each individual note is now
associated with a unique resonator whereas the skirt on traditional steelpan, Type 1
rear attachments 14 as well as Type 3 rear attachments 14 provide only a single
resonator for all notes.

1415 In addition, as the tubes are open on both sides, its resonance modes occur at all
multiples of the fundamental resonance frequency and there are no resonance nulls as
for the traditional steelpan. These benefits facilitate a more optimal acoustic radiator
design.

1420 However, for maximum acoustic effect the tube length required could be quite long.
Indeed, for the G-6Bass the longest tube is of 349 cm/135 in long. This problem can
easily be addressed by folding the tube as is done on a tuba, for example.

1425 Figure 5 shows the preferred embodiment of a G-Pan with a Type 2b rear attachment
14 that utilizes tuned resonant sections 20 of the structure of the rear attachment 14
that resonate at the fundamental frequency of the notes closest to the rim of the pan.

1430 In the preferred embodiment of a Type 2b rear attachment 14 resonant sections 20 are actually tuned notes similar to those that are formed on the playing surface 1. Alternative implementations include, for example, the use of reeds, cut into the body of the rear attachment 14 and tuned to the required frequency by adjustment of reed length.

1435 The preferred embodiment of Type 2b rear attachment 14 has the advantage over Type 1 and Type 3 rear attachments 14 of readily facilitating the sound projection to be tuned for individual notes on the instrument. Indeed, the tuned sections 20 can be damped or muted to reduce their respective contributions to the sound field allowing for field adjustments that would result in a degree of uniformity in the sound levels of all notes. Damping could be achieved by mass loading, for example. In addition, Type 1440 2b rear attachments 14 have the advantage over Type 2a rear attachments 14 of being easier and cheaper to manufacture as well as being more portable.

1445 Type 3 rear attachments 14 are designed to protect the rear of the playing surface 1 while at the same time enhancing the sound radiation characteristics of the G-Pan through acoustic resonance of the air enclosed by the rear attachment 14 and playing surface 1. A pure Type 3 rear attachment 14 utilizes a very rigid rear attachment structure as in the case of a Type 1 design but does not include the use of solid resonators as is the case of Type 2 rear attachments 14 using, instead, the dynamics of the movement of the air in the enclosure created by the rear attachment 14 and the 1450 playing surface 1 to achieve the required radiation characteristics.

1455 It is possible to combine the characteristics of both Type 2 and Type 3 configurations into a rear attachment 14 that includes sound resonators on the body of rear attachments 14 that are designed to factor in acoustic considerations.

1460 Fig. 6 shows a preferred embodiment of a G-Soprano with a Type 3 rear attachment 21. Said rear attachment 21 is comprised of an inverted dome or bowl structure with a port opening 22 at the very base of the bowl. Said port opening 22 is fabricated large enough to allow for direct radiation from the innermost ring, Ring 2 1k, of the G-Soprano, corresponding to the highest musical ranges on the pan. Fig. 6a shows the top view, as seen by the player. Fig. 6b shows a cutaway view of the side perspective. Figure 6c shows the bottom view. The port opening 22 is clearly shown at the centre where it barely covers the twelve notes 1a of Ring 2 1k on the playing surface 1.

1465 The volume of the cavity created by the Type 3 rear attachment 21 and the playing surface 1 as well as the port size are designed to enhance the lowest note frequency on the instrument. This design is best suited for the G-Mid and G-6Bass, where it brings a slight improvement in portability, but is just as easily applicable to G-3Mids and G-Soprano instruments. The design also has to be such that the loading on the notes on 1470 the playing surface is minimal.

The G-Pan with Type 3 rear attachment 21 can be modeled as a Helmholtz resonator which is known to have resonant frequency

$$f_r = \frac{c}{2\pi} \sqrt{\frac{\pi r_p^2}{V(1.7r_p)}} = \frac{c}{2} \sqrt{\frac{r_p}{1.7\pi V}}$$

1475

Where c is the speed of sound, nominally 340m/s, $r_p = d/2$ is the port radius, d is the port diameter, and V the volume enclosed by the G-Pan and ported rear attachment. The factor $1.7 r_p$ is the equivalent length L of the classical resonator which has a volume V that is closed except for an opening to the air through a tube of length L and

1480

radius r_p .

The corresponding frequency response is bandpass with a Q-factor given by

$$Q = 2\pi \sqrt{\frac{V(1.7r_p)^3}{(\pi r_p^2)^3}} = 2 \sqrt{\frac{4.9V}{\pi r_p^3}}$$

1485 where

$$Q = \frac{f_r}{B}$$

where B is the 3-dB bandwidth of the resonator.

1490

In order to apply these formulae, the volume V must be calculated. An estimate of this quantity is obtained by assuming that the playing surface 1 is a spherical cap with base radius r and height h_{ps} . It is also assumed that the Type 3 rear attachment 21 is that part of a spherical cap of height h_{ra} that shares the same base as the spherical cap that is the playing surface that remains after removal of a smaller spherical cap of height h_p and base with radius r_p . The removal of said spherical cap creates the port 22 with radius r_p . To better illustrate the variables defined reference is now drawn to Fig. 7 which applies this assumption in representing the side view of the G-pan with Type 3 attachment 21 shown in Fig. 6 and also illustrates the notation used to establish a formula for V .

1495

1500

The volume V is obtained by subtracting the combined volumes of the spherical cap removed from the Type 3 rear attachment 21 to create the port and the volume enclosed by the playing surface from the total volume of the spherical cap from which the Type 3 rear attachment 21 is formed. This is given by

1505

$$V = \frac{\pi}{6} \left[(3r^2 + h_{ra}^2) - (3r^2 + h_{ps}^2) - (3r_p^2 + h_p^2) \right]$$

1510

The aforementioned describes the equations relevant to the spherical Type 3 ported rear attachment 21. A preferred approach to the design of the spherical Type 3 ported rear attachment 21 would be to first choose suitable values for Q-factor, Q , and resonant frequency, f_r . The required port radius and instrument volume can be calculated from

$$r_p = \frac{1.66c}{\pi Q f_r}$$

and

$$V = \frac{0.24c^3}{\pi^2 Q f_r^2}$$

1515

Q, f_r should be chosen so that

$$Qf_r \geq \frac{\pi r_{pmax}}{1.66c}$$

1520 where r_{pmax} is the maximum allowable port radius; this should be typically 25% of the radius of the base of the spherical cap that forms the playing surface 1 or less to ensure Helmholtz-like behaviour as well as realistic solutions.

1525 The inequality shows that the trade-off that must be considered in selecting Q and f_r . Since the Helmholtz resonator is essentially a single frequency resonator, one strategy is to align set f_r just above the lowest note frequency of the pan and to set Q so that the bandwidth is as wide as possible without significantly reducing loudness at the lower frequencies. A Q-factor of 8.65 results in a 1 semitone bandwidth while a Q-factor of 2.87 provides a bandwidth of ± 3 semitones with a consequent reduction in loudness at the resonant frequency.

1530 The heretofore mentioned disclosure describes the equations relevant to the spherical Type 3 ported rear attachment 21. A preferred approach to the design of the spherical Type 3 ported rear attachment 21 would be to first choose suitable values for Q-factor, Q , and resonant frequency, f_r . The required port radius and instrument volume can be calculated from

1535
$$r_p = \frac{1.66c}{\pi Q f_r}$$

and

$$V = \frac{0.24c^3}{\pi^2 Q f_r^3}$$

Q, f_r should be chosen so that

$$Qf_r \geq \frac{1.66c}{\pi r_{pmax}}$$

1540 where r_{pmax} is the maximum allowable port radius; this should be typically 30% or less of the radius, r , of the base of the spherical cap that forms the playing surface 1 to ensure Helmholtz-like behaviour as well as realistic solutions.

1545 The inequality shows the trade-off that must be considered in selecting Q and f_r . Since the Helmholtz resonator is essentially a single frequency resonator, one strategy is to align set f_r just above the lowest note frequency of the pan and to set Q so that the bandwidth is as wide as possible without significantly reducing loudness at the lower frequencies. It should be noted that a Q-factor of 8.65 results in a 1 semitone bandwidth, while a Q-factor of 2.87 provides a bandwidth of ± 3 semitones with a consequent reduction in loudness at the resonant frequency.

1555 The Type 3 rear attachment 21 is easily shown to improve upon the skirt used in traditional steel pans as well as Type 1 and Type 2a attachments by way of its increased portability. For example, assume that the rear attachment is designed to resonate at the frequency of the lowest note of a G-3Mid steelpan. For a steelpan of diameter 67.3 cm/26.5 in this corresponds to A_2 with a fundamental of 110 Hz and requires a tube length of 138.9 cm/54.7 in.

- 1560 However, it requires a spherical Type 3 ported rear attachment 21 of the sort described with a spherical cap height, h_{ra} , of only 34.3cm/13.5 in. For this design, the playing surface depth is $h_{ps} = 20.3$ cm/8.15 in, the port radius is $r_p = 9.3$ cm/3.7 in and the port height of $h_p = 1.3$ cm/ 0.5 in resulting in a Q factor of 18.2. The port radius can be increased to 18.9 cm/7.4 in and the Q-factor decreased to 8.5 while
- 1565 maintaining the same resonant frequency by placing a cylindrical tube of length 10.6 cm/ 4.2 in and diameter 67.3 cm/26.5 in between the playing surface and the aforementioned rear attachment. The modified rear attachment doubles the enclosed volume and results in an overall length of 44.9 cm/17.7 in.
- 1570 On the other hand, the Type 2a tube cluster design and Type 2b rear attachment 14 provide more versatility in tuning the radiation from each note on the instrument as each note has its own resonator. Moreover, unlike the skirt used in traditional steelpans, the preferred embodiment of a G-pan with a Type 3 rear attachment 21 displays only a single resonance and therefore exhibits no resonance nulls in its
- 1575 frequency response and is therefore more suited as an acoustic resonator.

- The Type 3 rear attachment 21 is easily shown to improve upon the skirt used in traditional steelpans as well as Type 1 and Type 2a attachments by way of its increased portability. For example, a G-3Mid with a lowest note of A_2 corresponding to a fundamental of 110 Hz, requires tube lengths of up to 151 cm/60 in length.
- 1580 However, it requires a spherical Type 3 ported rear attachment 21 of the sort described with a spherical cap height of only 38.1 cm/15 in. On the other hand, the Type 2a tube cluster design and Type 2b rear attachment 14 provide more versatility in tuning the radiation from each note on the instrument as each note has its own resonator. Moreover, unlike the skirt used in traditional steelpans, the preferred
- 1585 embodiment of a G-pan with a Type 3 rear attachment 21 displays only a single resonance and therefore exhibits no resonance nulls in its frequency response and is therefore more suited as an acoustic resonator.

- 1590 The following describes a preferred embodiment of a range of instruments that could be used to form an orchestra of G-Pan instruments. Such an orchestra would exclusively comprise the four instruments described earlier, i.e., the G-Soprano, G-Second, G-3Mid and G-6Bass. Together, these instruments span the musical range G_1 to B_6 . This improves on the prior art by eight (8) semitones as traditional acoustic
- 1595 steelpans span the musical range A_1 to F_6 . Moreover, the G-Pan utilizes only four distinct instruments to cover this range whereas traditional steelpans utilize as much as eleven (11) or more distinct instruments.

- 1600 Table 1 shows a comparison of the G-Pan ensemble range with the typical musical ranges of traditional steelpans. It is immediately obvious that the new G-Pan design removes the clutter that results from having such a large number of instruments to cover a smaller musical range by reducing the number of instruments to four. The G-Pan ensemble is therefore now more in line with more traditional instruments as is shown for the case of string instruments in Table 1, for example. It will be noted that
- 1605 a string orchestra can effectively cover a wide musical range with just four instruments.

18 August 2008

1610 The G-6Bass of the present invention covers the musical range G_1 to C_4 , a total of 30 notes or $2 \frac{1}{2}$ octaves, on 6 drums. The G-6Bass therefore exceeds the combined ranges of the traditional nine-bass and six-bass steelpans.

Table 1

G-3Mids cover the musical range A_2 to A^b_5 , a total of 36 notes or 3 octaves, on 3 drums. The G3-Mid therefore covers the baritone to alto range and exceeds the combined ranges of the 3-cello, 4-cello and double guitar steelpan as well as a significant amount of the quadraphonic steelpan and tenor bass steelpan ranges.

1620

Although the preferred embodiment of the G-3Mid instrument of the present invention incorporates three octaves of notes to ensure maximum clarity and musical activity through judicious spacing between notes, the G-3Mid instrument can accommodate as many as 45 notes on its playing surface thus exceeding the typical musical range of the quadraphonic steelpan in the prior art.

1625

G-Seconds cover the musical range D_3 to $C^{\#}_6$, a total of 36 notes on 2 drums. It targets the alto and tenor ranges and exceeds the combined ranges of the traditional double second and double tenor steelpan. The role of the G-Second instrument of the present invention is to provide support to the G-Soprano which will be the front line instrument in most performances.

1630

G-Sopranos cover the musical range C_4 to B_6 , a total of 36 notes or 3 octaves, on a single drum. It targets the soprano range and exceeds the combined musical range of the Low Tenor steelpan and High Tenor steelpan.

1635

The note ranges shown for the G-pan ensemble in Table 1 are nominal values as the design allows for variation in the lowest notes by plus or minus 2 semitones.

1640

In comparison to the prior art, the preferred embodiment of the G-Pan ensemble of the present invention utilizes only two given note layout designs. Both said layout designs seek to ensure that, as far as is possible, adjacent notes differ by the same consonant interval, while facilitating easy hand movements to play any of the more common scales, through a logical and consistent distribution of notes.

1645

The first given preferred layout design of the present invention preserves the relative note placement of the circle of fourths and fifths on all of the said instruments of the ensemble, when the notes are to be distributed over one, three, or six drums. The sequence of an octave of notes in the fourths and fifths layout is, increasing in fifths from C, C, G, D, A, E, B, $F^{\#}$, $C^{\#}$, A_b , E_b , B_b , F.

1650

The second given preferred layout design complements the aforementioned first design, in that it is applied to instruments where the notes are distributed over two or four drums and is based on the two whole tone scales that complement each other in any given contiguous octave of notes. Starting from C, the first whole tone scale is C, D, E, $F^{\#}$, A_b , B_b while the second is $C^{\#}$, E_b , F, G, A, B.

1655

The given preferred note layout for the G-Soprano instrument of the present invention is shown in Fig. 8 of the drawings, while the preferred note layout for the G-Second instrument of the present invention is shown in Fig. 9. The preferred note layout for the G-3Mid instrument of the present invention is shown in Fig. 10 of the drawings, followed by the preferred note layout for the G-6Bass instrument of the present invention as shown in Fig. 11.

1660

1665 The G-Soprano layout of the present invention is an extension of the prior art, as it applies to the tenor steelpan and as shown in Fig. 8, is obtained by repeating the complete circle of fourths and fifths in three concentric rings of 12 notes each, comprised of an outer ring, Ring 0 1i, a middle ring, Ring 1 1j, and an innermost ring, Ring 2 1k. As is the case of the traditional tenor pan, the C note is placed at the bottom of the circle, corresponding to the part of the drum that is closest to the player, so as orientate the layout. This orientation is maintained even if the G-Soprano range begins at a lower pitch. Tests have shown that the G-Soprano as implemented on the 67.31 cm/26.50 inch drum can accommodate a 3-octave range starting from A₃.

1675 Although the G-Soprano instrument in Fig. 8 shows the notes progressing in fifths in an anti-clockwise direction, the pan can be implemented by reversible rendering of this layout as well.

1680 The preferred embodiment of the G-Soprano instrument implements the fourths and fifths layout, with fifths progressing in the anti-clockwise direction. The layout of notes on each drum of the G-Soprano is therefore such that physically adjacent note pairs are separated by a musical interval of fourths or fifths. Musical dissonance is therefore reduced as these intervals are recognized as consonant.

1685 Reference is now made to Fig. 9. The G-Second instrument's note layout used is known in the prior art and is based on a division of the C-major scale into whole tones, i.e. intervals of two semitones. The notes are chosen by first selecting a root note on the circle of fourths and fifths and selecting every other note on the circle while circumventing the circle in the direction of fifths. This will give the six lowest notes on the right drum 2 of the G-Second instrument. The remaining six notes on the scale are then allocated to the remaining drum 3. On each drum, octaves of the lowest notes are created and the process repeated until the double octave is achieved. Due to space limitations, the first octave of each of the two lowest notes is placed on the outer circle of notes alongside said notes. This is seen for the D, E^b, E and F notes on the preferred embodiment in Fig. 9. For all other notes the octave and double octaves are placed in the preferred manner, i.e., on two separate concentric circles of notes on the inner portion of the drum.

1700 For all but the G-Second instrument of the ensemble of the present invention, the preferred G-pan note layout is derived by uniform division of the circle of fourths and fifths into groups of consecutive notes on said cycle. In the case of the G-Second, any attempt at such a division will result in two notes on each drum of the G-Second being one semitone, or a minor second apart resulting in a strong likelihood of dissonance of the worst kind.

1705 The allocation of notes based on whole tones helps to overcome this problem. In addition, the note allocation is such that adjacent notes are a major or minor third apart except for one pair of notes on each drum, that is an augmented fourth apart, corresponding to what is considered to be the most favourable of the intervals considered to be dissonant. Coupling between these two notes, B₃ and E^b₄ on the left drum and B^b₃ and E₃ on the right drum, can be reduced by application of methods described above.

1715 The two-drum complement of the ensemble of the present invention that makes up the G-Second is designed to support the G-Soprano which will be the front line instrument in most performances. In this respect it has an advantage over the three-drum G-3Mid, as the lower number of component drums more readily facilitates the performance of fast musical passages.

1720 Reference is now made to Fig. 10 which shows the preferred layout configuration for the G-3Mid instrument of the present invention. The G-3Mid represents a major departure from the prior art as it distributes the cycle of fourths and fifths over three drums, an approach that has, hitherto, never been applied.

1725 The G-3Mid layout is derived by assigning three octaves of four consecutive notes in the circle of fourths and fifths to each of the three drums in the G-Mid set. This places 12 notes on each drum of the G-3Mid. The four notes assigned to the first drum 4 are obtained by selecting a root note and the next three notes progressing in fifths. The next four notes in the cycle of fourths and fifths progressing in fifths are then assigned to the second drum 5. The final four notes in the cycle of fourths and fifths progressing in fifths are then assigned to the third drum 6. As there are 12 notes in an octave, there are consequently 12 unique ways of allocating notes to the 3 drums using this procedure. The choice of the root note depends on a variety of factors, most significantly musical range, drum size, the size of note templates used by the tuner and preservation of the G-Soprano note layout alignment.

1735 In the case of the G-3Mid with note layout as shown in Fig. 10, for example, if the root note is C three octaves each of C, G, D and A would be allocated to the first drum 4. The next 4 notes on the cycle, progressing in fifths, i.e. three octaves of E, B, E[#] and C[#] would then be placed on the second drum 5. Finally the last 4 notes on the cycle, progressing in fifths, i.e. three octaves of A^b, E^b, B^b, and F would be placed on the third drum 6.

1740 The layout of notes on each drum of the G-3Mid is such that physically adjacent note pairs are separated by a musical interval of fourths, fifths or sixths. Musical dissonance is therefore reduced as these intervals are recognized as consonant.

1750 Reference is now made to Fig. 11 which illustrates the preferred layout configuration for the G-6Bass instrument. The G-6Bass layout is an extension of what obtains for the 6-Bass in the prior art and is obtained by assigning the full three octaves of a note and two octaves of its fifth to each of the six drums 7, 8, 9, 10, 11, 12 that comprise the G-6Bass. This places 5 notes on each drum of the G-6Bass. The two notes assigned to the first drum 7 are obtained by selecting a root note and its fifth.

1755 The next two notes in the cycle of fourths and fifths progressing in fifths are then assigned to the second drum 8. This process is continued until the last two notes on the cycle of fourths and fifths are assigned to the sixth drum 12. As there are 12 notes in an octave, there are therefore 12 unique ways of allocating notes to the 3 drums using this procedure. The choice of the root note depends on a variety of factors, most significantly musical range, drum size, the size of note templates used by the tuner and preservation of the G-Soprano note layout alignment.

1760

1765 In the preferred embodiment the G-6Bass covers 2 ½ octaves an increase of an entire octave over what obtains in the traditional six-bass. Moreover, the G-6Bass exceeds the combined ranges of the nine-bass and six-bass steelpan and substantially covers the tenor bass steelpan range. With the procedure described, the lowest six notes in the G-6Bass range are implemented in three full octaves; these therefore also establish the highest six notes in the range of the instrument. The remaining notes on the G-6Bass complement the octave range of the first six and are implemented in two octaves.

1775 The layout of notes on each drum of the G-6Bass is such that physically adjacent note pairs are separated by a musical interval of fourths, fifths. Musical dissonance is therefore reduced to the minimum possible consonant intervals. This is significant for the bass range where the critical band of frequencies associated with the perception of dissonant tones is smaller in the bass range than for other musical ranges.

1780 It is an object of the present invention that the preferred embodiment of instruments in the G-Pan ensemble shall have playing surfaces that are 67.31 cm/26.50 in. in diameter an increase of 11.43 cm/4.5 in over what obtains in the prior art thus facilitating the generation of musical sound at higher sound intensity levels.

1785 A further object of the present invention, is that as a direct consequence of the use of larger drums, the G-Pan ensemble of instruments shall offer a musical range which spans the musical range G₁ to B₆ and thus improve on the prior art by eight (8) semitones, in as much as traditional acoustic steelpan span the musical range A₁ to F₆.

1790 Yet a further object of the present invention is that the G-Pan ensemble of instruments, shall offer significantly enhanced capabilities over the prior art, by use of only two note layout templates, an improvement over the prior art in which the note layout philosophy varies significantly, resulting in an increase in flexibility in performance, as players can now more easily adapt to any instrument in the G-Pan orchestra.

1795 Still another significant object of the present invention is that for all instruments which have the notes distributed over one, three, or six drums, the G-Pan ensemble utilizes a note layout template that optionally utilizes the relative note placement of the circle of fourths and fifths, or the reverse.

1800 Moreover a further object of the present invention is that for all instruments on which the notes must be distributed over two, or four drums, the G-Pan ensemble shall employ a note layout template, that is based on the two whole tone scales that complement each other, in any given contiguous octave of notes.

1805 Another object of the present invention, is that the G-Pan ensemble of instruments shall utilize only four preferred distinct instruments, the G-6Bass, G-3Mid, G-Second and G-Soprano, to cover the aforementioned musical range G₁ to B₆, whereas traditional prior art steelpan utilize as many as eleven (11) distinct instruments or more, to cover the more limited musical range A₁ to F₆, the current invention therefore improving on the prior art, by removing the clutter which results from having eleven steelpan instruments to cover a smaller musical range and the

1810

prohibitive transportation costs and concomitant restrictive mobility for the income earning potential of steel pannists undertaking social engagements and performances.

- 1815 Yet another object of the present invention, is that the preferred embodiment of the G-6Bass instrument shall cover the musical range G_1 to C_4 , a total of 30 notes or $2 \frac{1}{2}$ octaves, on 6 drums and therefore exceed the combined ranges of the traditional nine-bass and six-bass steelpan thus providing for a more compact instrument in the bass range, that is more portable than what obtains in the prior art, while improving performance versatility by reducing the need for transposition, as is often required in the prior art.

- 1825 Still another object of the present invention is that the preferred embodiment of the G-3Mid instrument shall cover the musical range A_2 to A^b_5 , a total of 36 notes or 3 octaves, on 3 drums. The G3-Mid therefore covers the baritone to alto range and exceeds the combined ranges of the 3-cello, 4-cello and double guitar steelpan as well as a significant amount of the quadraphonic steelpan and tenor bass steelpan musical ranges, thus providing for a more compact instrument in the baritone range, that is more portable than what obtains in the prior art, while improving performance versatility by reducing the need for transposition, as is often required in the prior art.

- 1830 Moreover as a further object, although the preferred embodiment of the G-3Mid instrument incorporates three octaves of notes to ensure maximum clarity and musical activity through judicious spacing between notes, the G-3Mid can accommodate as many as 45 notes on its playing surface thus exceeding the typical musical range of the quadraphonic steelpan.

- 1835 Consummately, another object of the present invention is that the G-3Mid instrument represents a major departure from the prior art, as its note layout is a distribution of the cycle of musical fourths and fifths over three drums.

- 1840 A further object of the present invention, is that the preferred embodiment of the G-Second instrument shall cover the musical range D_3 to $C^{\#}_6$, a total of 36 notes on 2 drums, since it targets the alto and tenor ranges and exceeds the combined ranges of the traditional double second and double tenor steelpan; thus providing for a more compact instrument in the alto and tenor ranges, that is more portable than what obtains in the prior art, while improving performance versatility by reducing the need for transposition as is often required in the prior art.

- 1850 Still another object of the present invention, is that the preferred embodiment of the G-Soprano instrument shall cover the musical range C_4 to B_6 , a total of 36 notes or 3 octaves, on a single drum ;while it targets the soprano range and exceeds the combined musical range of the low tenor steelpan and high tenor steelpan, thus providing for a more compact instrument in the soprano range, that is more portable than what obtains in the prior art, while improving performance versatility by reducing the need for transposition, as is often required in the prior art.

- 1855 A final object of the present invention, is that whereas in the prior art the rear attachment that is a single barrel or tube displays resonances that do not correspond to the fundamental frequencies of all notes on a given drum, Type 2a rear attachments

1860

1865 improve on the prior art by enhancing sound projection through the application of a tube cluster mechanism, that provides a tube resonator for each note on the playing surface. This is a novel approach that enhances the loudness and musical accuracy of the instrument and is not hitherto known in the prior art.

1870 Since other given modifications and features, which may be varied to fit such particular operating requirements and situations, will become apparent to those skilled in the art, from the herewithin detailed description, considered in conjunction with the accompanying drawings, it is to be understood however, that the present invention is not considered to be limited to the examples

1875 chosen.

GLOSSARY

1880 **Percussion:** the playing of music by striking an instrument.

Player: someone who plays a musical instrument.

1885 **Steelpan:** a definite pitch percussion instrument in the idiophone class, traditionally made from a cylindrical steel drum or steel container. The top of the drum or container is used to make the playing surface which is usually divided into sections by channels, grooves or bores. Each section is a note tuned to a definite pitch. The cylindrical side of the drum from which the steelpan is made is usually retained to act as a resonator and to provide physical support for the playing surface.

1890 **Pannist:** a person skilled in the art of playing a steelpan.

1895 **Fourth Musical Interval (Fourths):** Two notes vary by a fourth or are separated by a fourth musical interval if the ratio of their pitch frequencies is nominally $2^{5/12}$ on the scale of equal temperament.

1900 **Fifth Musical Interval (Fifths):** Two notes vary by a fifth or are separated by a fifth musical interval if the ratio of their pitch frequencies is nominally $2^{7/12}$ on the scale of equal temperament.

Fourths And Fifths Arrangement: An arrangement of musical notes in which the sequence of adjacent notes differ by a musical fourth interval in one direction and, therefore, a musical fifth interval in the opposite direction.

- 1905 **1 Playing Surface**
- 1a Notes**
- 1b Support Web**
- 1c Note Covers**
- 1d Primary Bowl**
- 1910 **1e Primary Bowl Flange**
- 1f Vibration Absorption Gasket**

1g	Secondary Bowl
1h	Secondary Bowl Gasket
1i	Ring 0
1j	Ring 1
1k	Ring 2
2	First Drum on G- Second Steelpan
3	Second Drum on G-Second Steelpan
4	First Drum on G-3Mid Steelpan
5	Second Drum on G-3Mid Steelpan
6	Third Drum on G-3Mid Steelpan
7	First Drum on G-6Bass
8	Second Drum on G-6Bass
9	Third Drum on G-6Bass
10	Fourth Drum on G-6Bass
11	Fifth Drum on G-6Bass
12	Sixth Drum on G-6Bass
13	Chime
13a	Support Ring
13b	Abutment
13c	Suspension Wheel
13d	Suspension Wheel Axle
14	Rear Attachment
14a	Attitude Offset Weights
15	Support Stand
15a	Support Stand Uprights
16	Support Cups
17	Tube
18	Outer Shell
19	Frame
19a	Concentric Braces
19b	Radial Braces
20	Resonant Sections
21	Type 3 Rear Attachment
22	Port opening

What is claimed is:

1. A steelpan musical instrument of compound design comprising:

a playing surface having first and second hemispherical note bearing surfaces and including a plurality of at least four independent note areas on each note bearing surface, each independent note area tuned to a definite pitch distinct from the pitch of the others of the at least four independent areas on said note bearing surface, the first hemispherical note bearing surface defining a centrally located aperture at the bottom of said first note bearing surface and having a first radius, said aperture passing entirely through said first note bearing surface; and

the second hemispherical note bearing surface having an outside radius larger than the first radius, whereby the secondary hemispherical note bearing surface is constructed and arranged to be inserted into the aperture and retained therein.

2. The steelpan musical instrument as claimed in Claim 1, further comprising at least one vibration absorption gasket separating the first note bearing surface and the second note bearing surface, said vibration absorption gasket being distinct and separate from said first note bearing surface and said second note bearing surface, thereby decoupling the vibrations between said first and second note bearing surfaces, effecting a resultant reduction in note coupling during excitation of said plurality of independent note areas on the note bearing surfaces by a factor of at least 0.47.

3. The steelpan musical instrument of Claim 1, wherein said first and second hemispherical note bearing surfaces comprise a metal selected from the group consisting of aluminum and its alloys, copper and copper alloys, manganese alloys, magnesium, zirconium, zinc, nickel,

titanium, carbon steels and stainless steels that are austenitic stainless steels stabilized by one of niobium and titanium that is non work hardened.

4. The steelpan musical instrument of Claim 1, having a plurality of substantially cylindrical note resonators forming a cluster mechanism, wherein each of said note resonators is attached to an independent note area on the lower surface of the hemispherical note bearing surfaces.

5. The steelpan musical instrument of Claim 1, wherein upon the striking of note bearing surfaces, said design minimizes dissonance caused by note coupling between notes, by way of the transfer of acoustic energy through a support web and a reduction in the sound produced by vibration of said support web, at non-musical resonant frequencies, through the application of mass loading.

6. The steelpan musical instrument of Claim 1, further comprising;

a pair of suspension wheels attached to the steelpan; and

a support stand including a pair of support cups, the support cups constructed and arranged to rotatably support the suspension wheels without constraining said steelpan to a fixed playing angle, thereby supporting said steelpan in a free swinging fashion.

7. A steelpan ensemble comprising the steelpan musical instrument of Claim 1, and consisting essentially of four distinct instruments.

8. The steelpan ensemble of Claim 7, wherein the four distinct instruments comprise a soprano instrument, a second instrument, a mid instrument and a bass instrument.

9. The steelpan ensemble of Claim 8, wherein said mid instrument consists of three drums and spans the musical range consisting of A_2 to $G^\#$.
10. The steelpan ensemble of Claim 8, wherein said bass instrument consists of six drums and spans the musical range G_1 to C_4 .
11. The steelpan ensemble of Claim 8, wherein said second instrument consists of two drums and spans the musical range D_3 to $C^\#_6$.
12. The ensemble of Claim 8, wherein the soprano instrument consists of one steelpan, the second instrument consists of two steelpans, the mid instrument consists of three steelpans and the bass instrument consists of six steelpans.
13. The steelpan ensemble of Claim 8, wherein the soprano instrument consists of one drum and spans the musical range C_4 to B_6 .
14. The steelpan musical instrument of Claim 1, further comprising a note cover configured to overlay one of said independent note areas.

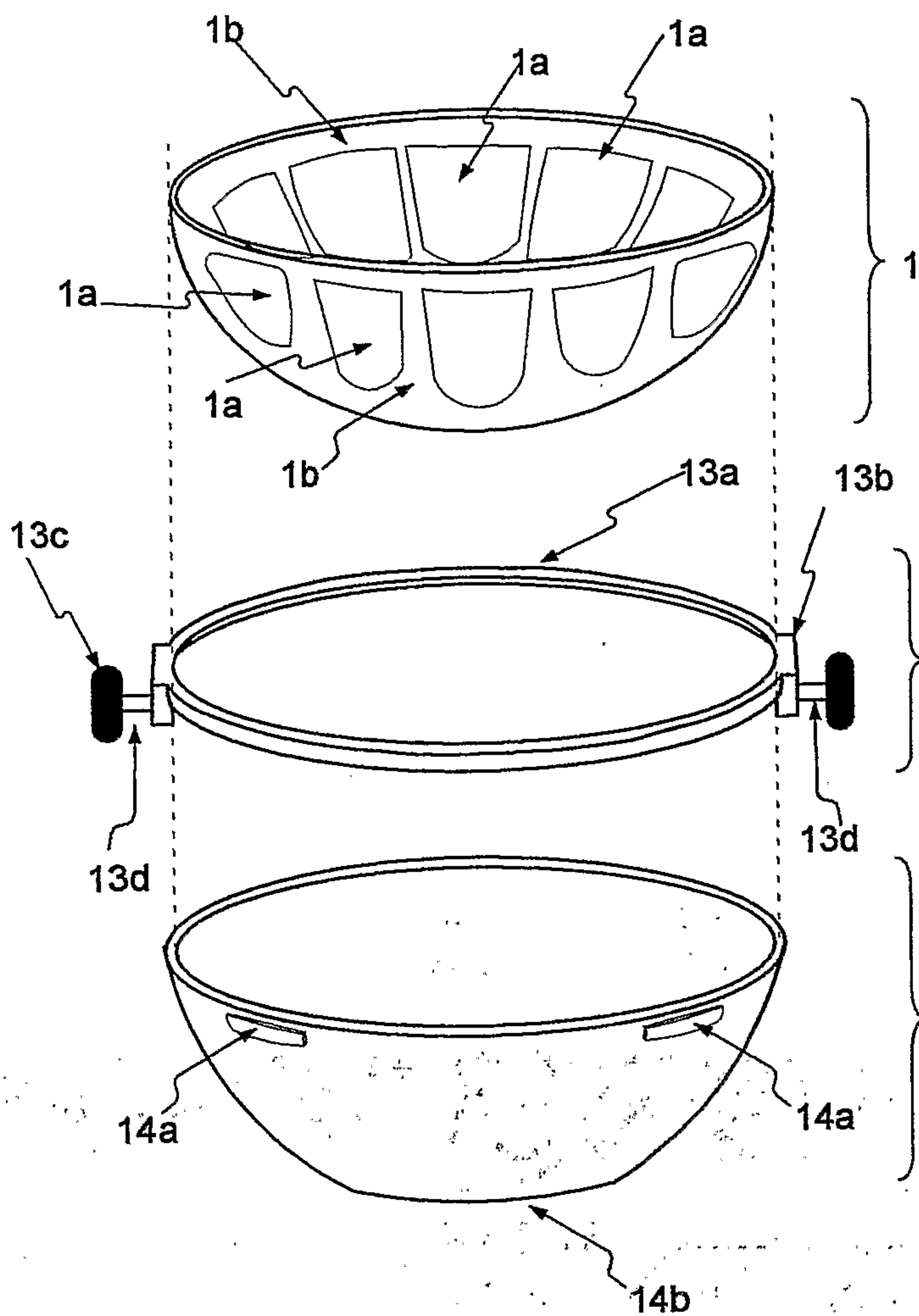


Fig. 1a

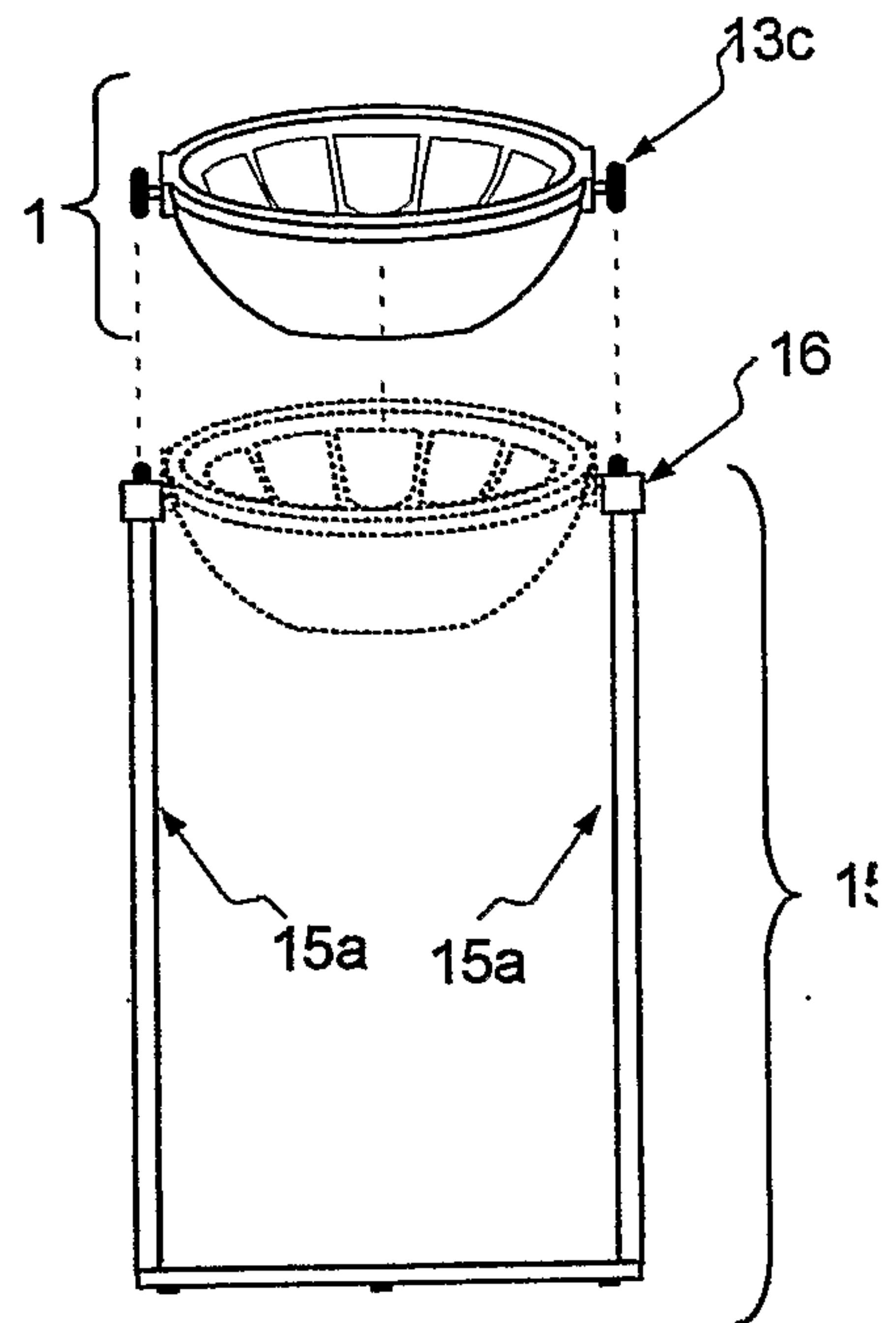


Fig. 1b

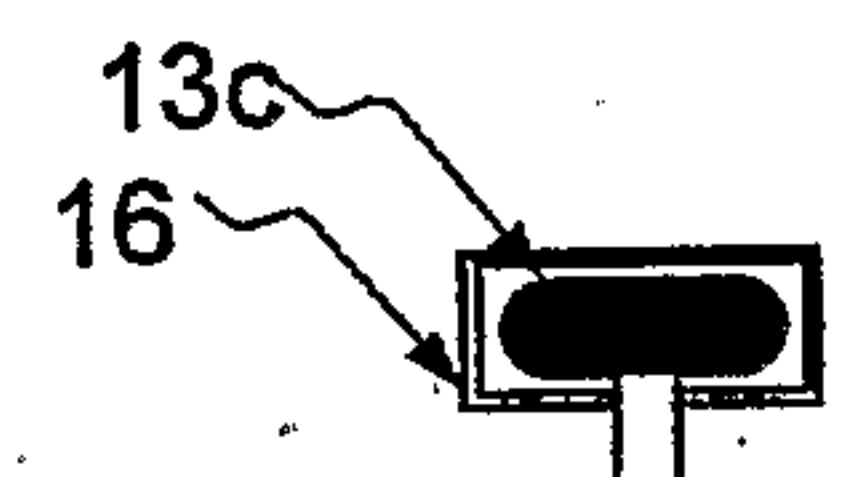


Fig. 1c

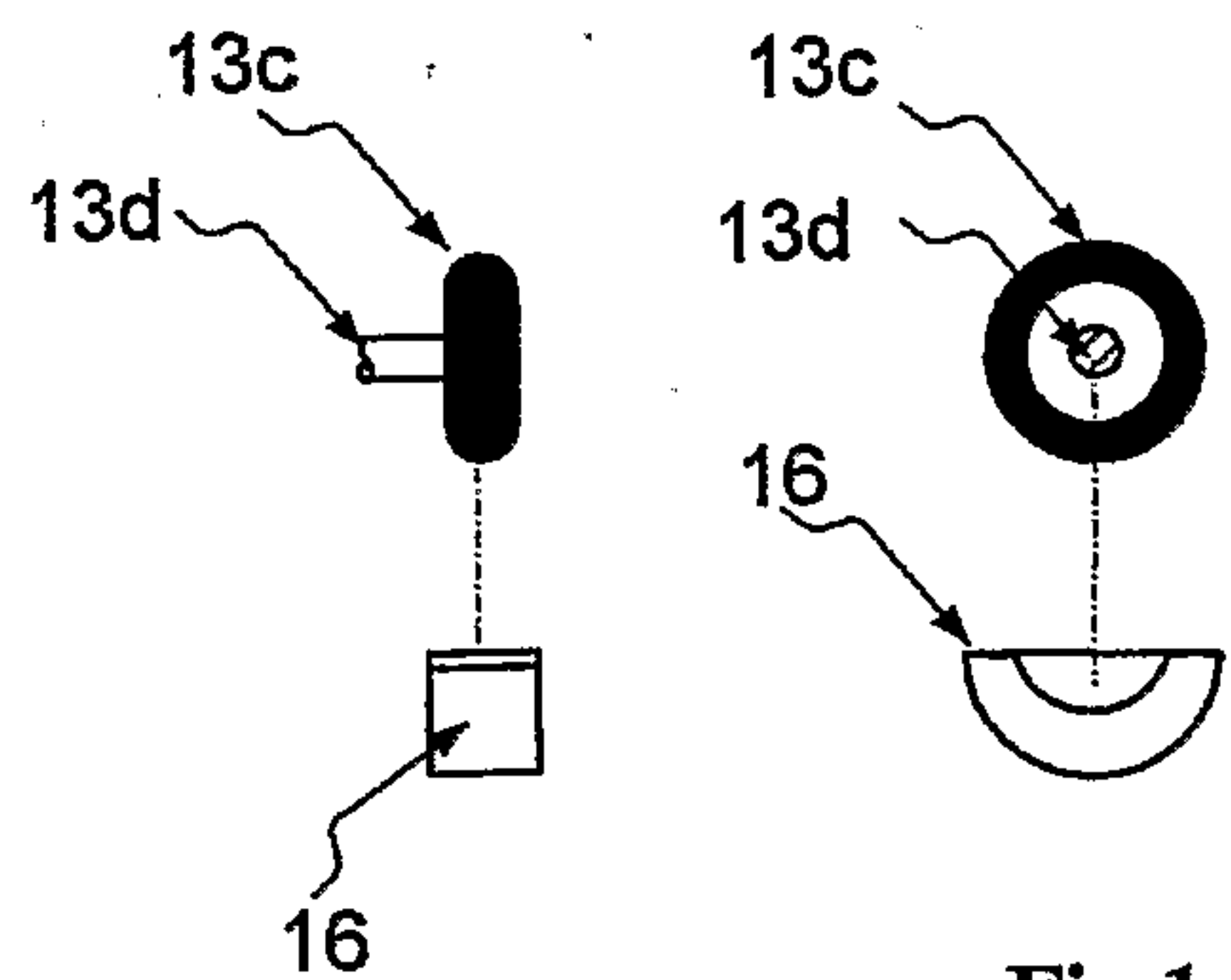


Fig. 1d

Fig. 1

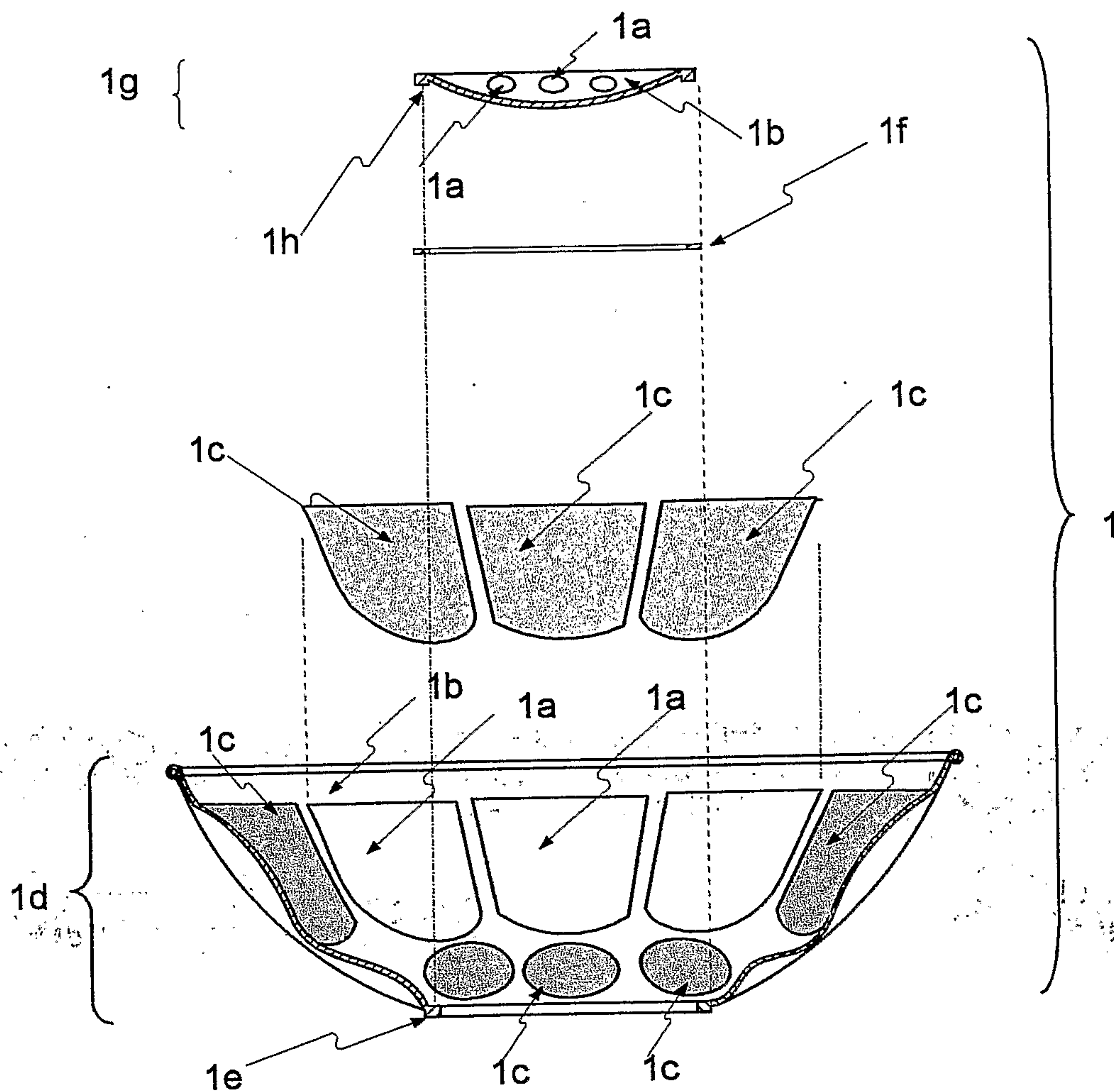


Fig. 2

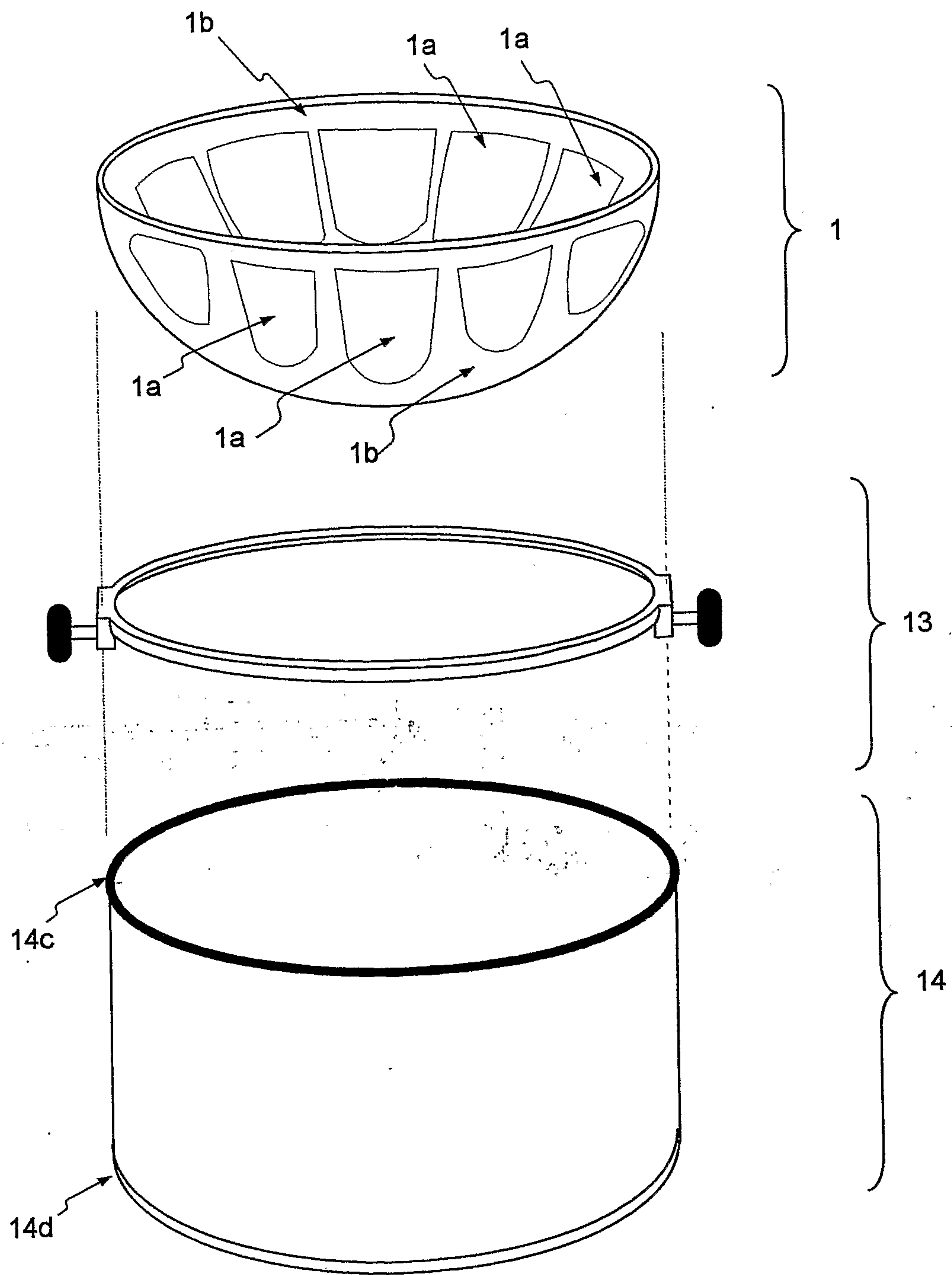


Fig. 3

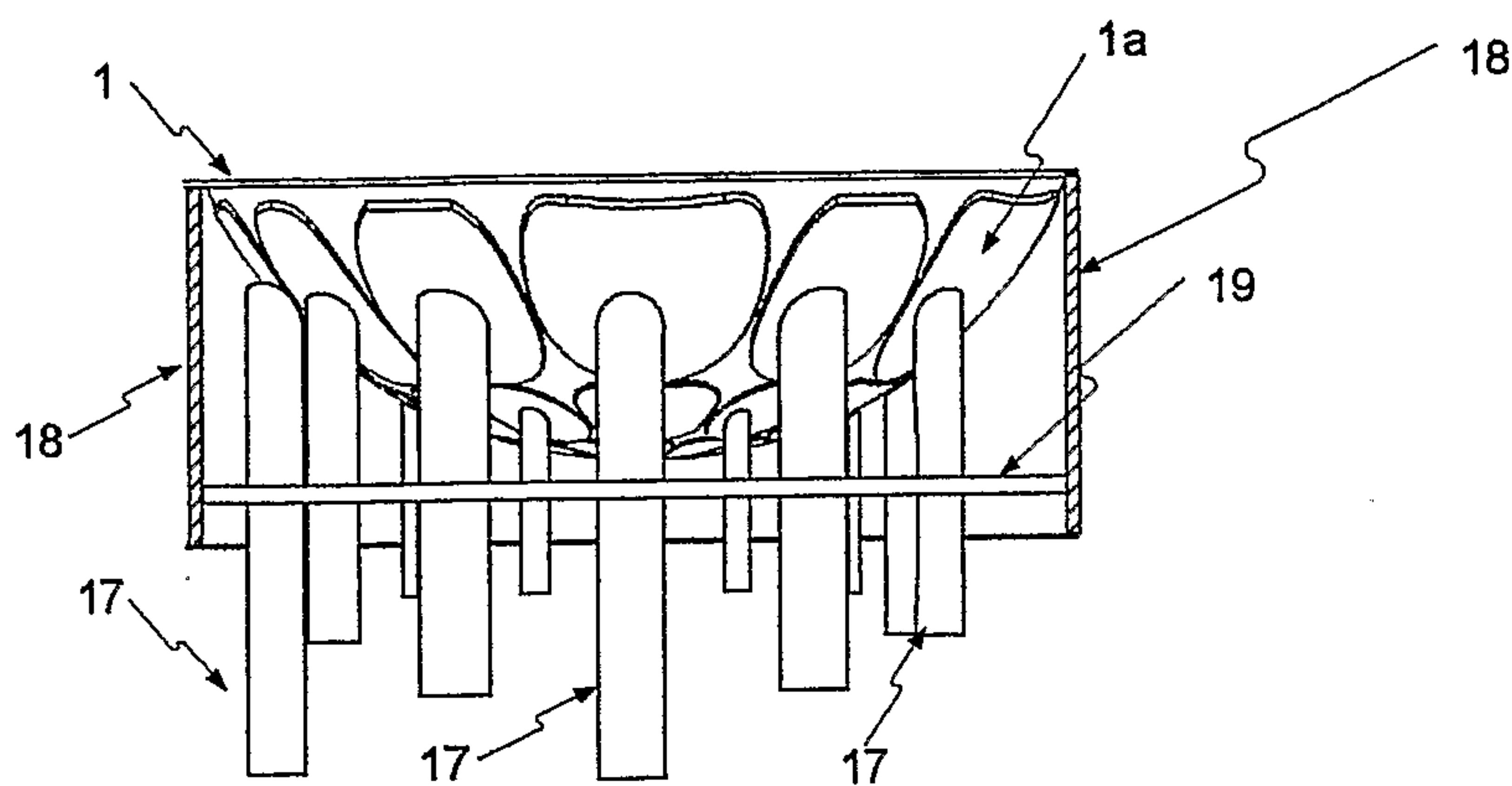


Fig. 4a

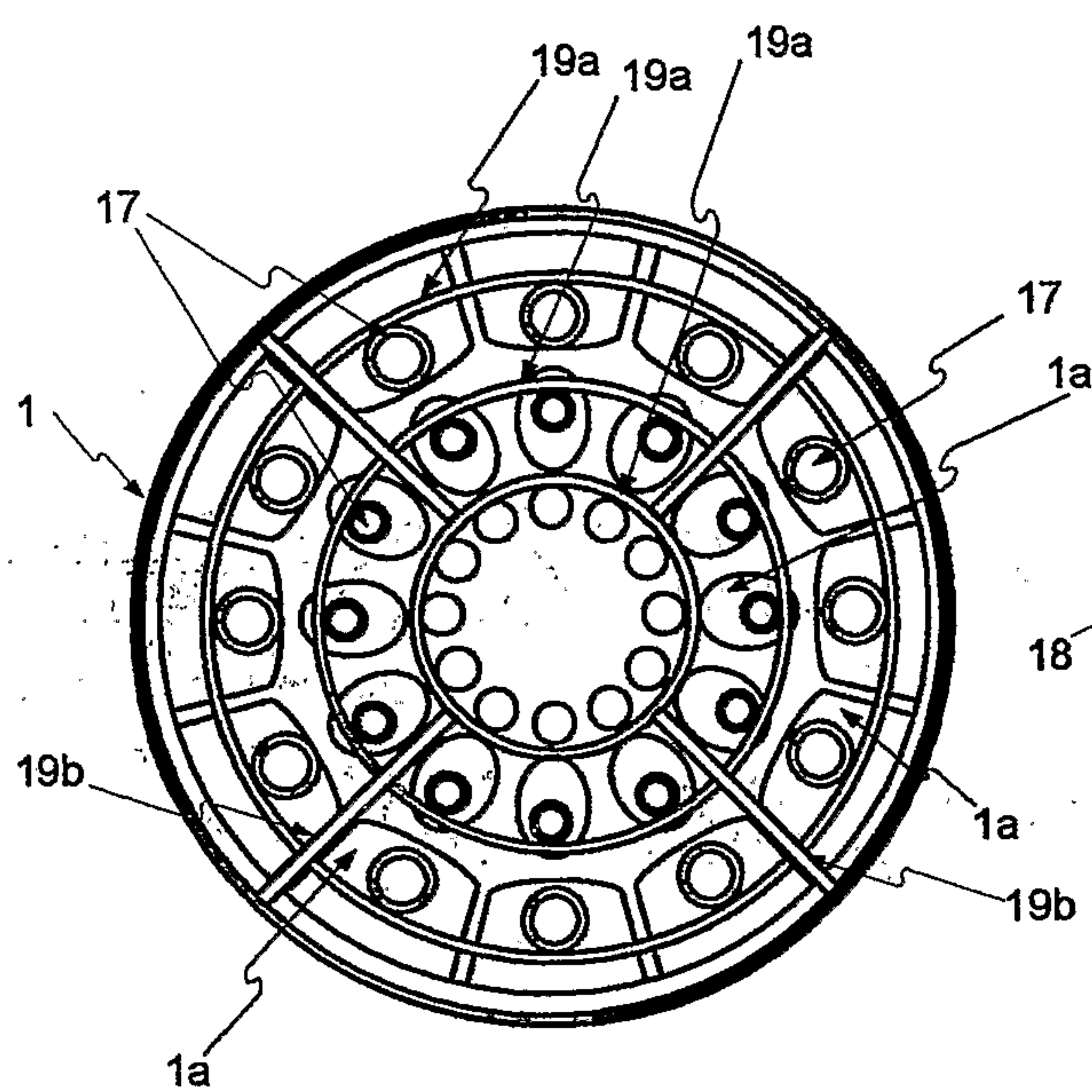


Fig. 4b

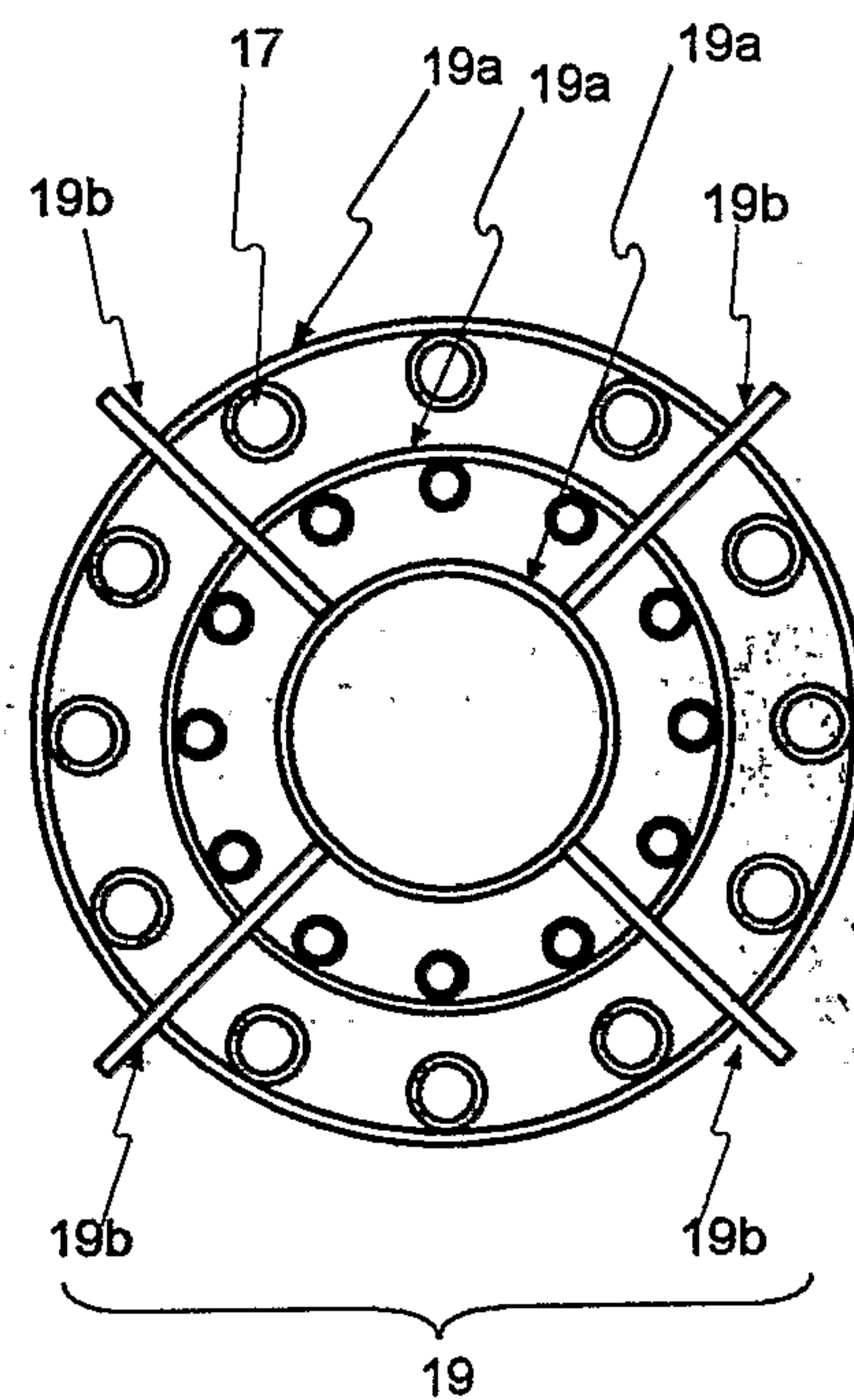


Fig. 4c

Fig. 4

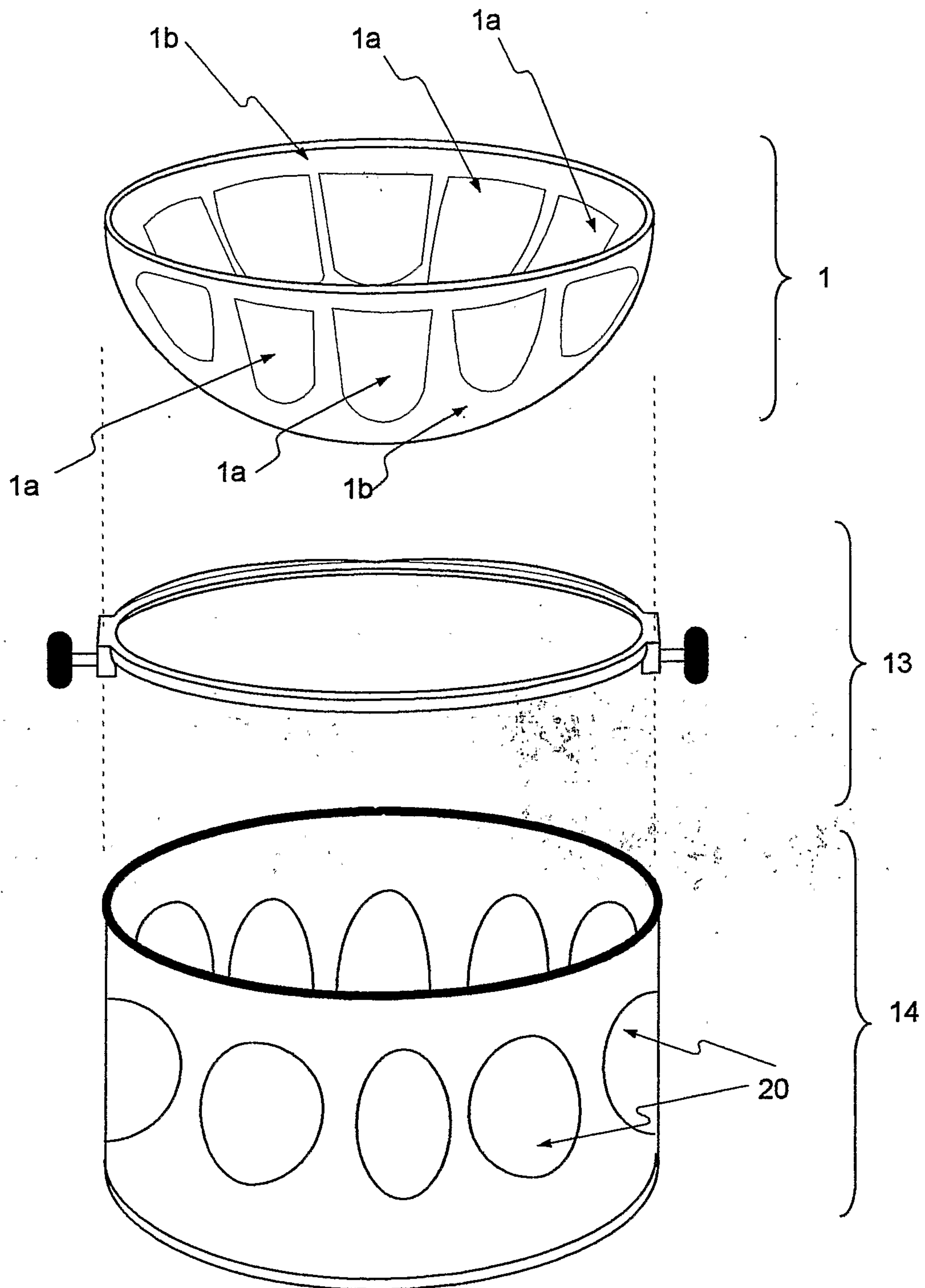


Fig. 5

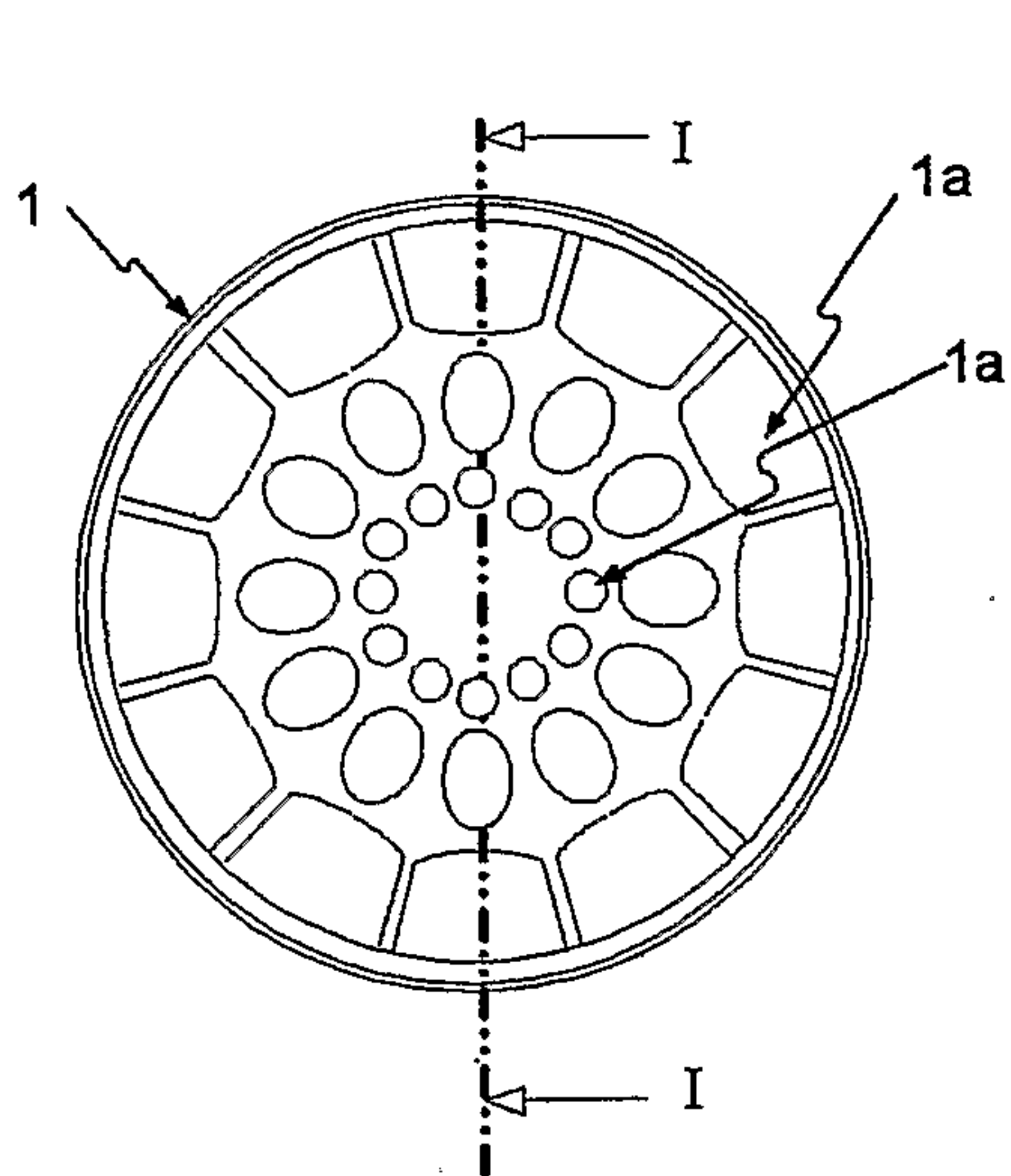


Fig. 6a

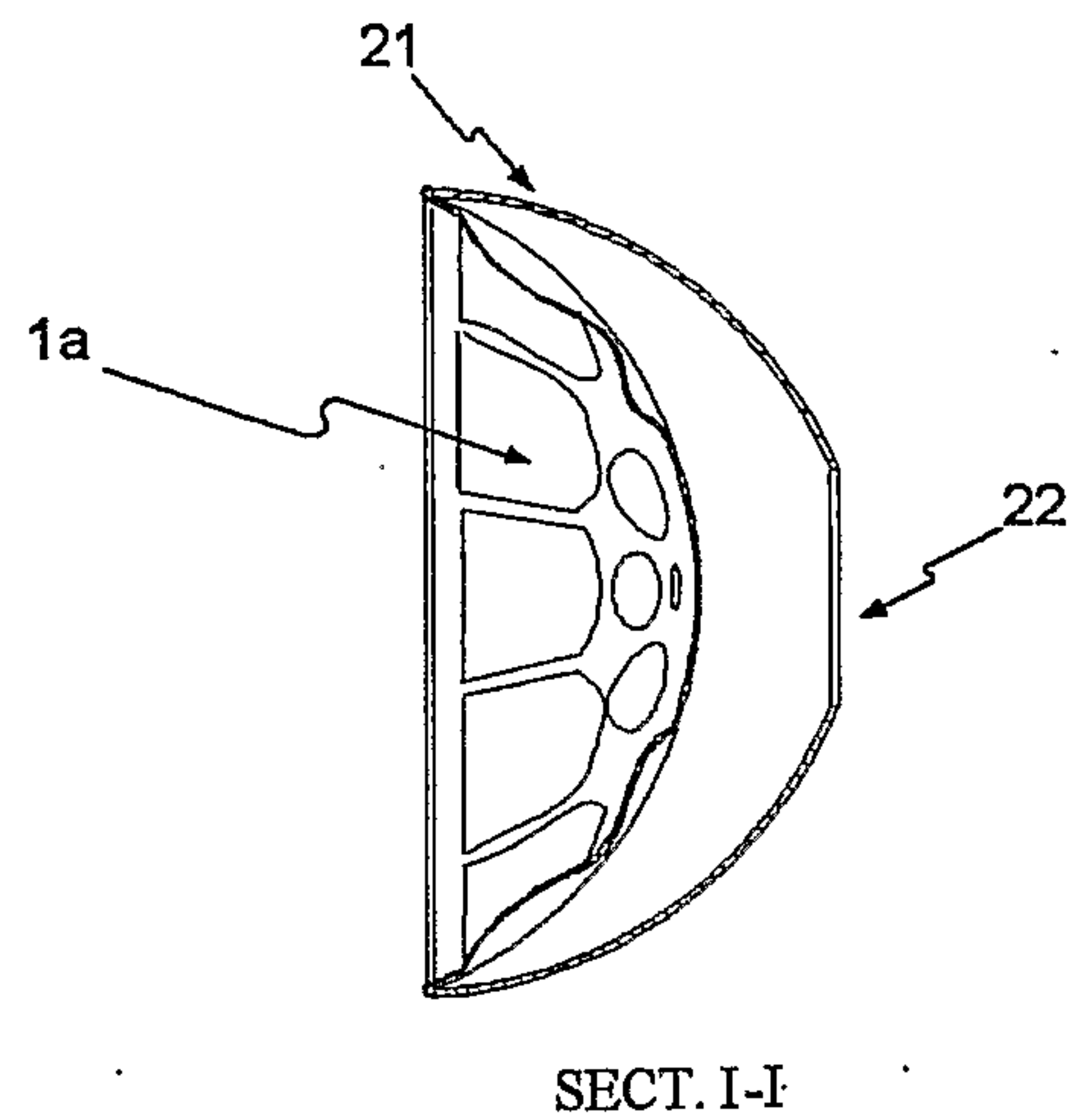


Fig. 6b

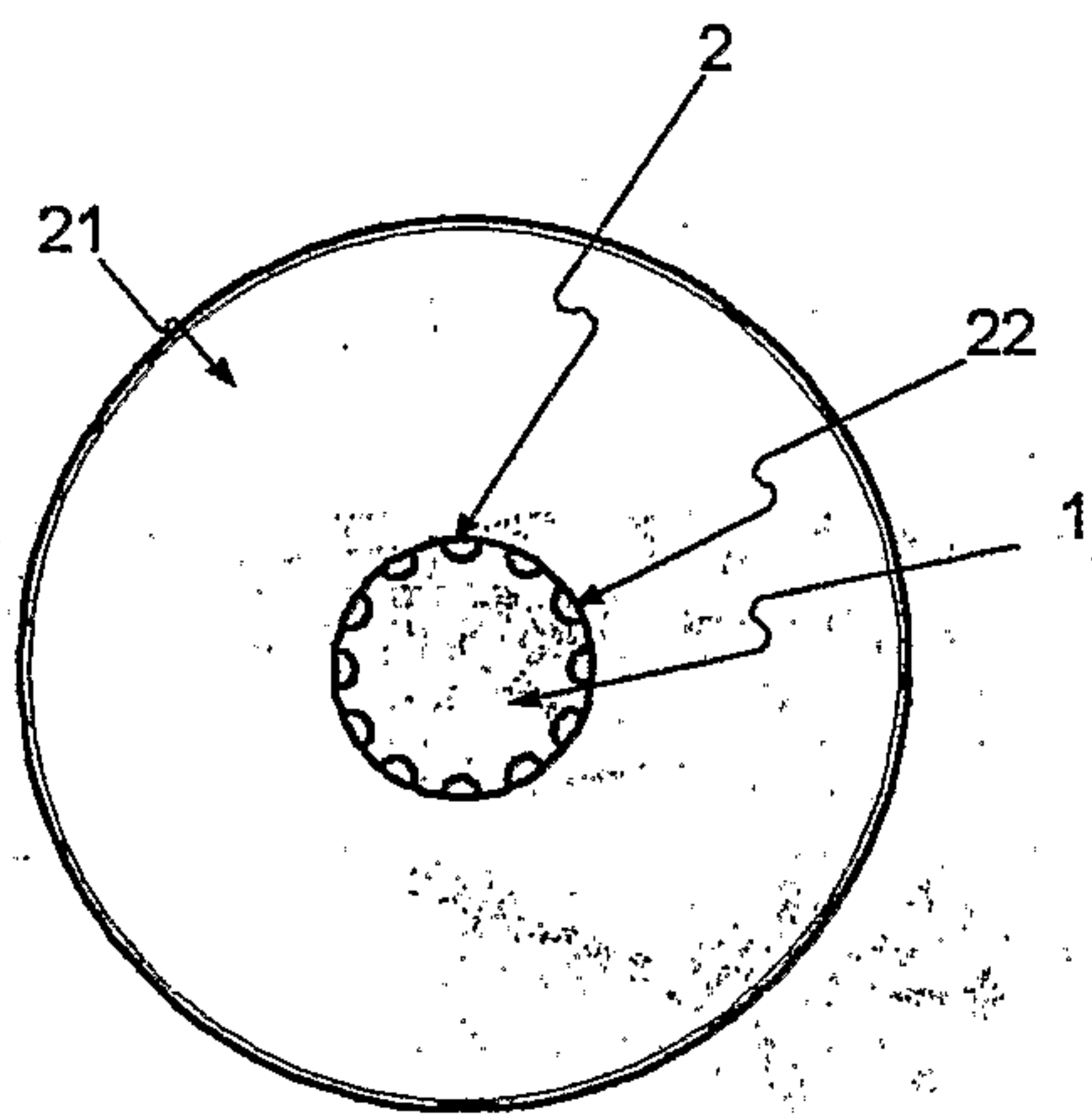


Fig. 6c

Fig. 6

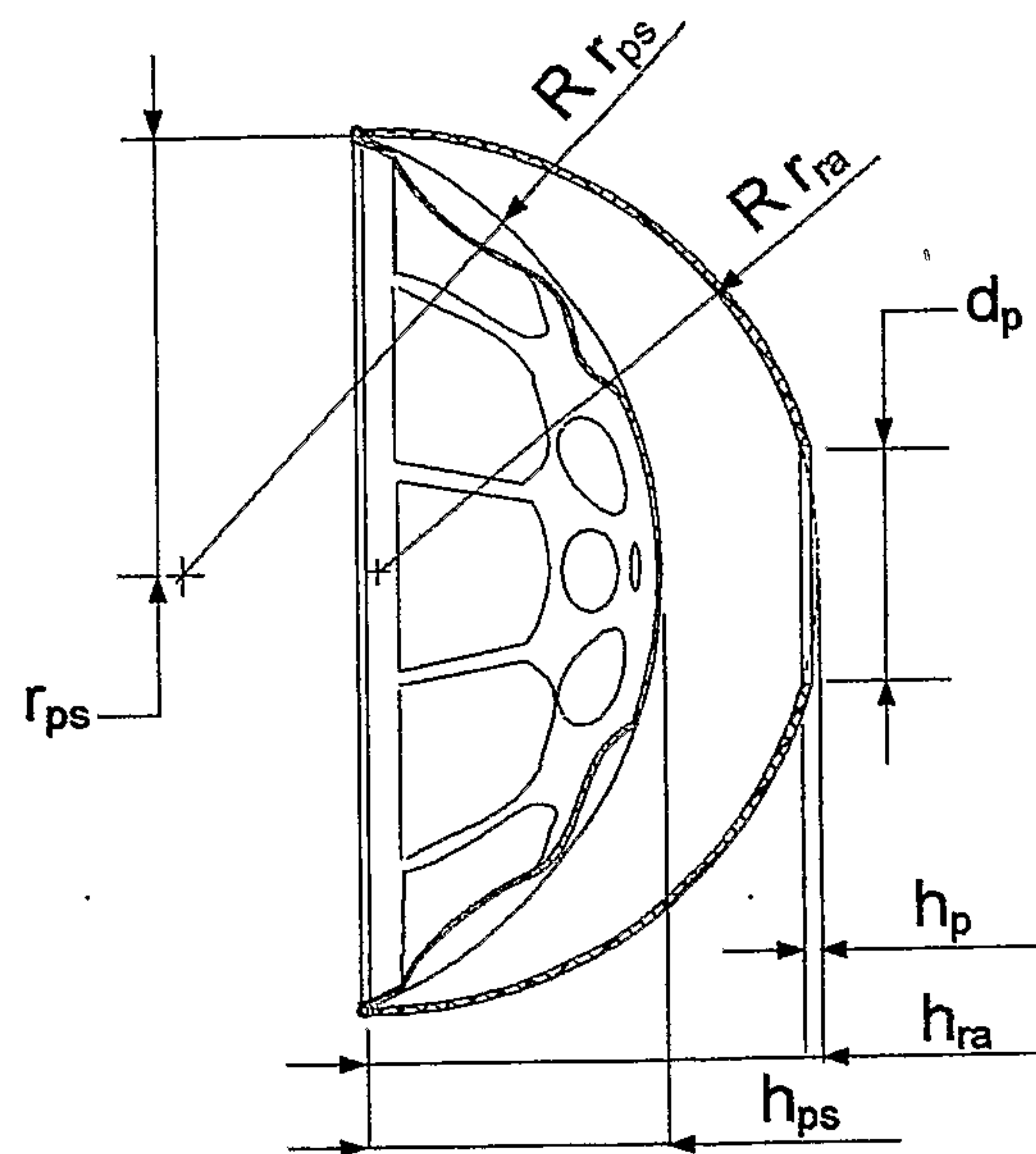


Fig. 7

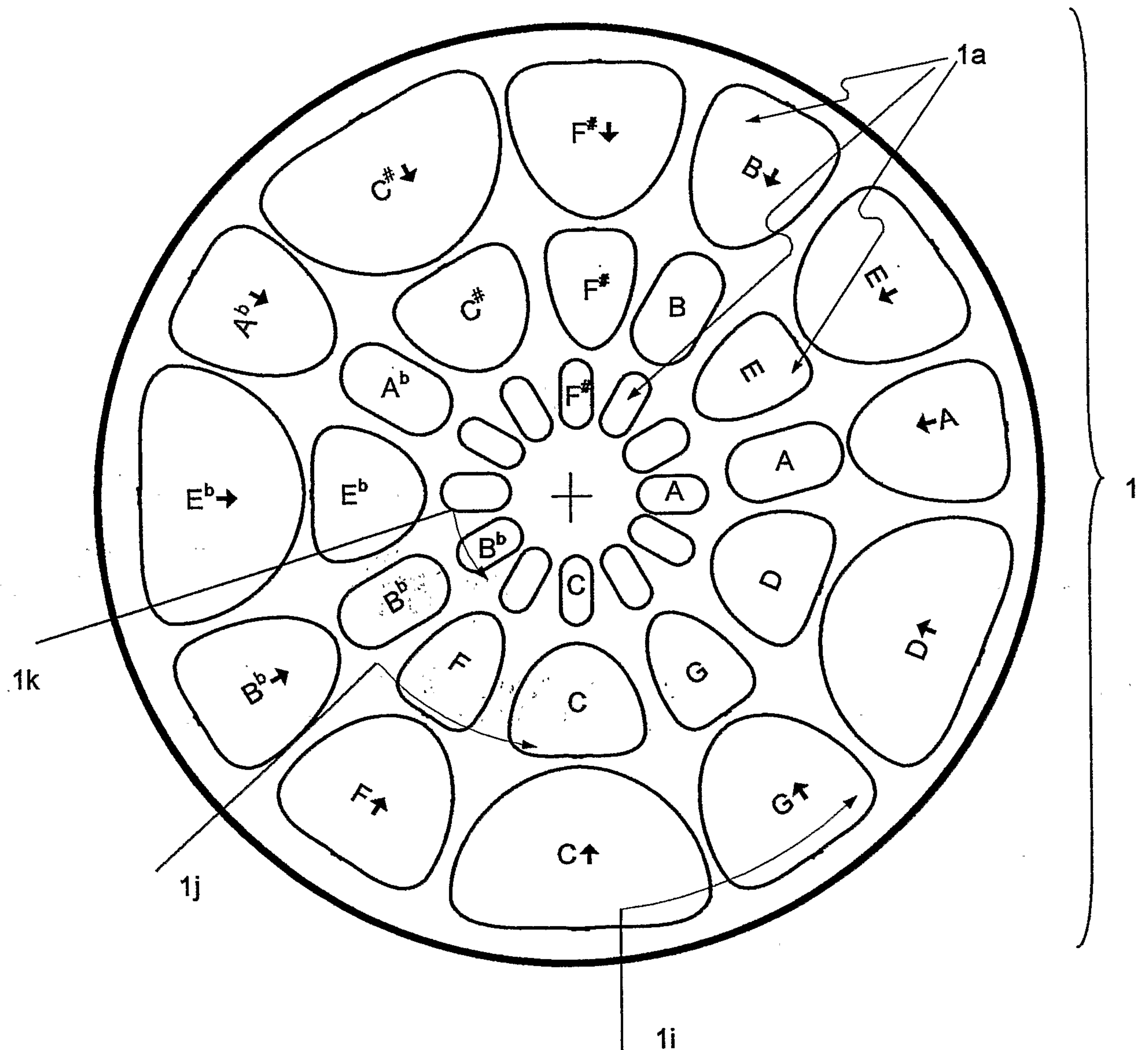


Fig. 8

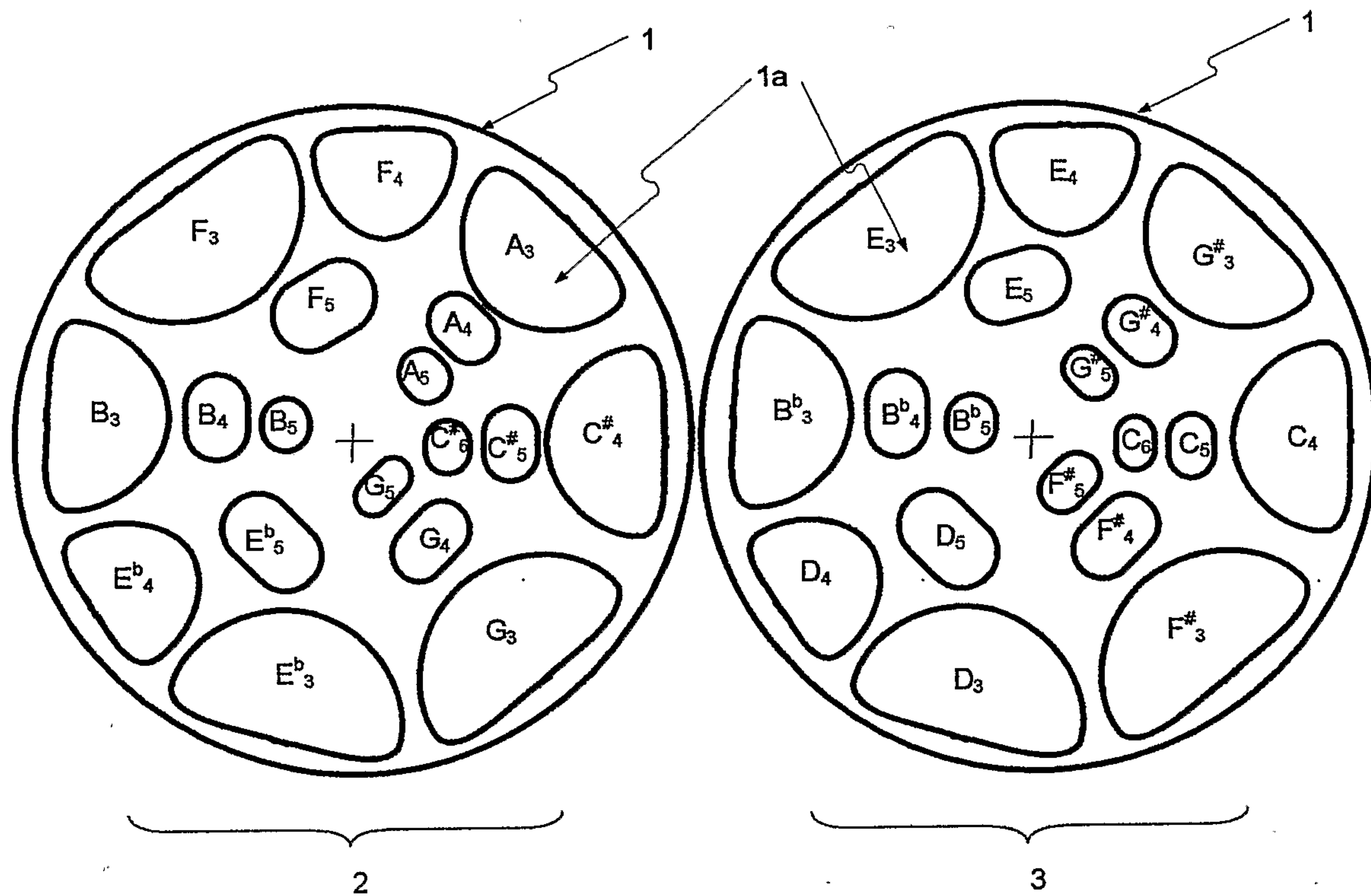


Fig. 9

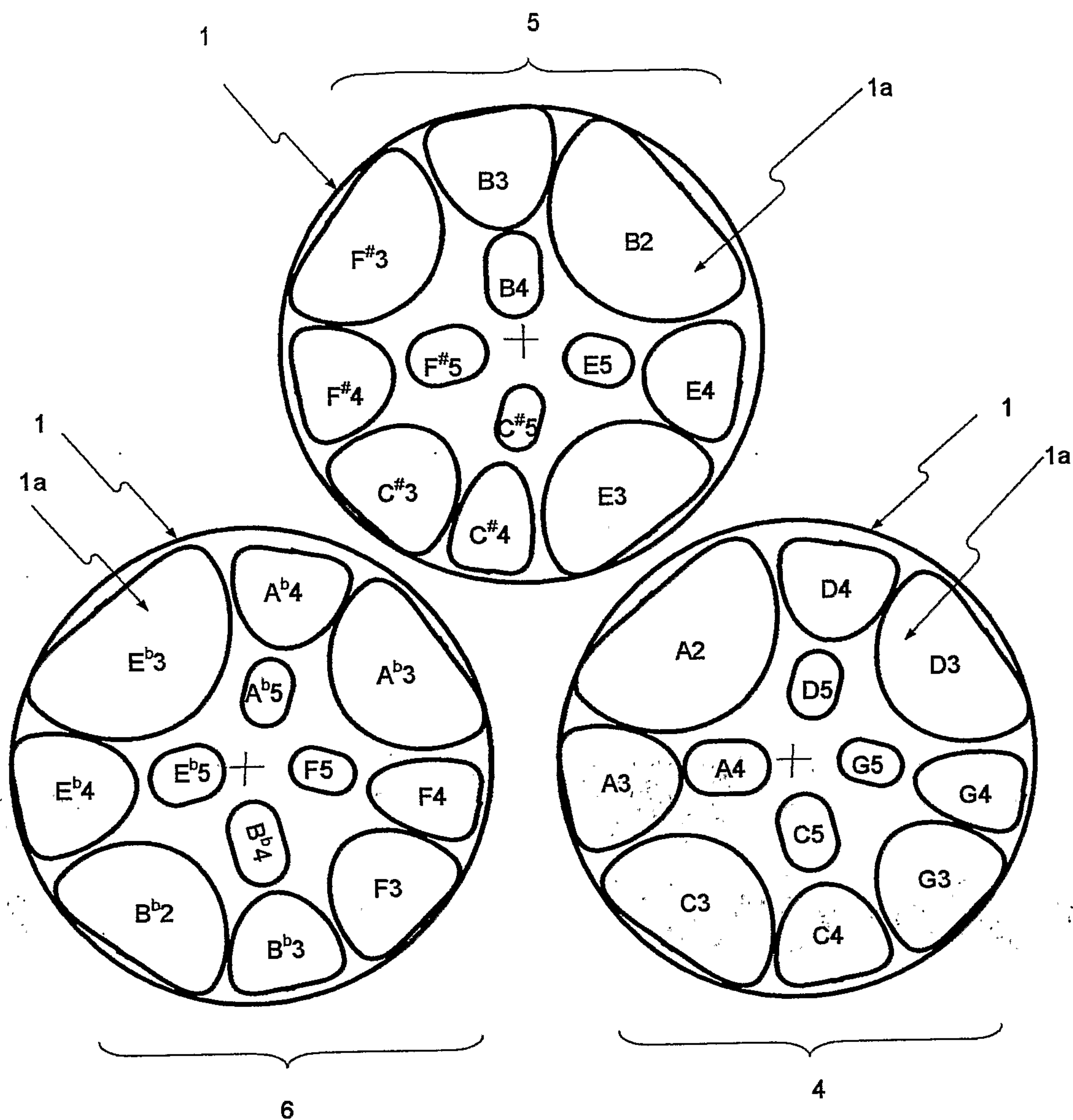


Fig. 10

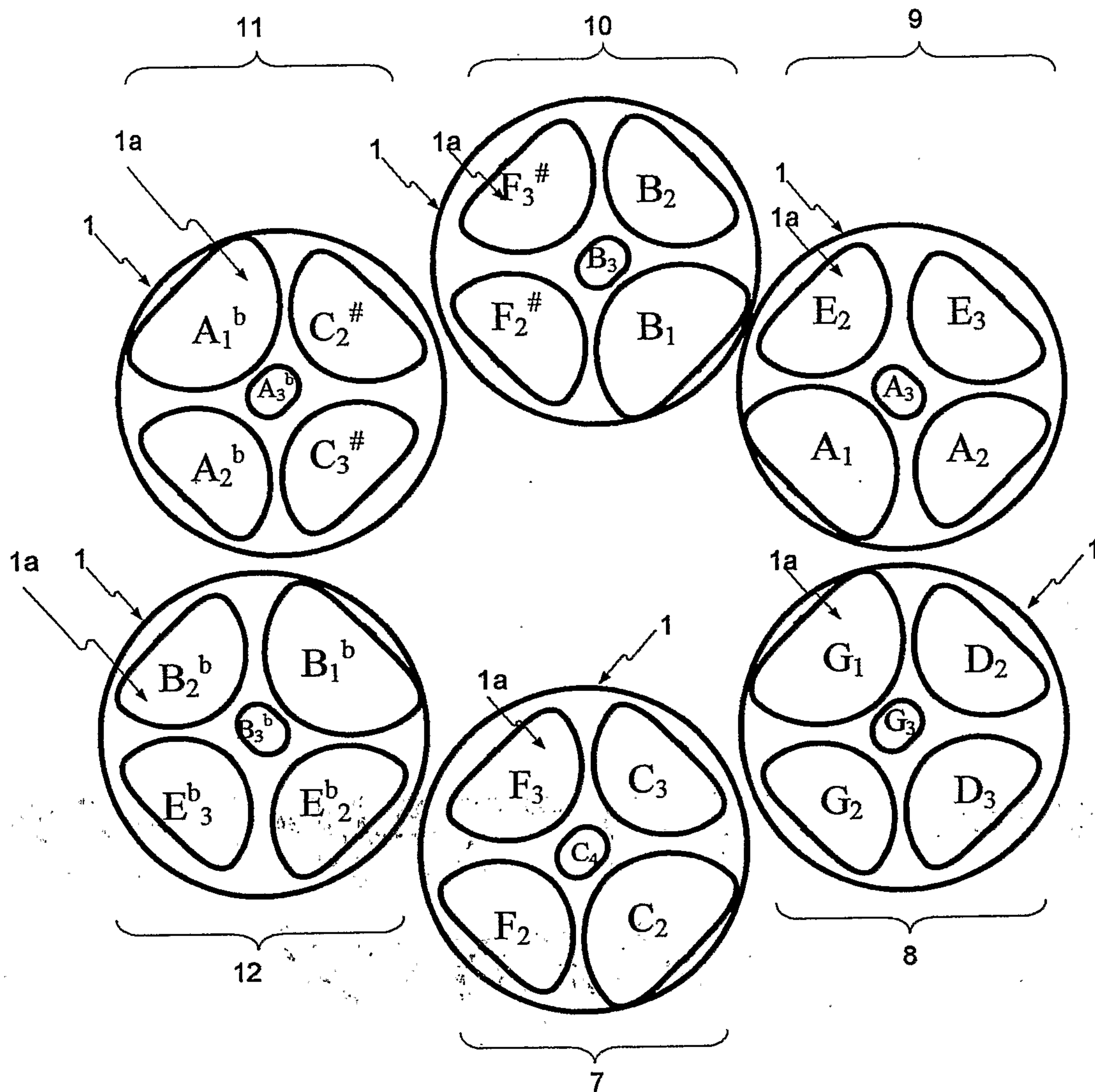


Fig. 11

