US00RE38939E

(19) **United States**
(12) **Reissued Patent**
Kessinger, Jr. et al.

(10) **Patent Number:** **US RE38,939 E**
(45) **Date of Reissued Patent:** ***Jan. 24, 2006**

(54) **INTERLOCKING SEGMENTED COIL ARRAY**

(75) Inventors: **Roy Lee Kessinger, Jr.**, Greenville, IN (US); **Paul Anthony Stahura**, South Bend, IN (US); **Paul Eric Receveur**, New Albany, IN (US); **Karl David Dockstader**, Prospect, KY (US)

(73) Assignee: **Kinetic Art & Technology Corporation**, Greenville, IN (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

(21) Appl. No.: **09/561,826**

(22) Filed: **Apr. 28, 2000**

Related U.S. Patent Documents

Reissue of:
(64) Patent No.: **5,744,896**
Issued: **Apr. 28, 1998**
Appl. No.: **08/651,973**
Filed: **May 21, 1996**

(51) **Int. Cl.**
H02K 1/22 (2006.01)
H02K 3/04 (2006.01)

(52) **U.S. Cl.** .... **310/268**; 310/208; 310/211; 310/198; 310/68 R; 29/605; 29/596

(58) **Field of Classification Search** .... 310/46, 310/63 R, 198, 206, 207, 208, 211, 248, 268, 310/156.32, 156.36, 156.37, 156.34; 29/605, 29/596

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,215,876 A * 11/1965 Nichols et al. 310/268
3,226,586 A 12/1965 Henry-Baudot 310/254
3,348,086 A 10/1967 Monma 310/268
3,678,314 A 7/1972 Carter 310/268
3,686,521 A 8/1972 Henry-Baudot 310/46
3,700,944 A * 10/1972 Heinz 310/168
3,790,835 A * 2/1974 Takeda 310/268

(Continued)

FOREIGN PATENT DOCUMENTS

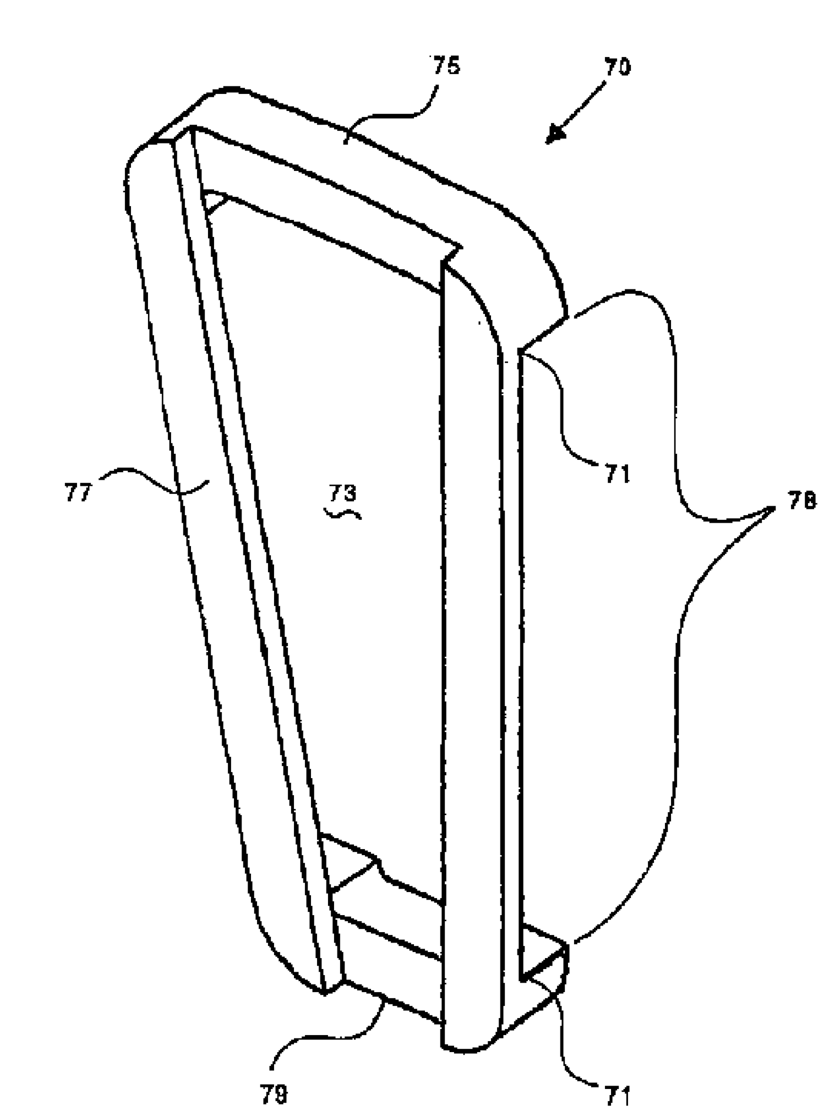
EP	94202793.9 A2	1/1995
GB	1581350	12/1980
JP	56-121359	9/1981
JP	56-153962	11/1981
JP	57-135645	8/1982
JP	60-051447 A *	3/1985
JP	62-193543	8/1987
JP	1-264558	10/1989
SU	1056929 A	11/1983

Primary Examiner—Karl E. Tamai
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

Disclosed is a Segmented Coil Array ("SCA") for use in rotary electromotive devices, such as motors and generators, which employ multiple coils operating within an axial gap magnetic structure. Individual conductor coils have offset circumferentially extending portions so as to allow interlocking of adjacent coils radially extending portions to form a circular array in which all of the coils' working conductors, which are those in the axial magnetic field, can be oriented in the same plane. This construction allows minimum magnet gap spacing, thus, maximizing the available magnetic flux. The resulting SCA may easily be commuted as a three-phase motor, actuator, or generator. The invention also provides a structure whereby multiple coil arrays and associated magnetic rotors may be alternately stacked in layers so as to further increase the total coil working area within a motor or generator of a given diameter.

14 Claims, 10 Drawing Sheets



U.S. PATENT DOCUMENTS

3,988,024	A	*	10/1976	Watanabe et al.	274/1 E
3,999,092	A	*	12/1976	Whiteley	310/156
4,007,390	A	*	2/1977	Muller et al.	310/90
4,068,143	A	*	1/1978	Whiteley	310/268
4,319,152	A		3/1982	van Gils	310/201
4,361,776	A	*	11/1982	Hayashi et al.	310/268
4,371,801	A	*	2/1983	Richter	310/156
4,420,875	A	*	12/1983	Coquillart	29/597
4,551,645	A	*	11/1985	Takahashi et al.	310/46
4,743,813	A	*	5/1988	Tassinario	318/138
4,839,543	A	*	6/1989	Beakley et al.	310/12
4,868,443	A		9/1989	Rossi	310/268
5,087,844	A		2/1992	Takedomi et al.	310/12
5,146,144	A	*	9/1992	Lee	318/138
5,168,185	A	*	12/1992	Umehara et al.	310/15
5,304,884	A	*	4/1994	Kitajima et al.	310/198
5,396,140	A	*	3/1995	Goldie et al.	310/268
5,397,953	A	*	3/1995	Cho	310/254
5,589,722	A	*	12/1996	Sakaguchi et al.	310/180
5,619,087	A		4/1997	Sakai	310/268
5,744,896	A	*	4/1998	Kessinger, Jr. et al.	310/268
5,767,600	A		6/1998	Whiteley	310/184

* cited by examiner

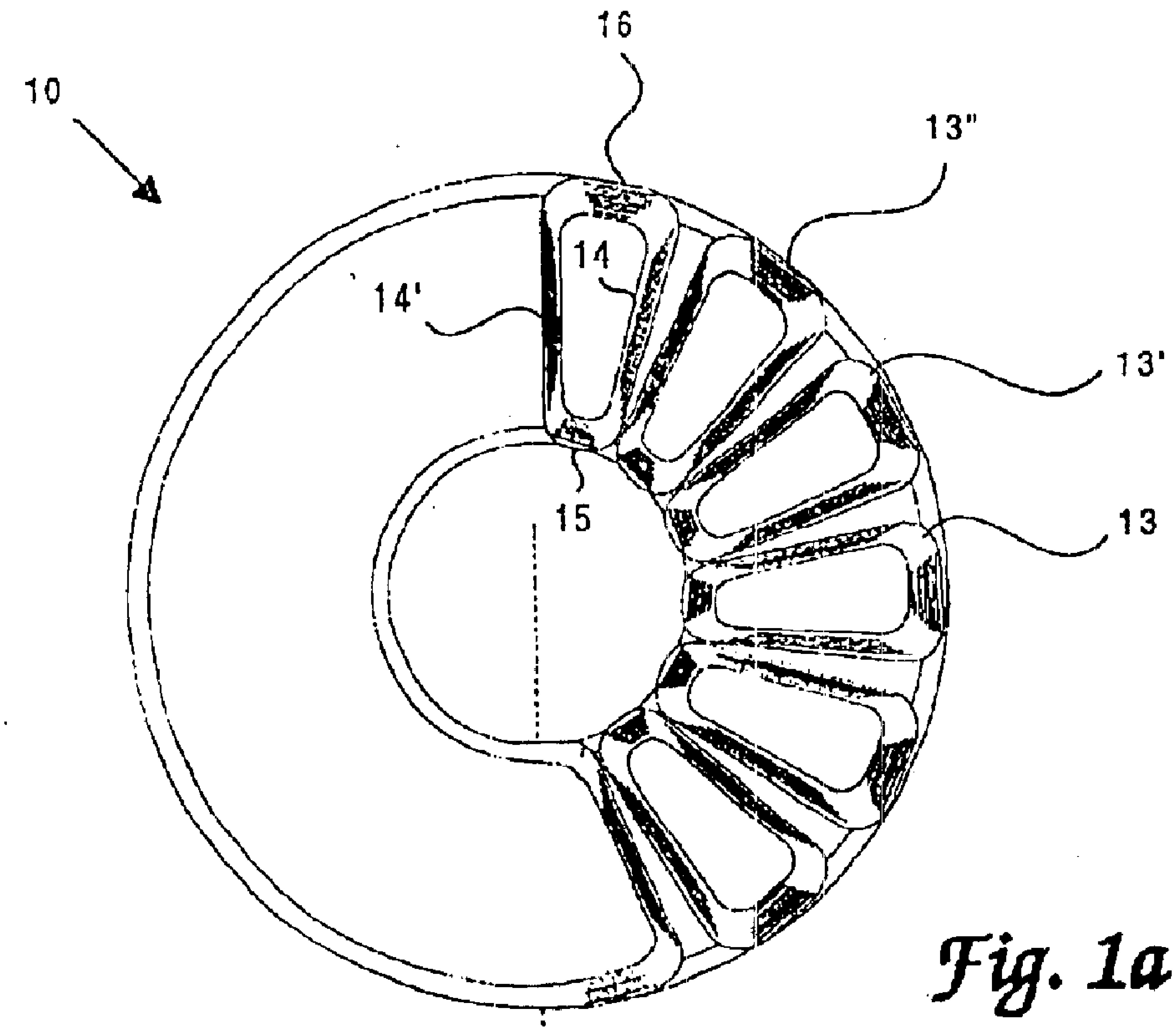


Fig. 1a

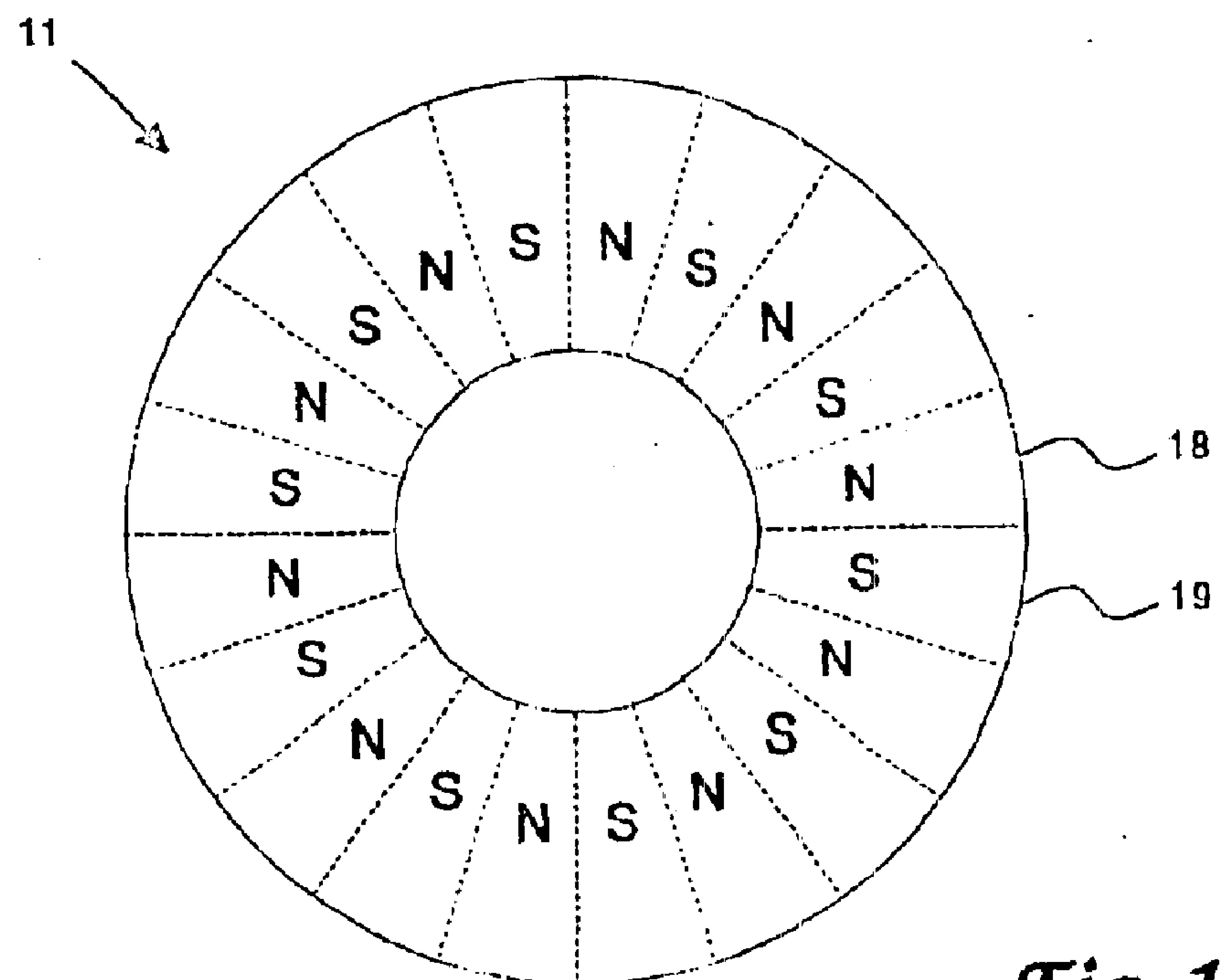


Fig. 1b

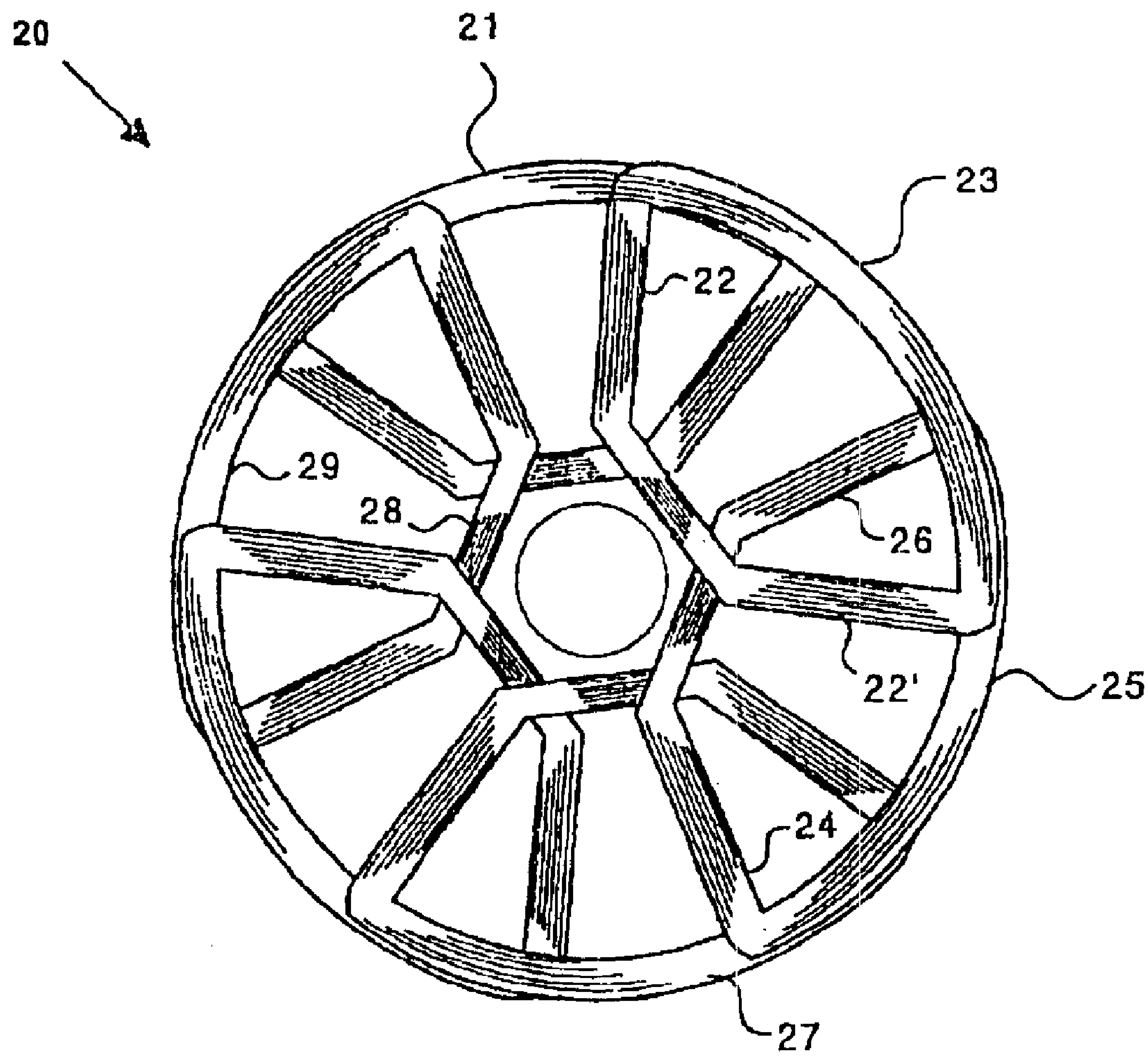


Fig. 2

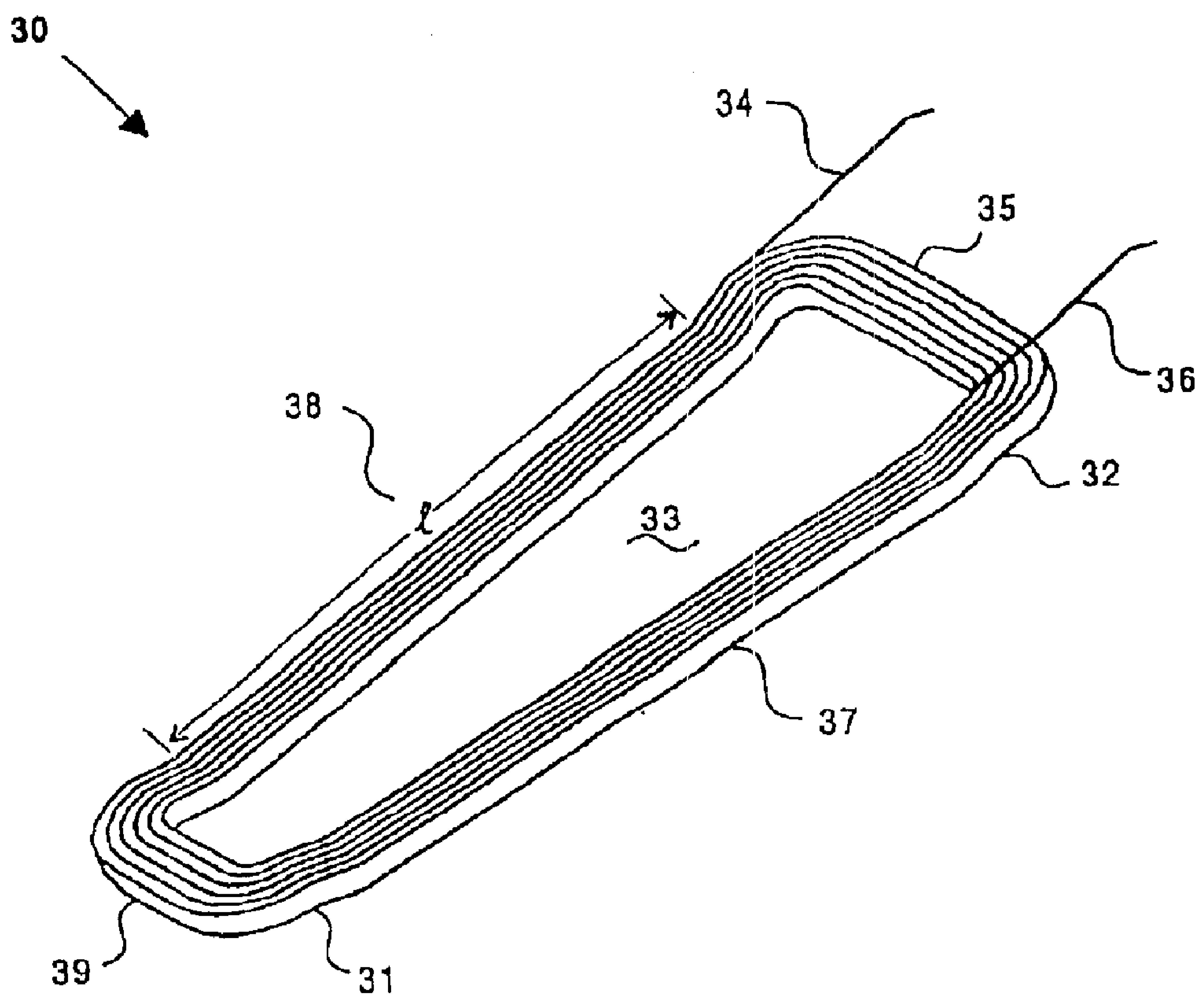


Fig. 3

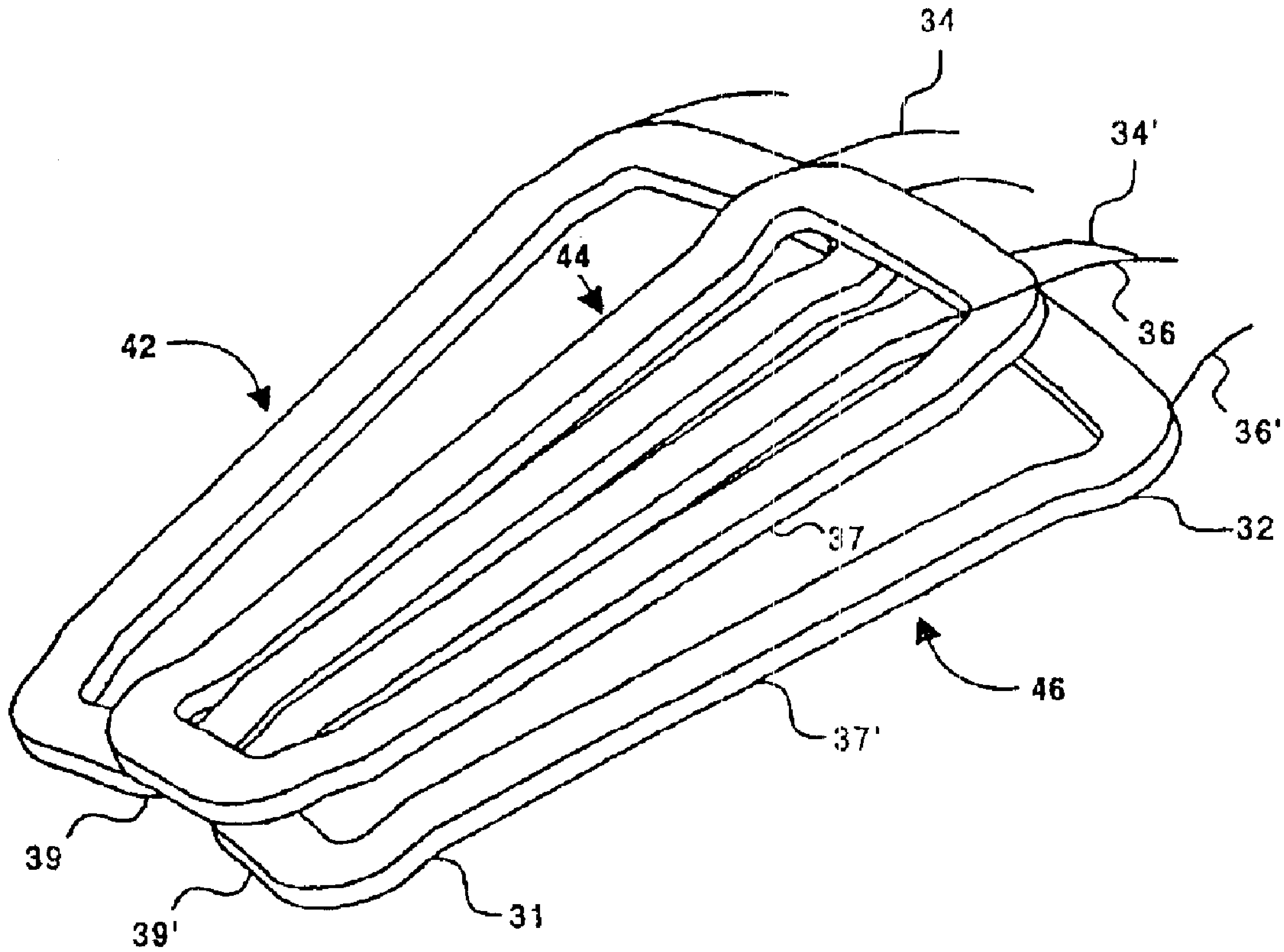


Fig. 4

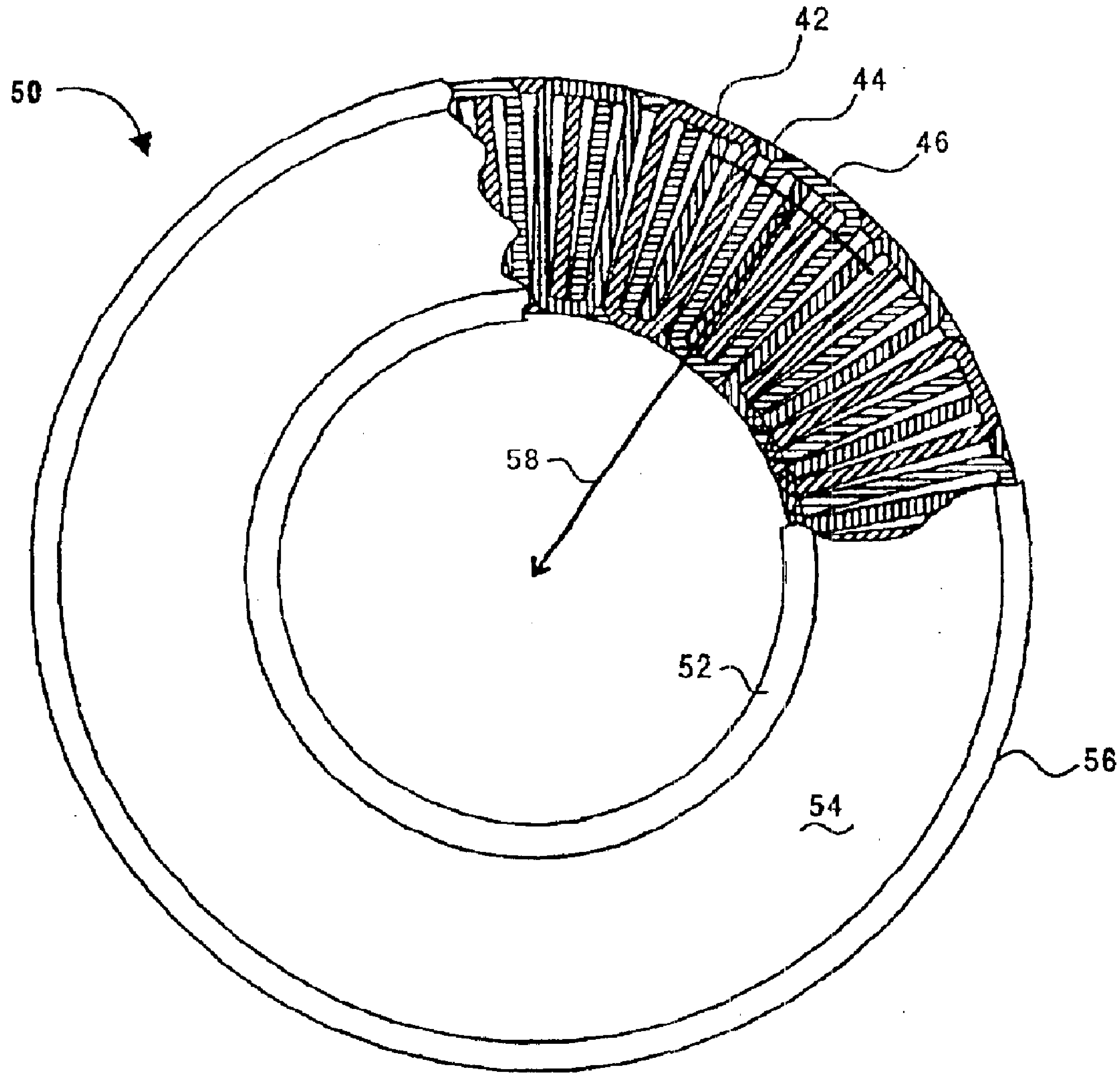


Fig. 5

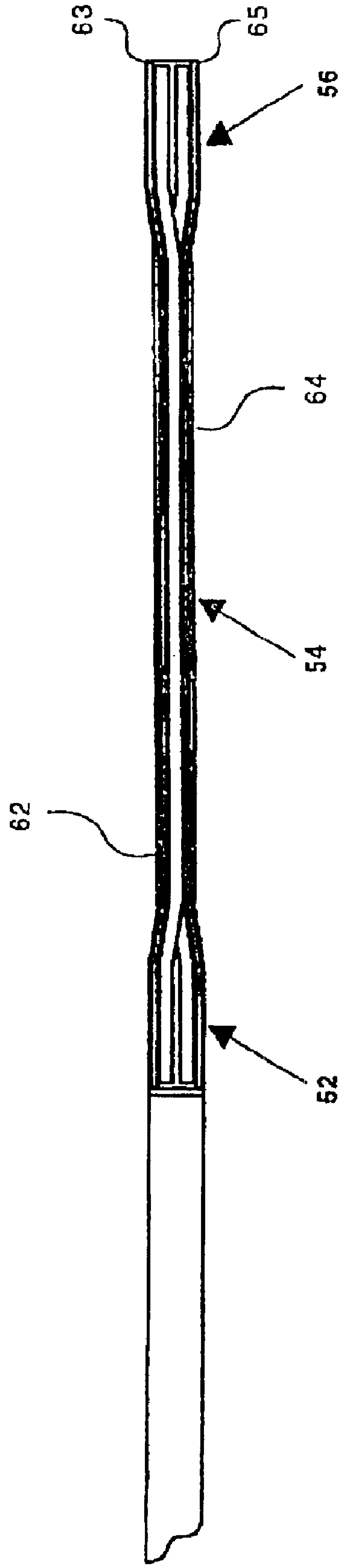


Fig. 6

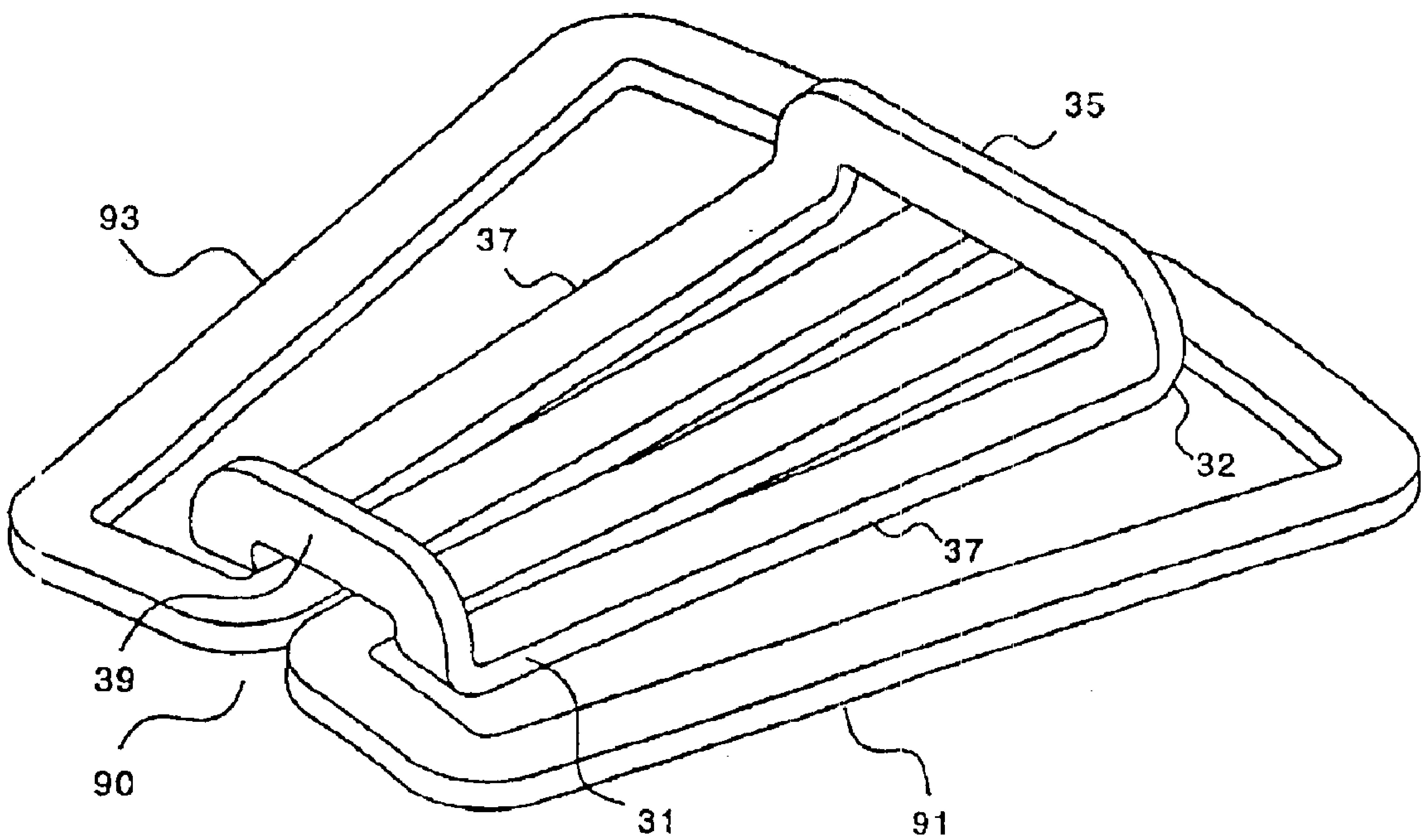


Fig. 7

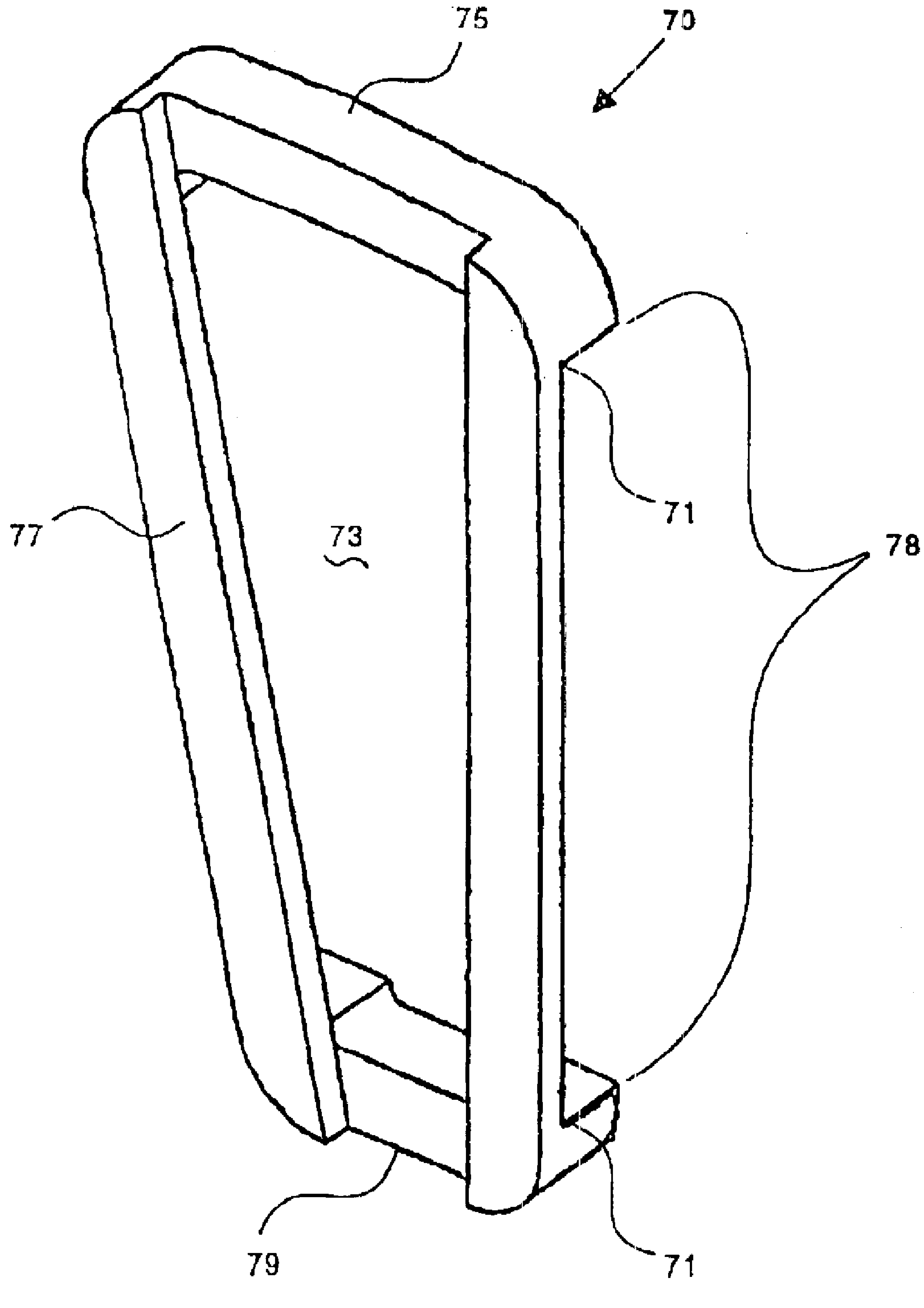


Fig. 8

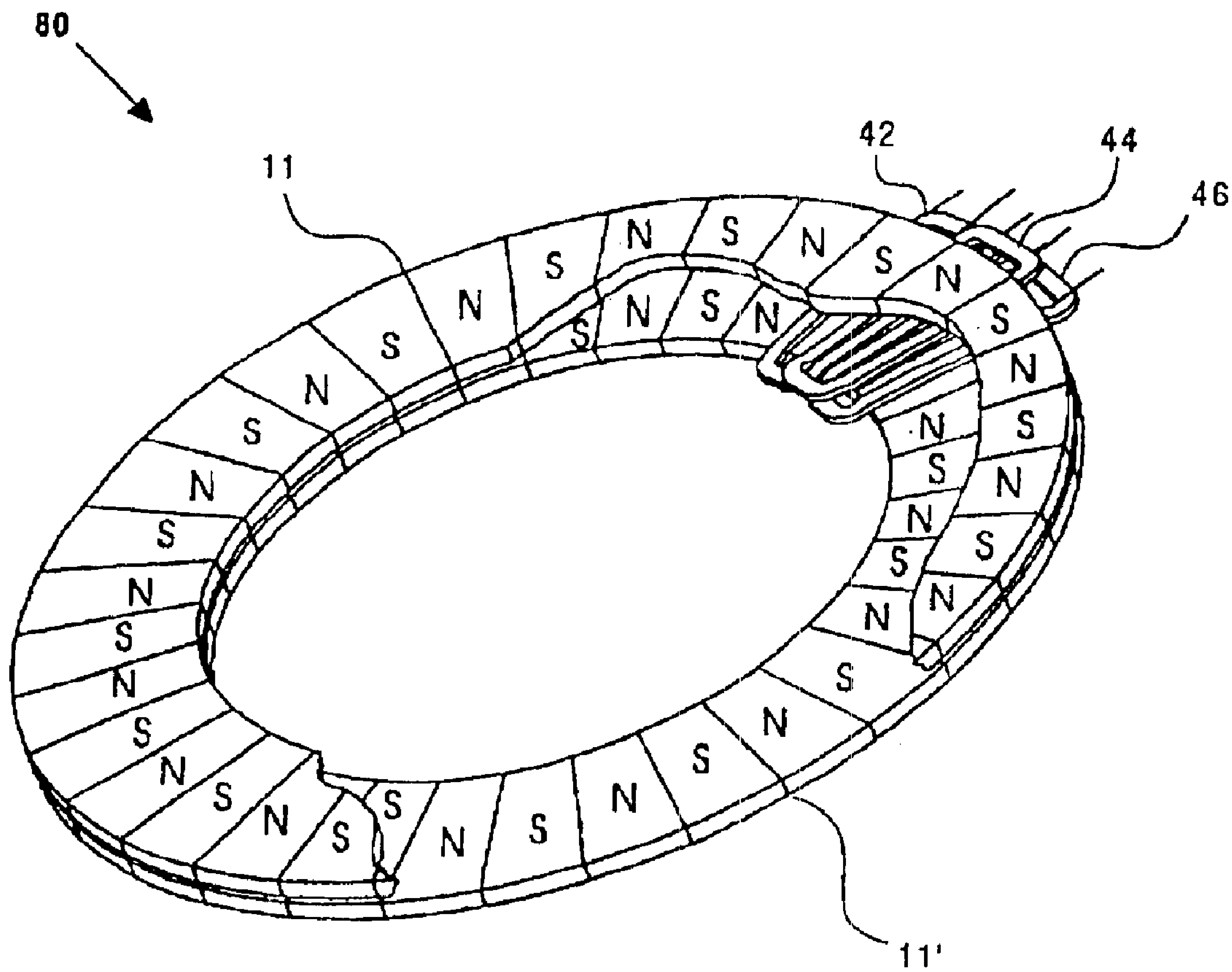


Fig. 9

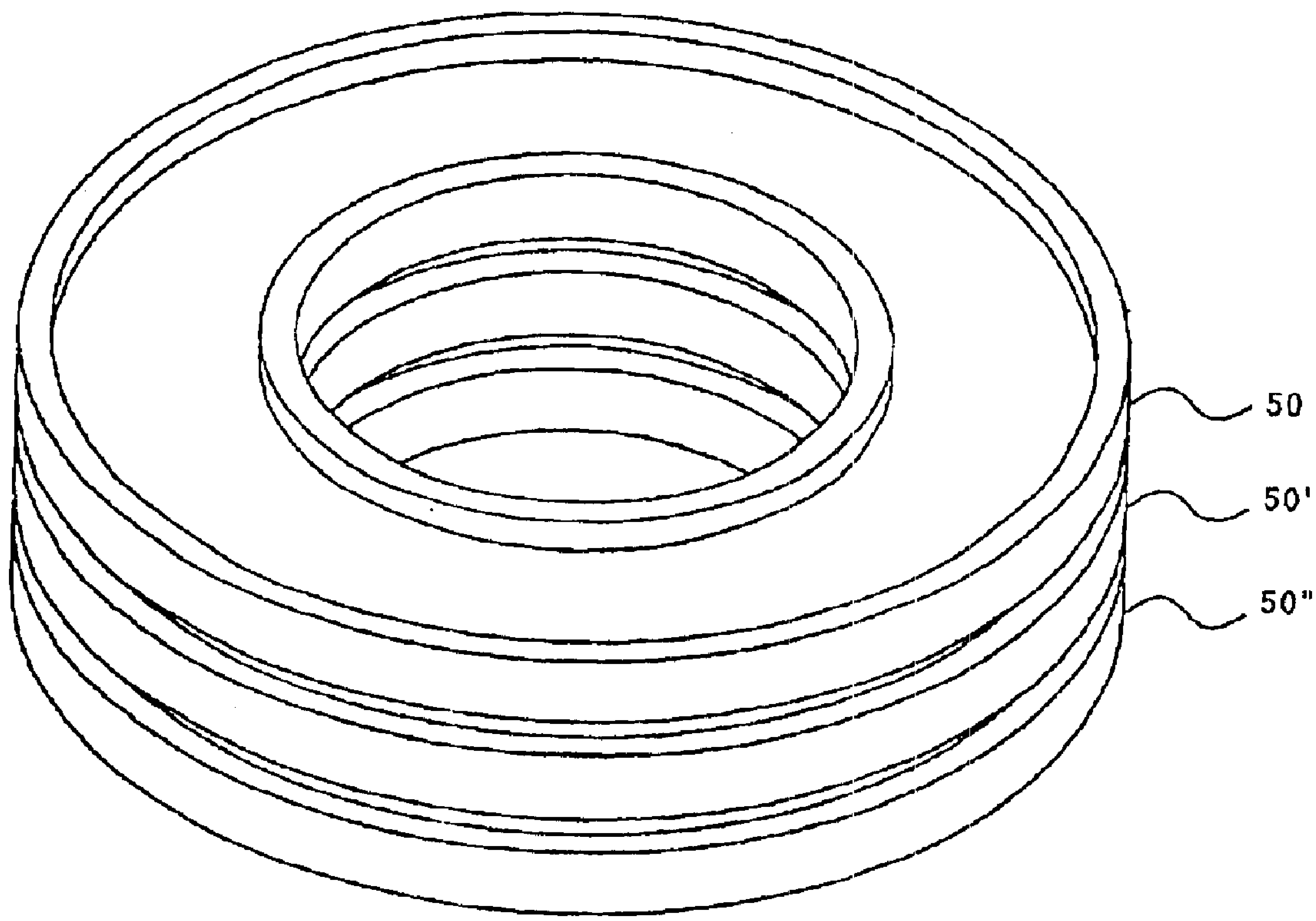


Fig. 10

INTERLOCKING SEGMENTED COIL ARRAY

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

This present invention relates generally to electrical generator or motor structures and more specifically to brushless electromotive devices of the type which employ a flat coil array or structure operating within an axially-oriented magnetic field having flux lines mostly perpendicular to the working conductor portion of the coils. This may include disc or pancake rotary motors as well as linear motors having such flat coils and magnetic structure.

BACKGROUND OF THE INVENTION

Motors employing disc-shaped coil armatures and brush commutation have been in use since the late 1950's. Brushless disc-type motors were later developed, employing rotating magnets, coil stators and electronic commutation. Such motors have been used in large numbers in audio and video tape recorders and computer disc drives. In such a motor, a magnetic rotor disc with alternating North/South pole pieces rotates above and/or below a plane containing several flat, stator coils lying adjacent one another. Current flowing in the conductor wires of the coils interacts with the alternating magnetic flux lines of the disc, producing Lorentz forces perpendicular to the radially directed conductors and thus tangential to the axis of rotation. While current flows through the entire coil, only the radial extending portions of the conductors (called the working conductors) contribute torque to the rotor. See, for example, U.S. Pat. Nos. 3,988,024; 4,361,776; 4,371,801; and 5,146,144. A variation of this arrangement is known in which the circumferential portions (nonworking conductors) of the wire-wound coils overlap each other. See, for example, U.S. Pat. Nos. 4,068,143; 4,420,875; 4,551,645; and 4,743,813. While this arrangement allows closer packing of the working conductors, it also requires that the gap between the rotor's magnets and flux return be about twice as thick as would be required for a single thickness of a non-overlapping coil, thus reducing the magnetic flux density and thus reducing the motor's efficiency.

SUMMARY OF THE INVENTION

In view of the well known disadvantages in the above-mentioned prior art, it is an object of the present invention to provide a novel coil structure which more efficiently provides electromotive interaction between these new coils and the magnets within a rotary motor or generator of the type having a generally flat, ring-shaped coil structure and employing an axial gap magnet structure, such as in disc or pancake motors, while minimizing the thickness of the coil and magnet flux gap. Specifically, the invention relates to the construction and shape of the individual coils making up a coil array (circular or arc-shaped arrangement of coils) so as to allow interlocking or overlapping of multiple coils to form a thin disc coil array having double the density of, but not significantly more thickness than, non-overlapping coil arrays. The radially extending conductor portions of each coil all lie in a first plane while the circumferentially extending portions of each coil's conductors lie above and below said first plane.

Another object of the present invention is to maximize the total length of the working conductors within a circular coil array by overlapping three adjacent coils, so as to maximize the electromotive interaction for a motor or generator of a given diameter. For any given device diameter, conductor cross-sectional area, and magnetic flux density, this technique maximizes the torque which may be produced by a motor, or the voltage produced by a generator.

Another object of the invention is to provide a mechanism whereby multiple coil arrays may be closely stacked with corresponding magnetic rotors in alternating layers so as to increase the total coil area within a motor or generator of a given diameter. This increased coil area allows increased interaction between coils and magnets, improving the power conversion with the motor or generator.

BRIEF DESCRIPTION OF THE DRAWINGS

While this specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is now regarded as the invention, it is believed that the broader aspects of the invention, as well as several of the features and advantages thereof, may be better understood by reference to the following detailed description of presently preferred embodiments of the invention when taken in connection with the accompanying drawings in which:

FIG. **1**a is an illustration of a prior art (planer) coil assembly;

FIG. **1**b is an illustration of a prior art magnet rotor associated with the coil assembly of FIG. **1**a;

FIG. **2** is an illustration of another prior art (partially overlapping) coil assembly;

FIG. **3** is an illustration of a single wire-wound coil according to this invention;

FIG. **4** is an illustration of three coils of FIG. **3**, overlapped in their proper orientation according to this invention;

FIG. **5** is an illustration of a Segmented Coil Array ("SCA") coil platter, with a partial cutaway showing the multiple internal coils of FIG. **3**, according to this invention;

FIG. **6** is an enlarged cross-sectional illustration of the SCA plater of FIG. **5**;

FIG. **7** is an illustration of three coils of an alternative embodiment of the present invention, overlapped in their proper orientation according to this invention;

FIG. **8** is an illustration an alternate form of coil having lower resistive losses;

FIG. **9** illustrates a basic electromotive device showing three nested coils in their proper orientation to two adjacent magnet rotors; and

FIG. **10** is an illustration of three coaxially stacked SCA coil platters of FIG. **5** suitable for use in an electromotive device.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and particularly to FIG. **1**, there is shown a prior art planer coil assembly **10** and a magnet rotor **11** which may be used to make a typical prior art disc-type motor. This coil assembly **10** consists of several individual coils **13**, **13'**, **13"** arranged in a circular pattern, each coil **13** having two radially extending conductor portions or legs **14**, **14'**, an inner circumferentially extending leg **15** and an outer circumferentially extending leg **16**, all lying in a single plane. In a motor utilizing such a coil assembly, the magnet rotor **11**, having alternating North/South poles **18**, **19** arranged in a corresponding circular pattern and affixed to a central shaft (not shown), rotates in a plane closely adjacent to, but spaced slightly above and/or below, the plane containing the coils **13**, **13'**, **13"**. While two magnet rotors **11** may be used, one on either side of the coil assembly **10**, only one may be used if a magnetic flux return, such as a soft iron disc (not shown), is placed on the other side of the coil assembly opposite the rotor. In use, electrical current in the radially extending conductors **14**,**14'** of the coil assembly **10** interacts with the alternating magnetic flux lines from the north **18** and south **19** poles of the rotor, producing Lorentz forces perpendicular to the radial conductors **14**,**14'** and thus tangential to the rotor's **11** axis of rotation. While current flows through the entire coil **13**, only the radial conductor legs **14**, **14'** (called the working conductors) contribute torque to the rotor **11** while the non-working legs **15**, **16** merely complete a current path.

FIG. **2** shows a somewhat different prior art coil assembly **20** in which the working conductor legs **22**, **22'** of the wire-wound coil **23** overlap the adjacent coils **21**, **25**. Likewise, the radial legs **24**, **26** of coil **25** overlap adjacent coils **23**, **27**. While this overlapping arrangement allows denser packing of the working conductors **22**, **24**, **26**, it also requires that the spacing or gap between the rotor's magnets and flux return be twice as wide as would be required for a single thickness of the coil shown in FIG. **1**.

FIG. **3** illustrates one individual coil **30** constructed according to the present invention. The coil **30** comprises round or flat conductor wire spirally wound in a keystone or trapezoidal shape defining a central open space **33**. The open space **33** is bounded by two radially extending side portions or working legs **37** lying in a first plane, an outer circumferentially extending base portion **35** and an inner circumferentially extending base portion **39** lying in a second plane, parallel to but spaced apart from and above the first plane. As will be explained later, the open space **33** must be wide enough to accommodate two adjacent working legs **37**. The electrically conducting coil leads **34**, **36** extending from the outer circumference of the coil provide a means for applying an electrical current through the coil from an external source (not shown). Near each end of the radially extending legs **37** are offsetting bends **31** and **32** that provide the transition from the second plane to the first plane. These offsetting bends **31** and **32** are an important feature of the present invention and are required for the desired high density packing arrangement presented in FIG. **4** below. Between the offsetting bends **31** and **32** is working portion **38** of the coil's radially extending legs **37** to which magnetic flux is applied during use by an adjacent magnet rotor **11**. The length l of this working portion **38** is called the working length. Preferably, the working length l of the individual coils are optimized for maximum torque or voltage production by ensuring that such working length l is about 42% of the distance from the center of the coil platter to the outer point of the coil working length, which distance is called the critical radius of the platter.

As one example of a preferred embodiment, FIG. **4** shows three typical coils **42**, **44**, **46** which would be arranged with **45** others in the same manner to form an assembly of **48** coils for this particular diameter array. The coils are arranged such that the working portions **38** of each coil are all in the same first plane and the central open space **33** of one coil **44** (between its working legs **37**) is filled by one working leg **37'** from each of the adjacent coils **42**, **46**. The rest of the coil **44** (mostly the inner **39** and outer **35** circumferentially extending portions) cannot reside in the same first plane because it would require parts of different coils to pass through the same space. This is the reason the offsetting bends **31** and **32** are important, so that the ends will lie in a second (and third) plane whereby the coils may be nested to achieve a high density.

A complete array of coils, affixed to each other and/or to a suitable structural material to form a coil platter (or an arc-shaped portion of the total coil platter) may be referred to as a Segmented Coil Array ("SCA"). A complete coil platter **50** is depicted in FIG. **5**. (This particular illustration does not show the coil leads **34**, **36** for clarity). This SCA platter **50** is composed of **48** individual coils **30** molded into an epoxy resin or other easily moldable material for support, which optionally may be further strengthened by also molding in layers of fiber reinforcing fabric. Since the inner **39** and outer **35** ends of each coil **30** lie in planes slightly above and below a first plane containing the working legs **37**, the molded platter **50** has a thin center face **54** with a thicker inner rim **52** and outer Tim **56**. Any other even numbers of coils other than **48** may also be used in an SCA, depending on the electrical or mechanical properties desired.

It has been discovered that for a given SCA diameter, the working length of the individual coils may be optimized for maximum torque production, in a motor, or voltage production, in a generator. This is done by making the coil working length 42% of the critical radius. This critical radius **58** is indicated in FIG. **5** and is defined as the distance from the center of the coil platter to the outermost points of the working length, before reaching the outer rim **56**.

A cross section of a portion of the coil platter **50** of FIG. **5** is illustrated in FIG. **6**. Preferably, the exterior surface of the center face **54** is coated with one or two layers of PFTE **62**, **64** to provide abrasion resistance and low friction characteristics. Similarly, one or two pieces of thin fiberglass cloth **63**, **65** may be added over the coils, under PFTE, to further increase strength and stiffness of the platter.

FIG. **7** illustrates three coils of an alternative coil configuration **90**. An SCA formed with alternative coil configuration **90** is comprised of a first and a second multiplicity of coils of equal number. The coils of the first multiplicity of coils (e.g. coils **91**, **93**) are formed and circumferentially oriented to lie in a first plane. The coils of the second multiplicity of coils are formed such that the working legs **37** of each coil lie in a first plane, and the outer circumferentially extending base portion **35** and inner circumferentially extending base portion **39** of each coil lie outside the first plane. As previously described with regard to the coil configuration embodiment depicted in FIG. **3**, offsetting bends **31** and **32** near each end of the radially extending legs **37** of the coils of the second multiplicity of coils provide the transition of the base portions **35** and **39** from the first plane to outside the first plane. FIG. **7** depicts the angles of the offsetting bends **31** and **32** as being approximately 90 degrees in this alternative coil configuration **90**, but any angle of the offsetting bends **31** and **32** sufficient to allow the first and second multiplicity of coils to nest as depicted such that the working legs **37** of all coils of both the first and second multiplicity of coils lie substantially in a single plane is acceptable.

FIG. **8** illustrates yet another alternate coil configuration **70** useful with the present invention and having lower electrical losses than coil **30** above. The coil **70** comprises flat conductor wire or ribbon (i.e. having a rectangular cross-section) spirally wound to form a basic keystone or trapezoidal shape surrounding a central open space **73**, much like coil **30** above. The open space **73** is, like in coil **30**, bounded by two radially extending portions or working legs **77** lying in a first plane, an outer circumferentially extending base portion **75** and an inner circumferentially extending portion **79** lying in a second plane, parallel to but spaced apart from the first plane. In contrast to the offsetting bends **31** of coil **30** that provide a gradual transition from the first plane of the radial legs to the second plane of the base portions, the low-loss coil **70** is machined after winding so that there are abrupt offsetting steps **71** near each end of the radially extending legs **77**. Further, sufficient material is machined away from the radially extending legs **77** so that, at least over the working length **78**, the legs **77** have a smaller cross-sectional area than the base portions **75**, **79**. The electrical resistance in the larger base portions **75**, **79** of coil **70** will be less than in corresponding base portions **35**, **39** of coil **30**, when both have the same sized working legs, thereby reducing the I^2R losses of coil **70**. As explained earlier, the open space **73** must be wide enough to accommodate two adjacent working legs **77** to achieve the high density nesting shown in FIG. **4**. Coil leads would typically extend from the outer circumference of the coil, but are not shown here to improve clarity.

In operation within a typical electromotive device, a circular coil platter **50** is exposed to an axially directed magnetic flux produced by a magnet rotor **11**, i.e. flux perpendicular to the plane containing the coils' working lengths. One such way of providing this flux is illustrated in FIG. **9** in which a magnet rotor **11** (which could be composed of permanent magnet segments or electromagnets and which would be affixed to a central rotatable shaft, not shown) is positioned adjacent one or both sides of the coil platter to form a basic electromotive device **80**. If only one magnet **11** is used in a particular device, some type of flux return, such as a soft iron disc, should be placed adjacent the opposite side of the coil platter. Here, only three coils **42**, **44**, **46** of an entire platter **50** of **48** coils **30** are shown for clarity in this example. As the coils are appropriately energized (by any well known control circuit, not shown), a rotating force or torque is produced in the magnet rotor(s). Depending on the results desired and the corresponding mechanical arrangement, the magnet rotor may cause a shaft to revolve at high speed or merely turn a small angle at high torque.

As illustrated in FIG. **10**, it is beneficial to stack multiple coil platters **50**, **50'**, **50"** along a common central axis with alternating layers of magnetic rotors **11**. This arrangement increases the total working area, and thus the power, within an electromotive device of given diameter. For clarity, the coil leads and magnet rotors are again not shown in FIG. **10**. The details of various possible mechanical arrangements to adapt the present invention to common industrial devices are so well known that they need not be discussed here.

While the present invention has been described in terms more or less specific to preferred embodiments, it is expected that various alterations, modifications, or permutations thereof will be readily apparent to those skilled in the art. For example, the invention may be embodied in an electrical generator as well as a motor. Instead of a circular coil array, the coils of the invention may be formed into a linear array or a partial circle rather than a complete circular array. Therefore, it should be understood that the invention is not to be limited to the specific features shown or described, but it is intended that all equivalents be embraced within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

[1. A segmented coil array for use in rotary electromotive devices with one or two magnet rotors, such as motors and generators, of the type which employ an axial gap magnetic structure, composed of an even multiple of individual wire-wound coils, each coil having substantially the same structure and size and comprising circumferentially extending base portions and radially extending side portions, the radially extending side portions and circumferentially extending base portions joined at their respective ends to define a generally trapezoidal shape: the coil array formed into a ring of partially overlapped alternating coils such that the radially extending side portions of each coil are coplanar.]

[2. The coil array of claim **1** wherein each individual coil has offsetting bends near each end of said radially extending side portions which cause the circumferentially extending base portions of the coil to lie outside the plane containing the radially extending side portions so as to allow partial overlapping of each coil by its two adjacent coils.]

[3. A segmented coil array, according to claim **2**, in which each coil's circumferentially extending base portions and radially extending side portions define a space containing one radially extending portion from each of its two adjacent coils thereby doubling the density of the coil's working conductors.]

[4. The coil array of claim **1** wherein a plurality of the individual coils have offsetting bends near each end of said radially extending side portions which cause the circumferentially extending base portions of the coil to lie outside the plane containing the radially extending side portions so as to allow partial overlapping of each coil by at least two adjacent coils.]

[5. A segmented coil array, according to claim **1**, in which the individual coils are over-molded with a moldable material to form a ring of suitable structural integrity and heat tolerance.]

[6. The segmented coil array of claim **5** in which the moldable material is epoxy.]

[7. The segmented coil array of claim **5** additionally comprising layers of fiber reinforcing fabric.]

[8. A segmented coil array, according to claim **1**, herein the coils are oriented to form a linear array.]

[9. A segmented coil array, according to claim **1**, wherein the coils are oriented to form a partial ring.]

10. [The coil array of claim **1**] *A segmented coil array for use in rotary electromotive devices with one or two magnet rotors, such as motors and generators, of the type which employ an axial gap magnetic structure, composed of an even multiple of individual wire-wound coils, each coil having substantially the same structure and size and comprising circumferentially extending base portions and radially extending side portions, the radially extending side portions and circumferentially extending base portions joined at their respective ends to define a generally trapezoidal shape: the coil array formed into a ring of partially overlapped alternating coils such that the radially extending side portions of each coil are coplanar,* wherein the individual coils are formed such that the radially extending side portions of a coil have a smaller cross-sectional *electrical* conductor area than at least one of the circumferentially extending base portions.

11. [The coil array of claim **1**, wherein the multiple individual wire-wound coils] *A rotary electromotive device comprising two rotors, at least one of which comprises a magnet rotor, said two rotors sandwiching therebetween a segmented coil array to provide two axial magnetic gaps, said segmented coil array being composed of an even multiple of individual wire-wound coils, each coil having substantially the same structure and size and comprising* *circumferentially extending base portions and radially extending side portions, the radially extending side portions and circumferentially extending base portions joined at their respective ends to define a generally trapezoidal shape, the coil array being formed into a ring of partially overlapping alternating coils such that the radially extending side portions of each coil are coplanar, said coils being* affixed to each other *to* form a coil platter, having a central axis and known inner and outer diameters, in which the radially extending coil portions are the working conductors, and the working length of said conductors [is] *being* approximately 42% of the distance between the central axis of the coil platter and the outer diameter of the coil's working length, thereby optimizing the array for maximum torque, when used as a motor, or voltage production, when used in a generator.

[**12**. The coil array of claim **1**, wherein the coil array is operably located in a rotary electromotive device, such as a motor or generator, the motor or generator having alternating layers of magnetic material to produce an axial gap magnetic structure, and further having several additional coil arrays arranged in layers of electromagnetic coil arrays which are stacked so as to further increase the total coil area within said electromotive device, each layer of coil structure operating in a separate axial magnetic flux gap formed by the layers of magnetic material.]

[**13**. The device of claim **12** wherein said magnetic material is a disc shaped permanent magnet rotor affixed to a rotatable shaft.]

[**14**. The device of claim **12** wherein said magnetic material is a disc shaped electromagnet rotor affixed to a rotatable shaft.]

[**15**. A segmented coil array for use in rotary electromotive devices, such as motors and generators, of the type which employ an axial gap magnetic structure, comprising an even multiple of identically shaped individual wire-wound coils, each coil comprising circumferentially extending base portions, and radially extending side portions joined at their respective ends to form a trapezoid shape, each side portion having offsetting bends at each end of said side portion adjacent to each base portion so that said base portions lie in a plane parallel to said side portions; the coil array formed by arranging a first set of coils into a ring with side portions being adjacent, and overlapping a second set of coils such that the radially extending side portions of each set of coils are all coplanar and the offsetting bends of alternate coils are oriented in different directions so that the base portion of the first set of coils are parallel to the base portions of the second set of coils.]

[**16**. A segmented coil array, according to claim **15**, in which the individual coils are over-molded with a moldable material to form a ring of suitable structural integrity and heat tolerance.]

[**17**. The segmented coil array of claim **16** in which the moldable material is epoxy.]

[**18**. The segmented coil array of claim **15** additionally comprising layers of fiber reinforcing fabric.]

19. [The coil array of claim **15**] *A segmented coil array for use in rotary electromotive devices, such as motors and generators, of the type which employ an axial gap magnetic structure, comprising an even multiple of identically shaped individual wire-wound coils, each coil comprising circumferentially extending base portions, and radially extending side portions joined at their respective ends to form a trapezoid shape, each side portion having offsetting bends at each end of said side portion adjacent to each base portion so that said base portions lie in a plane parallel to said side portions; the coil array formed by arranging a first set of coils into a ring with side portions being adjacent, and overlapping a second set of coils such that the radially extending side portions of each set of coils are all coplanar and the offsetting bends of alternate coils are oriented in different directions so that the base portions of the first set of coils are parallel to the base portions of the second set of coils,* wherein the individual coils are formed such that the radially extending side portions of a coil have a smaller cross-sectional *electrical conductor* area than at least one of the circumferentially extending base portions.

20. [The coil array of claim **15**, wherein the multiple] *A segmented coil array for use in rotary electromotive devices, such as motors and generators, of the type which employ an axial gap magnetic structure, comprising an even multiple of identically shaped individual wire-wound coils, each coil comprising circumferentially extending base portions, and radially extending side portions joined at their respective ends to form a trapezoid shape, each side portion having offsetting bends at each end of said side portion adjacent to each base portion so that said base portions lie in a plane parallel to said side portions; the coil array being formed by arranging a first set of coils into a ring with side portions being adjacent, and overlapping a second set of coils such that the radially extending side portions of each set of coils are all coplanar and the offsetting bends of alternate coils are oriented in different directions so that the base portions of the first set of coils are parallel to the base portions of the second set of coils and slightly above and below the co-planar radially extending side portions, the* individual wire-wound coils *being* affixed to each other *to* form a coil platter, having a central axis and known inner and outer diameters, in which the radially extending side portions include a working length, and the working length is approximately 42% of the distance between the central axis of the coil platter and the outer diameter of the coil's working length, thereby optimizing the array for maximum torque, when used in a motor, or voltage production, when used in a generator.

21. In a method of manufacturing a stator for an axial gap electrical machine, the steps comprising

spiral winding a flat ribbon conductor into a plurality of coils having radially extending sides and circumferential ends in substantially the same structure and size around a central void;

forming at least one portion of the plurality of spiral wound coils to offset their circumferential ends from their radially extending sides by machining the radially extending sides of said at least one portion of coils to provide said offset of their circumferential ends; and

arranging the coils into a circumferentially extending stator with their radially extending sides lying generally coplanar by overlapping said at least one portion of coils in the arrangement with their radially extending side portions lying in the central voids of the remaining portion of the unformed coils and with their offset circumferential ends overlapping the circumferential ends of the remaining portion of the unformed coils.

22. A segmented coil array for use in rotary electromotive devices of the type which employ an axial gap magnetic structure, composed of a plurality of individually wound coils comprised of flat ribbon conductor, each coil comprising circumferentially extending base portions and radially extending side portions, the radially extending side portions and circumferentially extending base portions being joined at their respective ends to define a generally trapezoidal *shape; a portion of individually wound coils being machined to offset their circumferentially extending base portions from their radially extending side portions, the coil array being formed into a ring of partially overlapped alternating coils such that the radially extending side portions of each coil are coplanar.*

23. The coil array of claim 22, wherein the individual coils are formed such that the circumferentially extending base portions of a coil have a larger cross-sectional area than one of the radially extending side portions.

24. The coil array of claim 22 wherein at least one circumferentially extending base portion has less electrical resistance than the radially extending side portions.

25. The coil array of claim 22 wherein each individual coil has offsets near each end of said radially extending side portions which cause the circumferentially extending base portions of the coil to lie outside the plane containing the radially extending side portions so as to allow partial overlapping of each coil by its two adjacent coils.

26. A coil array, according to claim 25, in which each coil's circumferentially extending base portions and radially extending side portions define a space containing one radially extending portion from each of its two adjacent coils thereby doubling the density of the coil's working conductors.

27. A coil array, according to claim 22, in which the individual coils are over-molded with a moldable material to form a coil platter with structural integrity and heat tolerance.

28. The coil array of claim 27 in which the moldable material is epoxy.

29. The coil array of claim 27 comprising at least one layer of fiber reinforcing fabric incorporated in the coil platter.

30. The coil array of claim 22, wherein the multiple individual wound coils are affixed to each other form a coil platter, having a central axis and known inner and outer diameters, in which the radially extending coil portions are the working conductors, and the working length of said conductors is approximately 42% of the distance between the central axis of the coil platter and the outer diameter of the coil's working length.

* * * * *