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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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(54) Title: ULTRASONIC METHOD AND DEVICE FOR COSMETIC APPLICATIONS

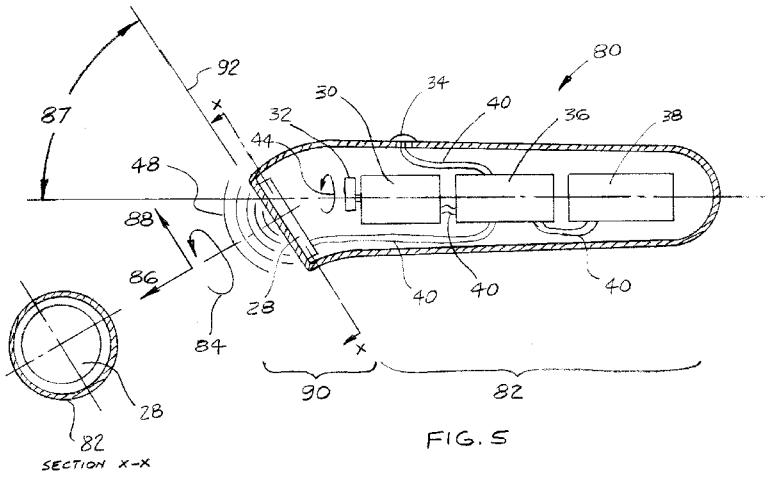


FIG. 5

(57) Abstract: A combination of low frequency high amplitude sonic frequency vibrations and high frequency low intensity ultrasonic pressure waves are applied to cosmetic compounds and to the skin to promote improved penetration of the cosmetic compounds into the epidermis. The cosmetic applicator device includes means for generating both sonic frequency vibrations and ultrasonic pressure waves adopted to deliver cosmetic compounds into the epidermis safely without significant temperature rise in the skin. Various removable applicator and skin cleaning attachments are also disclosed.

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Title: Ultrasonic Method and Device for Cosmetic Applications

SPECIFICATIONS

FIELD OF THE INVENTION.

This invention relates to sonic and/or ultrasonic devices and methods for cosmetic applications.

BACKGROUND OF THE INVENTION.

The stratum corneum, the outermost layer of the epidermis consists of dead cells (corneocytes). The purpose of this layer of dead skin is to form a barrier to protect underlying living tissue from infection, dehydration, and chemical attacks.

Unfortunately, the same low permeability barrier characteristic of the stratum corneum, which protects the body from infections, also resists the penetration of beneficial cosmetic and chemical compounds, such as moisturizers, alpha-hydroxyl acids, collagen, vitamins and vasodilators. In addition, oily and congested skin conditions are also reducing the penetration of beneficial skin treatment compounds.

The invention is concerned with methods and apparatus facilitating the use of sonic and ultrasonic energy coupled to the skin to temporarily increase the permeability of the skin and enhance the absorption of beneficial cosmetic and chemical compounds into the skin.

DESCRIPTION OF PRIOR ART.

Numerous attempts have been made in the past to enhance the penetrations of cosmetic compounds into the skin by chemical, electrical and ultrasonic means.

The application of chemicals to modify the skin structure to allow the penetration of cosmetics was found to be dangerous because while it provided access for cosmetics to penetrate, it left the body unprotected against harmful environments, interacting with corneocytes causing irritation, erythema (red skin) and contact dermatitis.

The application of electrical fields to create transient transport pathways by a method called electroporation, and the method to electrically charge molecules to increase their penetration into the skin called iontophoresis (US6,169,920), have both been proven costly and ineffective. Electrical abrasion devices for increasing the skin's permeability (US 8,386,027) remove some layers of the stratum corneum causing intense irritation and discomfort.

The effort of prior art of ultrasonically induced drug delivery (sonophoresis) described in US 6,322,532 is focused in driving drug molecules through the skin by high frequency and high intensity ultrasonic pressure waves. This procedure suffers from the disadvantage of tissue heating and the associated modification and sometimes destruction of healthy cells.

Notwithstanding the teaching of the prior art, the ability to deliver cosmetic compounds into the skin below the stratum corneum safely, effectively, inexpensively and easily has remained unsolved.

Responding to the above described unresolved needs, the object of this invention is to provide a skin care method and apparatus to safely increase the permeability of the stratum corneum and deliver cosmetic compounds deeply into the dermis.

SUMMARY OF THE INVENTION

As noted in the description of prior art, the safety of the typical sonophoresis apparatus is compromised by the high intensity requirements of the process, resulting in excessive tissue heating and its associated consequences.

The objective of the invention is to improve the safety of typical sonophoresis apparatus to deliver cosmetic compounds into the dermis at reduced ultrasound intensity.

The method of the invention achieves this objective of utilizing lower intensity ultrasonic pressure waves by augmenting the ultrasonic pressure waves with non-tissue heating low frequency sonic vibrations applied to the skin in combination with the high frequency ultrasound. The low frequency sonic vibration component of this new method increases the permeability of the skin and allows a lower intensity non-tissue heating ultrasound component to drive the cosmetic compound through the stratum corneum into the dermis. Furthermore, since oils and various contaminants on the skin can reduce the penetration of cosmetic compounds, an optional pre treatment skin-cleansing step is part of the disclosed method.

A novel apparatus is provided having the capability to simultaneously generate tactile sonic frequency vibrations and ultrasonic pressure waves and apply them to the skin. To emphasize, the key characteristic of the invention is the synergistic application of tactile sonic frequency vibrations with the ultrasonic pressure waves, which allow the utilization of lower intensity non-tissue heating ultrasound to facilitate the penetration of and to drive cosmetic compounds safely into the dermis.

In the above discussion, the terms cosmetic compounds and vasodilators includes but not limited to skin care products such as anti wrinkle lotions, moisturizers, antioxidant vitamins, alpha-hydroxyl acids, liposomes, collagen, elastin, hair growth and hair remover compounds and others.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a longitudinal cross section of the invention consisting of the device handle, the motion transducer neck, the applicator portion including an ultrasonic transducer, the driving motor, electronic controls and battery.

FIG. **2** shows the cross section of the neck of the device, which is configured to act as a motion transducer.

FIG. 3A shows the applicator head of the device in contact with the skin.

FIG. 3B illustrates the sonic frequency component of the device and its effects on the stratum corneum.

FIG. 4 illustrates the simultaneous application of the sonic frequency vibration and ultrasound pressure wave components of the device and their combined effects on the stratum corneum.

FIG. 5 shows a longitudinal cross section of an alternative configuration of the invention.

FIG. 6 shows a removable applicator head designed for convex areas of the anatomy.

FIG. 7 shows a removable applicator head designed for concave areas of the anatomy.

FIG. 8 shows a removable brush head for cleansing the skin.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 and FIG. 2 show the invention of the ultrasonic cosmetic applicator **20** in a preferred configuration. The applicator **20** comprises a tubular shaped handle portion **22**, a neck portion **24**, and an applicator head portion **26** constructed of a rigid plastic material such as Acrylonitrile Butadiene Styrene (ABS), an ultrasound transducer **28**, a driving motor **30**, an eccentric weight **32** mounted on the output shaft of the driving motor **30**, an electronic module **36**, a battery pack **38**, and interconnecting wiring **40**.

The ultrasound transducer **28** is typically constructed of a piezo-electric ceramic material such as PZT-8 grade Lead Zirconate Titanate manufactured by Morgan Matroc, Inc., or similar products manufactured by numerous other entities. The construction of the ultrasound transducer **28** can be a single or a multiple element unit, as it is commonly practiced by people familiar in the art.

The ABS material utilized for the applicator **20** is due to the ABS excellent acoustic characteristics. However, numerous other rigid plastic materials could be substituted to achieve various cost and performance goals of the designers.

Control switch **34** energizes the driving motor **30**, which rotates the eccentrically mounted weight **32** between 2,000 and 25,000 RPM, ideal speed being at 9,000 RPM, generating a 33 to 417 Hertz sonic frequency rotational vibration **44** of the handle **22** and neck **24** portions of the applicator **20**, which is considered a relatively low sonic

frequency vibration in the art, which defines sonic frequency vibration as being 10 to 20,000 Hertz. As shown in FIG. 2 the cross section of the neck **24** is designed to be relatively thin in the vertical direction **X** compared to the lateral direction **Y** thereby significantly increasing the vertical vibration **42** amplitude of the applicator head **26** while significantly decreasing lateral vibration **46** amplitude of the applicator head **26**. In other words, the neck portion **24** of the applicator **20** is designed to be a motion transducer to convert the rotational vibration **44** of the handle **22** portion of the applicator **20** into a substantially vertical vibration **42** of the applicator head **26,** converting the rotational energy of the motor **30** into vertically vibrating energy of the applicator head **26**.

The battery pack **38** can be constructed as a single cell or multi cell battery pack, of various chemistries, such as Alkaline Manganese, Nickel-Cadmium, Ni-Mh, Lithium or other newer construction.

The major function of the electronic module **36** is to convert the low voltage DC power, typically 1.5 to 4.8 VDC, of the battery pack **38** into high voltage (4.8 to 60 Volt) typically sinusoidal wave ultrasonic frequency (typically 15 kHz to 20 MHz) DC power in a continuous wave or burst wave modality.

Simultaneously with energizing the driving motor **30**, switch **34** also activates the electronic module **36**. Through the interconnecting wiring **40** the electronic module **36** energizes the ultrasound transducer **28** which contracts and expands in tune with the high frequency DC power and converts this electronic power into ultrasonic pressure waves **48** at a typical intensity from 0.05 to 0.5 W/cm^2.

In FIG. 3A the applicator head **26** of the applicator **20** is shown in position on top of the outer surface of the stratum corneum **52**, consisting of flat dead cells filled with keratin fibers surrounded by ordered lipid bilayers **54A** shown in a relaxed position **58**. The ordered structure of the stratum corneum **52** and the ordered lipid bilayers **54A** are forming a normally almost impermeable skin structure. A thin layer of cosmetic compound **50** is shown to be disposed between the applicator contact surface **92** of the applicator head **26** and the stratum corneum **52**. A typically very limited amount of small

molecules **56** of the cosmetic compound **50** are shown to be penetrating slightly into the ordered lipid bilayers **54A** without assistance from the applicator head **26**.

FIG.3B shows the applicator head **26** activated in the vertically vibrating **42** mode on top of the stratum corneum **52** and a thin layer of cosmetic compound **50** is shown to be disposed between the applicator contact surface **92** of the applicator head **26** and the stratum corneum **52**. The vertical vibration **42** of the applicator head **26** (also depicted with solid and dashed lines to illustrate vibration) repeatedly compresses and relaxes the stratum corneum **52** and the ordered lipid bilayers **54A** from the relaxed position **58** to the compressed position **60** in tune with the high amplitude low frequency vibration mode of the applicator head **26**. Under the repeated and continuing influence of this high amplitude low sonic frequency vibration **42** and the resulting repeated compression and relaxation cycles of the stratum corneum **52** and the ordered lipid bilayers **54A**, the ordered lipid bilayers **54A** beginning to disorganize and develop larger passage ways for the molecules **56** of the cosmetic compound **50** to pass through. The disorganized lipid bilayers **54B** are depicted with dashed lines.

FIG. 4 shows the applicator head **26** in contact with the stratum corneum **52** while having a thin layer of cosmetic compound **50** disposed between the applicator contact surface **92** of the applicator head **26** and the stratum corneum **52**. The ultrasound transducer **28** is shown being energized by the electronic module **36** through the connective wiring **40** and radiating ultrasonic pressure waves **48** into the stratum corneum **52** and the disorganized lipid bilayers **54B**. While the sonophoresis art has been demonstrated to work in the frequency range of 20 kHz to 20 MHz and in both of a continuous wave and a burst wave modality, it is important to select the right combination of frequency, driving voltage, and modality to match the size and characteristics of the piezo electric transducer selected for the system. Hard piezo materials such as the PZT8 formulation will output high ultrasonic power intensities with the associated heating of tissues when driven by high voltages. To avoid overheating the tissue, a 20% duty cycle (20% on 80% off) burst modality has been proven helpful in prior art.

Now, according to the invention, safety of the sonophoresis process can be further enhanced by the simultaneous application of a non tissue heating high amplitude low sonic frequency mechanical vibration **42** and the ultrasonic pressure waves **48** to the stratum corneum **52**. Due to the presence of the high amplitude low sonic frequency vibration **42** applied to the stratum corneum **52**, which establishes the initial pathways through the stratum corneum **52**, the intensity of the ultrasonic pressure waves **48** can be reduced significantly, resulting in proportional reduction of tissue heating, while maintaining the effectiveness of the process.

The high frequency ultrasonic pressure waves **48**, as shown in FIG. 4, penetrate the disorganized lipid bilayers **54B** much deeper than the lower sonic frequency vibrations **42** do. These ultrasonic pressure waves **48** in a preferred frequency range of 20 kHz to 2 MHz and in a 20% duty cycle burst modality are developing mild cavitation deep within the lipid bilayers **54B** resulting in microscopic air and/or vacuum pockets **66** which act to further break up the organized lipid bilayers **54A** shown in Fig. 3A into disorganized lipid bilayers **54B**, generating more and deeper passage ways for the cosmetic compound molecules **56** to penetrate through the stratum corneum **52**, through the disorganized lipid bilayers **54B**, through the bottom layer of the epidermis **62** and into the dermis **64**.

FIG. 5 shows a longitudinal cross section of an alternative configuration of the invention wherein the applicator **80** comprises a tubular shaped handle portion **82** terminating in an angular applicator head portion **90** constructed of a rigid plastic material such as Acrylonitrile Butadiene Styrene (ABS), an ultrasound transducer **28**, a driving motor **30**, an eccentric weight **32** mounted on the output shaft of the driving motor **30**, an electronic module **36**, a battery pack **38**, and interconnecting wiring **40**.

The ultrasound transducer **28** is typically constructed of a piezo-electric ceramic material such as PZT-8 grade Lead Zirconate Titanate manufactured by Morgan Matroc, Inc., or similar products manufactured by numerous other entities. The construction of the ultrasound transducer **28** can be a single or a multiple element unit, as it is commonly practiced by people familiar in the art.

The ABS material utilized for the applicator **80** is due to the ABS excellent acoustic characteristics. However, numerous other materials could be substituted to achieve various cost and performance goals of the designers. For example, the applicator contact surface **92** may be constructed of stainless steel or other metallic material.

Control switch **34** energizes the driving motor **30**, which rotates the eccentrically mounted weight **32** between 2,000 and 25,000 RPM, ideal speed being at 9,000 RPM, generating a 33 to 417 Hertz sonic frequency rotational vibration **44** of the handle portion **82** of the applicator **80**.

The angular positioning **87** of the applicator contact surface **92** of the applicator head portion **90** acts as a motion transducer converting the rotational vibration **44** of the handle portion **82** into an angular rotational vibration **84** of the applicator contact surface **92** of the applicator head portion **90**. The angular rotational vibration **84** creates a two dimensional vibration motion of the applicator contact surface **92** in the directions of motion vector **86** and motion vector **88**.

While FIG. 5 depicts an angularly fixed applicator head portion **90** construction, applicator **80** can also be constructed having a user adjustable angular applicator head portion **90** wherein the user can vary the angular positioning **87** of the applicator contact surface **92** to increase or decrease the vibratory motion in the directions of motion vector **86** and motion vector **88**. A decreasing angle **87** will decrease the vibration amplitude of motion vector **88** and increase the vibration amplitude of motion vector **86**.

The battery pack **38** can be constructed as a single cell or multi cell battery pack, of various chemistries, such as Alkaline Manganese, Nickel-Cadmium, Ni-Mh, Lithium or other newer construction.

The major function of the electronic module **36** is to convert the low voltage DC power, typically 1.5 to 4.8 VDC, of the battery pack **38** into high voltage (4.8 to 60 Volt) typically sinusoidal wave ultrasonic frequency (typically 15 kHz to 20 MHz) DC power in a continuous wave or burst wave modality.

Simultaneously with energizing the driving motor **30**, switch **34** also activates the electronic module **36**. Through the interconnecting wiring **40** the electronic module **36** energizes the ultrasound transducer **28** which contracts and expands in tune with the

high frequency DC power and converts this electronic power into ultrasonic pressure waves **48** at a typical intensity from 0.05 to 0.5 W/cm^2.

The embodiment of the invention as applicator **80** depicted in FIG. 5 functions the same way as the embodiment of the invention as applicator **20** depicted in Figures 1, 2, 3A, 3B, and 4. More particularly, the sonic frequency vibration of the applicator contact surface **92** of the applicator head **90** in the direction of motion vector **86** described in FIG. 5 functions the same way as the sonic frequency vibration of the applicator contact surface **92** of applicator head **26** in the direction of motion vector **42** described in FIG. 3B and FIG. 4. The ultrasonic pressure waves **48** radiated from applicator **80** described in FIG. 5 function the same way as the ultrasonic pressure waves **48** radiated from applicator head **26** described in FIG. 4. The underlying science of the two embodiments are identical.

FIG. 6 shows a removable applicator head **98** designed to conduct the low frequency orbital vibration **84** and vibration motion vectors **86** and **88** and the ultrasound pressure waves **48** into the hard convex areas of the anatomy, such as the scalp, the elbows, and similar areas.

The applicator contact surface **92** of the applicator head **90** as described earlier in FIG. 5 is typically made of rigid or semi rigid material designed for soft flexible surfaces of the anatomy, such as the cheeks, where the anatomy conforms to the applicator contact surface **92** under slight pressure and transmission of the ultrasonic pressure waves **48** to the anatomy is easily achieved. However, when the flat rigid applicator contact surface **92** is applied to a hard convex area, such as the scalp, it results in a very small single point contact, which limits the transmission of the ultrasonic pressure waves to the anatomy.

To maximize transmission of the ultrasonic pressure waves **48** to the hard convex areas of the anatomy the removable applicator head **98** is made of a flexible ultrasound conductive material such as silicone rubber and features a concave contact surface **96** which easily conforms to the anatomy under slight pressure. To further assure excellent transmission of the ultrasound pressure waves **48** from the ultrasound transducer **28** to the removable applicator head **98** a slight coating of ultrasound conductive material

such as water or gel can be applied between the applicator contact surface **92** and the removable applicator head **98**.

FIG. 7 shows a removable applicator head **100** designed for concave areas of the anatomy. Such small concave areas as between the eyes and the nose or between the cheeks and the nose are typically not accessible by the applicator contact surface **92** designed for larger soft surfaces of the anatomy. The removable applicator head **100** is constructed of rigid or semi rigid materials, such as ABS, or flexible silicone rubber conducting the low frequency orbital vibration **84** and vibration motion vectors **86** and **88** and the ultrasound pressure waves **48** into these small concave areas.

FIG. 8 shows a removable cleansing brush head **112** installed on the applicator head portion **90** of applicator **80**. The brush head **112** is typically constructed of a semi rigid ABS plastic material housing multiple tufts of bristles **114**. As described in detail in FIG. 5 the applicator motor **30** vibrates the applicator head portion **90** in an orbital vibration **84** pattern. This orbital vibration **84** is transferred to the brush head **112** and the plurality of bristle tufts **114**. When energized through the interconnecting wiring **40** the ultrasound transducer **28** generates and emits ultrasound pressure waves **48** which are conducted by the applicator contact surface **92** to the brush head **112** and the bristle tufts **114** and radiated from the bristle tufts **114** to the skin of the user. Applying slight pressure of the orbitally vibrating **84** bristle tufts **114** against the skin the user effectively cleansing the skin by the synergistic scrubbing action of the bristle tufts **114** and the ultrasound pressure waves **48** radiated by the bristle tufts **114**.

Fig. 8 also shows an optional construction of the applicator head portion **90** incorporating a stainless still cup **110**.

While the preceding description contains much specificity, these should not be construed as limitations on the scope of the invention, but rather as an exemplification of preferred and additional embodiments thereof. Skilled artisans will readily be able to change dimensions, shapes, and construction materials of the various components described in the embodiments and adopt the invention to various types of sonic and

ultrasonic energy applications. For example, additional removable and interchangeable applicators for enhanced cleansing of the skin such as sponges, cotton pads, lotion dispensers enhanced by the sonic and ultrasonic frequency motion of the applicator head are possible. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their legal equivalents.

Patent Application of Robert T. Bock

Title: Ultrasonic Method and Device for Cosmetic Applications

CLAIMS

What is claimed:

1. An improved method of facilitating the penetration of cosmetic or chemical compounds into a person's skin comprising, applying said compound to the skin, then applying sonic frequency vibrations to said compound and said skin to disorganize the top layer of the stratum corneum and the lipid bilayers and to safely increase the permeability of said skin, concurrently applying ultrasonic pressure waves to said compound and said skin of sufficiently high intensity to cause mild cavitation in said skin thereby opening up deeper passageways through said stratum corneum by further disordering said lipid bilayers and further increasing the permeability of said skin to allow the deeper penetration of the molecules of said compound applied to said skin.

2. The method as defined in claim 1 wherein the sonic frequency vibrations applied in the range of about 33 to about 250 Hz, and the ultrasonic pressure waves are applied in the range of about 15 kHz to about 20 MHz in a continuous wave modality.

3. The method as defined in claim 1 wherein the sonic frequency vibrations applied in the range of about 33 to about 250 Hz, and the ultrasonic pressure waves are applied in the range of about 15 kHz to about 20 MHz in a pulsed wave modality.

4. The method of claim 2 or 3, wherein said skin is cleaned by a device powered by low sonic frequency vibrations in combination with ultrasonic pressure waves prior to the application of said compound to the skin.

5. A device to improve penetration of cosmetic or chemical compounds into the skin comprising, a handle end and an applicator end, means to generate sonic frequency vibrations of said applicator end operative to increase permeability of said skin, an ultrasound transducer located in the applicator end, means to generate and connect ultrasonic frequency electric signals to said ultrasound transducer, said ultrasound

transducer generating ultrasonic pressure waves when energized by said ultrasonic frequency electric signals operative to transmit said ultrasonic pressure waves from said applicator end into said skin operative to increase permeability of said skin and to increase penetration of said compound into said skin.

6. The device of claim 5 further comprising a battery supplying power to said means to generate ultrasonic frequency electric signals and said means to generate sonic frequency vibrations of said applicator end.

7. A device as defined in claim 5 or 6 wherein the sonic frequency vibrations of the applicator end are in the range of about 33 to about 250 Hz, and the ultrasonic pressure waves generated by the piezoelectric transducer are in the range of about 15 kHz to about 20 MHz in a continuous wave modality.

8. A device as defined in claim 5 or 6 wherein the sonic frequency vibrations of the applicator end are in the range of about 33 to about 250 Hz, and the ultrasonic pressure waves generated by the piezoelectric transducer are in the range of about 15 kHz to about 20 MHz in a pulsed wave modality.

9. A device as defined in claim 7 or 8 wherein the sonic frequency vibrations of the applicator end are converted by motion transducer means into a relatively large vibration amplitude component perpendicular to the skin versus a relatively small vibration amplitude component of said sonic frequency vibrations parallel to the skin.

10. The device of claim 9 wherein the vibration amplitude conversion of the motion transducer means is variable by the user.

11. The device of claim 5 wherein the applicator contact surface is flat.

12. The device of claim 5 further comprising a removable applicator accessory having a concave contact surface.

13. The device of claim 5 further comprising a removable applicator accessory having a convex contact surface.

14. The device of claim 5 further comprising a removable brush accessory having at least one tuft of bristles utilizing said sonic and said ultrasonic frequency vibrations operative to cleanse said skin to further enhance penetration of said compounds into said skin.

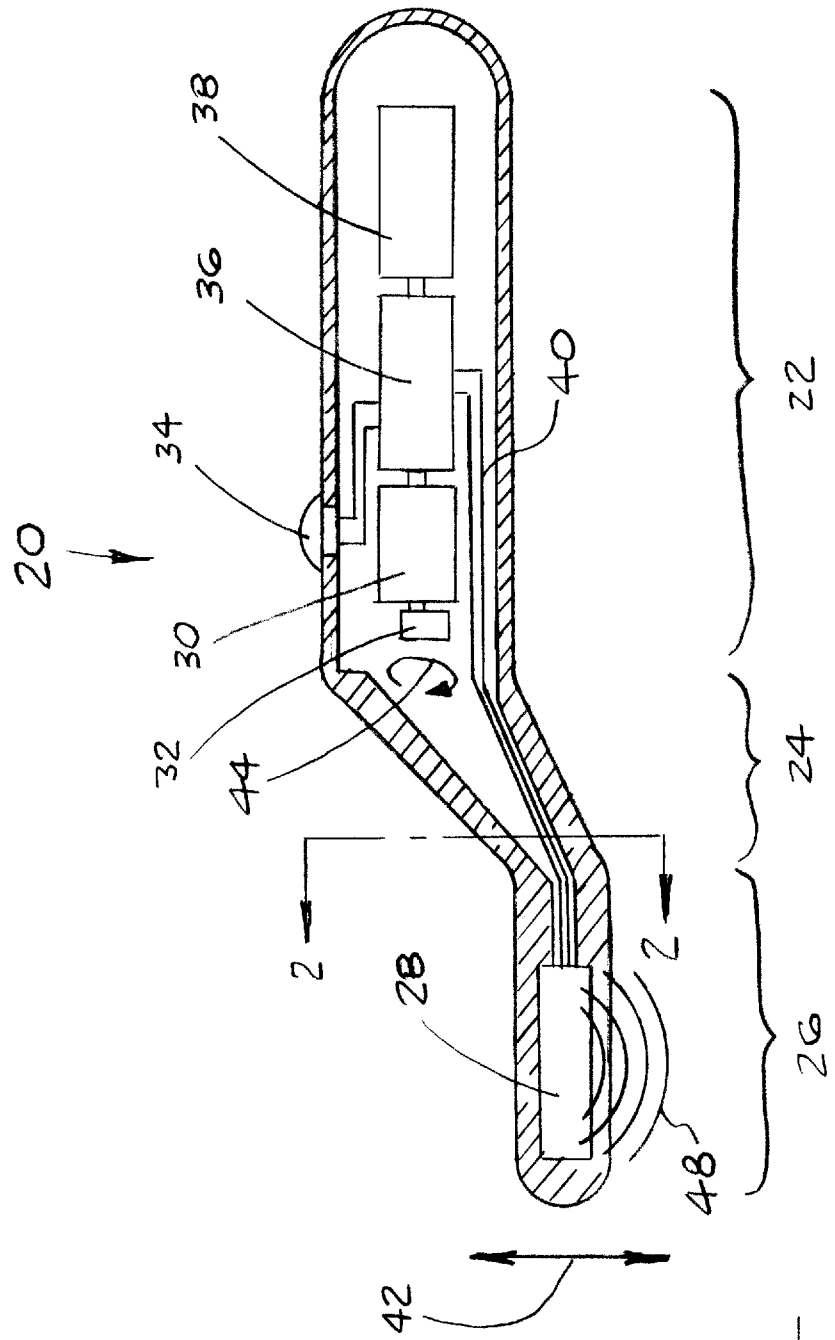

20
22
24
26
28
30
32
34
36
38
40
42
44
48
2
2

FIG. 1

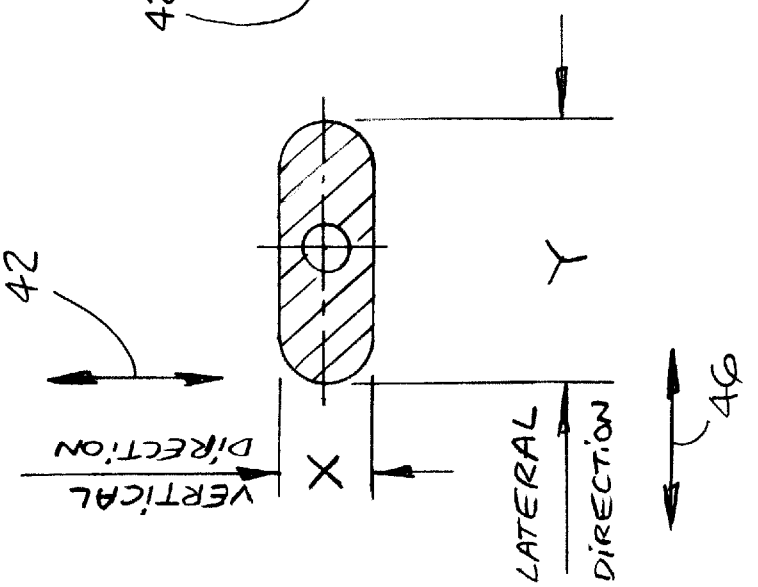

42
VERTICAL DIRECTION
X
Y
LATERAL DIRECTION
46

FIG. 2

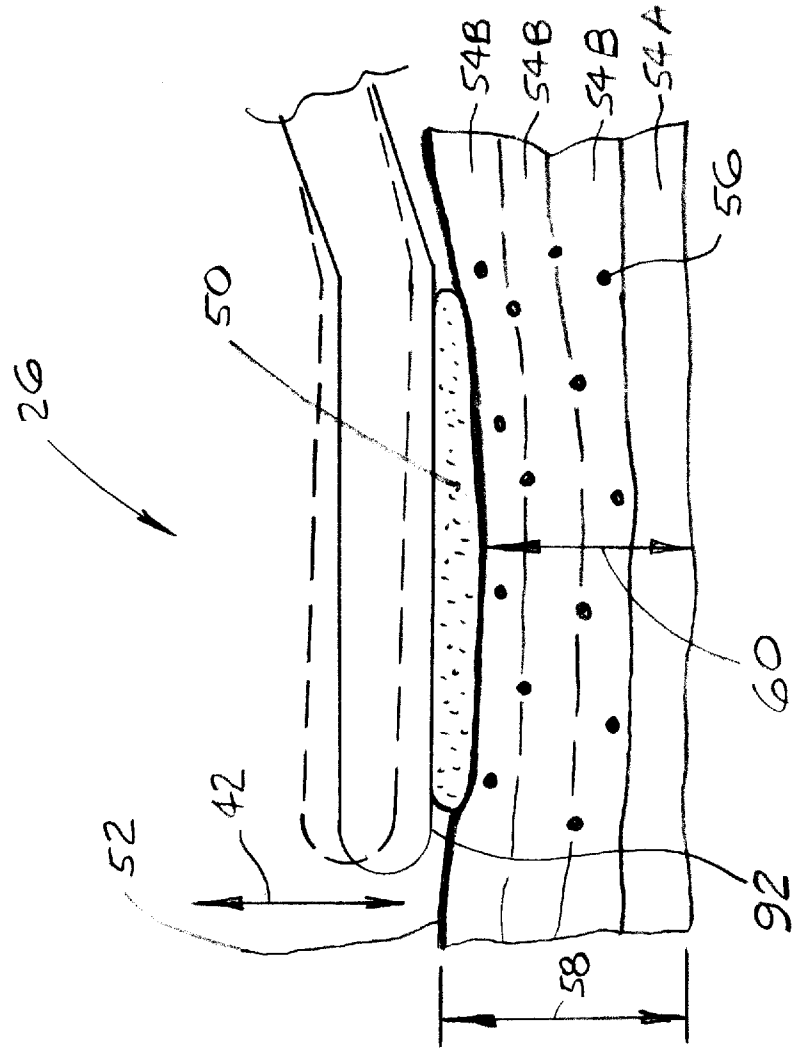

26
50
54B
54B
54B
54A
56
60
42
52
92
58

FIG. 3B

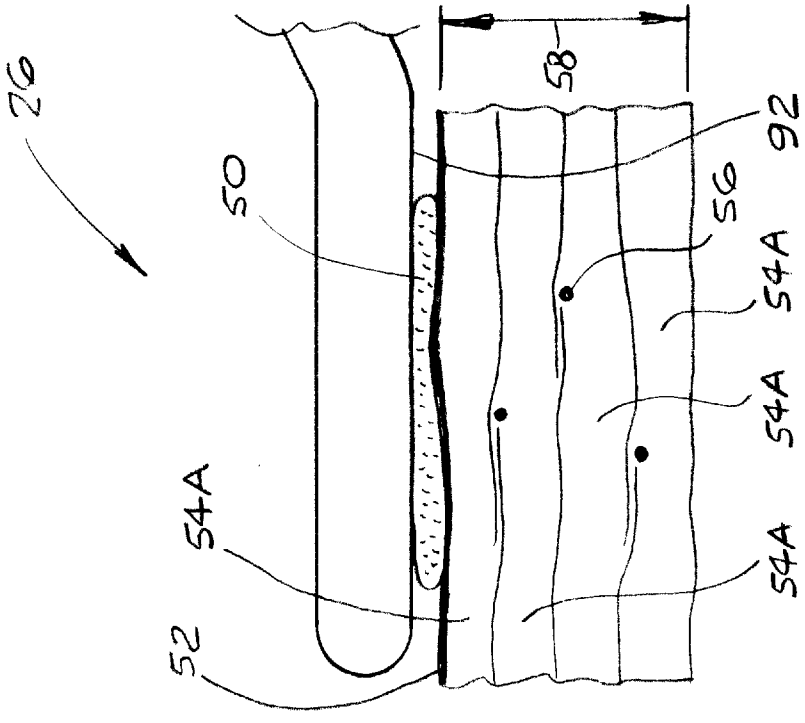

26
58
50
92
56
54A
54A
54A
54A
52

FIG. 3A

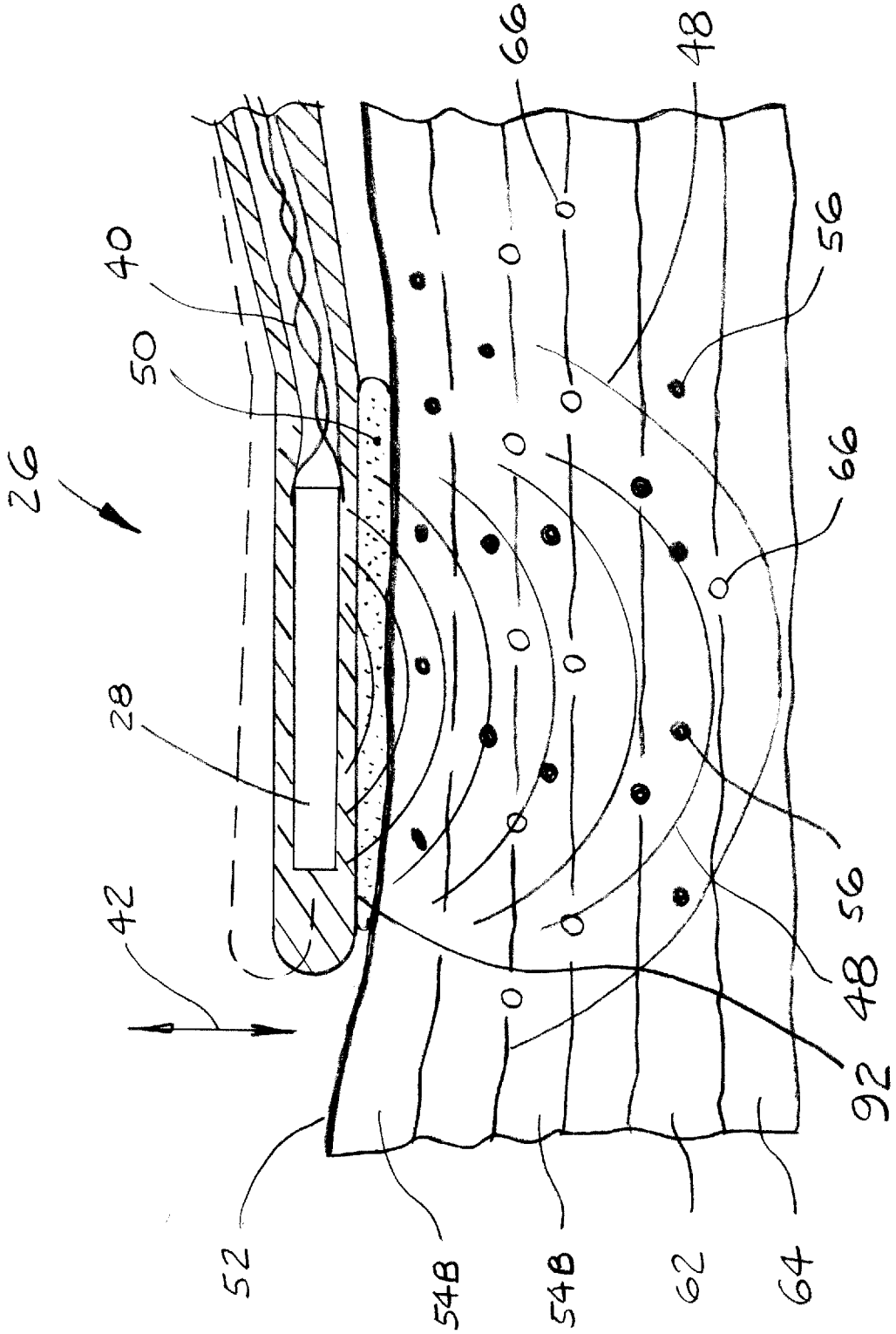


FIG. 4

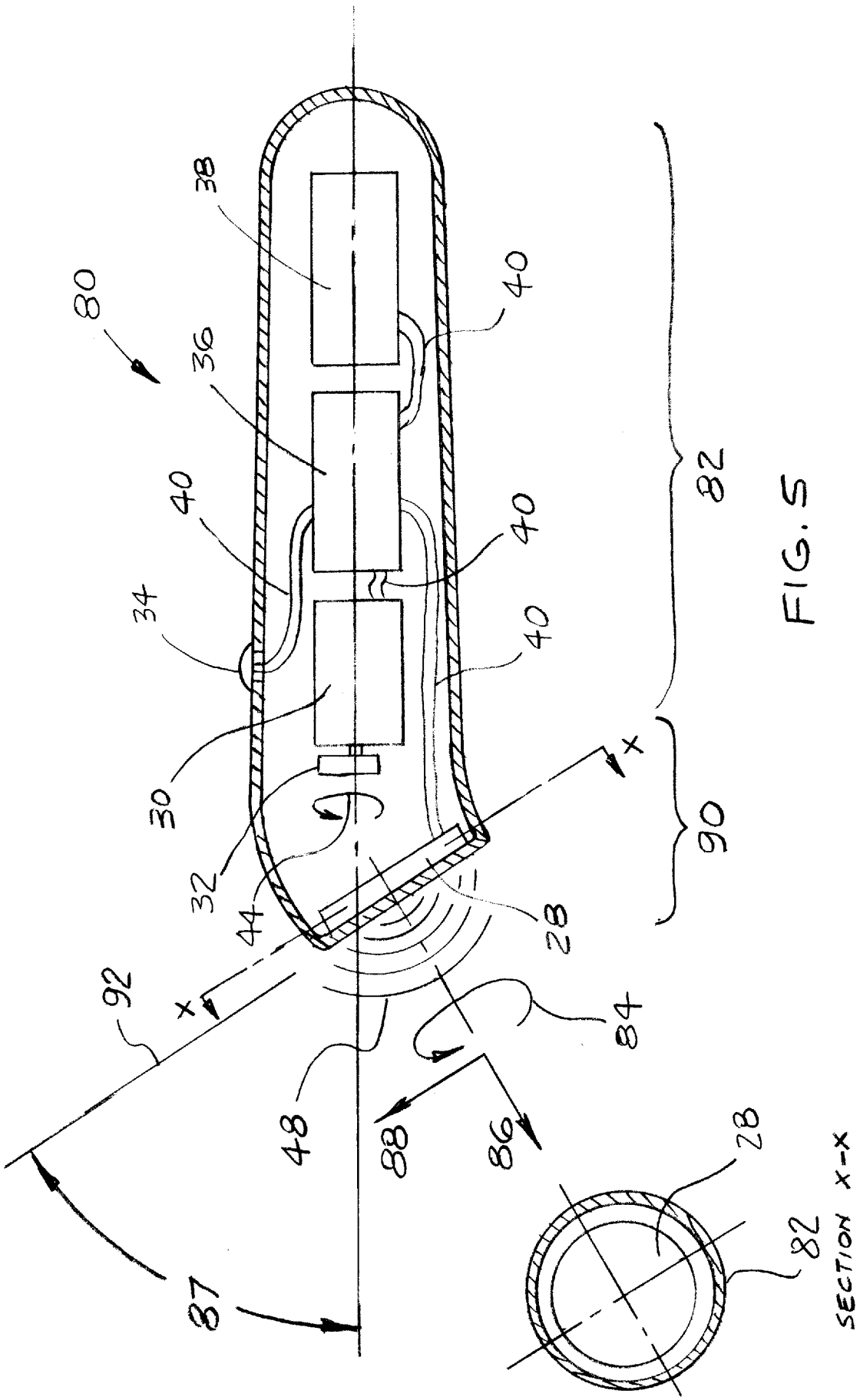


FIG. 5

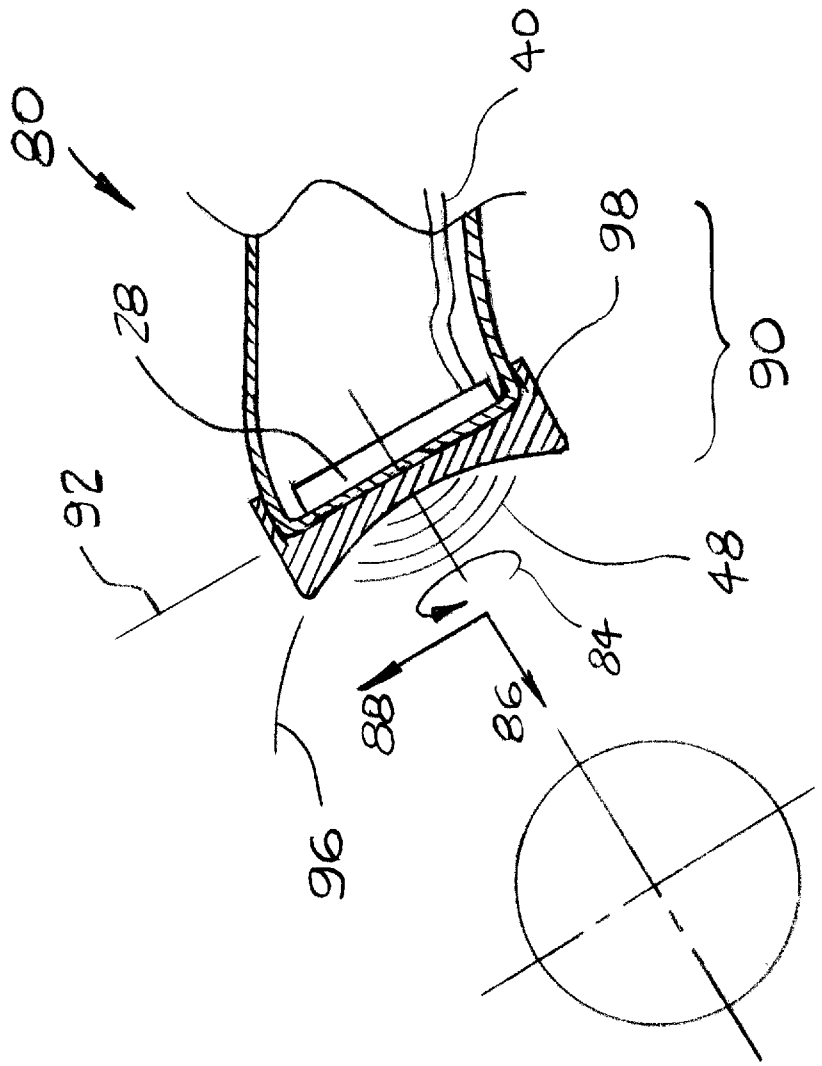


FIG. 6

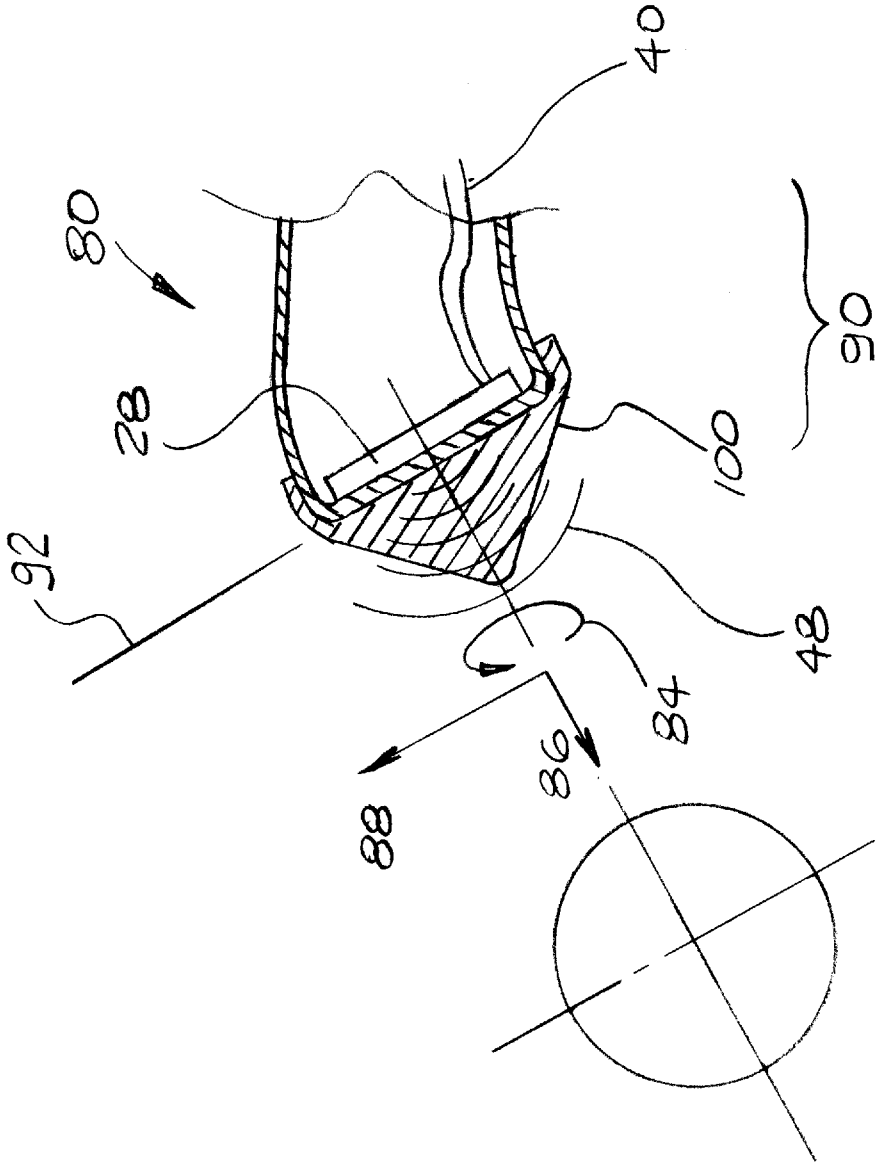


FIG. 7

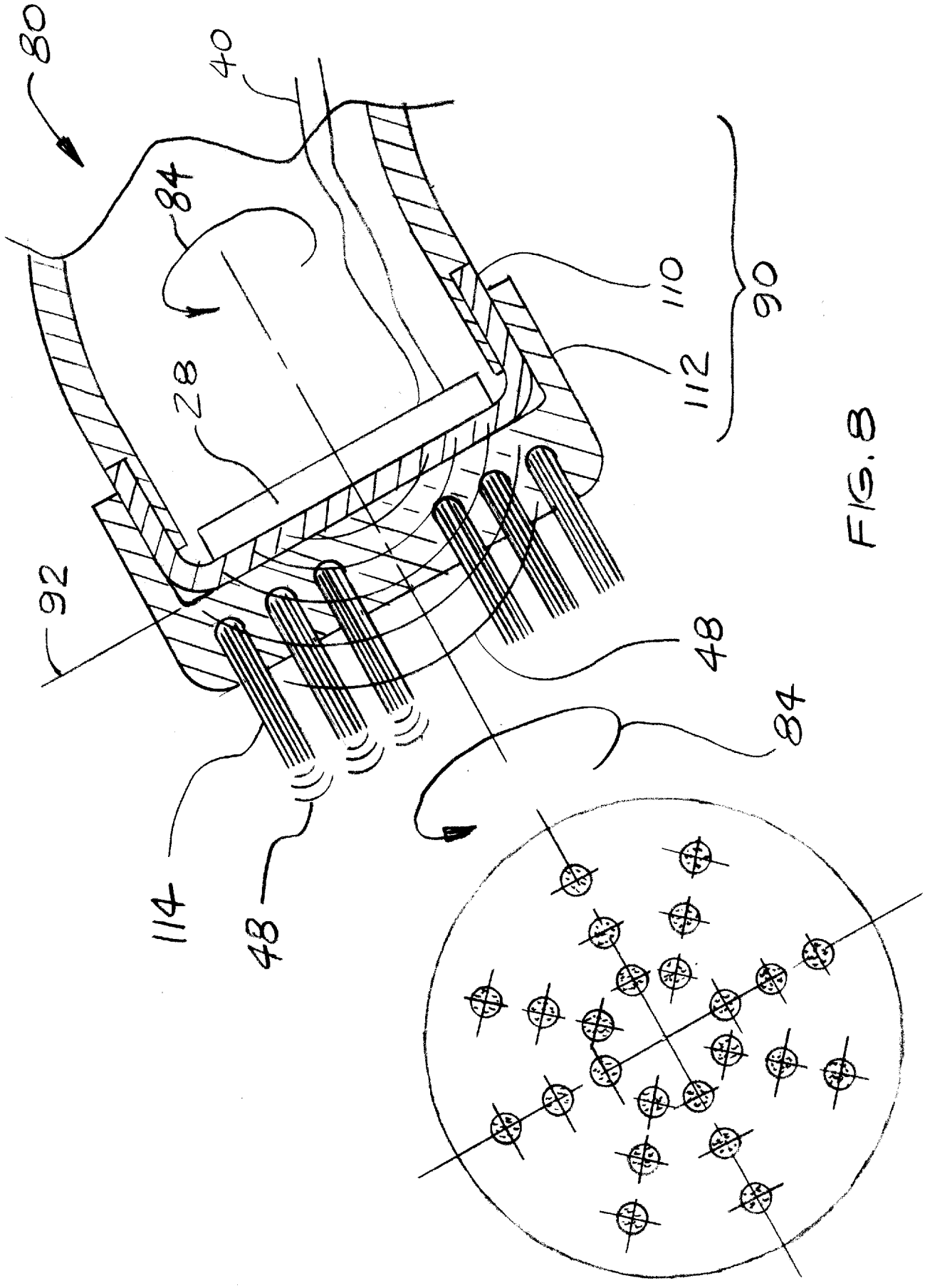


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/21737

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 9, 10
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/21737

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 17/225 (2015.01)
CPC - A61B 2017/22088; A61M 2037/0007
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): A61B 17/225 (2015.01)
CPC: A61B 2017/00765, 2017/22088; A61M 2037/0007, 37/0092; USPC: 601/2; 604/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; Google Patent; EBSCO; PubMed/Medline. Search terms: "stratum corneum", cavitation, compound, cosmetic, demis, dermal, epiderm*, moisturizer, penetration, permeability, skin, sonophoresis, topical, ultrasonic, ultrasound

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2009/0318853 A1 (REED, J et al.) December 24, 2009; figures 1, 4; paragraphs [0057], [0059], [0103], [0104], [0123]	5, 6, 11, 14 --- 12, 13
Y	US 5267985 A (SHIMADA, J et al.) December 07, 1993; abstract; figure 1; column 3, lines 8-12, 15-26, 59-61; column 5, lines 12-13, 39-45; column 7, lines 8-10; claims 1-8	1-4, 7-8
Y	US 5618275 A (BOCK, RT) April 08, 1997; figures 1A-B, 2A-B; column 1, lines 12-16; column 2, lines 22-28; column 3, lines 19-30, 35-45; column 4, lines 12-14, 26-42, 64-65; claim 1	1-8
Y	WO 97/22325 (SONEX INTERNATIONAL CORPORATION) June 26, 1997; page 4, lines 16-22; page 5, lines 8-17; page 6, lines 1-3, 7-12; page 7, lines 14-21; page 9, lines 6-17; page 10, lines 9-11; claims 4, 5, 7; figures 1-4	5-8
Y	US 6666835 B2 (MARTIN, RW et al.) December 23, 2003; figures 1A, 3, 4; column 3, lines 10-13; column 6, lines 1-7, 25-33	12-13
Y	US 2013/0345616 A1 (CHANG, FJ) December 26, 2013; figures 2C, 3A, 4, 5A-B; paragraphs [0005]-[0007], [0024]-[0025], [0027], [0036]-[0038], [0041], [0048]). [0060]	4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 June 2015 (03.06.2015)	02 JUL 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)