

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2016244192 C1**

(54) Title
Oral device and method for use thereof

(51) International Patent Classification(s)
A61J 7/00 (2006.01) **A61M 11/00** (2006.01)

(21) Application No: **2016244192** (22) Date of Filing: **2016.10.11**

(43) Publication Date: **2016.11.03**

(43) Publication Journal Date: **2016.11.03**

(44) Accepted Journal Date: **2018.06.21**

(44) Amended Journal Date: **2019.01.17**

(62) Divisional of:
2013205102

(71) Applicant(s)
Trudell Medical International;The University of Western Ontario

(72) Inventor(s)
MARTIN, Ruth E.;SIEFFERT, Marcus;SCARROTT, Peter;RIFANI, Andreas;ARMSTRONG, Kelly

(74) Agent / Attorney
Spruson & Ferguson, GPO Box 3898, Sydney, NSW, 2001, AU

(56) Related Art
US 5186047 A
EP 0818213 A2

2016244192 11 Oct 2016

ORAL DEVICE AND METHOD FOR USE THEREOF

ABSTRACT

An oral device (2) comprising: an intraoral bolus simulator (12) comprising an exterior surface and having an interior volume fillable with a fluid; and an extraoral user interface (4) extending from said bolus simulator (12).

ORAL DEVICE AND METHOD FOR USE THEREOF

[0001] This application claims the benefit of U.S. Provisional Application No. 61/791,535, filed March 15, 2013, and of U.S. Provisional Application No. 61/617,459, filed March 29, 2012, both entitled "ORAL DEVICE AND METHOD FOR THE USE THEREOF," the entire disclosures of which are hereby incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates to an oral device and in particular a device used to simulate a bolus and/or apply a sensory stimulus to the oral cavity or oropharynx.

BACKGROUND OF THE INVENTION

[0003] Swallowing is a complex sensorimotor function that serves the dual functions of transporting material from the mouth to the stomach while protecting the respiratory tract from foreign material. Swallowing involves four stages: the oral preparatory, oral, pharyngeal and esophageal stages. While the oral preparatory and oral stages are under voluntary control, with contributions from the cerebral cortex, the pharyngeal and esophageal stages are autonomic, being controlled by a brainstem network. The pharyngeal stage is triggered when an appropriate pattern of sensory stimulus excites sensory receptors within the oral cavity, oropharynx, and/or pharynx.

[0004] Dysphagia, or swallowing impairment, occurs in a number of common diseases and conditions including stroke, cerebral palsy, head and neck cancer, and Parkinson's disease. Dysphagia may affect any or several of the stages of swallowing. For example, a common swallowing abnormality in dysphagia is reduced, or delayed, triggering of the pharyngeal stage of swallowing. As a result, individuals with dysphagia often swallow less frequently when compared with healthy individuals. In addition, when swallowing is performed, the swallow may be slow and/or weak, thus placing the individual at risk of reduced nutritional intake or entry of foreign material into the respiratory tract.

[0005] Dysphagia also may result from a lack of saliva, called xerostomia. Xerostomia and associated swallowing impairment occurs in a number of patient diagnostic groups including persons who have undergone radiation therapy in the region of the salivary glands for treatment of cancer of the head or neck, persons with certain systemic conditions, e.g., Sjogren's syndrome, and persons taking medications that reduce salivary flow. When experiencing dysphagia following radiation therapy, patients may perceive their mouths to be even dryer than objective measures of saliva indicate. Unfortunately, the severity of dysphagia is correlated with the degree of perceived mouth dryness. Therefore, both dry mouth and the perception of dry mouth may be problems for patients who have undergone radiation therapy of the head and neck. In addition to the association between dry mouth and dysphagia, dry mouth is unpleasant to the patient, thereby reducing the quality of life.

[0006] A variety of stimulus modalities have been applied in attempts to elicit or facilitate swallowing, including electrical stimulation of the pharynx, neck or laryngeal musculature, thermal stimulation of the faucial pillars, modification of diet, exercises, postural adjustments and the use of gustatory stimuli, such as a sour bolus, or combinations thereof. Air-pulse trains also have been considered as a stimulus that may facilitate the pharyngeal swallow. Some devices have been suggested for delivering such air-pulse trains, as disclosed for example in US Patent Publication No. 2010/0016908, published January 21, 2010, the entire disclosure of which is hereby incorporated herein by reference. Air pulse trains are directed to the oral cavity by way of an oral device, which is positioned and secured through various devices. For example, the '908 publication describes, in one embodiment, an "over-the-ear" oral device configured such that the flexible tubing that delivers the air pulse trains wraps around the ears of the user.

OBJECT

[0006a] It is an object of the present invention to substantially overcome or at least ameliorate one or more of the disadvantages of the prior art.

SUMMARY

[0006b] In one aspect, the invention provides an oral device comprising:

an extraoral handle defining a longitudinal axis; and

a bolus simulator connected to said extraoral handle, wherein the bolus simulator and extraoral handle are moveable along said longitudinal axis between a use position, wherein the

bolus simulator is disposed in an oral cavity, and a non-use position, wherein the bolus simulator is removed from the oral cavity, the bolus simulator comprising a bottom engageable by the user's tongue, an opposite top and a peripheral side disposed between the bottom and top, wherein said bolus simulator comprises a non-removable outer jacket having an exterior surface defining said bottom and top, an interior surface defining a cavity, and a reinforcement member comprising a ring coupled to said jacket and extending around said peripheral side of said bolus simulator, wherein said ring defined a central opening having an axis perpendicular to said longitudinal axis, wherein said jacket surrounds said ring and covers an entirety of said central opening, wherein said cavity is a closed volume and not in fluid communication with said exterior surface during use such that any material contained in said cavity cannot be swallowed or aspirated.

[0006c] In another aspect, the invention provides an oral device comprising:

an extraoral handle;

a bolus simulator comprising a non-removable jacket having a textured exterior surface and defining a closed interior cavity not in fluid communication with said exterior surface during use such that any material contained in said closed interior cavity cannot be swallowed or aspirated, a reinforcement member comprising a ring coupled to said jacket and extending around at least a portion of a periphery of said bolus simulator, wherein said ring defines an opening having a central axis, and a hydrophilic coating covering at least a portion of said exterior surface; and

a tether connecting said extraoral handle and said bolus simulator, wherein said tether and said extraoral handle define a longitudinal axis perpendicular to said central axis of said opening of said ring.

[0006d] There is also disclosed an oral device comprising:

an intraoral bolus simulator comprising an exterior surface and having an interior volume fillable with a fluid; and

an extraoral user interface extending from said bolus simulator.

[0007] There is also disclosed herein an oral device comprising:

an intraoral bolus simulator comprising an exterior surface and having an interior volume fillable with a fluid; and

an extraoral user interface extending from said bolus simulator,

wherein said interior volume comprises an inlet and an outlet, and wherein said interior volume is reconfigured from a first volume wherein said interior volume is filled with a first amount of fluid to a second volume wherein said interior volume is filled with a second amount of fluid, and

further comprising a reservoir spaced from said interior volume, and said inlet and outlet communicate with said reservoir.

[0008] In various embodiments, the fluid may be a gas or a liquid, or combinations thereof.

[0009] In one embodiment, the interior volume may include an inlet and an outlet. The interior volume is reconfigurable from a first volume, wherein the interior volume is filled with a first amount of fluid, to a second volume, wherein the interior volume is filled with a second amount of fluid. A reservoir may be provided, such that the amount of fluid in the device remains fixed, but transferable between the interior volume and the reservoir. In other embodiments, the amount of fluid may be variable, wherein it is introduced by way of a pump.

[0010] In one embodiment, a gas passageway may be segregated from the interior volume. The gas passageway extends through the bolus simulator, which includes a gas outlet with the gas passageway. A gas, including without limitation air, may be directed to various regions of the mouth of the user.

[0011] In various embodiments, the oral device may be configured with a shield disposed between said intraoral and said extraoral portions. In various embodiments, the shield may be scented, flavoured, or both. In various embodiments, a tether may extend between the shield and the bolus simulator. The tether may be flexible, and/or may be configured as a fluid passageway, whether to transmit a gas or liquid.

[0012] In various embodiments, the bolus simulator may include a solid core, which may be formed for example and without limitation from a flavour impregnated polymer. In other embodiments, the bolus simulator may include a liquid core. In some embodiments, the exterior surface of the bolus simulator, whether defined by the core or by an outer coating, is textured. An outer coating may also be flavoured. In addition, a coating and/or the core may be provided with a pharmaceutical agent, which may be transmitted to the user.

[0013] There is also disclosed herein an oral device comprising:

- an extraoral handle;
- a shield connected to said handle;
- a tether extending from said shield; and
- a bolus simulator connected to said tether,

wherein said tether defines a fluid passageway communicating with said bolus simulator, said tether communicates with an outlet port on said bolus simulator, and further comprising a liquid conduit communicating between said interior volume and a reservoir.

[0014] In one embodiment, an oral device includes an extraoral handle and a bolus simulator connected to the extraoral handle. The bolus simulator includes a bite sensor and at least one electrode exposed on an exterior surface of the bolus simulator and operably coupled to the bite sensor. The electrode transmits a current to the mouth of the user as a function of the amount of force applied to the bite sensor.

[0015] There is also disclosed herein a method of inducing swallowing comprising:

- gripping an extraoral user interface connected to an intraoral bolus simulator;
 - inserting said intraoral bolus simulator into a mouth of a user between the user's tongue and palate, wherein said intraoral bolus simulator comprises an exterior surface and has an interior volume fillable with a fluid;
 - manipulating the bolus with the user's tongue; and
 - expelling at least a portion of said fluid from said interior volume,
- wherein said expelling said at least said portion of said fluid comprises moving said fluid from said interior volume into a reservoir.

[0016] Other methods of use and of assembling the oral device are also provided.

[0017] For example and without limitation, various embodiments of the oral device may provide for multiple stimuli, including without limitation, gustatory, scent, somesthetic, thermal and auditory stimuli. In applicable embodiments, the fluid bolus may provide a more accurate simulator than solid devices, while at the same time providing in some embodiments an additional air pulse stimulant. The device is extremely portable and easy to use. Many embodiments provide for the user to use the device on their own, for example at home. At the same time, the device is provided with various safeguards, such as a shield and tether, which

prevent the bolus simulator from being swallowed and/or blocking the patient's airway. In addition, in some embodiments, the device may be provided with means to deliver pharmaceutical and/or antiseptic agents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

[0019] Figures 1A and B are perspective views of two mold components.

[0020] Figure 2 is a perspective view of the mold components in Figure 1 in a closed configuration.

[0021] Figure 3 is an exploded view of a pair of insert components making up portions of an oral device.

[0022] Figure 4 is a perspective view of the insert components of Figure 3 disposed in one of the mold halves of Figure 1.

[0023] Figure 5 is a cross-sectional perspective view of Figure 3.

[0024] Figure 6 is a perspective view of one embodiment of an oral device.

[0025] Figures 7A-C provide perspective views of an alternative embodiment of closed and open molds with an insert component disposed in one of the mold components.

[0026] Figures 8A-C provide perspective views of an alternative embodiment of closed and open molds with an insert component disposed in one of the mold components.

[0027] Figure 9 is a perspective view of one embodiment of an oral device. [0028] Figures 10A and B are perspective views of an alternative mold configuration.

[0029] Figures 11 and 12 are perspective views of an alternative mold configuration.

[0030] Figures 13 and 14 are perspective views of an alternative mold configuration.

- [0031] Figure 15 is a perspective view of an alternative embodiment of an oral device.
- [0032] Figure 16 is a perspective view of a handle incorporated into the embodiment of Figure 15.
- [0033] Figures 17A and B are perspective views of a mold set and mold for one embodiment of a handle.
- [0034] Figure 18 is a cross-sectional view of the oral device shown in FIG. 15.
- [0035] Figure 19 is a perspective view of one embodiment of a mold core.
- [0036] Figure 20 is a partial, enlarged perspective view of valves overmolded on the handle.
- [0037] Figure 21 is a perspective view of lost core wax insert.
- [0038] Figure 22 illustrates a duck bill valve core coupled to the handle.
- [0039] Figure 23 is a perspective view of an alternative embodiment of an oral device.
- [0040] Figure 24 is a perspective view of an alternative embodiment of an oral device configured with a single gas passageway.
- [0041] Figure 25 is a perspective view of an alternative embodiment of an oral device configured with a pair of gas passageways.
- [0042] Figure 26A is a side cross-sectional view of one embodiment of an oral device with a fluid filled bolus simulator being manipulated inside a user's mouth.
- [0043] Figure 26B is a side cross-sectional view of the oral device shown in Figure 26A positioned near the back of the mouth and delivering a gas pulse.
- [0044] Figure 27 is a perspective view of an embodiment of an oral device having a liquid filled bolus simulator and gas passageway.
- [0045] Figure 28 is a cross-sectional view of the oral device shown in FIG. 27.
- [0046] Figure 29 is an enlarged view of the bolus simulator and gas passageway taken along line 29 in FIG. 27.
- [0047] Figure 30 is an enlarged view of fluid reservoir taken along line 29 in FIG. 27.

- [0048] Figure 31 is an alternative, partial cross-sectional view of the oral device shown in FIG. 27.
- [0049] Figure 32A is a side view of an oral device with a fluid reservoir being manipulated a user.
- [0050] Figure 32B is a side view of the oral device shown in Figure 32A with fluid being displaced to the fluid reservoir and a gas passing through a gas outlet at the rear of the user's mouth.
- [0051] Figure 33 is a partial perspective view of an alternative embodiment of an oral device.
- [0052] Figure 34 is a top view of the oral device shown in FIG. 33.
- [0053] Figure 35 is a cross-sectional view of the oral device shown in FIG. 34 taken along line 35-35.
- [0054] Figure 36 is a partial perspective view of an alternative embodiment of an oral device.
- [0055] Figure 37 is a cross-sectional view of the oral device shown in FIG. 36 taken along line 37-37.
- [0056] Figure 38 is a partial perspective view of an alternative embodiment of an oral device.
- [0057] Figure 39 is a partial perspective view of an alternative embodiment of an oral device.
- [0058] Figure 40 is a top view of the oral device shown in FIG. 39.
- [0059] Figure 41 is a cross-sectional view of the oral device shown in FIG. 40 taken along line 41-41.
- [0060] Figure 42 is a perspective view of a self-inflating oral device.
- [0061] Figure 43 is a partial, cross-sectional view of the oral device shown in FIG. 42.
- [0062] Figures 44A-E are various views of an alternative embodiment of an oral device.
- [0063] Figure 45A is a perspective view of the oral device shown in FIG. 44 as applied to a user.

[0064] Figure 45B is a perspective view of the oral device shown in FIG. 45A prior to application to a user.

[0065] Figures 46A-F are various views of one embodiment of an oral device.

[0066] Figures 47A-F are various views of one embodiment of an oral device.

[0067] Figures 48A-D are various views of one embodiment of an oral device.

[0068] Figures 49A-D are various views of one embodiment of an oral device.

[0069] Figures 50A-E are various views of one embodiment of a shield for an oral device.

[0070] Figures 51A-E are various views of one embodiment of a shield for an oral device.

[0071] Figures 52A-E are various views of one embodiment of an oral device.

[0072] Figures 53A-E are various views of one embodiment of an oral device.

[0073] Figures 54A and B are cross-sectional side views of an oral device with a self-inflating bolus simulator after being inflated and then deflated.

[0074] Figure 55A and B are cross-sectional views of a gas pulse and non-gas pulse oral devices in operation.

[0075] Figure 56A-D are various views of one embodiment of an oral device.

[0076] Figure 57A-D are various views of one embodiment of a handle for an oral device.

[0077] Figure 58A-E are various views of one embodiment of a bolus simulator and tether.

[0078] Figure 59A-E are various views of a shield for an oral device.

[0079] Figure 60 is an exploded view one oral device embodiment.

[0080] Figure 61 is an exploded view of an alternative embodiment of an oral device.

[0081] Figure 62 is an exploded view of an alternative embodiment of an oral device.

[0082] Figure 63 is an exploded view of an alternative embodiment of an oral device.

- [0083] Figure 64 is an exploded view of an alternative embodiment of an oral device.
- [0084] Figure 65 is an exploded view of an alternative embodiment of an oral device.
- [0085] Figure 66 is an exploded view of an alternative embodiment of an oral device.
- [0086] Figure 67 is an exploded view of an alternative embodiment of an oral device.
- [0087] Figure 68 is an exploded view of an alternative embodiment of an oral device.
- [0088] Figure 69 is an exploded view of an alternative embodiment of an oral device.
- [0089] Figure 70 is an exploded view of an alternative embodiment of an oral device.
- [0090] Figures 71A-C are various views of an oral device.
- [0091] Figures 72A-D are various view of a bolus simulator.
- [0092] Figures 73A-F are various views of an oral device.
- [0093] Figures 74A-F are various views of a bolus simulator.
- [0094] Figures 75A-E are various views of a shield.
- [0095] Figures 76A-E are various views of a handle.
- [0096] Figures 77A-D are various views of an oral device.
- [0097] Figures 78A-G are various views of an oral device.
- [0098] Figures 79A-C are various views of an oral device.
- [0099] Figures 80A-D are various views of an oral device.
- [00100] Figures 81A-E are various views of an oral device.
- [00101] Figures 82A-E are various views of a handle for an oral device.
- [0100] Figures 83A-E are various views of an oral device.
- [0101] Figures 84A-E are various views of a handle for an oral device.
- [0102] Figures 85A-G are various views of a bolus simulator for an oral device.

- [0103] Figures 86A-F are various views of a valve arrangement for an oral device.
- [0104] Figures 87A-E are various views of an oral device.
- [0105] Figures 88A-E are various views of a bolus simulator for an oral device.
- [0106] Figure 89 is a top view of an oral device.
- [0107] Figure 90 is a cross-sectional view of the oral device shown in FIG. 89 disposed in a user's mouth.
- [0108] Figure 91 is a cross-sectional view of the oral device shown in FIG. 89 disposed in a user's mouth during operation.
- [0109] Figure 92 is top view of an oral device.
- [0110] Figure 93 is a cross-sectional view of an oral device during operation.
- [0111] Figure 94 is a top view of an oral device during operation.
- [0112] Figure 95 is a perspective view of an oral device disposed in a mouth of a user.
- [0113] Figure 96 is a perspective view of an oral device disposed in a mouth of a user.
- [0114] Figure 97 is a perspective view of a bolus simulator.
- [0115] Figures 98A-D show the steps of inflating and deflating a bolus simulator.
- [0116] Figures 99A-G show various views of an oral device.
- [0117] Figures 100A-F show various view of an oral device.
- [0118] Figure 101 is a perspective view of an alternative embodiment of an oral device.
- [0119] Figure 102 is a partial, perspective view of a handle and intraoral portion shown in FIG. 101 in a released configuration.
- [0120] Figure 103 is a cutaway view showing the connection between the intraoral portion and the handle of FIG. 101.
- [0121] Figure 104 is a front view showing the catch mechanism included in the embodiment of the oral device shown in FIG. 101.
- [0122] Figure 105 is a side view showing the catch mechanism of FIG. 104.

- [0123] Figure 106 is a perspective view of an alternative embodiment of an oral device.
- [0124] Figure 107 is a perspective view of an alternative embodiment of an oral device.
- [0125] Figure 108 is a perspective view of an alternative embodiment of an oral device.
- [0126] Figure 109 is a perspective view of the oral device shown in FIG. 108 as applied to a user.
- [0127] Figure 110 is a top plan view of the oral device shown in FIG. 106.
- [0128] Figure 111 is a cross-sectional view of the oral device shown in FIG. 110 taken along line 111-111.
- [0129] Figure 112 is a side view of the oral device shown in FIG. 106.
- [0130] Figure 113 is an enlarged partial view of the oral device shown in FIG. 111 taken line 113.
- [0131] Figure 114 is a cross-sectional view of an oral device applied to a user.
- [0132] Figure 115 is a perspective view of an alternative embodiment of a bolus simulator.
- [0133] Figure 116 is a top view of the bolus simulator shown in FIG. 115.
- [0134] Figure 117 is a cross-sectional view of the bolus simulator shown in FIG. 116 taken along line 117-117.
- [0135] Figure 118 is a partial perspective view of an alternative embodiment of an oral device.
- [0136] Figure 119 is a partial cut-away view of the oral device shown in FIG. 118.
- [0137] Figure 120 is an enlarged partial view of the bolus simulator shown in FIG. 118 inserted in a mouth of a user.
- [0138] Figures 121-123 show different stages of the assembly of an oral device.
- [0139] Figures 124-126 show different stages of the assembly of another oral device.

[0140] Figures 127A-C show different stages of the assembly of another oral device.

[0141] Figure 128-136 show an alternative bolus reinforcement structures.

[0142] Figures 137-147 show various alternative embodiments of an oral device.

DETAILED DESCRIPTION OF THE DRAWINGS AND THE PRESENTLY PREFERRED EMBODIMENTS

[0143] The term “lateral,” “laterally,” and variations thereof refer to the widthwise or side-to-side direction between the cheeks of the user. The term “longitudinal,” “longitudinally,” and variations thereof refer to the lengthwise direction of a component. The term “upper” or “above” refers to the vertical direction or orientation towards the roof of the mouth of a user when sitting upright, while the term “lower” or “below” refers to the vertical direction or orientation towards the ground. The term “fluid” refers to either a gas or a liquid, or combinations thereof, including liquids with particles or solids suspended therein. It should be understood that when referring to “first” and “second” herein, it should be understood that any terms modified thereby, including for example volume and amounts of fluid, may vary between many different measures, not just two defined measures, and that the volume and amount of fluid may be infinitely adjustable along a continuum, with “first” and “second” merely referring to two different measures along such a continuum of such measures.

EXTRAORAL USER INTERFACE

[0144] Turning now to the drawings, FIGS. 23, 25, 27, 42, 46, 47 and 60-70, an oral device 2 is shown as including an extraoral user interface 4. The extraoral user interface may be configured with a contoured handle 6, having various grippable features, such as ribs, knurls or other features. In various embodiments, the extraoral portions may be constructed from medical grade or other materials. For example, the extraoral portions may be made of Saint-Gobain Tygon Plastic

Tubing, PolyFlav+EVA flavored plastics and/or Saline solution, 3D Systems Rapid Prototype Resin and/or Cast Urethane.

[0145] A shield 14, also forming part of the extraoral interface 4, is coupled to an intraoral portion 8, configured in one embodiment with a bolus simulator 12 and tether 10. In one embodiment, the shield 14 is integrally formed as part of the extraoral interface, and is configured as a thin flange extending transversely to a longitudinal axis of the handle. Referring to FIGS. 50, 51, 59, 64 and 75, the shield 14 may have a slight concave contour 16 facing the bolus simulator so as to conform to the face of the user. The outer, lateral edges 18 of the shield are flared outwardly, forming a concave contour 20 relative to a horizontal axis, and running transverse to the curved contour 16 formed about the vertical axis. The shield may be made of a hard plastic material such as polypropylene, polyethylene and/or nylon, including mineral filled or glass filled variations thereof, and may be scented, for example using a scenting agent. The shield also may be made of polycarbonate and phthalate and lead free polyvinyl chloride (PVC). In one embodiment, if more flexibility is desired, 70- to 90 Shore A durometer silicone material may be used. In one embodiment, the handle is made of polyethylene or polypropylene, while the shield is made of PolyFlav+EVA. In various embodiments, the shield is configured with one or more openings 201 or slots 52, 203 that receive the tether and/or provide through holes for fluid conduits 70, 56, 62, 66, 42, whether for a gas or liquid, and also a slot or groove 203 that receives and surrounds a portion of the handle as a support structure 22 is inserted into an interior of the shield.

[0146] In one embodiment, shown in FIGS. 48 and 49, the handle is provided with a shield support structure 22 extending substantially transverse to the handle. The support structure is configured in one embodiment as a flange with a plurality of alternating ribs 24 and recesses 26. The shield 14, shown in FIGS. 50, 51, 59 and 75, includes a shroud or cover that fits over and surrounds the internal support structure 22, thereby allowing the user to alter the materials interfacing with the outer lips and face of the user. Moreover, the outer cover portion of the shield 14

may be replaced, and/or the handle 6 removed for sanitizing. The shield may be formed as an inseparable assembly with a soft polymer user interface 14 overmolded or co-molded with the support structure 22, with the support structure made of one or more of the materials disclosed above. The outer casing, or interface material, of this two-shot component may be made of EVA, flexible PVC and/or silicone. The durometer values for the outer overmolded materials may range from 30 Shore A to 80 Shore A. Various scenting agents may be incorporated into the polymer or silicone material making up the outer user interface layer. The shield may be flavored or scented by way of material impregnation, or by mechanical bonding through dipping or coating. Portions of the shield may be flavored or scented, or the shield may be free of any such agents. In one embodiment, the outer user interface layer, which encases the support structure 22, is formed as a one piece injection molded part overmolded onto the support structure.

[0147] The shield 14 prevents the bolus simulator, or other intraoral portions, from travelling too far into the mouth cavity of the user, wherein the intraoral portion may induce a gag reflex or present a choking hazard. In addition, the shield functions as a barrier that prevents saliva or other deposits adhered to the intraoral portion from contaminating the extraoral portion, such as the handle, or the user's hand. Like the handle, it is preferable to provide the shield with aesthetic properties that avoid conjuring up an image of a device for use with infants or small children, such as a pacifier. The shield may also provide a measurement device, advising as to how far the bolus simulator has been inserted into the user's mouth.

[0148] Referring to FIGS. 95 and 96, a positioning handle 28 may be made of a thin, narrow strip of rigid, but deformable, material. One end of a tether portion 40, or intraoral portion, of the handle may have the same proximate shape, but with lesser dimensions, as the bolus simulator 32, thereby providing internal support for the bolus simulator. The handle may be smooth and light weight such that it does not cause injury to the oral tissues. Referring to FIGS. 106, 107, 110

and 111, the handle may be provided with lightening holes 316. A lanyard hole 318 may be provided at a distal end of the handle. In one embodiment, the overall weight of the oral device is less than or equal to 40 grams. The lightening and lanyard holes 316, 318 are sized and positioned to locate the center of mass of the oral device near the proximal end of the handle to minimize the distance from the device's centroid and the center of mass, which minimizes the pendulum effect of the handle with the device is being used off-hand. As shown in FIG. 113, a portion 320 of the handle protrudes into the center of the tether to provide a reinforcement for the tether core. While configured as a slender body, the handle may also be configured as a knob or loop.

[0149] The handle may be configured with a bright color such that it is easily seen. In one embodiment, the tether portion 40 of the handle exits the mouth of the user anteriorly between the upper and lower teeth, where it deforms to the occlusal relationship of the upper and lower teeth as the jaw is closed after positioning the bolus simulator, thereby allowing for use with the teeth in occlusion. The handle 28 includes an intermediate portion 34 that extends downwardly as the tether portion 40 is deformed, and a grippable portion 36 that extends outwardly for grasping by the user. In another embodiment, the handle exits from the lateral aspects of the bolus simulator and exits the mouth at the angle of the mouth, passing between the upper and lower teeth posterior to the canine at a point where the contacting surfaces of the upper and lower teeth are not in contact.

[0150] In yet another embodiment, shown in FIG. 96, a pair of positioning handles 30 exit the right and left sides of the end of the bolus simulator and exit the mouth at an angle, one handle 30 attached to and stabilizing the right side of the bolus simulator and the other attached to and stabilizing a left side. In one embodiment, the two positioning handles 30 extend downwardly, outwardly and then upwardly, terminating in hook portions 38 that may be secured over the ears of the user to further stabilize the bolus simulator while also freeing up the hands of the user or operator of the device.

[0151] In one embodiment, the handle 28, 30 and bolus simulator 32, as well as a tether and shield, are permanently affixed such that they may not be separated, with the assembly being particularly well suited for a single use, single session, or for several sessions by a single user.

[0152] Alternatively, as shown in FIGS. 62-67, 77C and 79C, the handle 6 may be releasably connected to the bolus simulator 12 with a tether 10, for example with a clip, snap-fit or engagement with a catch mechanism 43, such that the handle 6 may be separated, cleaned and reused with another bolus simulator 12. Referring to FIGS. 101-105, the handle incorporates a catch mechanism 43 that allows the intraoral portion 8, along with the shield 14, to be detached or released from the handle 6. FIG. 102 shows the detachable handle in a released or separated state revealing the catch mechanism 43. As shown in FIGS. 102-105, the handle includes an actuator, shown as a button 45, coupled to a pair of laterally spaced catch members 47 connected with a bridge member 53. The catch members 47 have an angled surface forming a wedge configuration. The actuator is connected to the catch members with a pair of legs 49, which function as a spring to return the actuator to an engaged position. The shield 14 is configured with a pair of hooks or attachment members 51 that extend longitudinally from the shield. In an assembled configuration, the handle's twin catch members 47 are engaged by the attachment members 51 so as to releasably couple the shield and the intraoral subassembly to the handle. As illustrated in FIGS. 104 and 105, releasing the shield 14 and intraoral portion 8 is accomplished by pressing the button 45 located in the middle of the catch mechanism 43 and thereby moving the twin catch members 47 in the same direction of the movement of the button 45, away from the attachment members 51 attached to the shield. This allows the shield and intraoral portion to be moved longitudinally out of engagement with the handle. Insertion is accomplished by movement in the opposite longitudinal direction, with the attachment members 51 either biasing the catch members 47, or with an assist from the button, until they are released into a releasable snap-fit configuration.

[0153] In one embodiment, the handle 6 may be configured with a vibratory element that imparts a vibration to the bolus simulator. For example and without limitation, a vibration in the frequency range of 2 to 70 Hz may be applied. The vibration may be initiated manually by the user or care giver through actuation of a button on the handle. Alternatively, the vibration may be triggered by movement of, or pressure applied to, the bolus simulator by the user.

[0154] In another embodiment, the handle may also be configured to emit a verbal cue, for example a human voice providing instructional information, for example "Get ready to swallow, swallow hard," etc. The verbal cue may be initiated manually by the user or care giver through actuation of a button on the handle 6. Alternatively, the cue may be triggered by movement of, or pressure applied to, the bolus simulator by the user.

[0155] In various embodiments, the handle may be made of the same types of materials as the shield, including a hard durometer (80 Shore A) silicone. In another embodiment, the handle includes a hard main core over molded with a softer material, such as silicone, flexible PVC or EVA with durometer values ranging from 40 Shore A to 80 Shore A.

[0156] Referring to FIGS. 44 and 45A and B, another embodiment of an oral device is shown. The oral device includes a pair of laterally spaced intraoral portions 112 defining intraoral conduits each having at least one outlet port 120 adapted to dispense at least one fluid pulse. An extraoral portion 114 is integrally formed with each of the intraoral portions. The extraoral portions define extraoral conduits in flow communication with the intraoral conduits. An auxiliary support device includes a yoke. In one embodiment, the yoke is configured as a Y-shaped frame 132 having a pair of arm portions 134 and an inlet portion 136, each configured with grooves or channels in which the extraoral portions are disposed and secured. The arm portions curve rearwardly from the inlet portion. In one embodiment, the arm portions extend at an angle α of about 20-60 degrees, and in one embodiment at an angle α of about 30-45 degrees, and in one embodiment at an angle α of 38.5 degrees. The frame shapes and holds the extraoral portions 114.

In addition, each of the pair of arm portions 134 includes a wing with an attachment member 140. At least one securing member 142, configured for example and without limitation as an elastic band, may be secured to the attachment members 140. The band may be configured as a pair of ear loops, or as a single headband that encircles the user's head and locates and holds the yoke in position.

[0157] In one embodiment, wing portions have a concave curved portion 144 that interfaces with the lips, or corner of the user's mouth, with the end portions of the yoke arms 134 extending into, and positioning intraoral portions 112 of the tubing, in the mouth of the user. In essence, the end portions and the attachment member 140 have a recess formed therebetween so as to locate the yoke relative to the user, and the lips/mouth in particular, with the force applied by the securing member 18 urging the yoke against the user's lips/mouth. The width (W) of the wing may be widened at the junction of the end portions and the wings at the area of contact with the user's lips/mouth so as to reduce the tissue contact pressure.

[0158] Referring to FIGS. 15, 16, 18, 24, 25, 27 and 28, fluid passageways 56 extend through the handle 6 and communicate with input ports 60 at distal end of the handle. Alternatively, the passageways, configured as conduits 56, extend from the handle. A fluid supply, such as a compressor or pump (hand or motor driven), may be coupled to the inlet ports 60 or conduits to supply a gas. The conduits 56 may be open to the ambient environment, or may be coupled to a gas source, such as oxygen, wherein other medicaments may be introduced into the gas passageway and delivered to the user. Alternatively, a liquid may be supplied to the inlet ports.

[0159] The purpose of the handle 6 is to be used in the insertion and extraction of the intraoral part of the device from patient's mouth, as well as a means to help maneuver the bolus simulator 12 inside the patient's mouth. To serve that purpose well, the handle shall be ergonomically friendly. In addition, since in the intended treatment regimen the intraoral portion may be left inside the patient's mouth for an extended period of time, the handle 6 should be light enough that it does not

have to be supported externally while the intraoral portion 8 is in the patient's mouth without causing discomfort.

[0160] From an aesthetic standpoint, while the handle 6 shall retain its ease-of-use characteristics, especially for someone with impaired fine motor skills, the handle should not conjure up any negative perceptions to the intended users or patients. As an example, for patients with early onset of dementia, who are otherwise able to lead a normal social life, having to use a device that resembles something that is intended for an infant or a severely disabled person, can be quite disheartening.

TETHER

[0161] The oral device also includes various intraoral components, including a tether 10 and a bolus simulator 12. In various embodiments, the intraoral components are constructed from medical grade material. For example, the intraoral components may be made of Dow Corning Silastic M room Temperature Vulcanization (RTV) Silicone, Dow Corning Silastic MDX4 RTV Silicone, Saint-Gobain Tygon Plastic Tubing, 0.04 inch Clear Mouth Guard Thermo-Forming EVA sheets, PolyFlav+EVA flavored plastics, PVC (lead and Pthalate free), EVA, and/or Saline solution. In one embodiment, the tether is made of a composite of fully cross-linked soft silicone outer casing and a harder silicone core. The outer casing may originate from a tubular portion of the pre-form that forms the bolus simulator, which tubular feature is compressed into a ribbon like shape in a subsequent molding process before the shield and handle components are molded thereover. The core may be an extension of the handle and shield formed during the overmolding process. Referring to FIG. 113, the overmold interface 111 between the tether 10 and the shield is shown, which minimizes the presence of crevices or gaps between the two components that may harbor contaminants. This type of smooth transition may alternatively be achieved by way of mechanical bonding including for example gluing, welding and heat staking.

[0162] The tether may be flavored or scented by way of material impregnation, or by mechanical bonding through dipping or coating. Portions of the tether may be flavored or scented, or the tether may be free of any such agents.

[0163] In one embodiment, shown in FIGS. 107 and 109, the tether may include a pair of spaced apart side portions 312 that define a space or opening 314 therebetween. The opening 314 allows for at least a portion of the user's tongue to be received therein, and for the tongue to touch the hard palate of the user's mouth to further facilitate swallowing. The side portions 312 may be configured as fluid conduits. As shown in the embodiment of FIG. 109, a right tether portion enters the user's mouth at the right angle of the user's lips, while the left tether portion enters the user's mouth at the left angle of the user's lips, which ensures that no material of the tether is disposed between the upper and lower lips at and near the sagittal midline where somatic sensitivity is greatest. Accordingly, the user experiences natural sensory feedback from the lips contacting each other during use. Similarly, no material is disposed between the maxillary and mandibular teeth anteriorly at and near the sagittal midline, and no material is disposed between the tongue tip/blade and the roof of the mouth (i.e., alveolar ridge posterior to the maxillary incisors). Therefore, the user may maintain a natural tongue/alveolar ridge relationship during use with the associated advantage that the user receives natural somatic sensory feedback from the oral cavity. In addition, the user may more easily use their tongue and lips in oral functions, such as during speaking, drinking and eating. It should be understood that one of the side portions may be eliminated altogether, with the tether being formed from a single, asymmetric side portion, whether left or right. This may be particularly well suited for users with unilateral oral impairment, such as patients with lateral oral resections for oral cancer, or unilateral oral paresis following stroke or other neurological condition.

[0164] The tether may be made of a single material, or a composite of materials such that it satisfies applicable pull and durability tests, including but not limited to EN13450 and EN1400. Included in the pull and durability test

requirements are the connection between the tether and the bolus simulator and the shield/handle. A single material design may include silicone (durometer Shore A 40 or higher), phthalate and lead free flexible PVC or EVA (durometer Shore A4 or higher). A composite material design may include reinforcing elements with a polymeric or silicone binder matrix. Various reinforcements may include woven fabrics, such as a KEVLAR material available from Du Pont, and/or tougher polymeric and silicone materials with higher durometer values than the binder. The binder material may be, but is not necessarily, the same as the overmolded layer of the shield or the casing of the malleable bolus simulator.

[0165] As shown in FIGS. 23-33, a tether 10 extends between the extraoral user interface 4 and the bolus simulator 12, and which retains the structural integrity between those components. The tether may also be configured to communicate any external dynamic input to the bolus simulator from the operator, e.g., manipulation of the handle. In one embodiment, the tether may be configured as a thin, flat piece of material that does not substantially interfere with a closing of the user's mouth or jaws, or otherwise hinder the acts of swallowing, mastication, or chewing. In one embodiment, shown in FIGS. 53, 62, 63 and 65-67, the tether has an opening 50 extending through an end thereof. The tether is inserted through a slot 52, 203 in the shield, formed in one embodiment as a cover, and into a slot 54 formed in the end of the handle. The opening 50 is engaged on a catch member to secure the tether to the handle as shown in FIG. 87.

[0166] Referring to FIGS. 15, 16, 18, 24, 25, 26A and B, 27 and 28, the tether 62 is configured as a gas passageway communicating with the handle conduits 56. As shown in FIGS. 25, 60 and 61, a continuous tube, or tubes, may function as both the gas conduit 56, extending through the handle, and as the tether 62. As shown in FIG. 18, a one-way fluid intake valve 64 is disposed between the handle conduits 56 and the tether conduits 62 to permit one-way flow passage of fluid to the tether conduits. As noted, the tether 10 may be configured with one or two conduits that extending from the handle to the intraoral bolus simulator. The conduits 62 may be configured as tubes, which serve alone as the tether, or may be

incorporated into an integral system, passing through or formed in a separately molded tether. A fluid, such as a gas, may be passed through fluid passageways 66 formed interiorly of the bolus simulator, and then out through exit ports 68 forming an outlet, wherein the fluid, such as gas pulses, may be directed at various locations of the user's mouth. Again, the passageway or conduit 66 formed in the bolus simulator may simply be configured as an end portion of a continuous tube that also makes up the tether conduit 62 and handle conduit 56 as shown in FIGS. 60 and 61.

[0167] As shown in FIGS. 28, 30, 31, 64 and 74, the tether 10 may also include or contain one or more fluid conduits 70 extending between an interior volume 72 of the intraoral bolus simulator and a reservoir 74. The fluid conduits 70 may be positioned next to, or spaced on opposite sides of, the gas conduit 66, but are segregated therefrom. In one embodiment, the reservoir 74 is positioned in the handle 6, for example in an opening 403 formed in the handle as shown in 64, on an opposite side of the shield 14 from the bolus simulator 12, such that the reservoir 74 is extraoral. In one embodiment, the sides of the reservoir are exposed to the user for actuation and manipulation. The reservoir 74 and conduits 70 may be separately formed and installed in the handle through the shield as shown in FIG. 64. The fluid conduits communicate with an interior volume of a bolus simulator via an inlet and outlet 83, 85, which may be the same opening. Alternatively, separate conduits may be provided to communicate from an inlet to the interior volume, and from an outlet to the reservoir. The reservoir 74 may also be provided as a component separate from the handle.

[0168] The tether 10 is flexible enough to allow for easy manipulation of the position of the bolus simulator 12 within the oral cavity, but strong enough to withstand chewing, biting, pulling etc., so as to prevent separation of the bolus simulator from the tether, and ultimately the handle or other user interface.

[0169] Referring to the embodiment of FIGS. 44 and 45, a tether 10 is coupled to the yoke 136 and extends longitudinally therefrom.

BOLUS SIMULATOR

[0170] Referring to FIGS. 23-25, 31, 33-43 and 60-67, the intraoral bolus simulator 12 may be configured in a number of different variations. In various embodiments, the intraoral bolus simulator is configured with a solid core 80, a fluid (gas or liquid) filled core 82, whether a constant or variable volume, or combinations thereof. In various embodiments, the gas may be air, oxygen, nitrogen, or other suitable and non-toxic gases. The fluid may be water or saline solution, and may include solid particles to provide additional texture. The core may be configured with a polymer, foam, fluid, foam gel, gel or combinations thereof in a polymeric pouch, which may present a tough but pliable characteristic.

[0171] In one embodiment, the bolus simulator has a solid inner core 80 and an outer coating 84. The outer coating may contain, or be impregnated with, a chemical agent, such as menthol, that gives rise to a cool percept when coming into contact with the oral mucosa. The outer coating may also include an oral antiseptic that may provide improved hygiene, which may help avoid aspiration pneumonia. The outer coating may also contain, or be impregnated with an oral medication. In one embodiment, the solid core 80 is made of flavored or non-flavored polymers, and is covered with a protective jacket 84 made of PVC (lead and Pthalate free), EVA or PolyFlav+EVA. In one embodiment, the bolus simulator has a length of about 2.0 ± 0.5 cm, a width at a distal end of about 2.0 ± 0.5 cm, a width at a proximal end of about 1.5 ± 0.5 cm and a height of about 1.0 ± 0.5 cm.

[0172] In one embodiment, referring to FIG. 97, the bolus simulator 12 is configured with a sensory stimulation region 92 and a bolus region 90, which extends about 0.5 cm wide along the length of a top and bottom of the simulator. This region may release a bolus, such as water, from the inner core into the oral cavity when pressure is applied by the user's tongue as the tongue moves toward the palatal contour. The remainder of the bolus simulator forms the sensory stimulation region 92, including the lateral and distal portions of the simulator, which are the regions that may contact various taste receptors for sour and bitter

taste stimuli. The sensory stimulation region 92 may be covered with a base layer of water insoluble material, or an outer coating, that provides a means of separating the inner core, which may include a bolus such as water, from a gustatory agent that may be included in an outer coating. In one embodiment, the sensory stimulation region includes the outer coating, while the bolus region is configured only with an inner core. The outer coating may include a carrier, or jacket, housing the stimulating agent. When contacted by saliva-covered mucosa of the tongue and palate, the carrier releases the stimulating agent into the oral cavity and oropharynx. Of course, the outer coating may be configured such that it does not leach into the oral cavity of the user, which may be important when in use by dysphagia individuals vulnerable to tracheal aspiration of oral secretions.

[0173] Various gustatory stimuli may be suitable for use with the device. The outer coating, or the inner core, may be coated or impregnated with a number of chemicals known to stimulate, facilitate or evoke swallowing by means of stimulating saliva, or by way of exciting gustatory sensory endings that impinge on the brainstem or cortical swallowing networks, or by exciting other sensory nerves that are involved in the triggering of swallowing. Various gustatory agents may include without limitation NaCl, sucrose, quinine or other bitter agents, or sour agents such as lemon juice. Flavouring agents may be mixed into a silicone material or by way of coating/dipping. The flavouring agents may be scent, taste or combinations thereof.

[0174] In one embodiment, the inner core 80 is made of an absorbent, deformable material, including for example foam. The inner core may include a bolus to be swallowed, such as water, which is released into the oral cavity and oropharynx when the user applies pressure to the inner core by moving the superior tongue surface toward the palate as occurs during the act of swallowing. For example, in one embodiment, a fluid, for example a liquid, of 1 to 3 ml, is released from the inner core by pressure applied by the approximation of the tongue and palate. The inner core may be remotely assembled with a fluid, or it

may be filled at the point of use, for example by dipping the core into a fluid such that the inner core may absorb or be filled with the fluid.

[0175] In some embodiments, the inner core 82 is formed as a closed volume or hydrostat, such that the fluid contained therein may not escape during use such that it cannot be swallowed or aspirated. If the fluid is a liquid, the properties of the liquid, including the viscosity, may be varied to simulate a variety of bolus types, including without limitation a thin liquid, a thick liquid, a honey thick liquid, a puree, a fine chopped mixture, etc. The malleable core, such as a liquid or gel, may be encased in a durable but flexible skin or pouch. The fluid filled bolus simulator 82 allows the user to manipulate the bolus simulator shape much like a masticated piece of real food, and provides an organic feel, which may aid in inducing swallowing and be manipulated to simulate swallowing. The flexible tether 10, with a minimum thickness, further provides for maximum maneuverability of the bolus simulator. In this embodiment, the bolus simulator 82 and a reservoir 74 communicating therewith may form a closed volume, but with the fluid being transferred back and forth between an inlet/outlet to the interior volume of the bolus simulator. The pouch may be made of silicone, EVA, phthalate free flexible PVC with durometer values ranging from 30 Shore A to 80 Shore A. The core may be composed of saline, edible and nonperishable oil, silicone gels such as SILPURAN and ELASTOSIL series gels available from Wacker, and/or propylene glycol. If both the pouch and core are made of silicone, it may be possible to vulcanize both materials together. The bolus simulator should meet the same strength and durability requirements as outlined for the tether, with additional burst resistance requirements if made from any of the materials other than the vulcanized silicone.

[0176] As shown in FIGS. 89-91, the bolus simulator 82 is configured with a sealed volume of air, gel, liquid, silicone or foam, with the outer skin configured in one embodiment with a flavoring.

[0177] Referring to FIGS. 33-41 and 47, the bolus simulator 80 may be configured as a solid piece of flavor impregnated polymer. Alternatively, as

explained above, a flavored core may be encapsulated in a porous, flexible and tough polymer jacket 84. The bolus simulator may assume any number of shapes, including a donut shape, a lollipop shape (e.g., circular, oval, triangular, elliptical, and so on.), combinations thereof, or other suitable shapes. When the bolus simulator is covered with a coating or jacket 84, the outer coating may function as an initial flavor burst once placed in the oral cavity, with a flavor impregnated core 80 providing a longer lasting flavor stimulation that is less intense in nature than the initial burst. As shown in FIGS. 36-38, 65, 67 and 77-79, the outermost surface 96 of the bolus simulator maybe provided with a plurality of bumps, ridges, depressions, knurls, etc., or combinations thereof, so as to provide a textured surface that stimulates the production of saliva upon mastication. As shown in FIGS. 81 and 82, the bolus simulator 80 may be solid, but have a gas passageway 66, or a pair thereof, extending therethrough and communicating with an outlet 68.

[0178] In one embodiment, and referring to FIGS. 106-107 and 110-117, a flexible silicone pouch 84 encases a vulcanized silicone gel core 80, which is cured into a specific form such that it is not free flowing like a liquid in the pouch. This provides the advantage of avoiding a loss of material in the event of a breach to the pouch. In addition, the gel core maintains a structural integrity of the bolus simulator. At the same time, the cured shape of the core allows the pouch to flex without substantial stretching. The pouch may be made from a flexible but non-stretchable material, such as flexible PVC, or from stretchable rubber with lower tensile strengths. The bolus simulator may include indentations 87 on one or both inferior and superior surfaces thereof. The indentations may be spherical, or otherwise shaped. The indentions may not be symmetrical, with a superior side shaped and contoured to mate with and fit against the roof of the user's mouth, while the inferior side is shaped and contoured to mate with the tongue. In other embodiments, the surfaces may be contoured differently to maximize the malleability of the bolus simulator.

[0179] In the various embodiments, the pouch 84, or jacket, e.g. silicone, may be permeable so as to allow the transfer of flavor from a flavored core to the outer surface of the pouch. Alternatively, the core may be dipped in a flavored solution, with the permeability of the pouch or jacket allowing the flavor to migrate into and remain within the pouch or the core, which may also retain the flavor from the agent. During use, the flavor is slowly released onto the outer surface of the pouch or jacket.

[0180] In one embodiment, shown in FIGS. 15, 18, 43, 54, 83-85, and 98-100, the bolus simulator has a gas filled bladder 98 with an interior volume that ejects a volume of gas in response to a proper manipulation by the user to provide a sensory stimulation of sensory fields in the back of the pharynx. In one embodiment, the gas is air. Referring to FIGS. 99A-G, the oral device includes a bolus simulator 98 and an extraoral user interface 204, configured as a short handle that may be grasped by the user. A curved shield 214 is coupled to the handle. A pair of air intake conduits 208, configured as silicone tubes in one embodiment, extend longitudinally from the shield. A one-way intake valving mechanism 210 and conduit 216 communicates between the air intake conduits 208 and the bolus simulator 98. A one-way, pressure-relief exhaust valve 228 communicates with the bolus simulator, releasing the fluid when a sufficient internal pressure is realized in the interior volume of the bolus simulator. The interior volume of the bolus simulator has an inlet and an outlet, which are spaced apart in this embodiment, and with the valving mechanism and conduits acting as a pump.

[0181] Alternatively, as shown in FIGS. 42, 43 and 70, the bolus simulator 98 may be filled and evacuated through the same port 220, configured with a two-way valve 222. The interior volume 230 is inflated by way of a sucking action through the valve 222. When a predetermined pressure is reached, the valve 222 then releases the air from the bolus simulator. In this embodiment, the port 222 defines both the inlet and outlet to the interior volume, which may change from at least a first to a second volume in response to first and second amounts of fluid

being received therein. In addition, the simulator, in combination with the valve 222 acts as a pump to fill the interior volume.

[0182] The bolus simulator 98 may be filled with a reticulated foam or sponge element to facilitate self-inflation. The sponge element may be impregnated with a flavoring that may be activated and released, or the outer casing of the bolus simulator may be coated or impregnated with a flavoring. The walls of the bolus simulator bladder 98 may have a variable thickness so as to alter the rigidity and control the shape changes of the bladder in operation. In addition, the bladder may be molded with different materials, in different layers and/or regions, to provide unique regional properties. For example and without limitation, the bladder may be made of a soft durometer rubber and co-molded or overmolded with a shield and handle.

[0183] In the embodiment shown in FIGS. 100 A-F, a bolus simulator is provided with a one-way exhaust valve. In this embodiment, a handle 258, configured with a thumb-hole 260 for gripping by the user or care giver, is coupled to a shield 262 opposite the bolus simulator. The handle includes an internal gas intake passageway 264 and a one-way intake valve 266. A nipple 268, or other coupling member, extends from the handle. A conduit 270, or tube, is coupled to the nipple, with a squeeze bulb connected to the conduit. The flow volume and pressure from the squeeze bulb may be controlled by a regulator 276. A clamp 274 may be coupled to the conduit to close the conduit. It should be understood that other fluid supply devices, such as an oxygen supply, may be coupled to the nipple.

[0184] Referring to FIGS. 15, 18, 69 and 83- 85, the bolus simulator 98 is self inflated from an external air source, such as the ambient environment, through the fluid passageways 56, 62 defining an inlet to the interior volume of the bolus simulator. The fluid, such as air, is released through a pair of duckbill valves 88 communicating the exit ports 68, defining an outlet to the interior volume of the bolus simulator. In this embodiment, the inlet and outlet to the interior volume, which may change from a first to a second volume in response to first and second

amounts of fluid being received therein, are spaced apart and separate. As shown in FIGS. 82-85, the intraoral portion may be separately formed with a shield cover that fits over the support structure formed on the end of the handle, with the fluid passageways lining up upon assembly.

[0185] Referring to FIG. 92, one embodiment of an oral device includes a bolus simulator 148 with a “bite” sensor 152 or tongue press sensor, which may be configured as a piezo device or as a resistive/capacitive sensor, either of which provides an output relative to an input force applied thereto. Electrodes 150 are disposed along opposite sides of the bolus simulator such that the electrodes are capable of contacting the side of the user’s cheek and/or tongue. The electrodes are operably coupled to the sensor 152. The bolus simulator may also be configured with various textures, flavoring, scent, shapes, malleability, etc. as otherwise herein described. The device may also be configured with a shield 14 and a handle 6.

[0186] In another embodiment, shown in FIGS. 27-32B, a fluid reservoir 74 is provided in the extraoral portion, for example as an expandable reservoir in the handle on an opposite side of the shield. The reservoir 74 provides a mechanism for adjusting the softness of the bolus simulator 82. For example, the user may manipulate the reservoir, which may have a flexible user interface. A fluid passageway 70 communicates between a bolus interior volume and the reservoir. The fluid may be formed of a gas, liquid, or combination thereof. The interior volume may be altered from a first volume to a second volume having respective first and second amounts of fluid through the inlet and outlet to the bolus simulator, which are one and the same in this embodiment.

[0187] Referring to the embodiment of FIGS. 44 and 45, the bolus simulator 80, 82 is connected to the tether 10 and is disposed between the intraoral gas conduits 112.

[0188] It should be understood that the various embodiments of bolus simulators may be incorporated into the various embodiments of oral devices. For example and without limitation, the various bolus simulators disclosed herein,

including the bolus simulator shown in FIG. 92, may be incorporated into the oral device shown in FIGS. 44 and 45.

[0189] Referring to FIG. 94, a pair of exhaust conduits 192 extend laterally from the bolus 98 and direct a fluid to opposite sides of the mouth. Valves 88 are located at the distal ends of the conduits 192. The bolus simulator 98 is connected to a tether.

[0190] Referring to FIGS. 118-128B, the bolus simulator 500 is provided with a reinforcement member 502. The reinforcement member 502 reinforces the bolus simulator so as to help prevent it from releasing particulates or suffer other damage, while maintaining soft and flexible properties. In one embodiment, the bolus simulator has a components made of elastomers and thermoplastics .

[0191] In one embodiment, the edges of the device are protected, since such edges may be experience localized concentrated biting with full force. As shown in FIGS. 118-120, a reinforcement member may be formed as a ring 502, which extends around the periphery of the bolus simulator. The reinforcement member may be co-moulded and/or mechanically attached to a softer portion of the bolus simulator, including the jacket 504 filled for example with a gel 506. The reinforcement member may be made of the same family of material as the softer portion or other more rigid materials material. For example, various elastomer and/or thermoplastics may be used for the reinforcement member and the softer portion. The reinforcement member may also be made of various hard plastics or metal. The edge of the bolus simulator may be provided with smooth rounded sides or wide sides with steep slopes to impede the ability of the use to grab the reinforcement member with their teeth 508. The reinforcement member also is resistant to any tearing forces applied by the user to the bolus simulator. As shown in FIGS. 121-123, an inside-out bolus jacket 504 is overmolded on the ring 502, and this is inverted to cover the ring, with a second cover 512 is then molded over the tether and the end of the bolus jacket to seal the jacket.

[0192] Referring to FIGS. 124-126, the ring may include a pair of legs 514 that form part of tether. A core 516 may be inserted in the ring, with a bolus jacket

504 molded over the ring and/or core. Referring to FIGS. 127A-C, the ends of the legs 514 may be configured with an interlock feature, such as an enlarged insert portion, which is received in a corresponding socket 520 in the extraoral handle, for example by mechanical attachment or snap-fit. A cover 522 may then be molded over one or more of the legs and handle to further define the tether and handle.

[0193] Referring to FIG. 128, the reinforcement member is configured as sheet, formed for example from a thermoplastic material, which is positioned as a septum 524 extending along the middle of the bolus. Referring to FIG. 129, the reinforcement member is configured as a thermoplastic mesh 526, which is over moulded with a bolus and/or tether jacket.

[0194] Referring to FIGS. 130-133 and 136, various embodiments are shown wherein the reinforcement member is integrally formed with the bolus simulator, preferably from the same material. In these embodiments, the geometry, shape and/or relative thicknesses help define a reinforcement member. For example, as shown in FIG. 130, the perimeter 528 of the bolus simulator may be made thicker, with the thickened portion forming a reinforcement member. In another embodiment, the entire jacket may be thickened.

[0195] Alternatively, and referring to FIGS. 131A-C, annular rings 530, 532 having different radii are formed on one or both of the opposite interior surfaces of the bolus simulator. In one embodiment, the rings 530 on one surface are offset or staggered relative to the rings 532 on the other surface, such that the rings acting in unison mesh or nest, and reinforce the bolus simulator when compressed. The edge portion may still be reinforced, whether with a separate member or integrally.

[0196] Referring to FIGS. 132A-C, one or both of the interior surfaces has rifling rings 534, 536 that extend radially outwardly from the center of the bolus to the edge portion. The edge portion may still be reinforced, whether with a separate member or integrally. The rifling ribs on the two surfaces may be oriented in opposite directions so as to avoid pinching of the bolus jacket.

[0197] Referring to FIGS. 133A and B, one or both of the interior surfaces may be configured with a honeycomb pattern of recesses 538 and ribs 540, again with the patterns on opposing surfaces being offset in one embodiment. In this idea the bolus jacket is made to be thicker to better withstand chewing.

[0198] Referring to FIGS. 136A-C, the outer surface of the bolus simulator jacket is provided with tiles 542, which may be the same or different material as the jacket. The patterned tiles allow the bolus simulator to flex but the tiles protect the bolus from puncture. The tiles may have various geometrical shapes, including triangular, rectangular, polygonal, round, oval, elliptical, obround and any other suitable shape. The shape of the tiles, and the spacing or gaps 544 between the tiles 542, ensures that they do not restrict the flexibility of the bolus.

[0199] Referring to FIGS. 134 and 135, the bolus may be made out of encapsulated foam with air pockets 548 that are connected via connectors 546. When the bolus is partially compressed the filler in the bubbles, which could be gas, liquid, viscoelastic or solid, in the compressed region migrates to the bubbles that are free of compression through the connectors.

[0200] Referring to FIG. 137, one embodiment of an oral device does not have an extraoral portion, but rather includes a mouthpiece or mouthguard 550 that is shaped to fit between the occlusal surfaces of the user's teeth. One or more tethers 554 extend from the mouthguard and are connected to a bolus simulator 552.

[0201] It should be understood that it may be desirable to provide the oral device with a limited use or end of life feature, which provide indicia to the user that the device should be discarded and replaced. Such a feature will promote the safe use of the device, both from a hygienic standpoint and material fatigue standpoint. Various types of features may be utilized, including a system based on the user or patient senses, or a system based on the diminishing of the use's satisfaction over time, or some combination thereof. A diminishing satisfaction feature and method may include a transition from pleasant to neutral, or from pleasant to non-pleasant.

[0202] In a pleasant to neutral system, the device will give the user added positive feature(s) that will diminish over time into something neutral. As disclosed herein, Polyflav may be molded into the bolus simulator. Likewise, flavourant coating may be added to introduce scent and taste. A hydrophilic coating may also be used. The hydrophilic coating may improve lubricity of silicone and TPE, and thereby enhance the feel of the bolus simulator inside the user's mouth. With the coating in place, the tendency of the user to feel that their tongue is exfoliated after using the oral device for an extended period of time may be reduced. In addition, the hydrophilic coating may be loaded with colourants and flavourants. It is possible to temporarily enhance the lubricity of the surface of the bolus simulator using corona and plasma treatment. In the silicone samples exposed to corona treatment, their hydrophobic surface properties were temporarily removed. The window when the hydrophobic surface property is altered may be enough to bond something to the silicone surface that may provide certain added benefit to the product. A similar method of surface treatment is plasma.

[0203] Under the pleasant to non-pleasant category, the initially positive feature(s) will diminish over time into something unpleasant. For example, a texture change, or tactile feature, may be achieved through coating. A certain unpleasant texture is put onto the surface of the uncoated device and then it is coated with temporary coating that has pleasant surface finish that wears through as the device is used to eventually reveal the unpleasant texture. In one embodiment, a loaded or unloaded hydrophilic coating may be used. Perceived heat or coolness using menthol or mint oil may also be suitable.

[0204] In another embodiment, the bolus simulator transitions from a smooth to lumpy configuration as the device is used, providing another tactile feature. In another embodiment, the taste and/or smell may transition from a pleasing to a displeasing smell. The device may have an initial unpleasant taste or scent that is masked by a coating that has a pleasant taste and/or smell that wears off as the device is used. In yet another embodiment, the shape of the bolus simulator may

change, signaling the user that the end of life has been achieved. For example, the bolus simulator may be configured with one or more valves and an external reservoir, which allows the bolus simulator to inflate or deflate as the device is use.

[0205] In another embodiment, the limit on use is a function of noticeable improvements in the patients. A family of oral devices with different types of features may be used. As a patient's condition improves, the patient moves on to the subsequent grade of oral device.

[0206] The device may be provided with a pure indicator, such as a color indicia that changes or disappears then it is time to replace the device.

[0207] Limited use features that rely on the patient to determine when the device is not usable may be challenging due to the expected range in cognitive abilities of the target patient group. In this situation, a care giver may have to rely on the patient to communicate how the device feels or tastes. For a caregiver, more obvious indicators may be helpful. Specific indicators like a change in colour may be beneficial. Other more obvious changes in state that are easily detectable by eye would likely work well, such as size variation or tactile variation. For example, a bolus that is flat and not full of air provides a visual indicia of end of life.

[0208] Referring to FIG. 138A and B, an oral device includes a bolus simulator, a tether, a shield, and a handle. The skin 560 and filler 562 of the bolus simulator, together with the tether, may be made out of hydrophilic material that will absorb liquid and, not only, retain the liquid to be released slowly into patient's mouth during use, but also change their material and/or surface properties because of the liquid within them. The liquid may be a flavourant that provides scent and/or taste sensations. Examples of hydrophilic material that can be used to include, but are not limited to, hydrogels and silicone hydrogels. The bolus simulator and tether may also receive corona or plasma surface treatment to modify their wet-abilities. This change in wettability may also alter the feel of the bolus simulator and tether inside the patient's mouth.

The intra-oral portion of the oral device that is covered with hydrophilic coating may be provided with a textured surface, which may both retain the coating better, and provide contrast in the user experience when the hydrophilic coating is dissipated.

[0209] The bolus simulator and the tether may also be coated with hydrophilic material to allow it to retain liquid on their surfaces, hence, alter their surface properties. This surface property changes will change the feel of the bolus and the tether inside patient's mouth.

[0210] Referring to FIG. 139, an intra-oral bolus simulator includes a bulb 564 filled with air and is connected to an extraoral reservoir 566 via an air passage 568. The extra-oral portion includes a one-way valve 570, configured in one embodiment as a duck bill valve, which communicates with the ambient environment. As the bolus simulator is masticated, the bulb 564 will deflate and pump air into the reservoir 566 through the passageway 568, and stretch or change the shape of the extra-oral portion. When the mastication pressure is released, air will fill the intra-oral bulb 564 again when the extra-oral reservoir 566 relaxes. However, not all of the air may be returned to the intraoral bulb, since a small amount of air escapes through the one-way valve 570. Over time, as the intra-oral bulb is masticated, it will get smaller and smaller, thereby providing indicia as to end of life and simulating a food bolus that breaks down as it is being masticated.

[0211] In another embodiment, air leaks out from bolus simulator in a controlled manner in a period of time that allows for a typical use session (20min to 1 hour). A reservoir would have to be refilled before each use. A valve may be used to control the leakage rate. The valve may be configured as a pin hole. Use could influence the speed at which air leaks out. If user compresses the bolus simulator, the internal pressure may increase causing the air to leak out faster. Air can be delivered to the bolus in a number of different ways, including using a pressurized canister of gas with a metering valve (similar to a Metered Dose Inhaler canister). The canister may have a one-use supply, or multiple

supplies. A mechanism could be incorporated into the device that would allow the user to fill the bolus or “prime” the device. The mechanism would advance in one direction or have a counter mechanism that tracks the number of uses and then locks the device once the maximum number of uses has been reached, thus preventing further use.

[0212] Referring to FIG. 140, in an alternative embodiment, the leak would occur in such a way that it would render the device unusable after a number of days of continued use (e.g. 7 days). The device may be provided with the bolus 574 “pre-filled” with gas. The bolus may be configured with a plug 576 that dissolves slowly with saliva. Chemical action would occur continuously when being used. Once dissolved it would release the air out of the device after which the device would not be usable. The plug could be on tether or anywhere it will be exposed to saliva. In one embodiment, a compartment 578 is provided in the middle of the bolus simulator, with the compartment being filled with hydrogel crystals. The compartment is open to the ambient environment at one side thereof, with an organic polymer plug positioned in the opening. The organic polymer dissolves in liquid. In use, the plug 576 will slowly dissolve in saliva until it disappears completely. After the plug has dissolved, the hydrogel crystals in the compartment 578 will come in contact with saliva and swell to the point that the Swab device is not usable anymore. A one way valve may be included to ensure that the air would leak out and not enter back in.

[0213] In an alternative embodiment, a device may include a prefilled canister of gas. When the user received the device it would have to be primed or activated. Activation would release the compressed gas from the canister and allow it to enter the bolus. After this point the canister and bolus would remain an open system. A controlled air leak somewhere in the system would slowly reduce the air pressure till at some point the bolus becomes flat and unusable.

[0214] In another embodiment, a gas filled bolus hardens over time, providing a tactile indicator. Two canisters deliver a set volume, with the second

canister delivering a much higher volume. After a predetermined number of inflations, the bolus is over inflated making it too large to be used.

[0215] In another embodiment, the bolus is filled with silicone that will harden when kneaded. In an alternative, the bolus includes a divider or dividers, with different compartments each filled with one of two parts uncured silicone. When the bolus is manipulated in the mouth cavity the two part silicone mixes and cures.

[0216] Referring to FIGS. 141-143, an oral device includes a replaceable bolus simulator, tether, and shield. The device includes a bolus jacket 590, a front shield 592, a metal pipe heat conductor 594 a battery 596, a rear shield 598, and liquid filler 600. The handle 602 includes outer shells 604, a latch mechanism 606, a heat sink 608, a thermoelectric element 610, and an electrical contact 612. When the handle is mated to the disposable portion, the latch mechanism retains the connection between the handle and replaceable portion. In addition, during the mating the electrical contacts make contact with the battery in the replaceable portion, thus, the circuit to the thermoelectric element is closed. Depending on the orientation of the handle with respect to the replaceable portion, due to the design of the electrical contacts, the connection causes the thermoelectric element to have hotter or colder bias on its face opposite to the heat sink. In the mated condition, the one face on the thermoelectric element, opposite to the one attached to the heat sink, makes contact with the replaceable portion's metal pipe heat conductor. This, in turn, warms or chills the liquid inside the bolus simulator. Through convection, over a period of time, the liquid inside the replaceable portion will have uniform temperature. The liquid filler can also be made out of material that will evaporate at mouth temperature and liquefy at a thermoelectric induced temperature or vice-versa. The former applies to condition where the thermoelectric element is in cooling mode. The latter is where the thermoelectric element is in warming mode. These conditions can be achieved through either having two separate replaceable portions for warm and cool effects, or having the

necessary liquids coexist within the cavity in the replaceable portion. With the former, there would be a need for a poke yoke feature to allow only one orientation. The connection between the liquid filler in the metal pipe heat conductor to the portion of it in the bolus simulator is facilitated via channels. Since the two connectors are identical, shape-wise, and installed in the opposite orientation, to each other with respect to the battery, the handle orientation dictates the thermoelectric temperature bias.

[0217] Referring to FIG. 147, in order to prevent choking in the event that the device gets lodged in the patient's breathing air path, vent holes 620 may be incorporated into the shield.

[0218] In one alternative, and referring to FIG. 146, an oral device 628 includes a bolus simulator filled with H₂O, Sodium acetate, and configured with an aluminum disc. Clicking the aluminum disc 632 triggers a chain reaction causing the liquid 634 to crystalize and release heat for 30 minutes. The pack is then recharged by boiling it, e.g., in a pot 636, for approximately 5 minutes. Energy is put back to the heat pack and the pack is ready to be reused again for additional cycles.

[0219] Materials used to form the handle and shield include silicone materials with durometers around 60 to 80 Shore A, including for example Bluestar's USP Class VI qualified Silbione® LSR 4370 is an example. Durometers for TPE options are similar to those of silicone. The bolus filler may be a gas, liquid, viscoelastic material or solid. Liquid contemplated could be saline or TPE oil. viscoelastic materials contemplated could be gels, gelatin, hydrogels, and silicone gels. An example of silicone gel is Wacker AG's Silpuran 2130 A/B.

OPERATION

[0220] In operation of the embodiment shown in FIG. 92, the oral device, and in particular the bolus simulator 148, is positioned on an affected/dysfunctional side of the user's mouth, for example by a stroke. Using muscles on an unaffected side (by way of the rigid mandible), the user bites down on the bolus, with the bite

force input applied to the sensor 152 resulting in a charge or current being delivered to the external electrodes 150, resulting in a mild oral electrical stimulation. The level of current or charge may be regulated through a control device to a predetermined level. The stimulation would provide real-time feedback to the neural system, thereby facilitating activation and potential modulation of the swallow related neural pathways.

[0221] The oral device may also be configured with, or operably coupled to, other feedback systems, including without limitation various visual and/or oral feedback systems such as a light, scaled numeric indicia, color gradations, sound output, or combinations thereof, that are indicative of the bite or tongue force applied by the user.

[0222] The oral device also may be used to register the tongue force of the user, for example when the device is positioned on the superior surface of the tongue, or alternatively cheek force when positioned along the side of the mouth, again with various biofeedback systems, including electrical stimulation, lights and sound corresponding to relative amounts of applied force. Any tongue manipulation (lateral, suck, push, pull) force may be a candidate for monitoring. The output results may also be recorded, manually or by a computer, to track progress.

[0223] In one embodiment, and referring to FIGS. 95 and 96, the bolus simulator 32 is positioned on the superior surface 300 of the rear tongue 302, that is, the region of the tongue surface medial to the molar teeth, or against the rear palate, with a flat surface of the simulator resting on the tongue. The mouth is then closed, with the bolus simulator 32 contacting both the superior surface of the tongue and the palate. The tongue and palate mucosa contact the outer coating so as to initiate a gradual release of any gustatory and thermal agents. Vibration of the bolus simulator may be initiated, and/or the user may be verbally cued (by the user, care giver or device) to prepare to swallow and then subsequently swallow. The tongue contains the bolus simulator by elevating around the bolus simulator at an anterior and lateral aspects. Due to its shape, size and position, the bolus

simulator contacts the superior tongue surface, left and right lateral tongue margins and palate. In various embodiments, the bolus simulator stimulates both sides of the oral cavity/oropharynx, or only one side of the oral cavity. If pharyngeal swallowing is triggered, the tongue presses against the palate in an anterior-to-posterior direction, which may release a bolus, such as a fluid, from the inner core in some embodiments. The user then swallows the bolus. Users with upper dentures should remove the dentures prior to use to avoid any interference with stimulation of the sensory receptive fields on the palate.

[0224] The physical specifications of the bolus simulator 32, 80, 82, 98 may stimulate the oral cranial nerve afferents. For example, when positioned on the superior surface 300 of the tongue, the bolus simulator may stimulate a variety of sensory receptors lining the tongue surface, as well as lining the hard and soft palates. The anterior 2/3 of the tongue receives somatic sensory innervations from the trigeminal (v) nerve, and taste sensation from the facial nerve (VII), and the glossopharyngeal extends into the anterior 2/3 of the tongue, particularly along the lateral tongue margin, with anastomoses between the IX and V nerves. In this way, the bolus simulator may stimulate the V, VII and IX afferent fibers that are critical for a number of oral sensorimotor behaviors including but not limited to normal food transport, mastication, taste, swallowing, speech production and salivation.

[0225] While the bolus simulator 32, 80, 82 may be positioned on the superior tongue surface 300 and maintained in a stationary position, the user, or caregiver, may also move the bolus simulator within the oral cavity by manually manipulating the handle. For example and without limitation, the bolus simulator may be rotated on the tongue surface, or displaced to make contact with the buccal cavity, hard and soft palates, sub-lingual region, tongue surface, and anterior facial pillar, the latter of which is believed to play a role in eliciting pharyngeal swallowing. Various approaches may also include stroking the bolus simulator along the tongue surface, which may excite both gustatory and somatosensory receptors. The user may also manipulate the bolus simulator as if it were a

masticated piece of food, ready to be swallowed, with the tether preventing actual swallowing of the device. The simulator can also be treated like a lollipop, with the user practicing sucking motions. Flavoring of the bolus simulator may help the user to imagine or conjure that the bolus simulator is a real piece of masticated food, with the scented shield also serving a similar function due to the position of the shield positioned under the nose.

[0226] In use as shown in 54A and B, the bolus simulator shown in FIGS. 99 and 100 is positioned in the mouth relative to the teeth and jaw. The oral device targets the start of the pharyngeal swallow phase. The pharynx is in communication with both the esophagus and the larynx. The device also encourages the user to engage motor functions (chewing, tongue movement, etc.) that may facilitate triggering or initiation of the patterned pharyngeal swallow. The device may also be used by persons with oral preparatory stage dysfunction, such as those with cancer resection, without the oral preparatory phase. The portion of the device that extends between the teeth and lips of the user is as thin as possible to facilitate full closure of the mouth and occlusion of the teeth. At the same time, the shield 214 may be moved and located to position the bolus simulator 98 in the proper location in the mouth.

[0227] After the device is positioned, the user chews or sucks on the air intake conduits 208, acting as a pump, to inflate the bolus simulator 98 by forcing air through the valving mechanism 210 through an inlet into the interior volume, with the bolus simulator 98 positioned on the anterior of the tongue to prevent gagging. The bolus simulator may also be inflated by an external source, such as a squeeze tube or motorized pump. In an alternative embodiment, the user may suck on an air inlet to inflate the bolus simulator. Also in one embodiment, the air intake passageways may be integrally formed as part of the bolus simulator, rather than being spaced therefrom.

[0228] The user then squeezes the bolus simulator 98 with their tongue, with the chewing, sucking and squeezing engaging the motor neurons in the preparatory phase. In addition, any flavorful coating or surface texture may further stimulate

the user. In response to pressure applied to the bolus simulator by the tongue during swallowing, air is forced out of the bolus simulator through the exhaust valve 228, or outlet, and into the mouth of the user, targeting for example the glossopharyngeal and /or superior laryngeal nerves. As the user squeezes the bolus simulator, due to the properties of the bladder such as the skin, the bolus simulator 98 distends out to the back of the tongue, promoting a tongue stripping wave associated with normal swallowing. As the bladder distends, the exhaust valve 228 releases the pressurized gas and directs it to the back of the throat, with the gas pulse creating a somatic stimulus on the site of the glossopharyngeal and superior laryngeal nerve receptive fields which are involved in the triggering of the pharyngeal swallow. The gas pulses may provide a sensation that there is a piece of food in the back of the user's mouth ready to be swallowed, and may trigger the nerves that initiate the involuntary portion of the swallowing sequence. The bladder 98, now flat and empty, retracts upon release of the tongue pressure to its original shape and position, ready for subsequent inflation and deflation cycles to facilitate reestablishment of the neural connections required for a normal swallow. The operation may then be repeated. No fluid, gel or foodstuff is released or positioned in the mouth during operation. Instead, the device simulates a bolus to trigger the patterned response.

[0229] Referring to FIGS. 100A-F, the squeeze bulb 272 is manipulated to force air through the conduit 270, 264, one-way valve 266 and into the bolus simulator 98. The air may then be released from the bolus simulator 98 by manipulation of the tongue, or by applying a pressure with the squeeze bulb that is sufficiently large enough to overcome the pressure release valve 228 so as to thereby open that valve and emit an air pulse from the bolus simulator.

[0230] Referring to FIGS. 42, 43 and 54A and B, the user self-inflates the bolus simulator through the two-way valve 222 by a sucking action. The valve 222 holds a predetermined pressure of fluid, or air in this instance. Upon a swallowing action, pressure from the tongue overcomes the predetermined pressure of the exhaust valve to release the air from the bolus simulator 98.

[0231] Referring to FIGS. 32A and B, during use, the user may actuate the reservoir 74 by pushing fluid from the reservoir 74 through the inlet to the interior volume 72 of the bolus simulator. The bolus simulator may also be filled from the reservoir 74 by way of a sucking action by the user, acting as a pump. The shield 14 may be scented. As the user squeezes the bolus simulator 98, due to the properties of the bladder such as the skin, the bolus simulator distends out to the back of the tongue, promoting a tongue stripping wave associated with normal swallowing. As the bolus simulator collapses, the fluid is forced from the interior volume 72 through the outlet and back into the reservoir 74. At the same time, gas may be directed through the gas outlet 68, segregated from the interior volume, to the back of the throat, with the gas pulse creating a touch sensation on the site of the glossopharyngeal nerve and/or the superior laryngeal nerve, which is the final trigger for the pattern response and a pharyngeal swallow. The bolus simulator 82, with its interior volume diminished, flattens and retracts upon release of the tongue pressure to its original position, ready for subsequent filling and evacuation cycles to facilitate reestablishment of the neural connections required for a normal swallow. No liquid, gel or foodstuff is released or positioned in the mouth during operation, but rather travel back and forth between the bolus simulator and the reservoir. Instead, the device simulates a bolus to trigger the patterned response.

[0232] Referring to FIGS. 27-32, during swallowing, the fluid may flow from the bolus simulator 82 to the reservoir 74, thereby allowing the bolus simulator interior volume to be substantially evacuated and cuing the user that there is no more food. This action may be combined with gas pulses being automatically directed to portions of the mouth due to the same stripping movement of the tongue. The ability of the fluid to escape from the bolus simulator to the reservoir provides a safety function preventing a bursting of the bolus simulator in the event that a user inadvertently applies an excessive pressure to the bolus simulator.

[0233] Referring to FIGS. 26A and B and 114, the user's tongue manipulates the liquid filled bolus simulator 82 to position it as if it were going to be swallowed. A scent may be emitted from the shield 14 below the user's nose,

which may further aid in saliva generation and/or induce swallowing. The tongue moves in a stripping wave movement that moves the bolus simulator toward the back of the mouth, with the one-way exhaust valve 88 then releasing the gas to the designated area of the user's mouth and throat. Alternatively, the gas may be delivered through a conduit, not constrained by valves, from an external gas supply, for example by delivering gas pulses through the ports 68. As shown in FIG. 94, conduits 192 may extend laterally from the bolus simulator and deliver a gas pulse to the sides of the user's mouth.

[0234] The deformable bolus simulator 82, whether variable in volume or when configured as a hydrostat as shown in FIG. 114, provides an opportunity for subtle movements of the tongue to be met by changes in the local sensory environment, which in turn may facilitate changes in tongue posture/position and corresponding oral sensory input. The user may participate in intensive oral sensorimotor transformations by maintaining the deformable bolus simulator on the superior surface of the tongue, and thereby simulate various properties of a food/liquid bolus to be swallowed. The device may also be used as a preventative measure, for example to maintain a strong and healthy swallow function in the elderly population, for example by helping them to maintain their ability to eat and drink.

[0235] Referring to the embodiment of FIGS. 44 and 45, the oral device includes conduits 112 for delivering air pulses, together with positioning a bolus simulator in the mouth of the user. The conduits and functioning of the device are disclosed and described in U.S. Applications 13/040,048 and 13/040,058, both filed March 3, 2011, the entire disclosures of which are hereby incorporated herein by reference. The bolus simulator may be configured as any of the embodiments disclosed herein. In this embodiment, the air pulses may be directed to areas of the mouth and throat at locations spaced from the bolus simulator.

[0236] In an alternative mode of operation, and referring to FIGS. 90-91, the bolus simulator 82 is positioned between the molars 400 on an affected side of the mouth, for example a stroke victim suffering from dysphagia. Using the muscles

on the unaffected side of the mouth, the bolus simulator 82 is compressed between the teeth 400, causing the simulator to be distended laterally. The distended portion applies a force to the side of the cheek on one side, and to the side of the tongue 302 on the other, thereby providing a tactile stimulation associated with a chewing action that may facilitate neural activation and potentially neural modulation with associated behavioural improvement in oral, chewing and swallowing functions.

ASSEMBLY AND MANUFACTURE

[0237] FIGS. 1-17 show various molds used to manufacture various embodiments of oral devices herein described. Referring to FIGS. 1A and B, a pair of mold halves 600, 602 are shown. A first mold half 600 has mold stand offs 604, a bolus simulator cavity 606 with a seal-off lip 608 formed around a perimeter thereof, tether and shield cavities 610, 612 and a cavity 614 for an extraoral coupling member. Various bolt holes 616 and alignment pins 618 are provided to interface and couple the two mold halves.

[0238] In operation, overmolding operations may be employed to form the intraoral portions, extraoral portions, and/or to join the intraoral and extraoral portions. For example, as shown in FIGS. 3-5, a handle adapter 620 and flavored core 622 are disposed as inserts between the mold parts 600, 602. A material, such as RTV Silicone, is then overmolded so as to encapsulate those components. As shown in FIG. 5, insert locators 624 position the core 622 and adapter 620 in the mold. The mold halves 600, 602 define the shape and contour of the bolus simulator, and may provide openings, for example, to the flavored inner core as shown in FIG. 6. The handle adapter 620, or extraoral coupling member may be coupled to a handle 6, for example with a set screw, snap-fit or interference fit. Mold gates and vents are provided in one of the mold halves, with the perimeter ridge providing a positive seal-off at the mold parting lines.

[0239] Alternatively, as shown FIGS. 7A-C, a mold configuration is shown with a handle adapter 630, but wherein the bolus simulator is formed as a solid,

homogenous component. Referring to FIGS. 8A-C, a handle insert 632 may be positioned between the mold halves with a shield and bolus simulator being overmolded over the support structure of the handle insert 632. A handle 6 and shield 14 is then coupled to the insert 632 as shown in FIG. 9, for example by sliding the handle onto the insert.

[0240] To provide for separable mold halves, and referring to FIG. 10, a 7 degree ramp cavity seal-off 301 may be provided, which allows clamping bolts to be oriented substantially perpendicular to the mold parting lines. A removeable piece 303 includes guides allowing disassembly from the main mold components 305. In addition, dovetail locking interfaces 640, shown in FIGS. 11 and 12, provide an interlocking mechanism between a pair of first mold halves 642 used to mold the bolus simulator, and a system of second mold components 644 used to mold the shield. Alternatively, as shown in FIGS. 13 and 14, the first and second pairs of mold halves may be coupled with bolts 646 extending perpendicular to the first set of clamping bolts 648.

[0241] With respect to an embodiment incorporating a self-inflating bolus simulator, as shown in FIGS. 15, 16 and 18, the handle 6 may be made of cast urethane, with a pair of fluid conduits 56 formed interiorly of the handle. Each conduit has an inlet port 60 formed adjacent a distal end of the handle. As shown in FIGS. 17A and B, a pair of intermediate mold halves 660, 662 are used, with a gate 664 and a vent 668 communicating with the mold cavity. A core 670, including a pair of metal rods 672 and an end piece 674 for the cutout for the center of the shield structure, are disposed between the mold halves, with paths 663 provided for the metal rods 672 and a pocket 667 for the insert 674. After the handle is molded, a pair of one-way inlet valves 64, shown as duck-bill valves in FIG. 20, are insert molded with a mold clamped over the handle. The valves are formed by using cores 680 (one shown) that are inserted into the handle opening prior to closing the mold halves around the handle as shown in FIG. 22. After the valves 64 are molded, a slit is cut in the end of each valve, for example using a razor. The cores 680 are then extracted through the slit. The final step is to mold

the bolus simulator using a lost core wax insert 682, shown in FIGS. 21, to form the inside contour as well as the one-way exhaust valve, configured as a duck bill valve. The wax core 682 is molded separately.

[0242] In some embodiments, the oral device, including the handle, tether, shield and bolus simulator are constructed as an inseparable assembly with overmolded silicone subcomponents, which may provide desired material strengths and durabilities at a minimum cost by eliminating some post molding assembly. Alternatively, as disclosed, one or more, including all, of the bolus simulator, tether and shield may be separable, removable and replaceable, for example by replacing one or more components that have lost their flavouring.

[0243] In some embodiments, the oral device has both lateral and vertical symmetry which helps to eliminate ambiguity in device placement in the user's mouth, although it should be understood that devices may be constructed without such symmetry to address additional functionalities. It should be understood that one or more, including all, of the bolus simulator, tether and shield components may be flavoured.

[0244] Although the present invention has been described with reference to preferred embodiments, those skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. As such, it is intended that the foregoing detailed description be regarded as illustrative rather than limiting and that it is the appended claims, including all equivalents thereof, which are intended to define the scope of the invention.

CLAIMS

1. An oral device comprising:
an extraoral handle defining a longitudinal axis; and
a bolus simulator connected to said extraoral handle, wherein the bolus simulator and extraoral handle are moveable along said longitudinal axis between a use position, wherein the bolus simulator is disposed in an oral cavity, and a non-use position, wherein the bolus simulator is removed from the oral cavity, the bolus simulator comprising a bottom engageable by the user's tongue, an opposite top and a peripheral side disposed between the bottom and top, wherein said bolus simulator comprises a non-removable outer jacket having an exterior surface defining said bottom and top, an interior surface defining a cavity, and a reinforcement member comprising a ring coupled to said jacket and extending around said peripheral side of said bolus simulator, wherein said ring defined a central opening having an axis perpendicular to said longitudinal axis, wherein said jacket surrounds said ring and covers an entirety of said central opening, wherein said cavity is a closed volume and not in fluid communication with said exterior surface during use such that any material contained in said cavity cannot be swallowed or aspirated.
2. The oral device of claim 1 wherein said bolus simulator further comprises a core disposed inside of said jacket.
3. The oral device of claim 1 wherein said exterior surface of said jacket is textured.
4. The oral device of claim 3 wherein said exterior surface of said outer jacket comprises opposite top and bottom exterior surfaces.
5. The oral device of claim 4 wherein each of said top and bottom exterior surfaces is textured.
6. The oral device of claim 3 further comprising a hydrophilic coating covering at least a portion of said exterior surface.
7. The oral device of claim 1 further comprising a pair of legs extending from said ring and forming a tether between said bolus simulator and said extraoral handle.

8. An oral device comprising:
 - an extraoral handle;
 - a bolus simulator comprising a non-removable jacket having a textured exterior surface and defining a closed interior cavity not in fluid communication with said exterior surface during use such that any material contained in said closed interior cavity cannot be swallowed or aspirated, a reinforcement member comprising a ring coupled to said jacket and extending around at least a portion of a periphery of said bolus simulator, wherein said ring defines an opening having a central axis, and a hydrophilic coating covering at least a portion of said exterior surface; and
 - a tether connecting said extraoral handle and said bolus simulator, wherein said tether and said extraoral handle define a longitudinal axis perpendicular to said central axis of said opening of said ring.
9. The oral device of claim 1 or claim 8 wherein said ring is made of a different material than said jacket.
10. The oral device of claim 8 wherein said tether comprises a pair of legs extending from said ring.
11. The oral device of claim 7 or claim 10 further comprising a casing encapsulating said pair of legs.
12. The oral device of claim 11 when dependent on claim 7 further comprising a coating covering at least a portion of an exterior surface of said casing.
13. The oral device of claim 7 or claim 8 further comprising a shield positioned between said tether and said extraoral handle.
14. The oral device of claim 1 or claim 8 wherein said cavity of said jacket is filled with a fluid.
15. The oral device of claim 14 when dependent on claim 1, wherein said fluid comprises air.
16. The oral device of claim 3 or claim 8 wherein said textured exterior surface comprises a plurality of depressions formed therein.
17. The oral device of claim 3 or claim 8 wherein said textured exterior surface comprises a plurality of raised portions.

18. The oral device of claim 6 or claim 8 wherein said hydrophilic coating is removable wherein said at least said portion of said textured exterior surface covered by said hydrophilic coating is exposed.
19. The oral device of claim 6 or claim 8 wherein said hydrophilic coating comprises a flavourant.
20. The oral device of claim 1 or claim 8 wherein said jacket is made of a silicone material and said reinforcement member is made of a thermoplastic material.
21. The oral device of claim 20 wherein said jacket and said reinforcement member are co-moulded.
22. The oral device of claim 1 or claim 8 wherein said reinforcement member and said jacket are made of the same material.
23. The oral device of claim 1 or claim 8 wherein said cavity of said jacket is filled with a gel.
24. The oral device of claim 8 wherein said textured exterior surface of said jacket comprises opposite textured top and bottom exterior surfaces.
25. The oral device of claim 1 or claim 8 wherein said jacket is flexible, wherein said bolus simulator is deformable between various shapes, and wherein said interior cavity is changeable between various shapes corresponding to said various shapes of said deformable bolus simulator.

Trudell Medical International
The University of Western Ontario
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

FIG. 1A

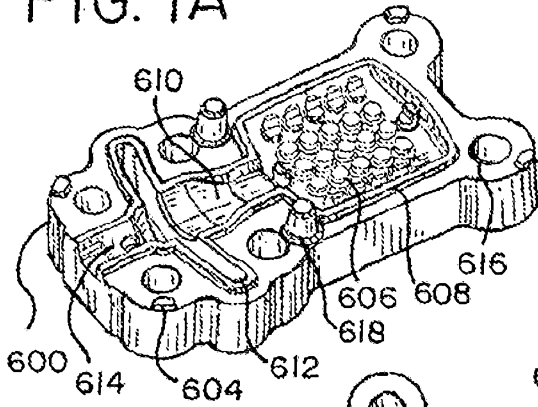


FIG. 1B

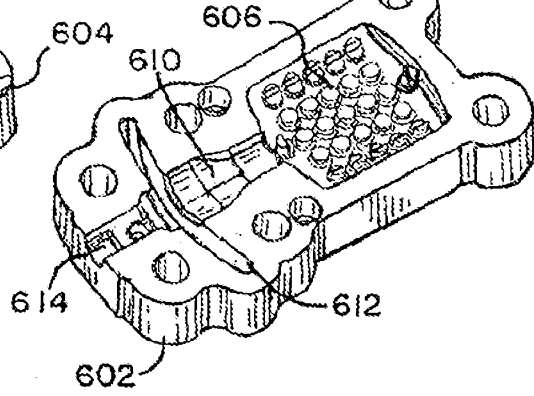


FIG. 2

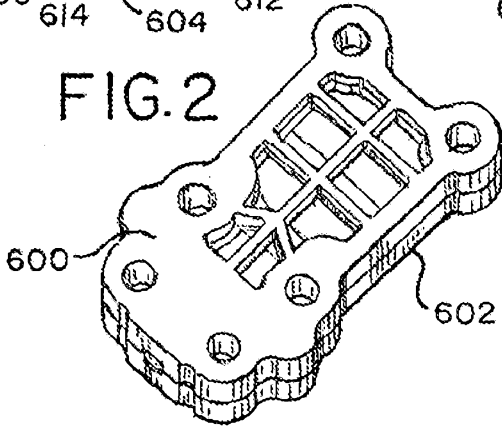


FIG. 3

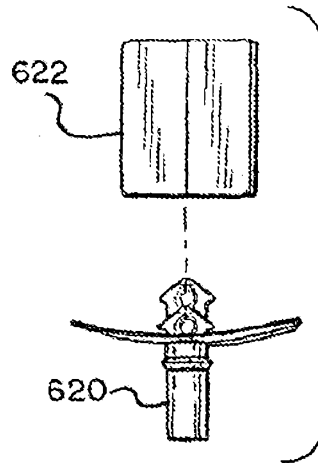


FIG. 4

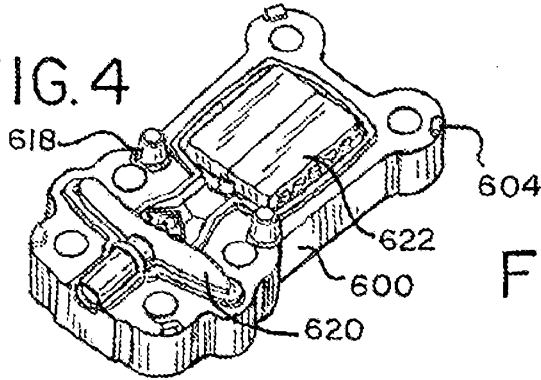


FIG. 6

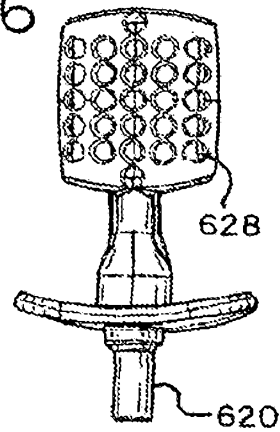


FIG. 5

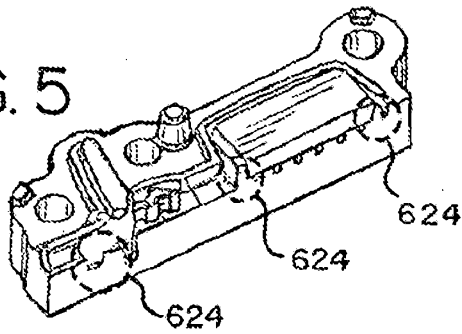


FIG. 7A

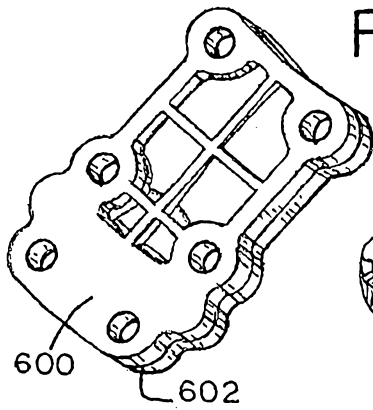


FIG. 7B

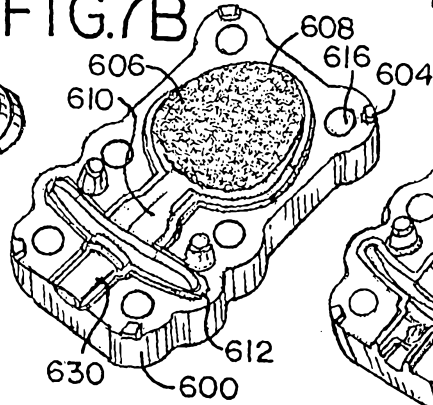


FIG. 7C

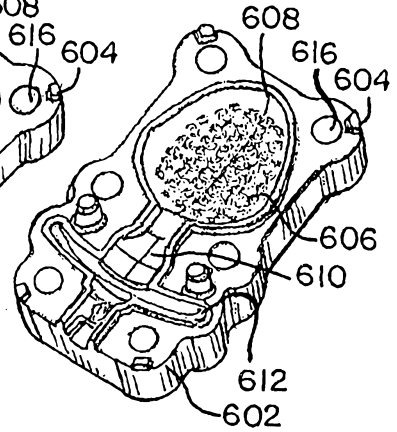


FIG. 8A

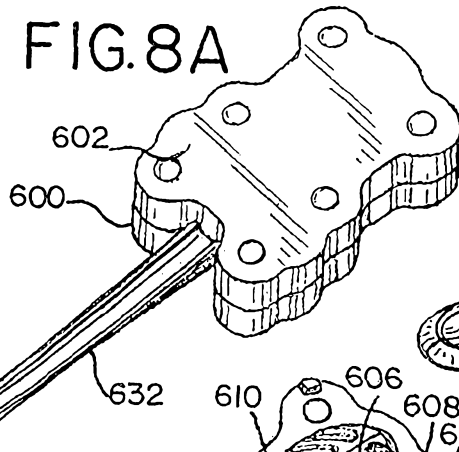


FIG. 9

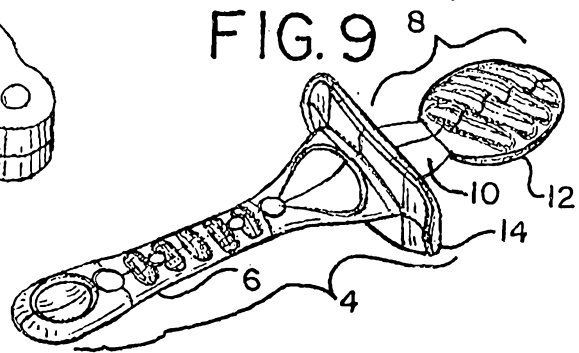


FIG. 8B

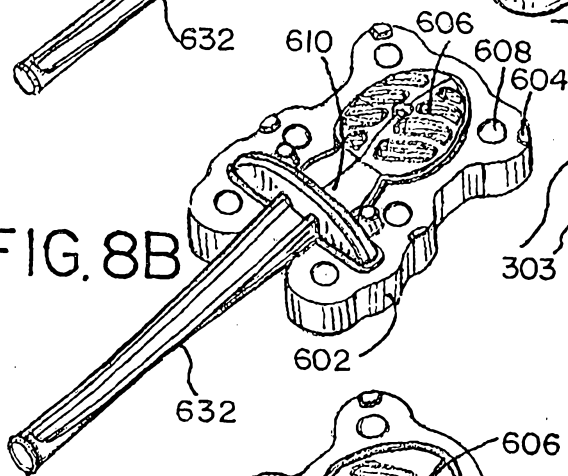


FIG. 10A

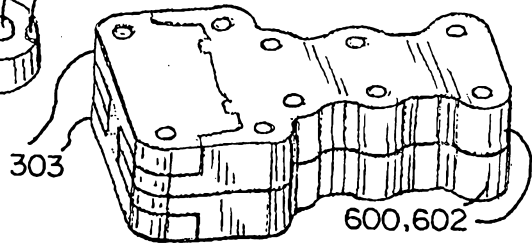


FIG. 8C

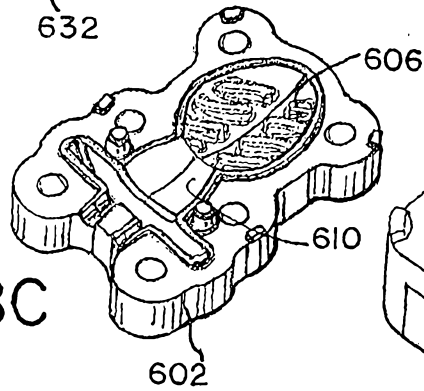


FIG. 10B

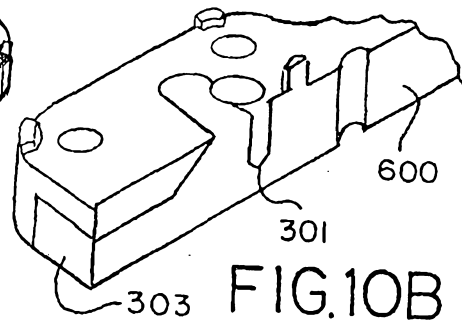


FIG. 11

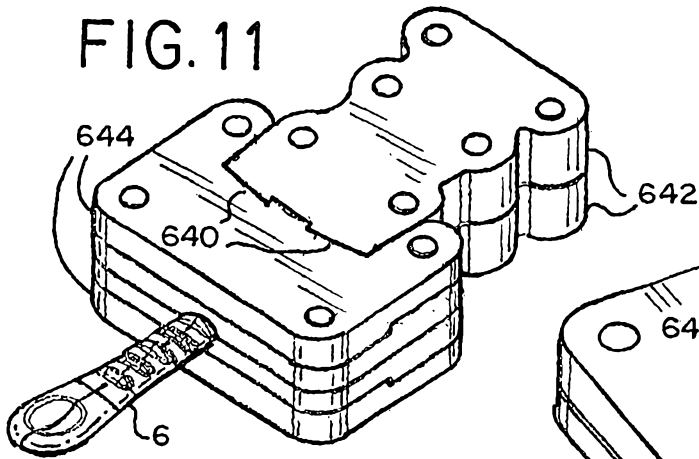


FIG. 12

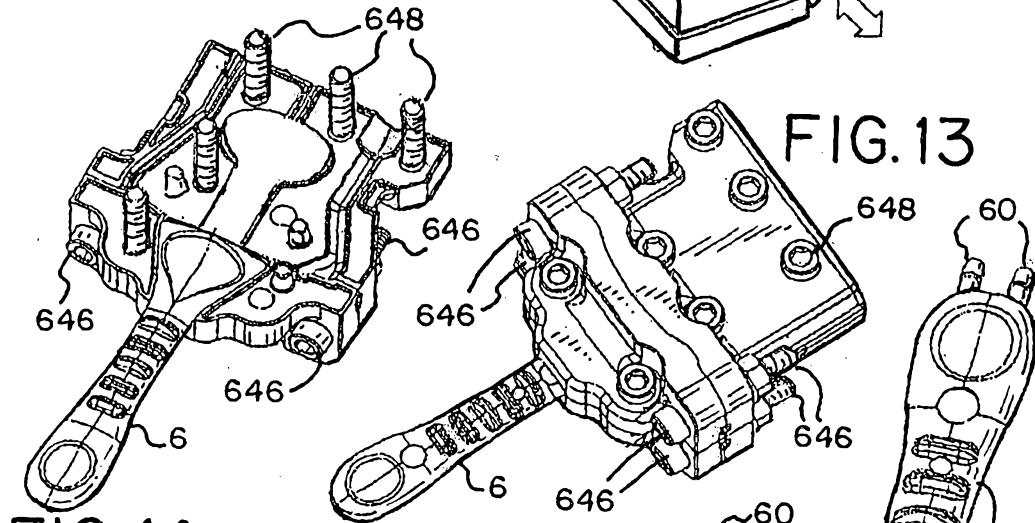
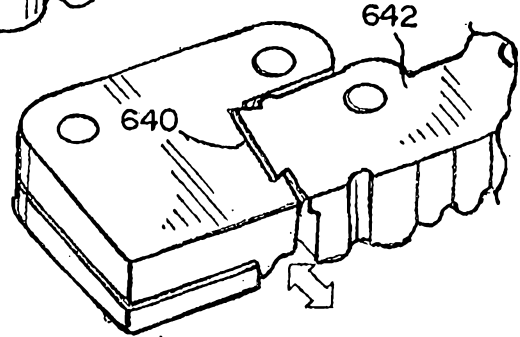


FIG. 14

FIG. 16

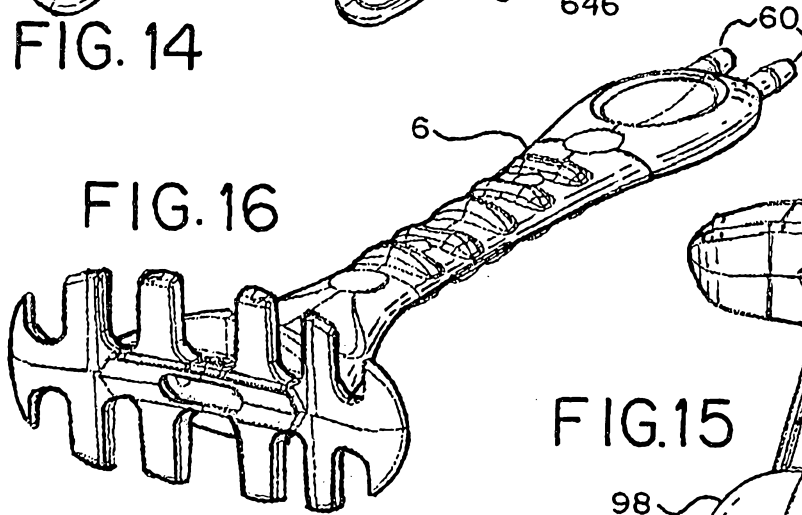
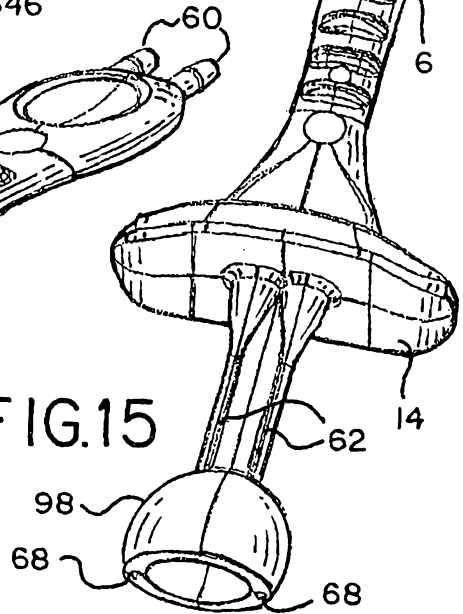
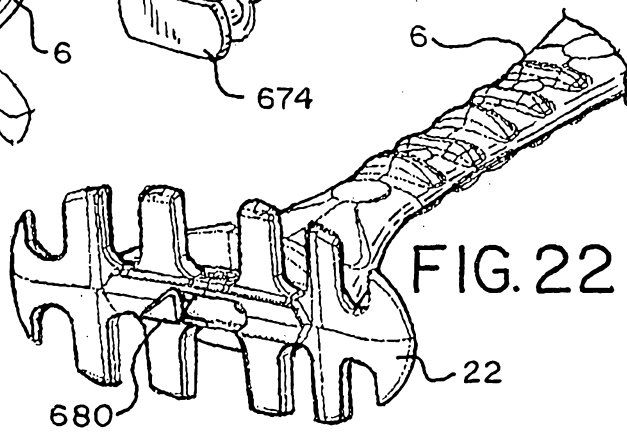
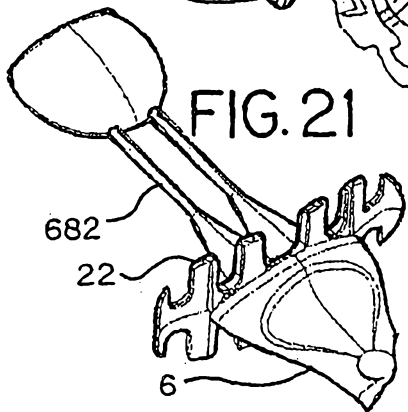
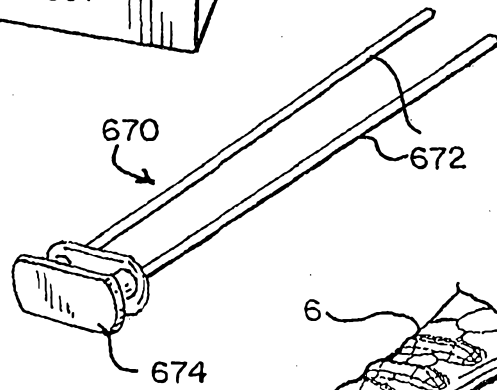
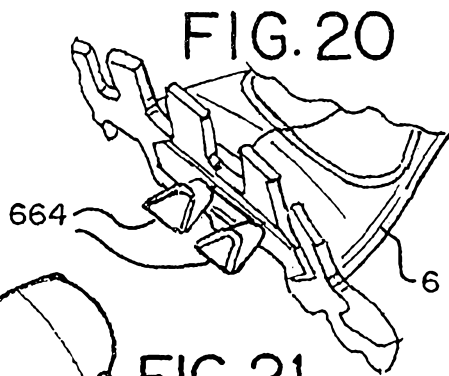
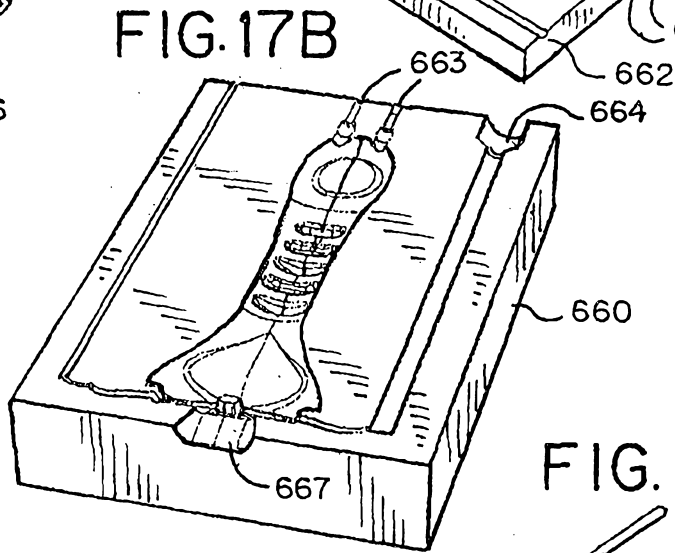
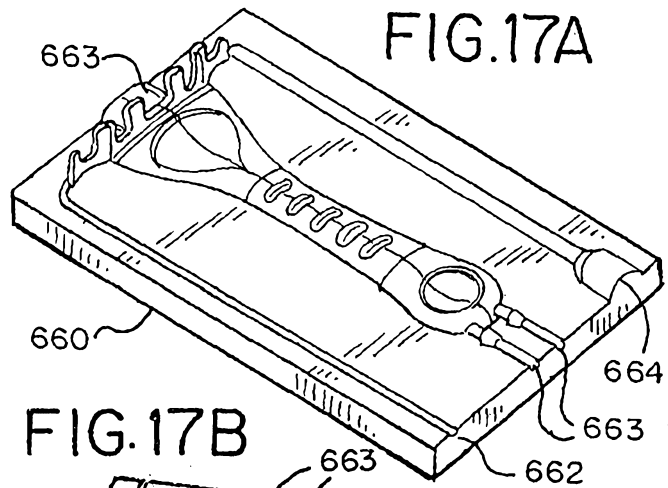
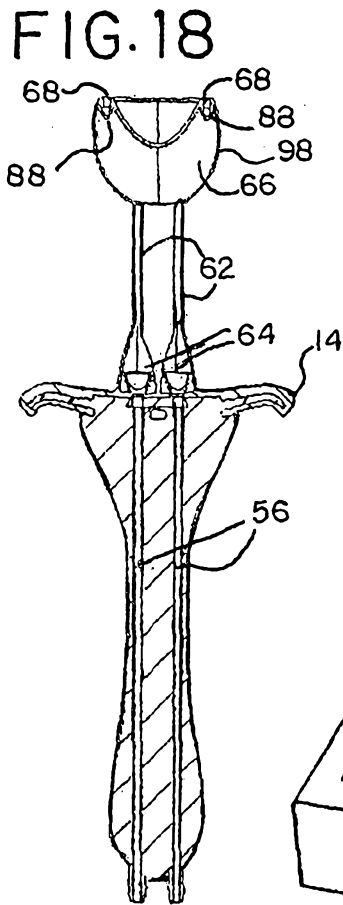


FIG. 15





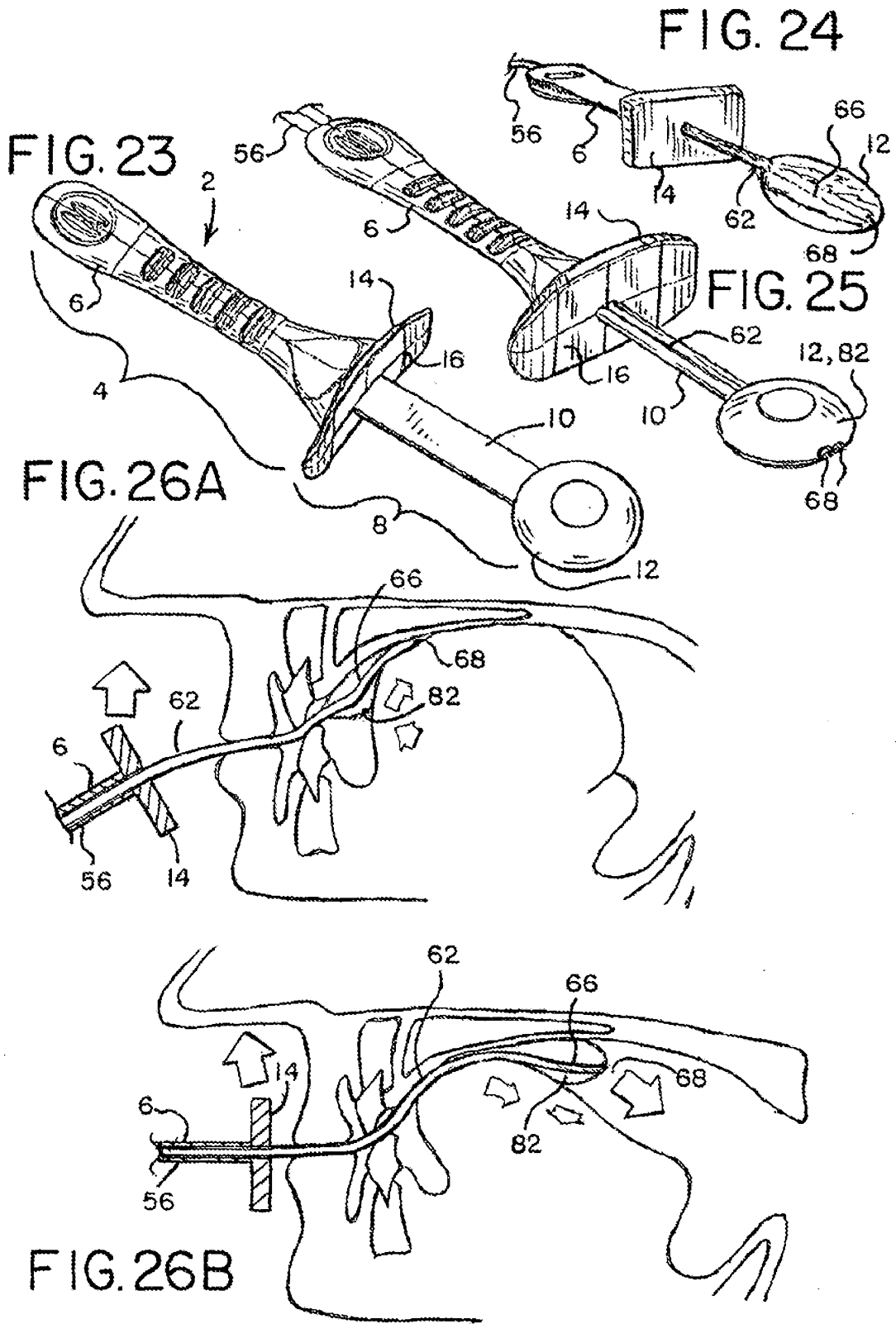


FIG. 27

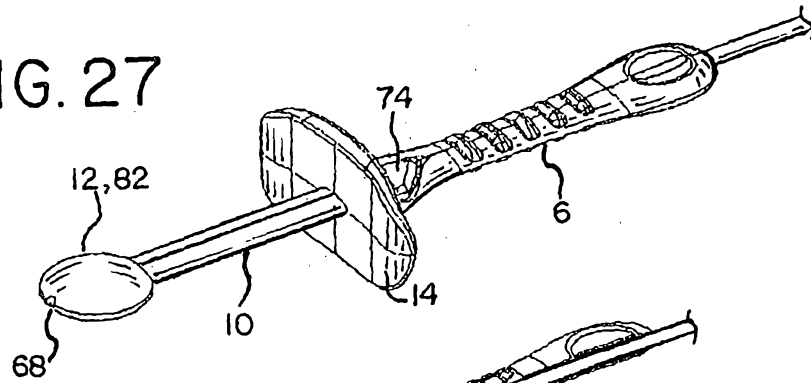


FIG. 28

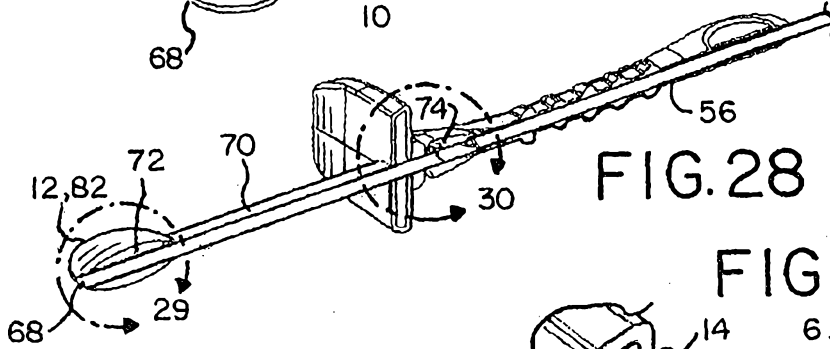


FIG. 30

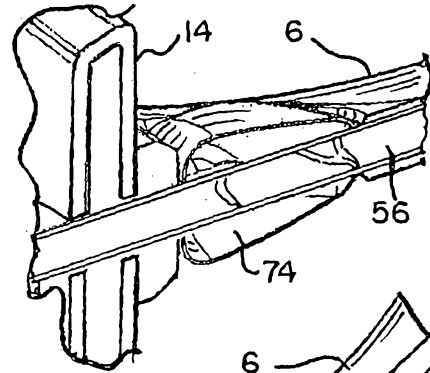


FIG. 29

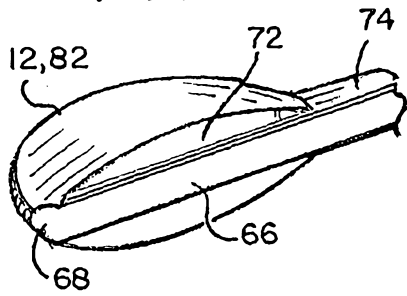


FIG. 31

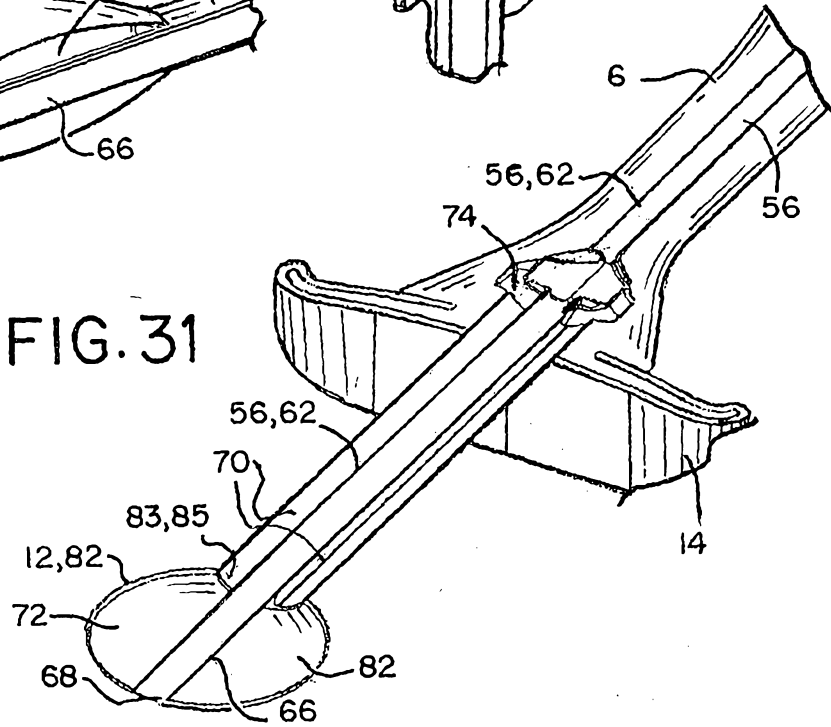


FIG. 32A

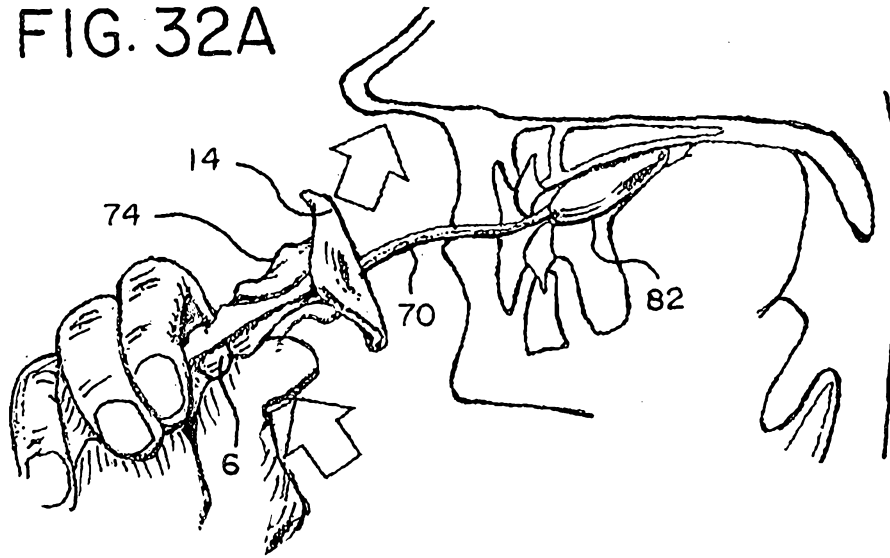


FIG. 32B

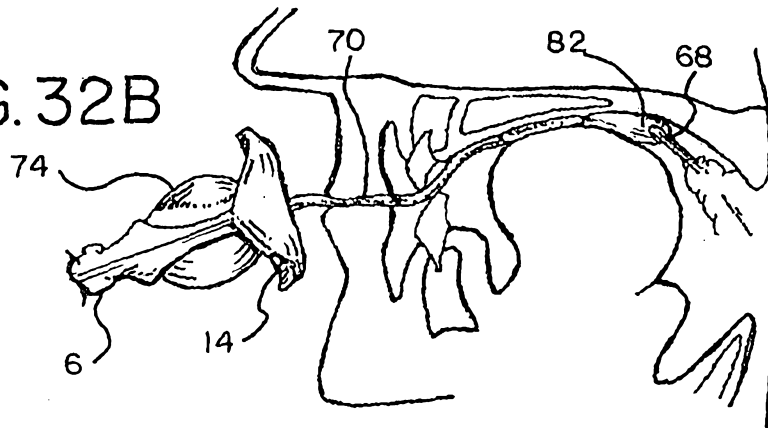


FIG. 33

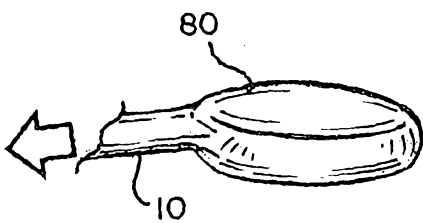


FIG. 34

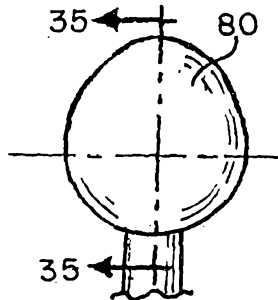
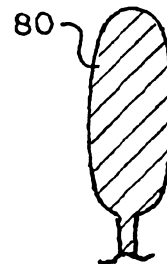


FIG. 35



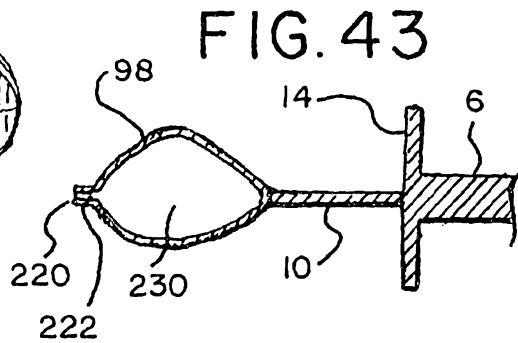
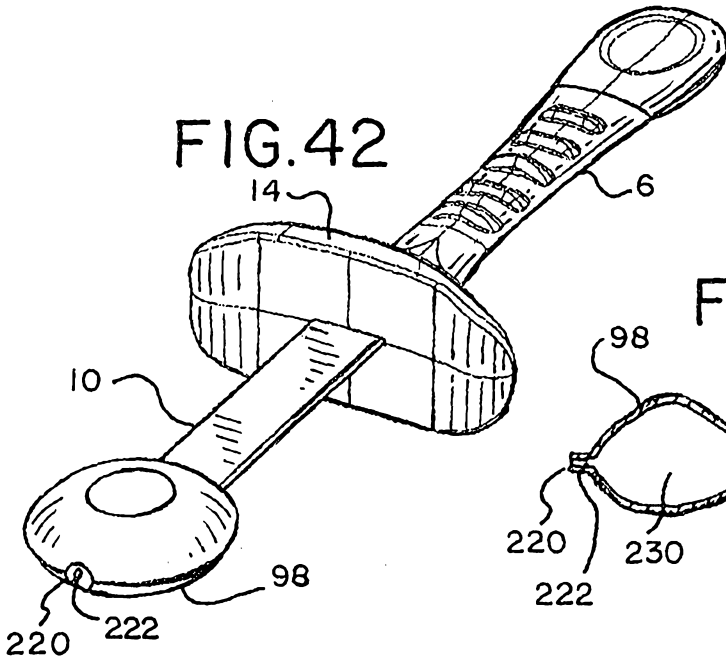
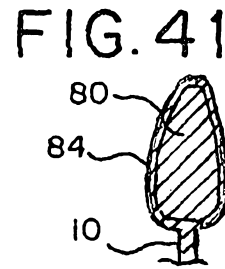
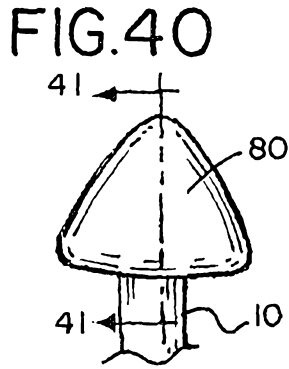
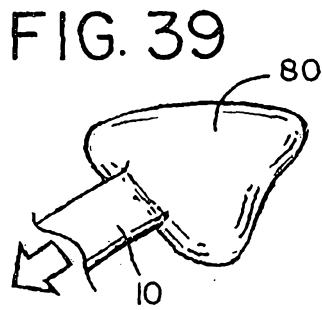
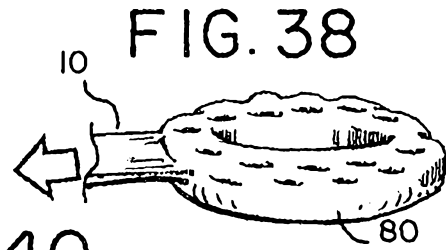
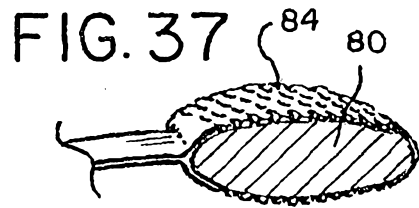
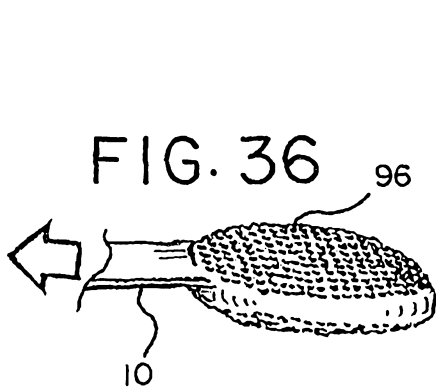


FIG.44A

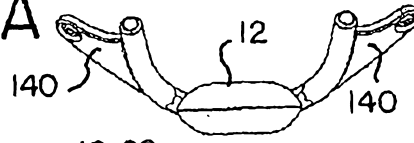


FIG.44D

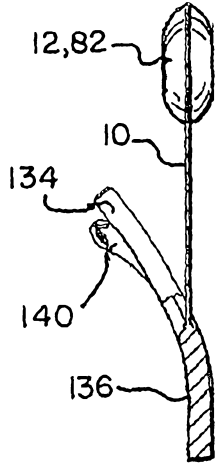


FIG.44E

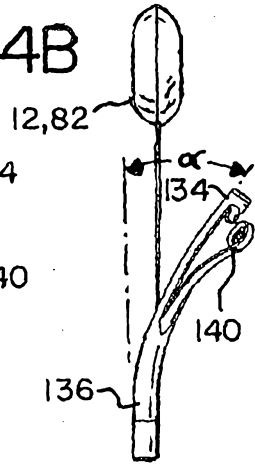


FIG.44B

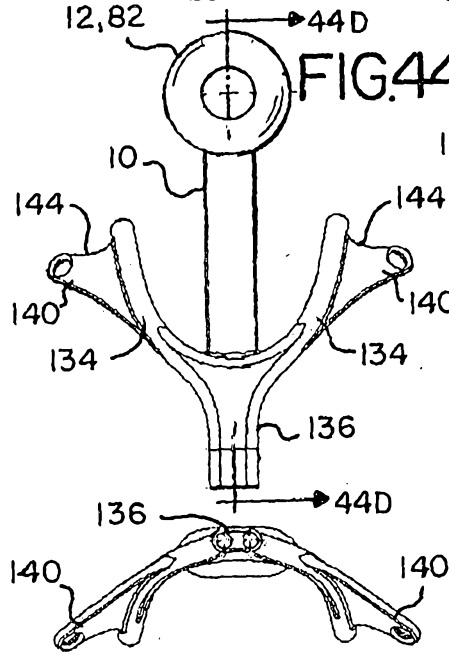


FIG.45A

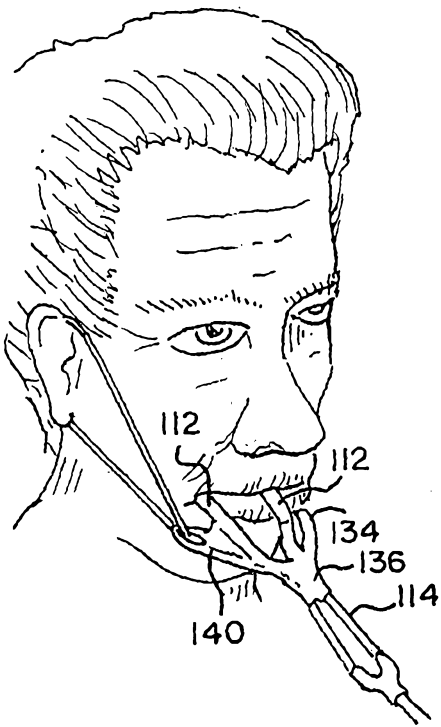
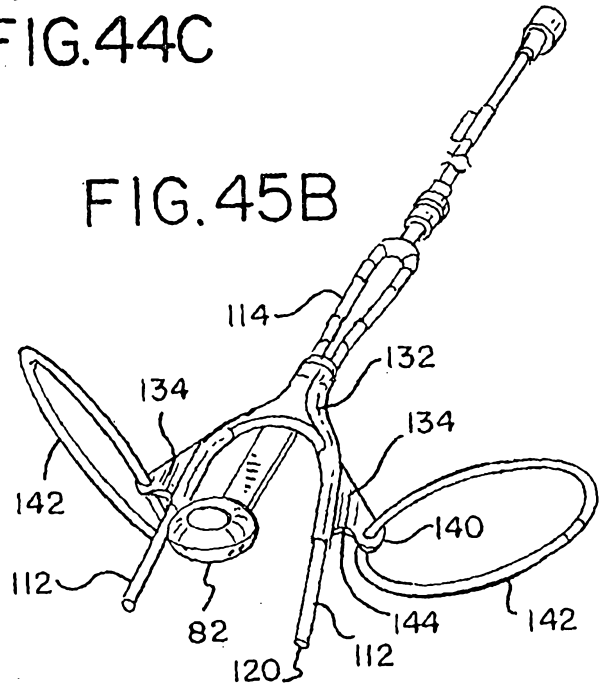


FIG.44C

FIG.45B



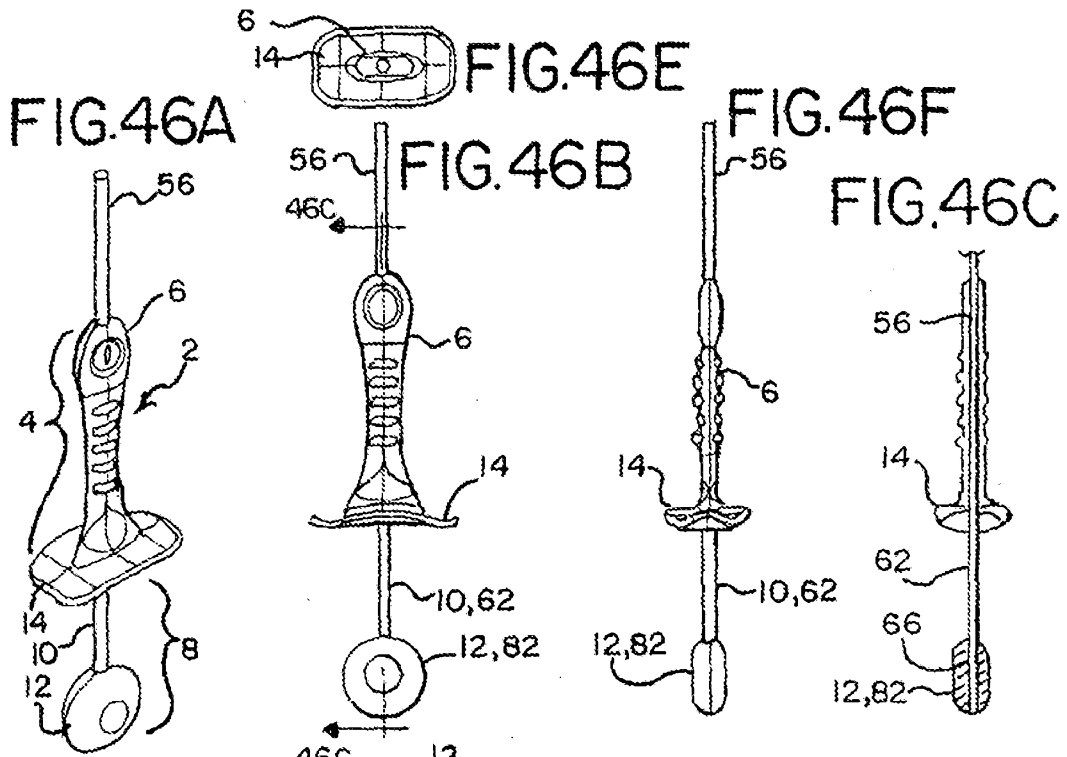


FIG. 46D FIG. 47E

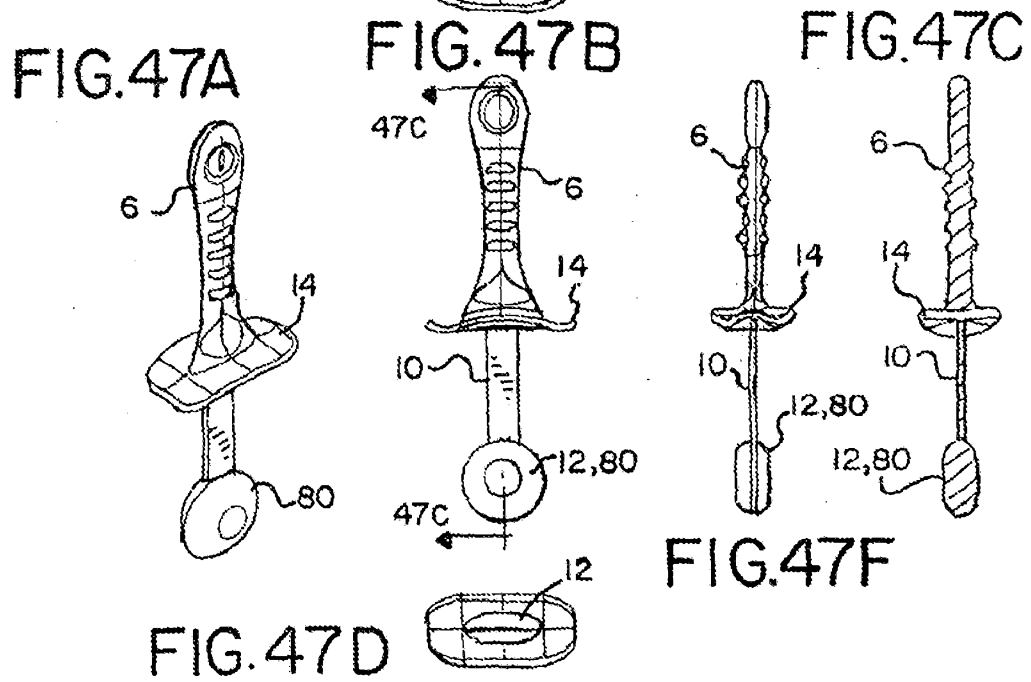


FIG. 48A

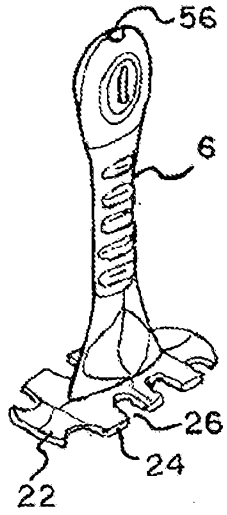


FIG. 48B

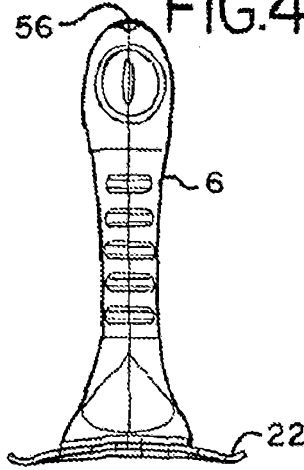


FIG. 48C

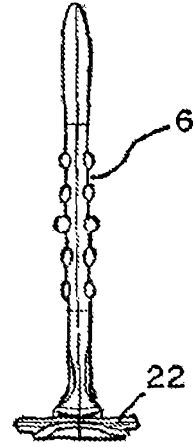


FIG. 48D

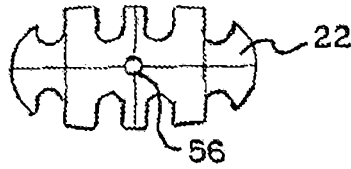


FIG. 49A

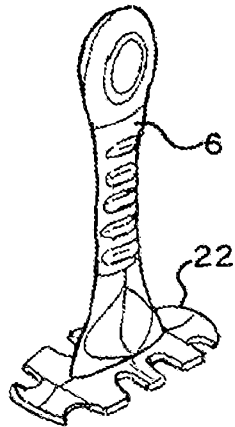


FIG. 49B

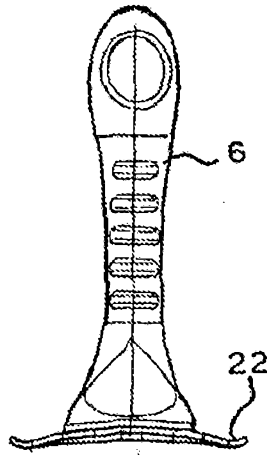


FIG. 49C

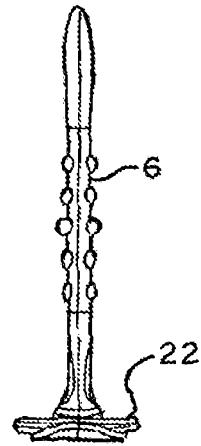


FIG. 49D

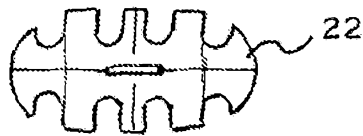


FIG. 50A

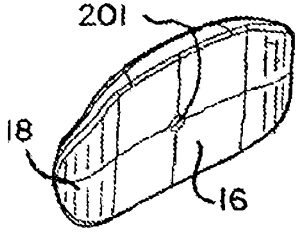


FIG. 50B

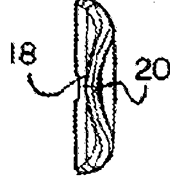


FIG. 50C

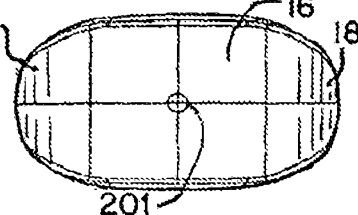


FIG. 50D



FIG. 50E

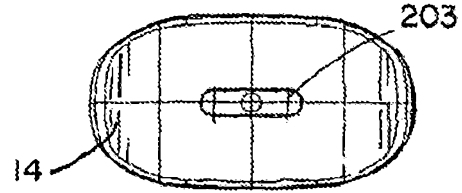


FIG. 51A

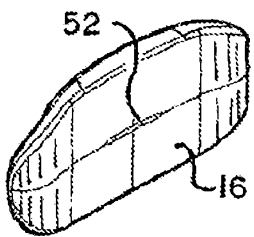


FIG. 51C

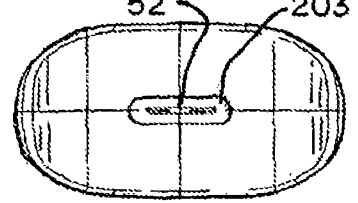


FIG. 51D

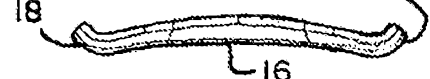


FIG. 51B

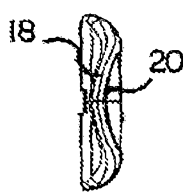


FIG. 51E

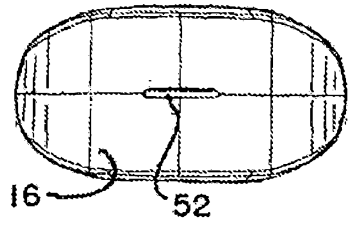


FIG. 52A

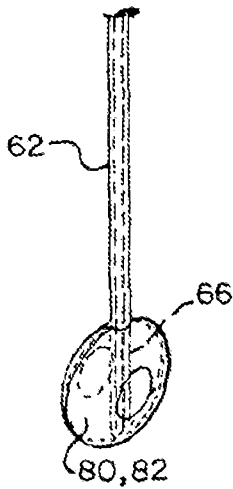


FIG. 52B

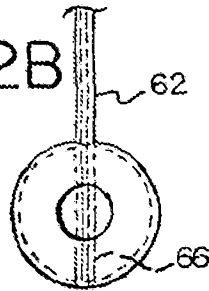


FIG. 52E

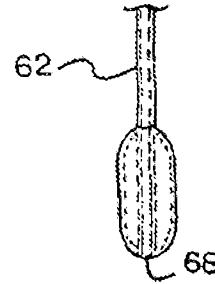


FIG. 52C

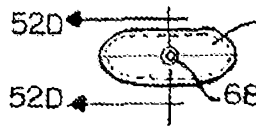


FIG. 52D

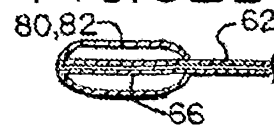


FIG. 53A

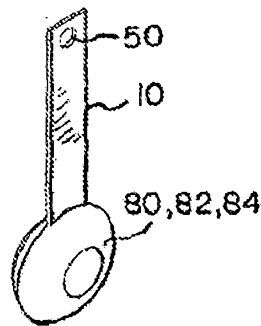


FIG. 53B

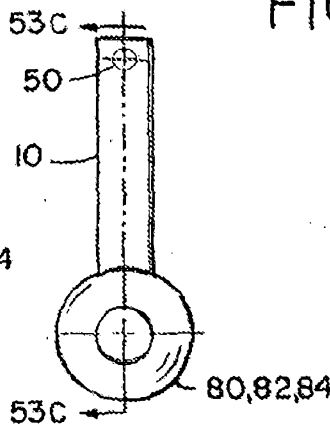


FIG. 53E

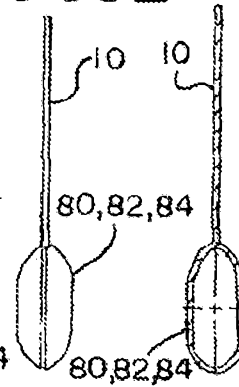


FIG. 53D

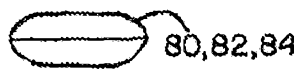


FIG. 53C

FIG. 54B

FIG. 54A

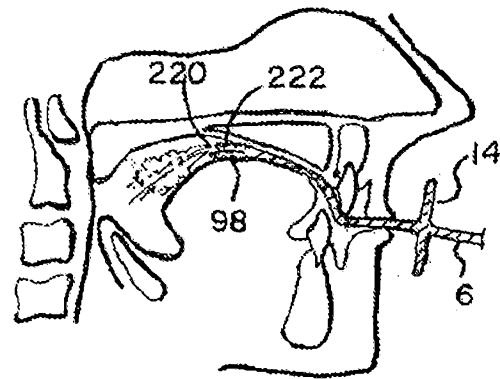
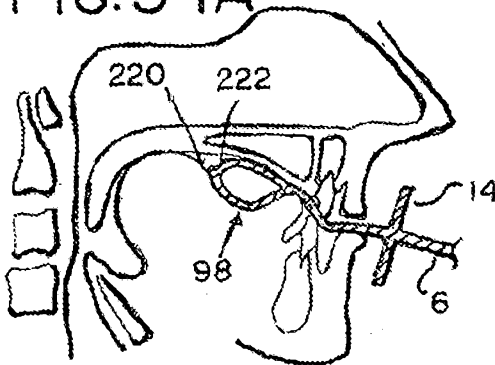


FIG. 55A

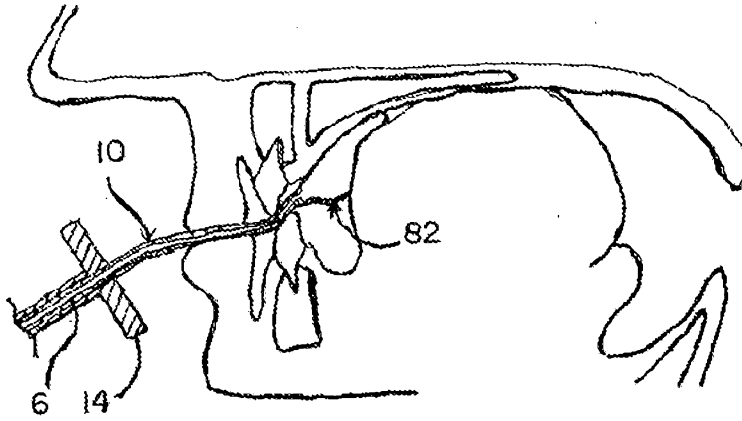


FIG. 55B

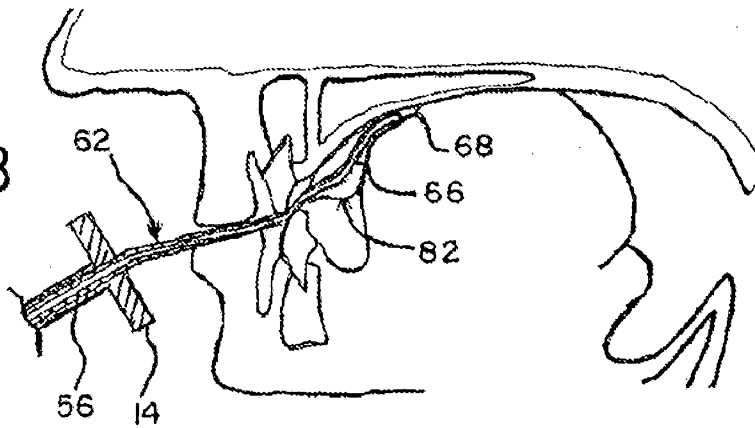


FIG. 56A

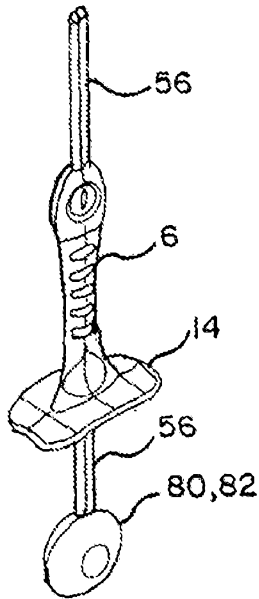


FIG. 56B

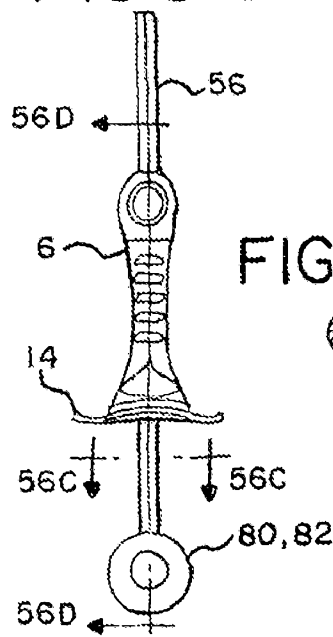


FIG. 56C



FIG. 56D

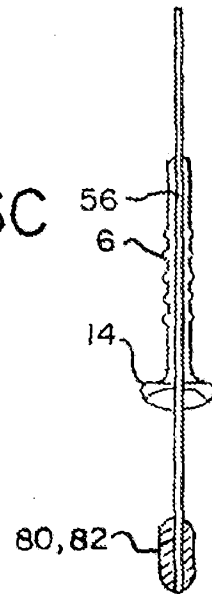


FIG. 57A

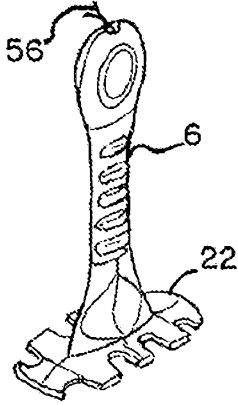


FIG. 57B

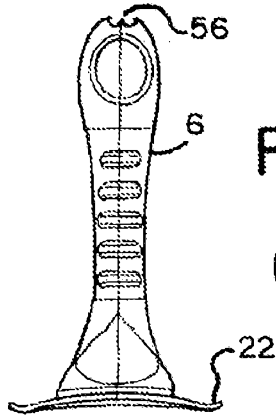


FIG. 57C

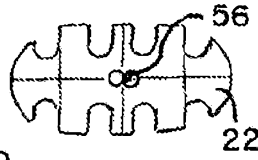


FIG. 57D

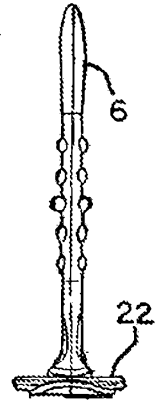


FIG. 58A

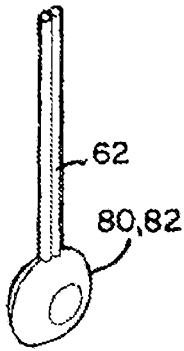


FIG. 58B

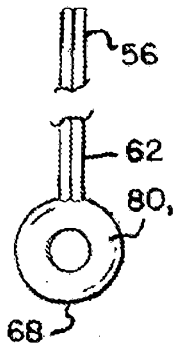


FIG. 58C

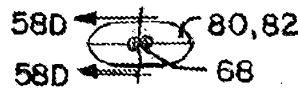


FIG. 58D

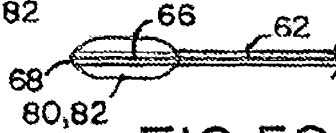


FIG. 58E

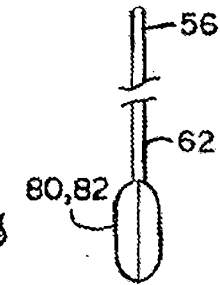


FIG. 59A

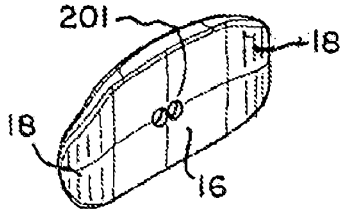


FIG. 59C

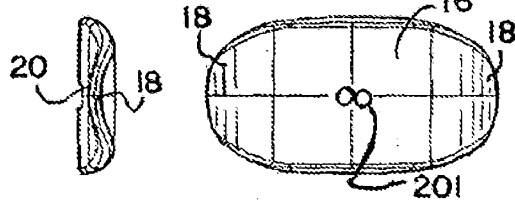
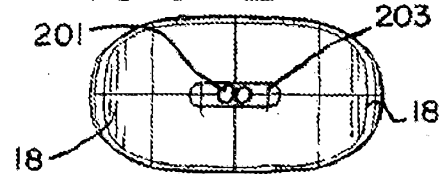


FIG. 59D



FIG. 59E



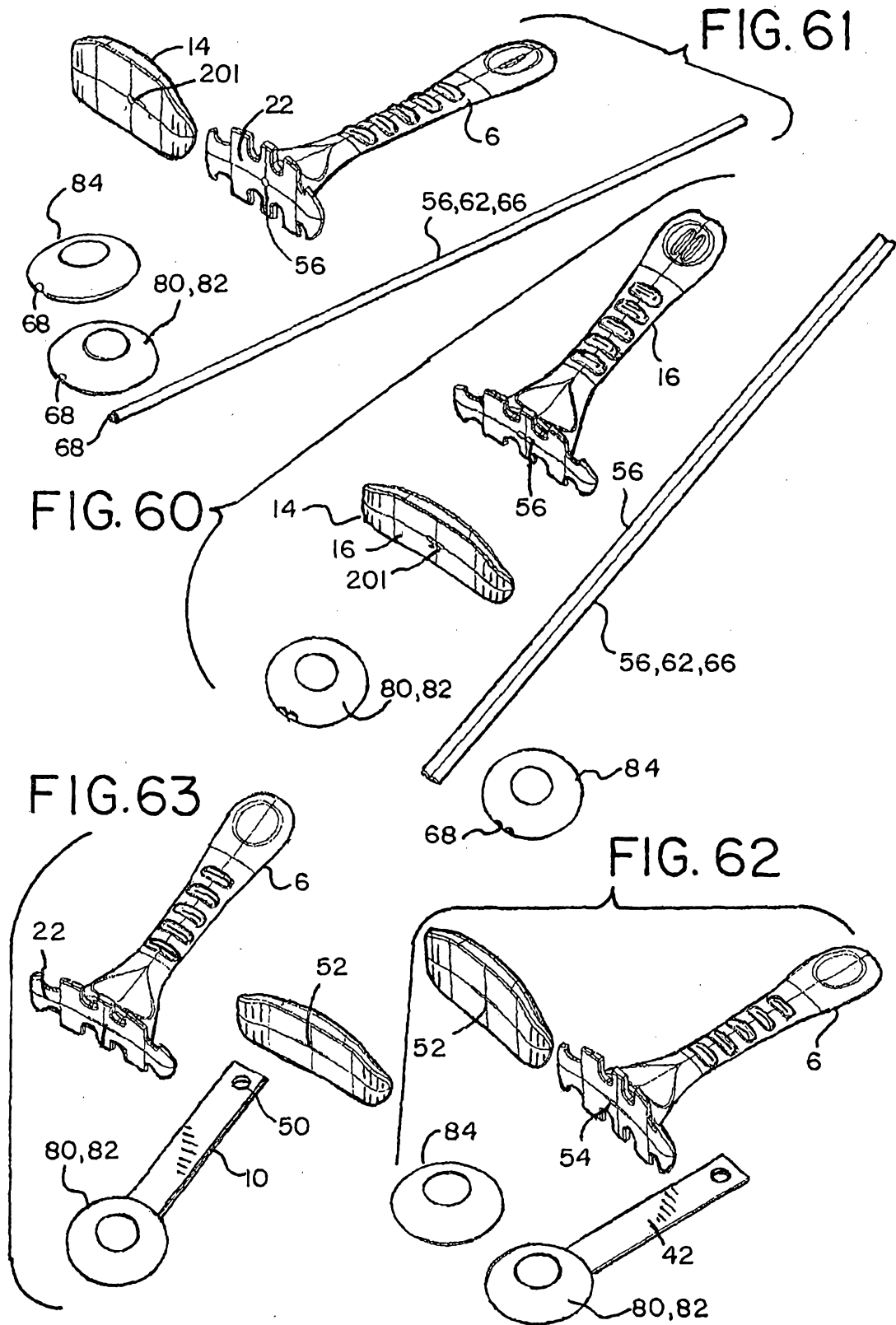


FIG. 64

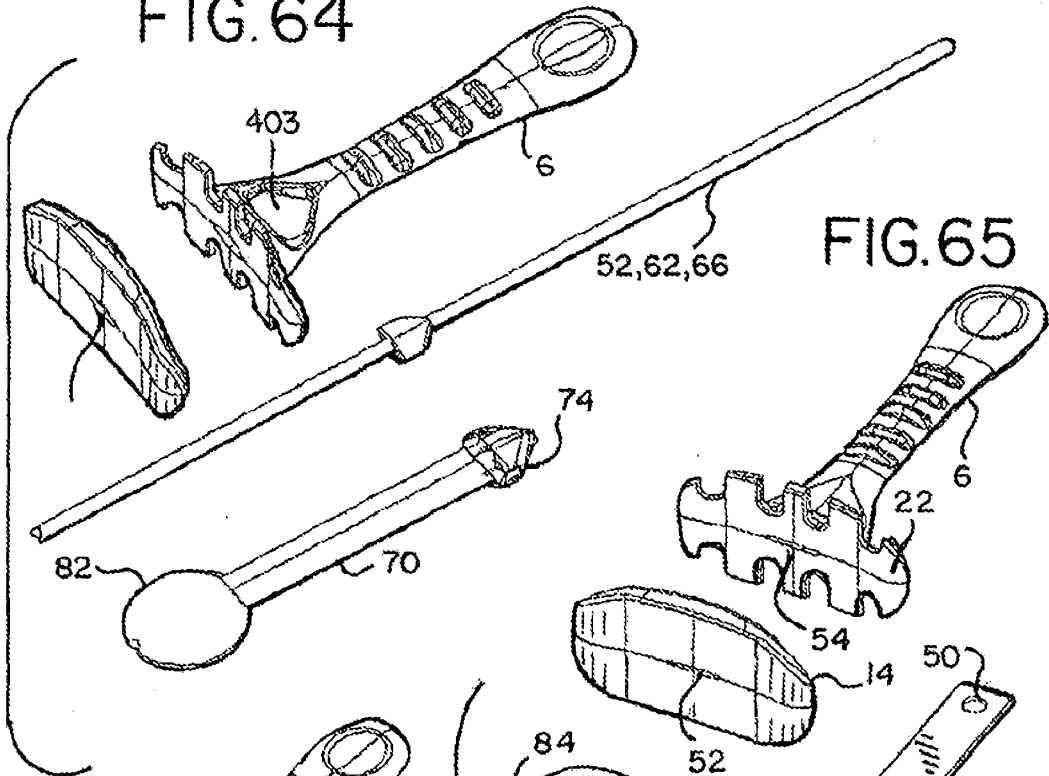


FIG. 65

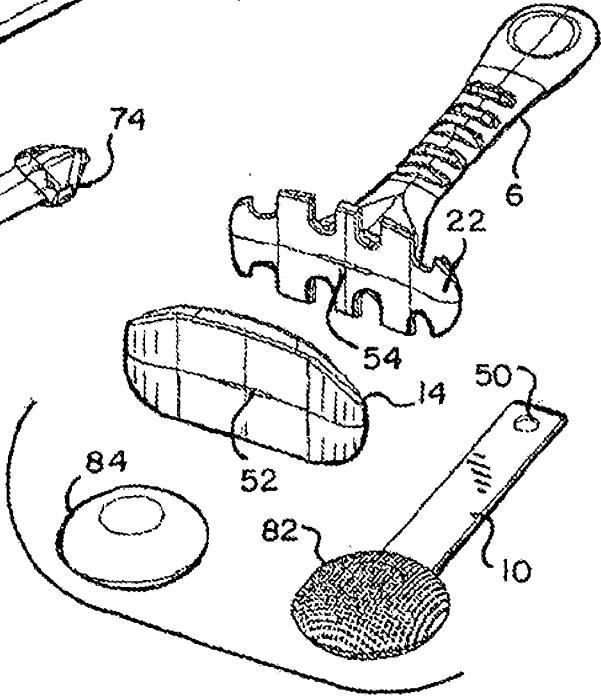


FIG. 66

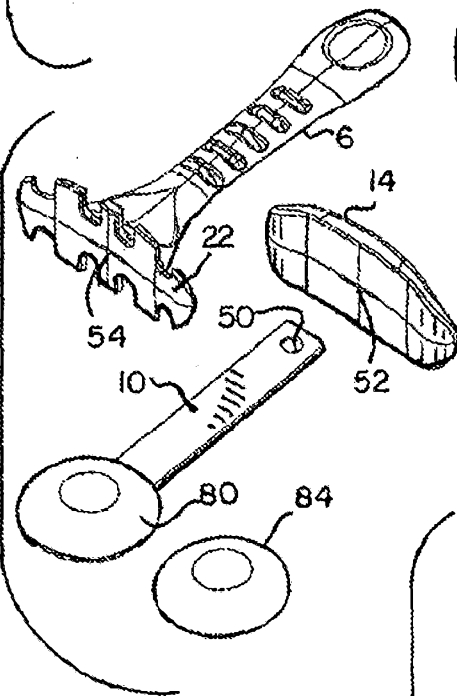
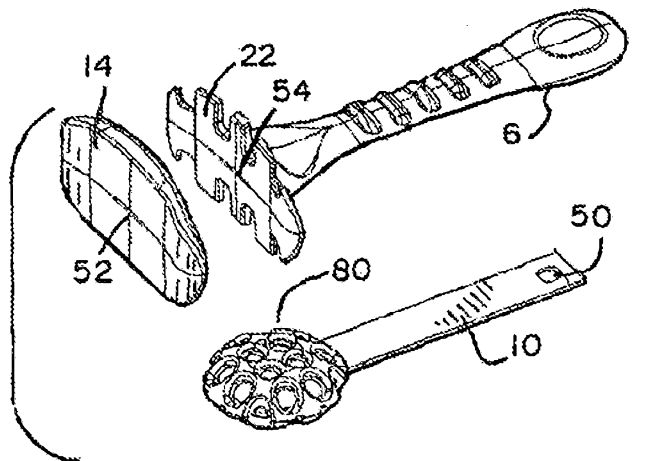


FIG. 67



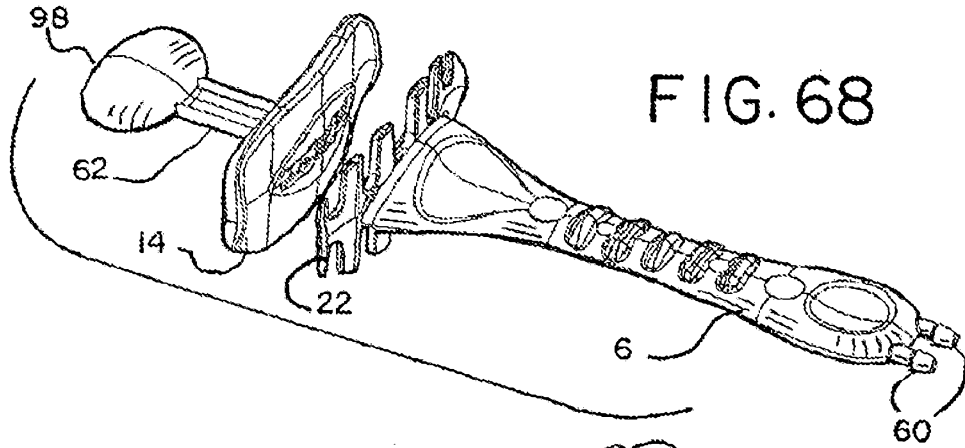


FIG. 68

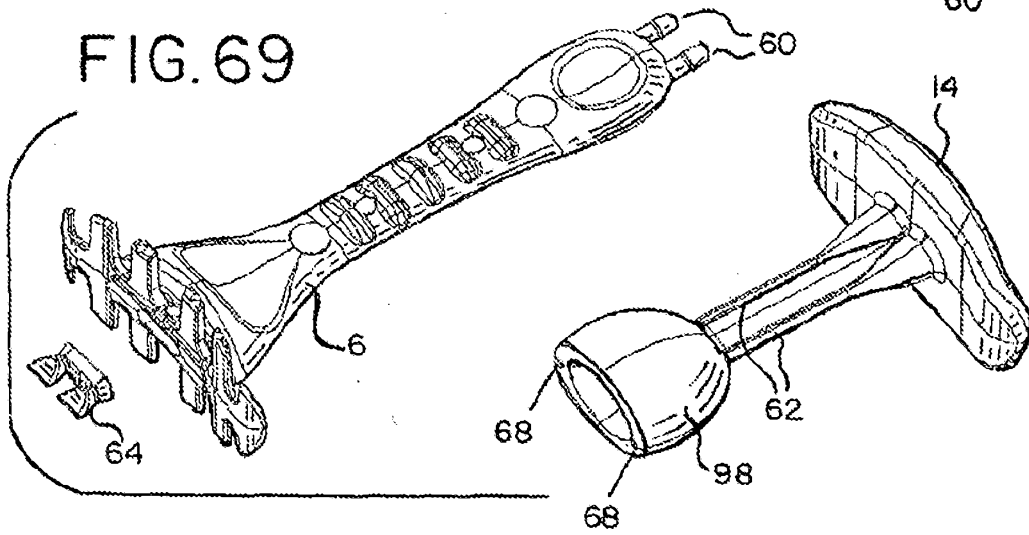


FIG. 69

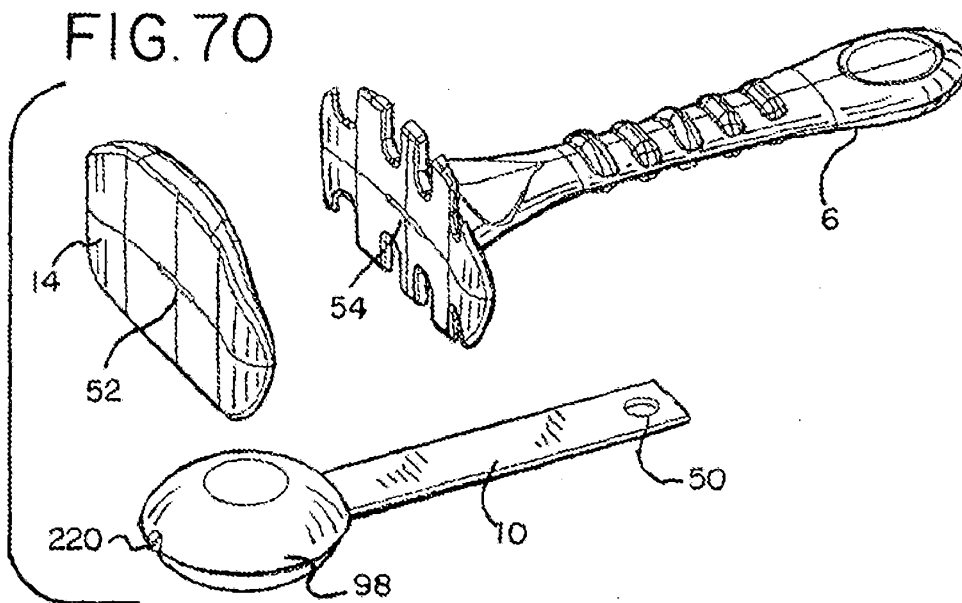


FIG. 70

FIG. 71A

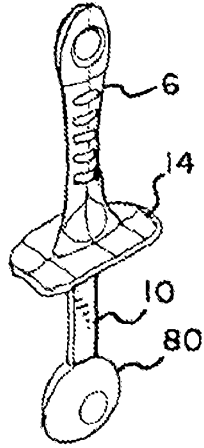


FIG. 71B

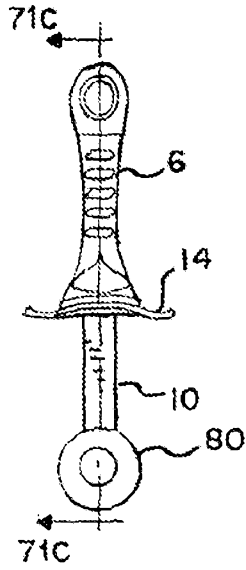


FIG. 71C

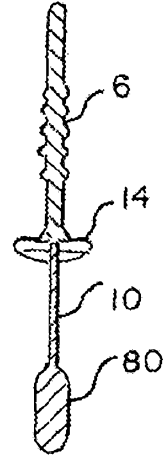


FIG. 72D

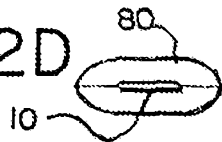


FIG. 72A

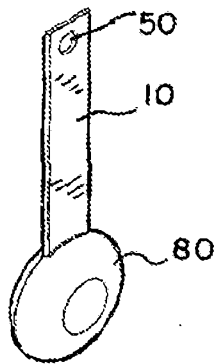


FIG. 72B

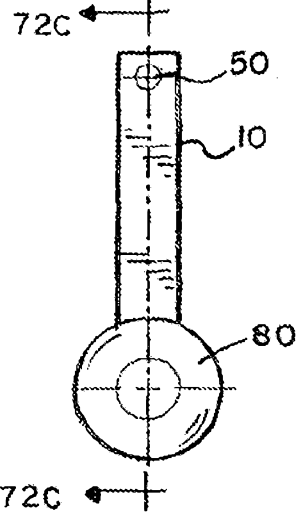
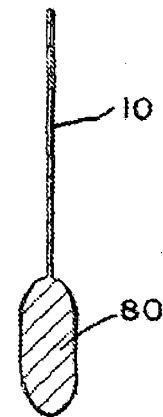
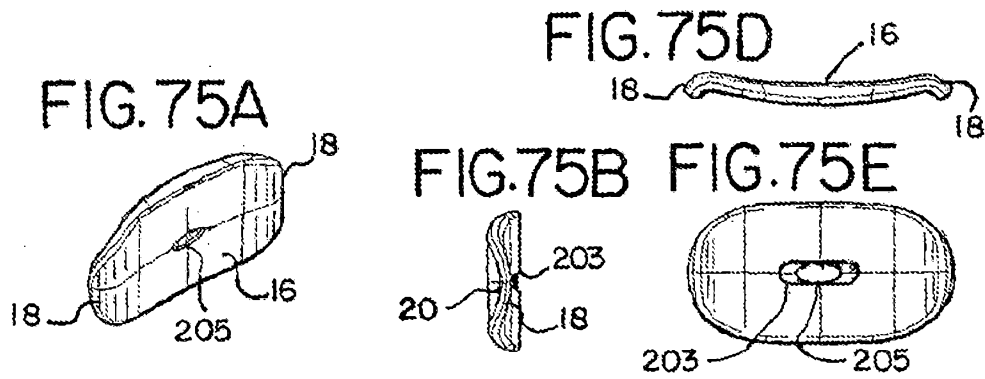
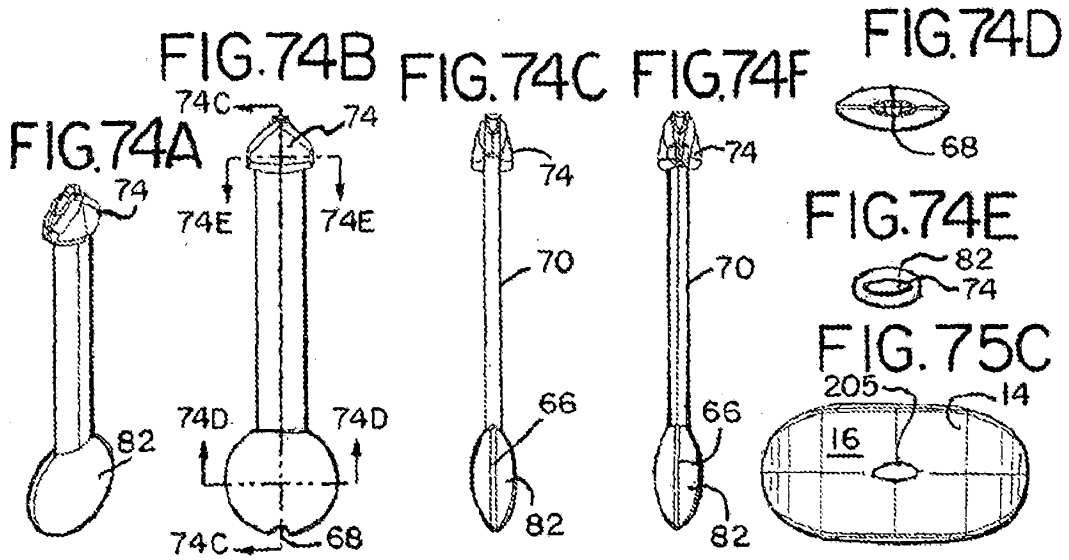
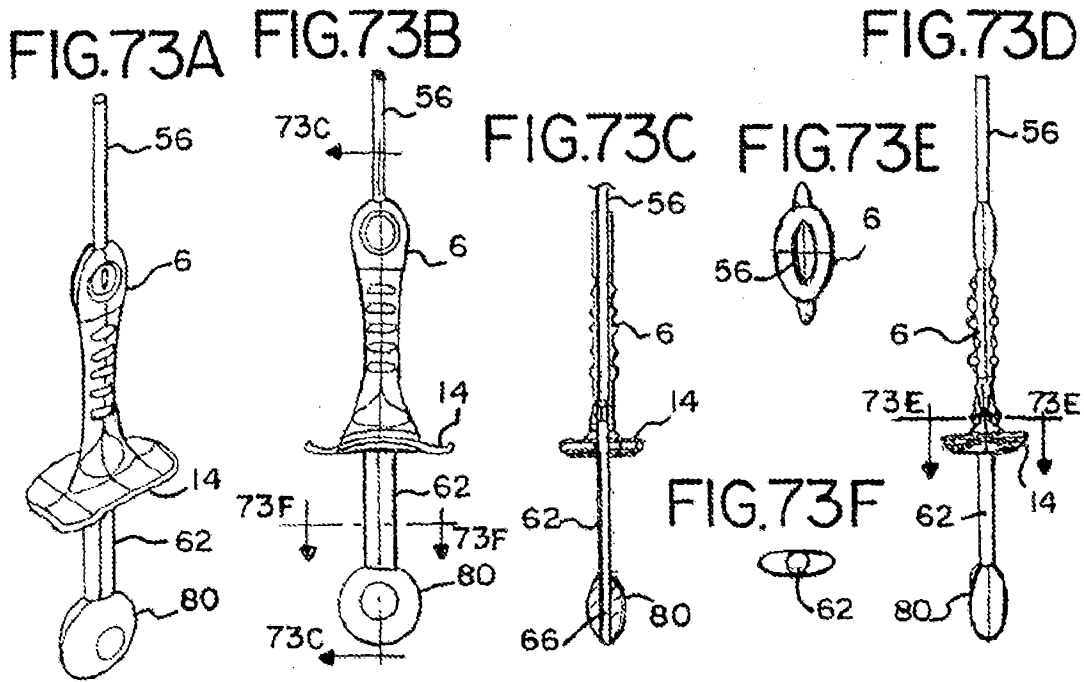


FIG. 72C





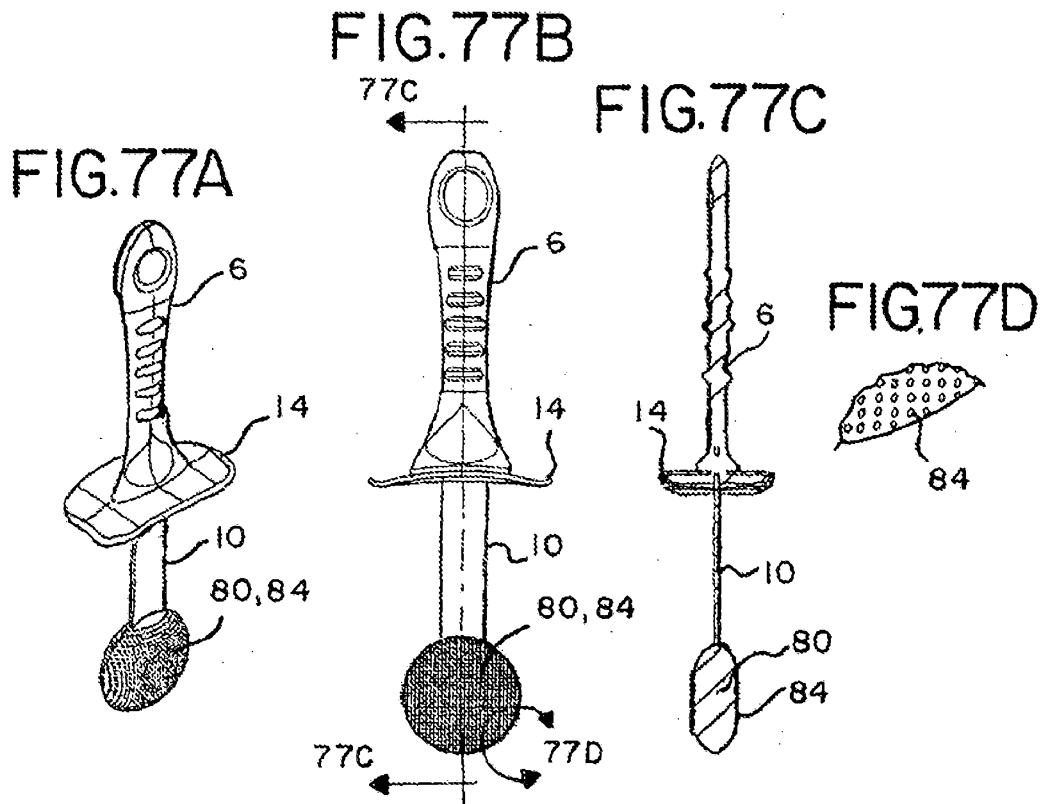
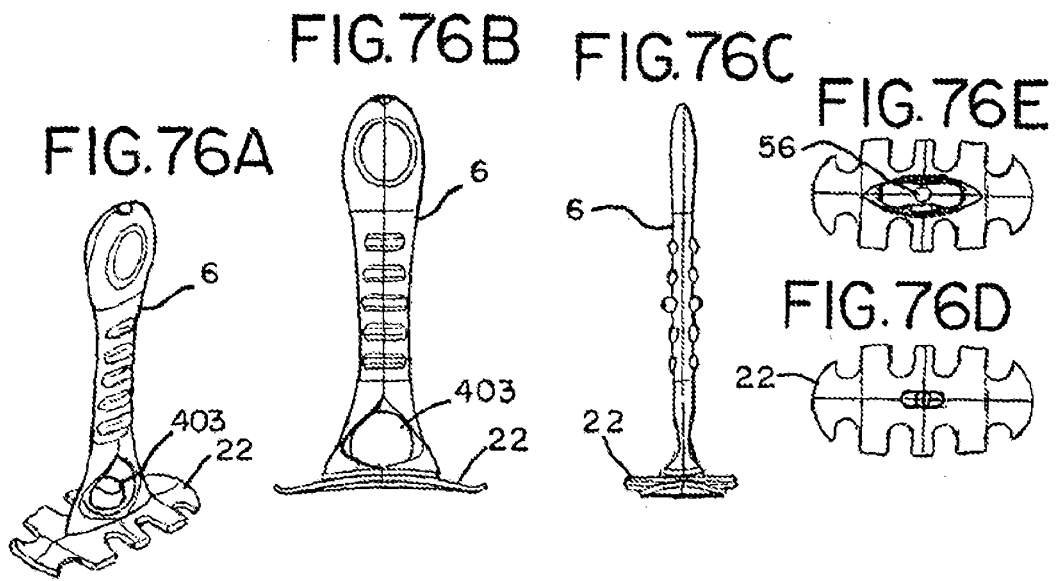


FIG. 78A

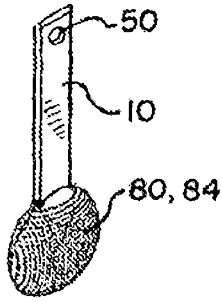


FIG. 78B

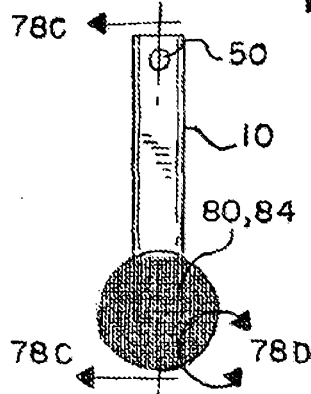


FIG. 78C

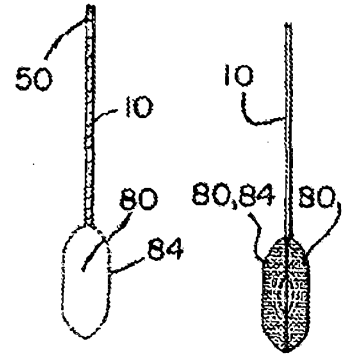


FIG. 78D

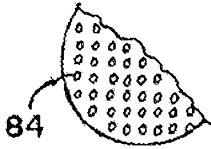


FIG. 78G



FIG. 78F



FIG. 78E

FIG. 79A

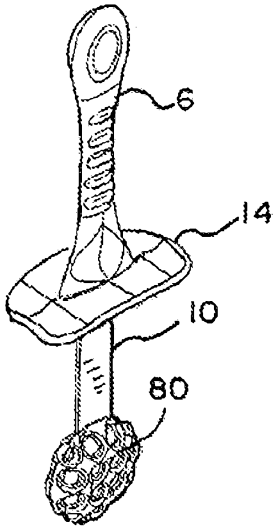


FIG. 79B

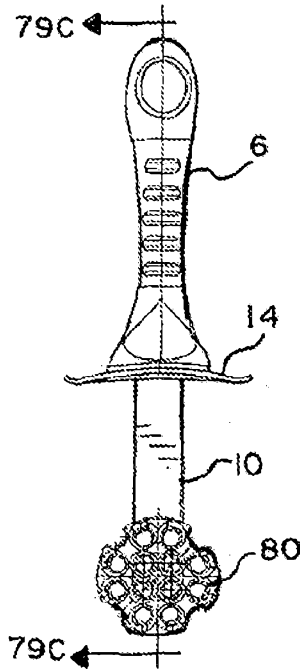
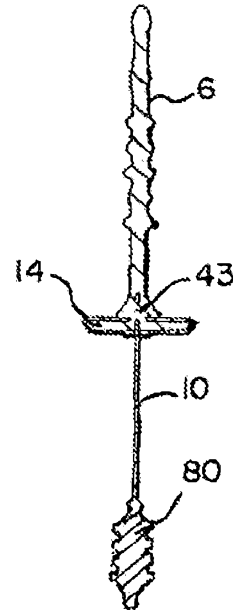


FIG. 79C



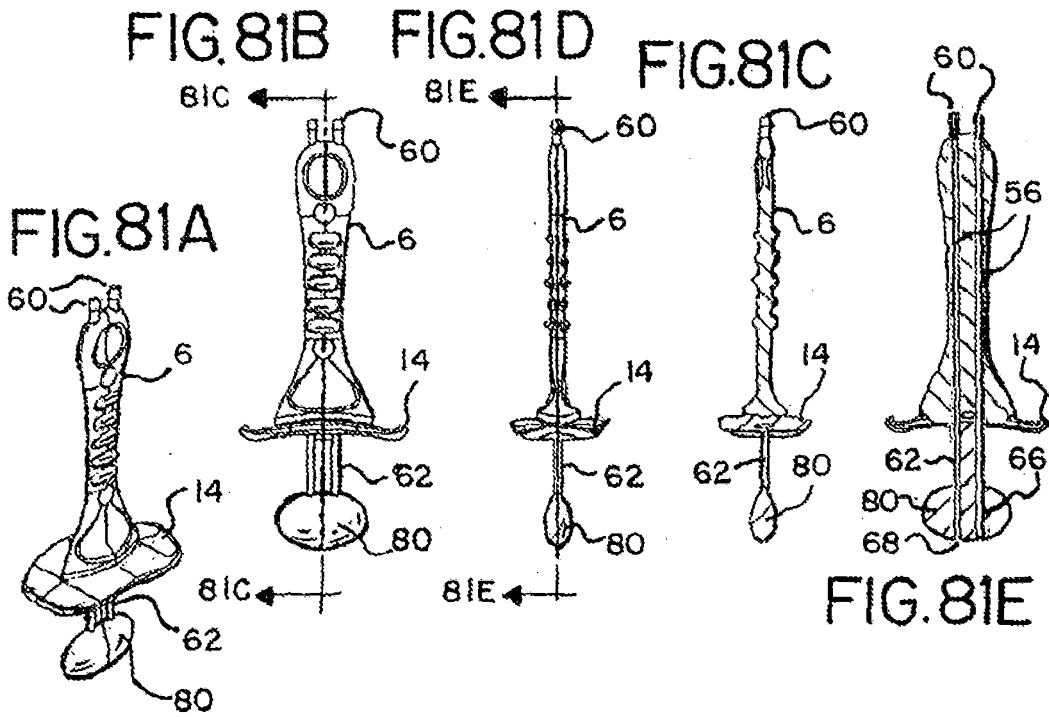
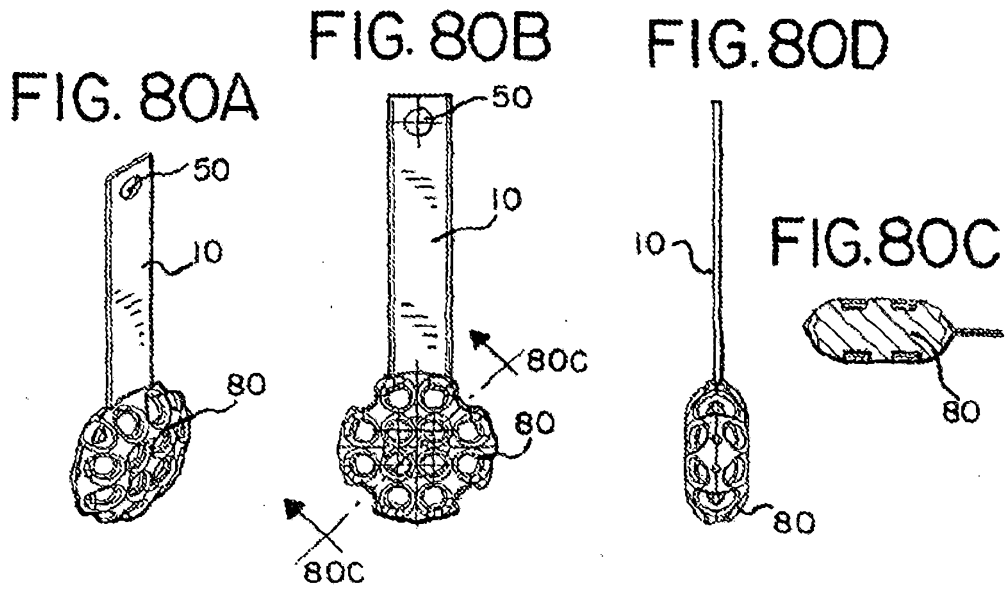


FIG. 82A

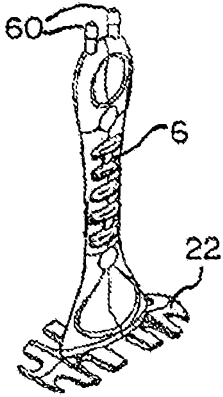


FIG. 82B

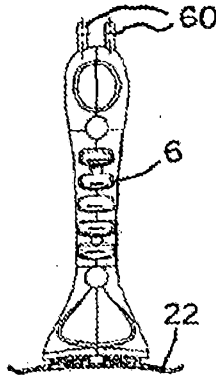


FIG. 82C

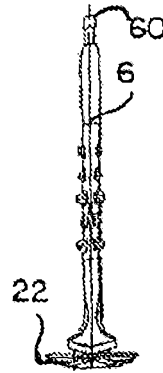


FIG. 82D

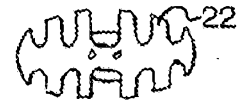


FIG. 82E



FIG. 83B

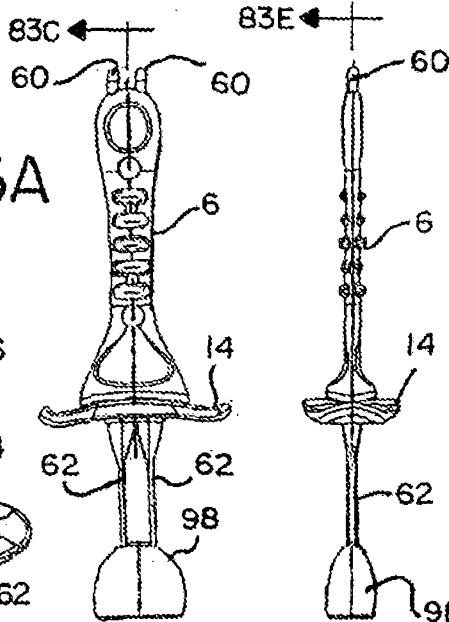


FIG. 83A

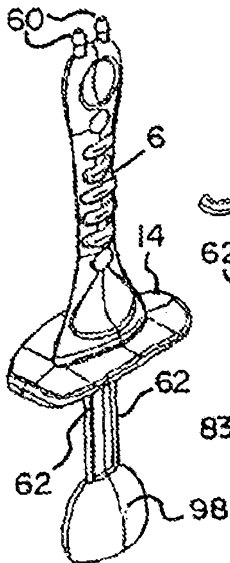


FIG. 83C

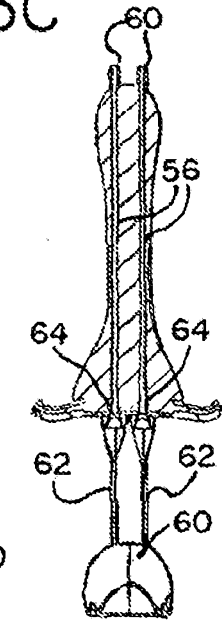
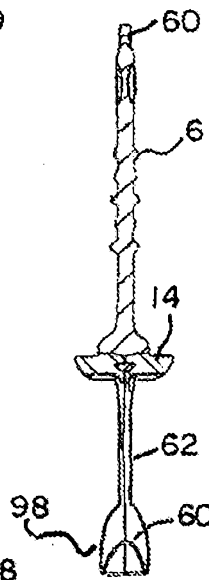


FIG. 83D

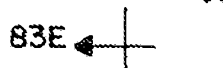


FIG. 83E



FIG. 84A

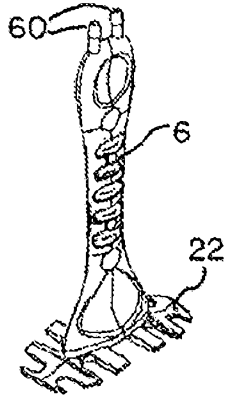


FIG. 84B

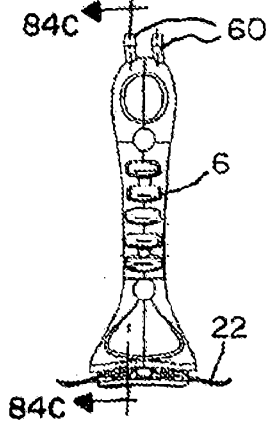


FIG. 84C

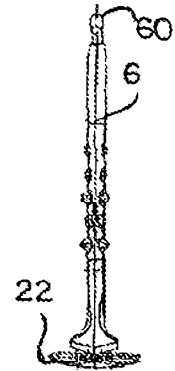


FIG. 84E



FIG. 84D

FIG. 85G

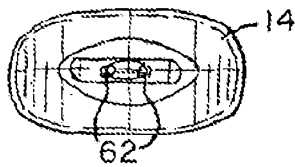


FIG. 85A

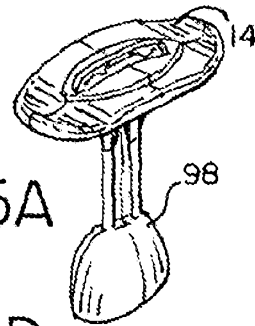


FIG. 85B

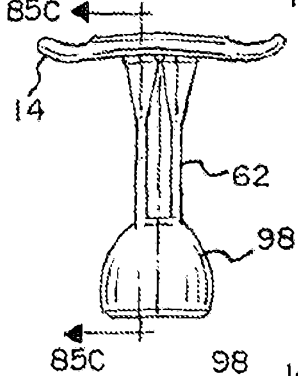


FIG. 85C

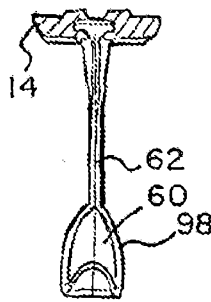


FIG. 85D

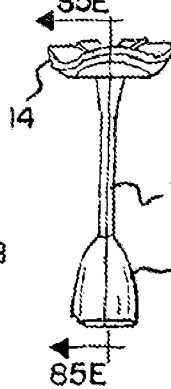


FIG. 85E

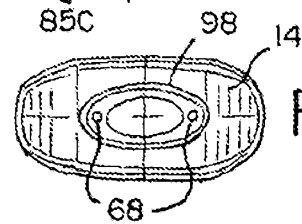
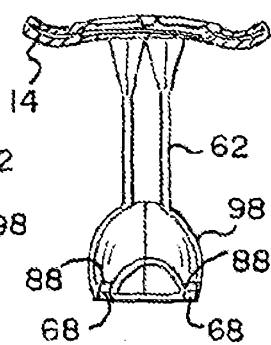


FIG. 85F

FIG. 86C

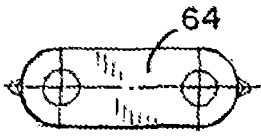


FIG. 86A

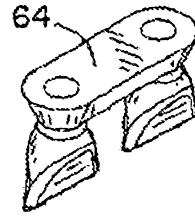


FIG. 86B

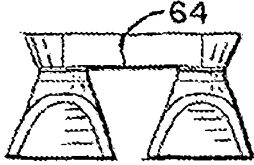


FIG. 86D

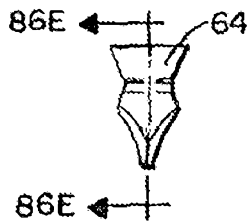


FIG. 86E

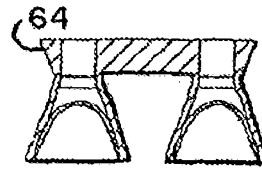


FIG. 86F

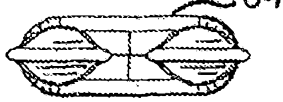


FIG. 87A

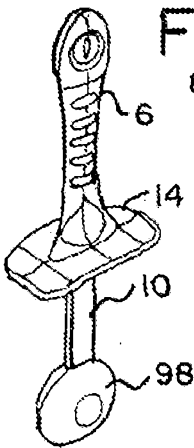


FIG. 87B

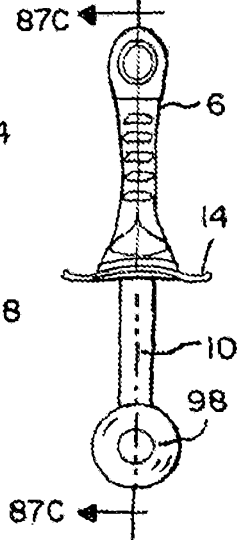


FIG. 87C

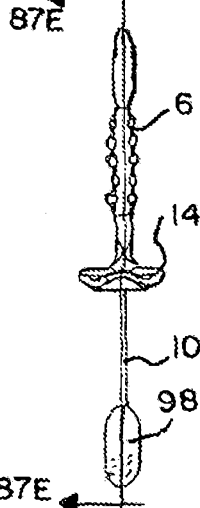


FIG. 87D

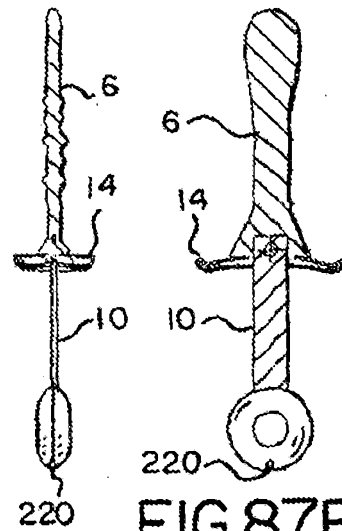


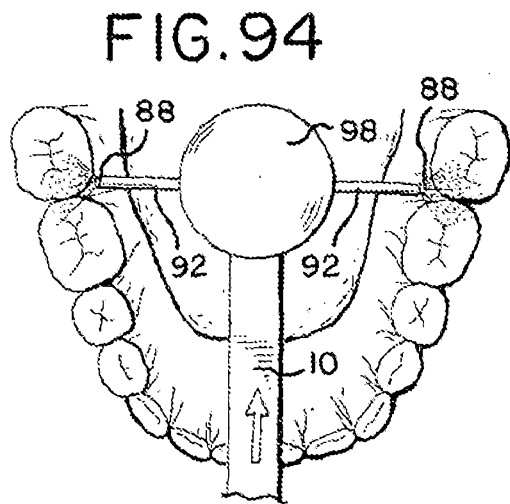
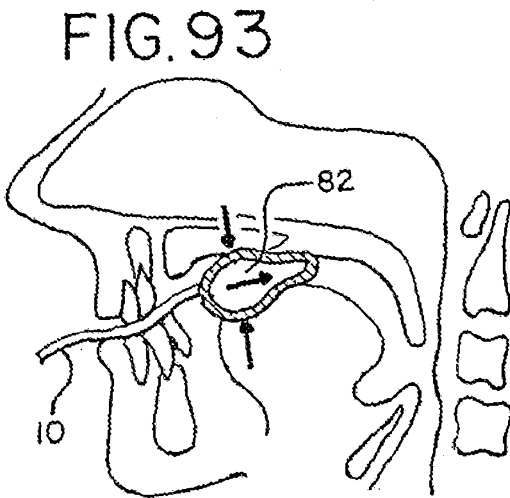
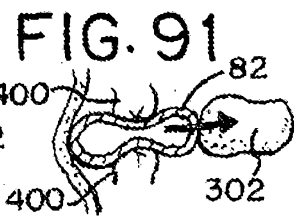
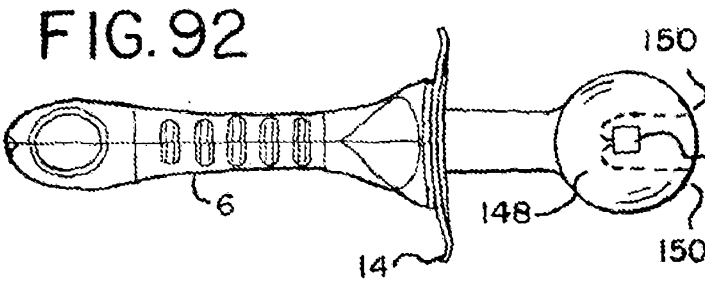
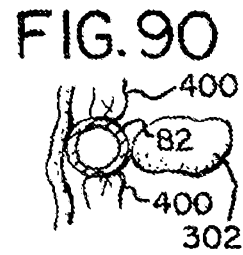
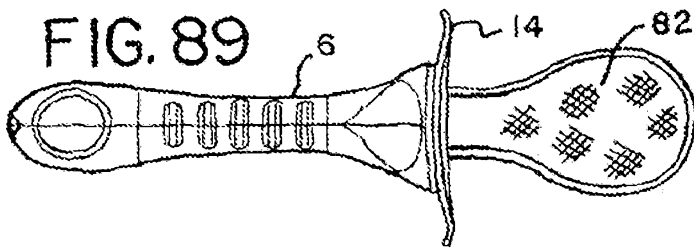
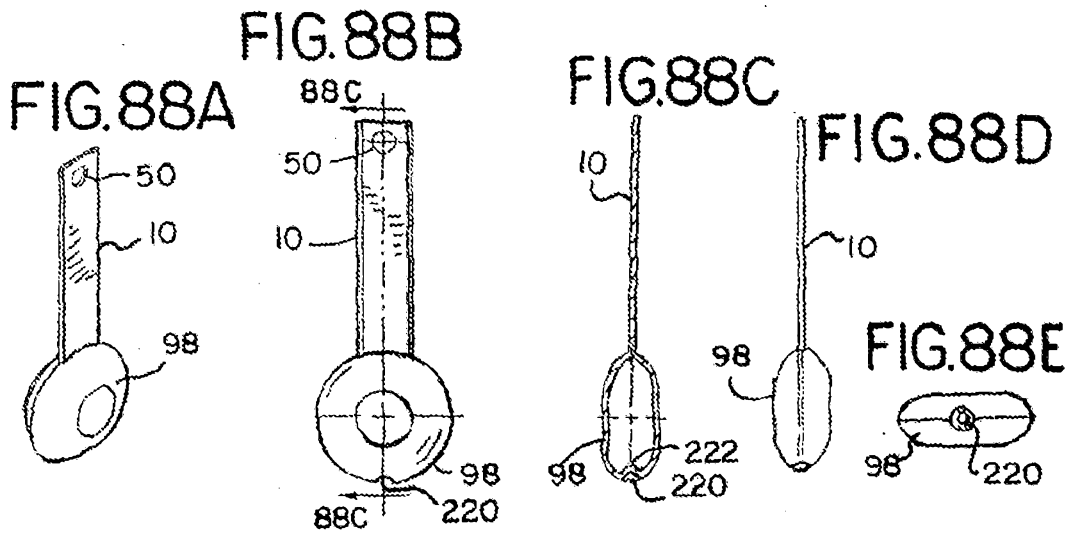
FIG. 87E

FIG. 87B

87C

87E

220



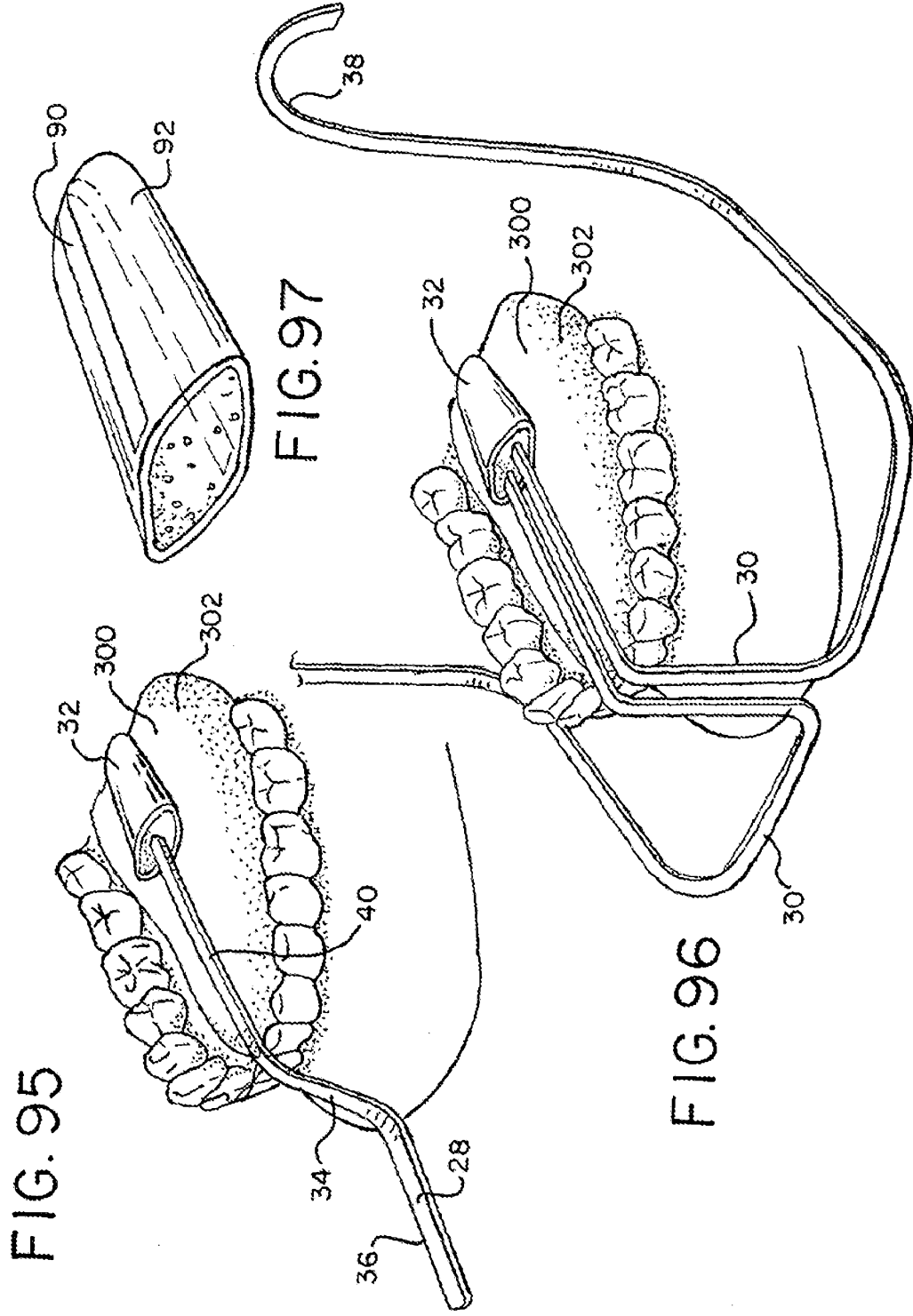


FIG. 95

FIG. 97

FIG. 96

FIG. 98A

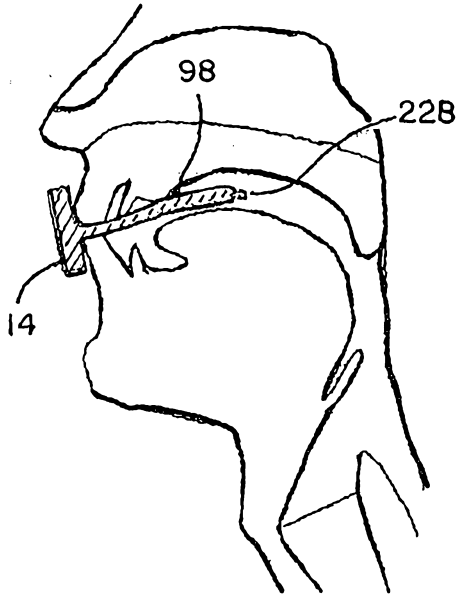


FIG. 98B

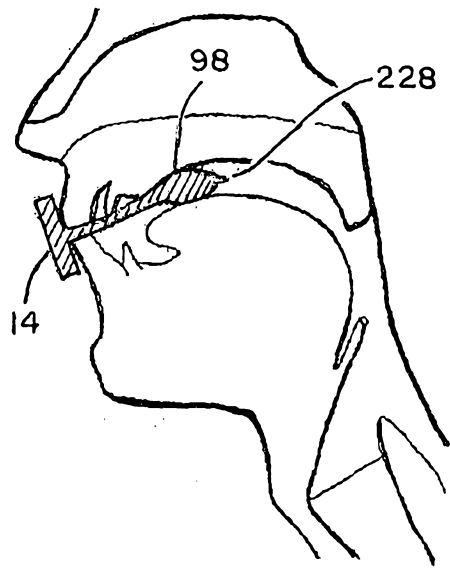


FIG. 98C

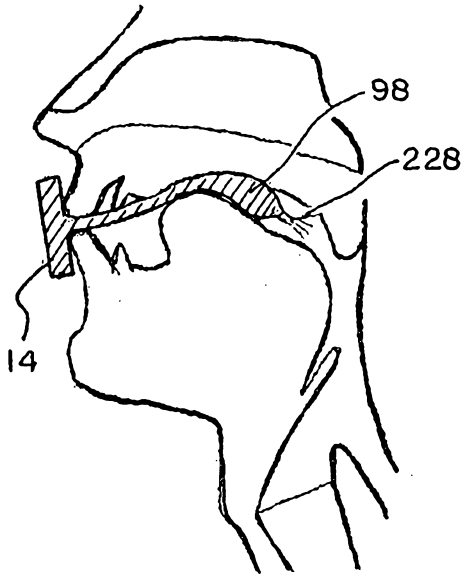


FIG. 98D

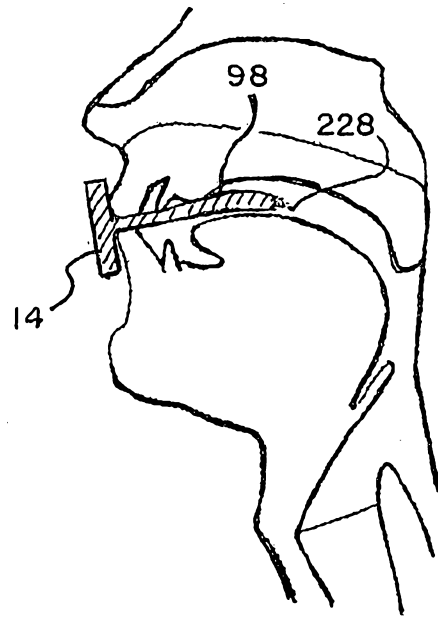


FIG. 99A

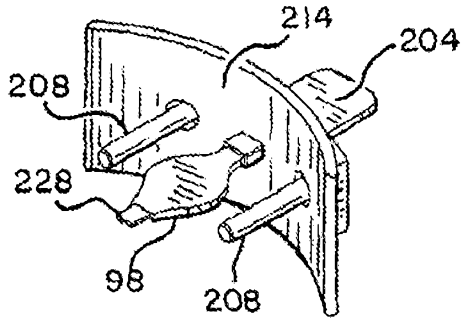


FIG. 99B

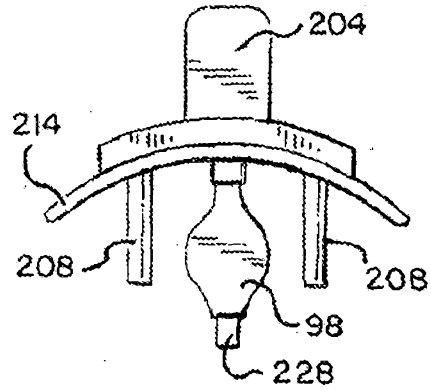


FIG. 99C

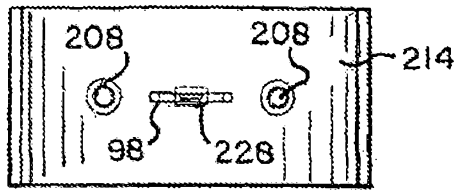


FIG. 99D

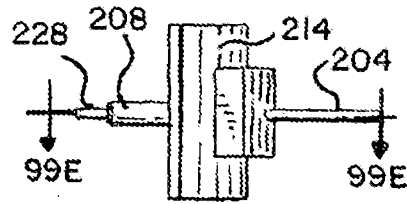


FIG. 99F

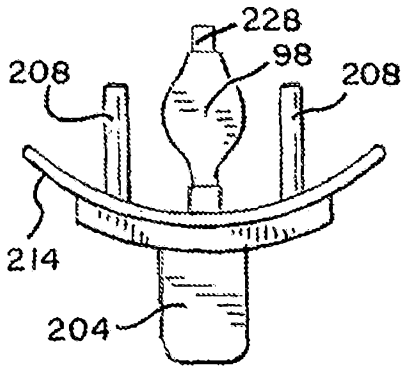


FIG. 99E

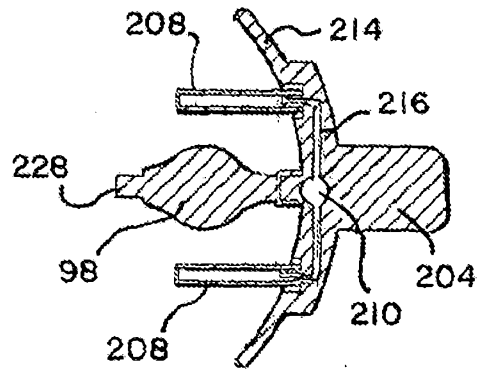


FIG. 99G

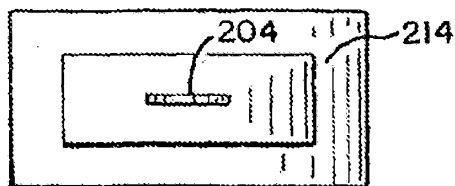


FIG. 100A

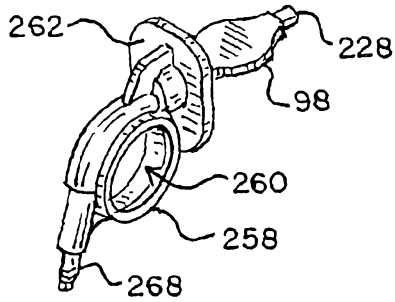


FIG. 100B

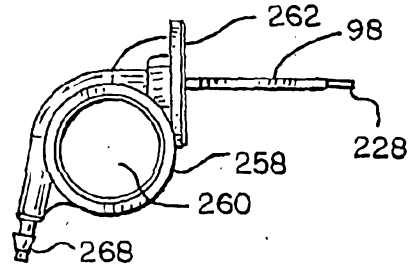


FIG. 100C

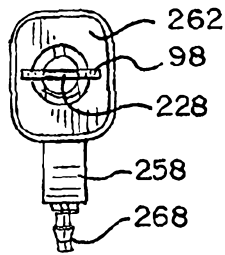


FIG. 100D

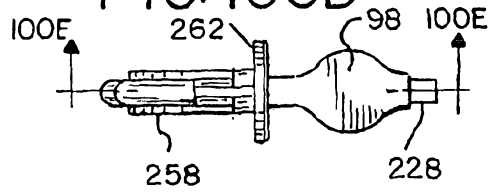


FIG. 100E

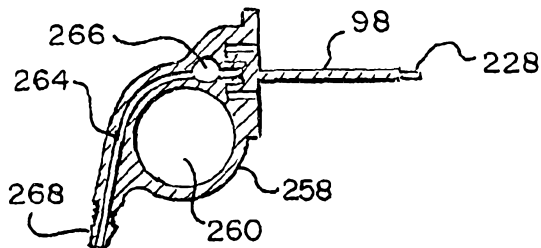


FIG. 100F

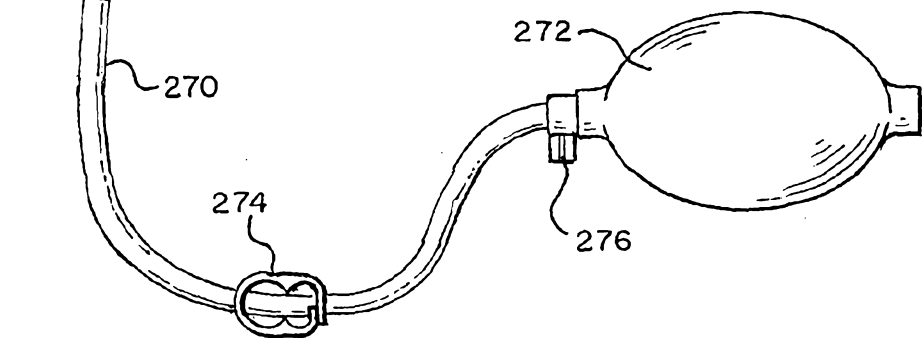
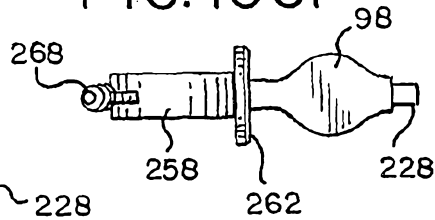


FIG. 101

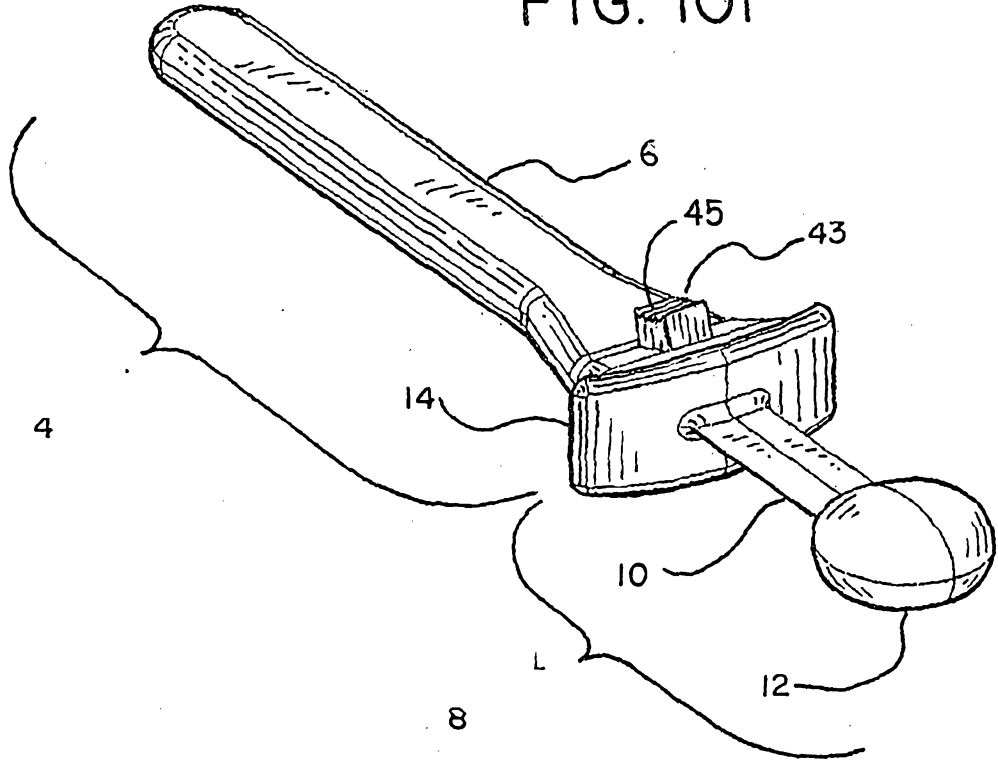


FIG. 102

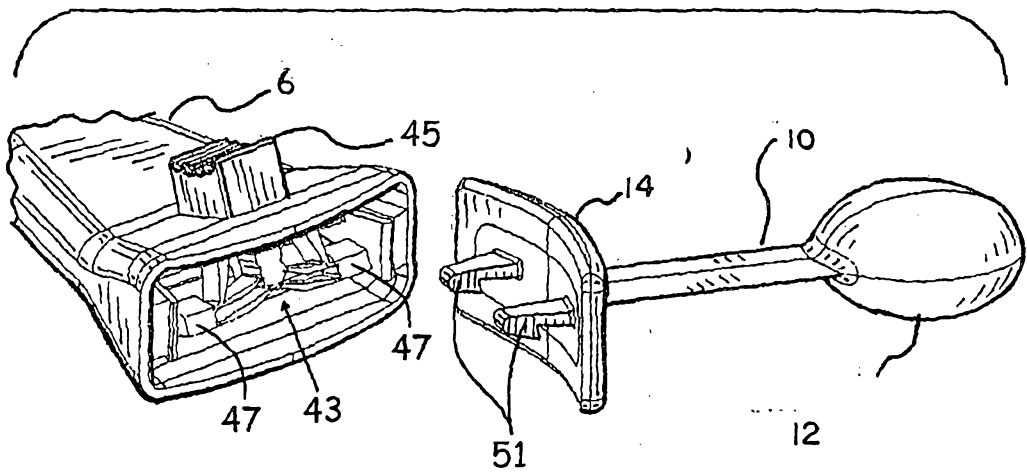


FIG. 103

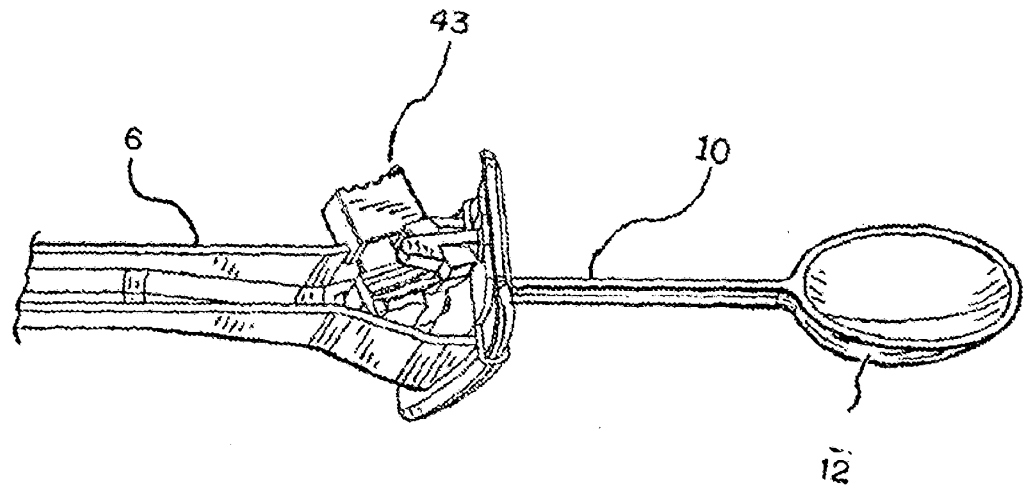


FIG. 104

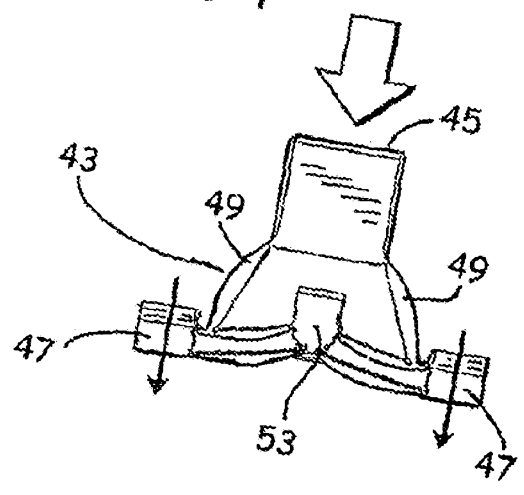
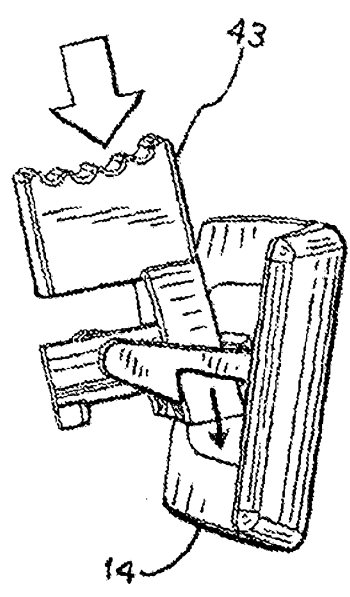
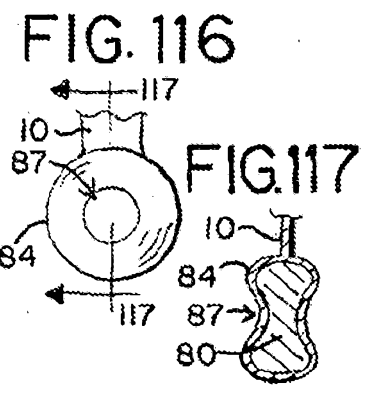
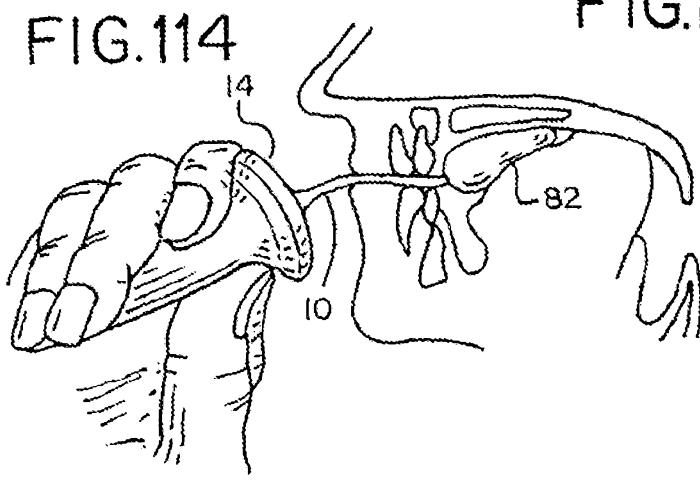
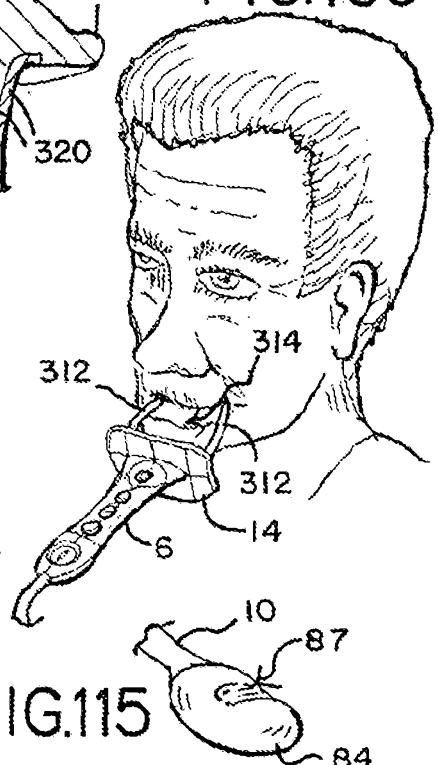
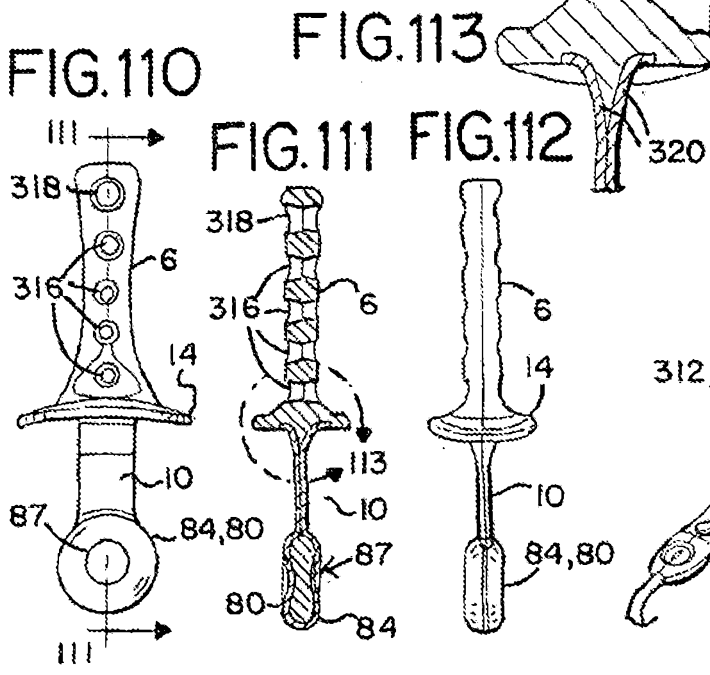
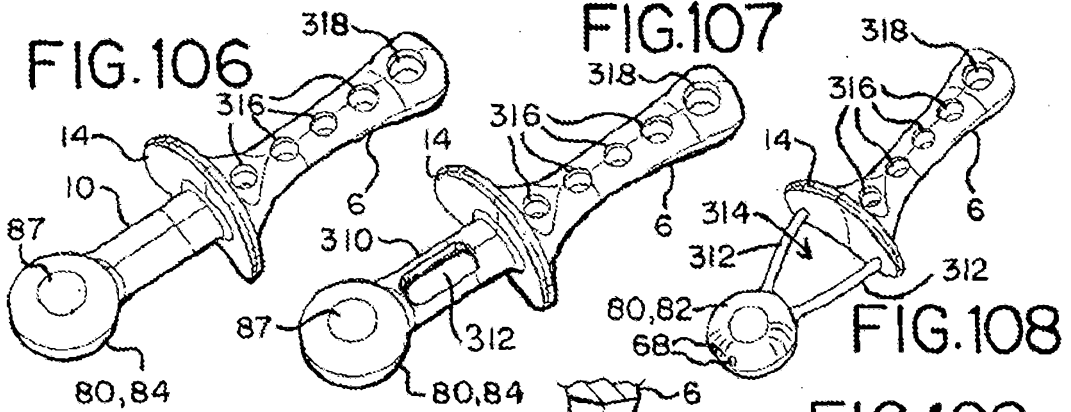


FIG. 105





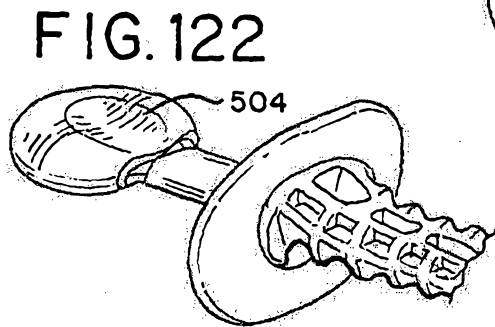
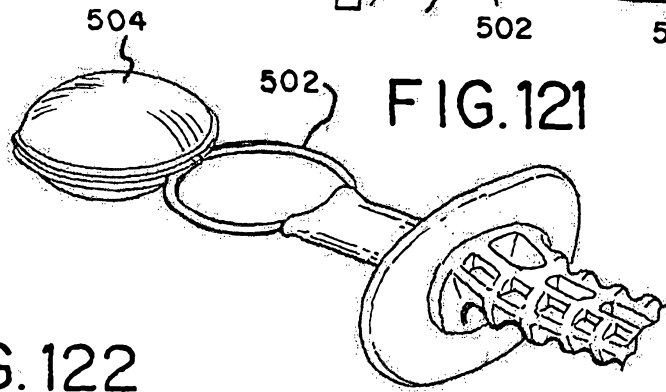
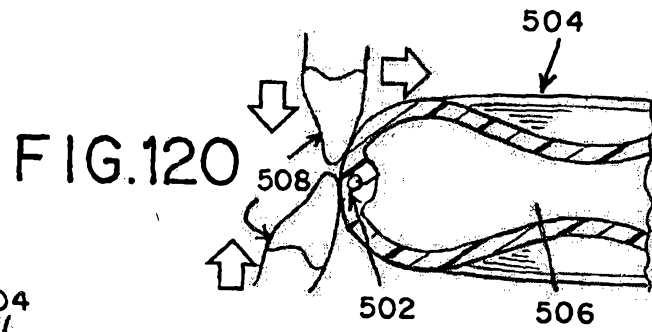
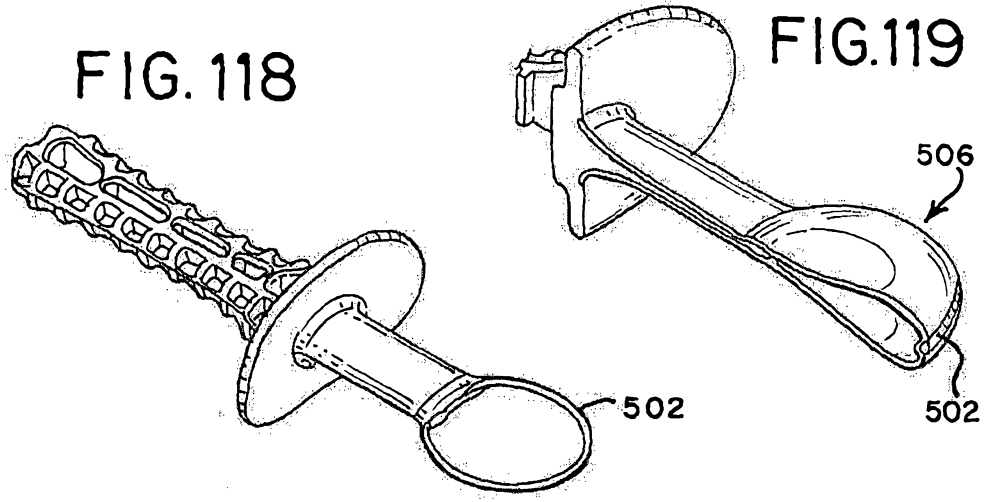


FIG.123

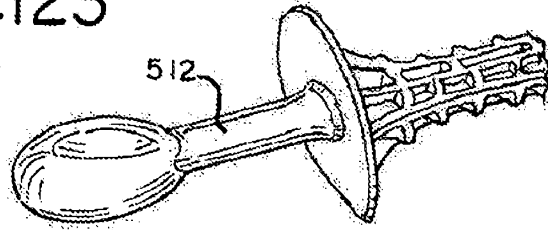


FIG. 124

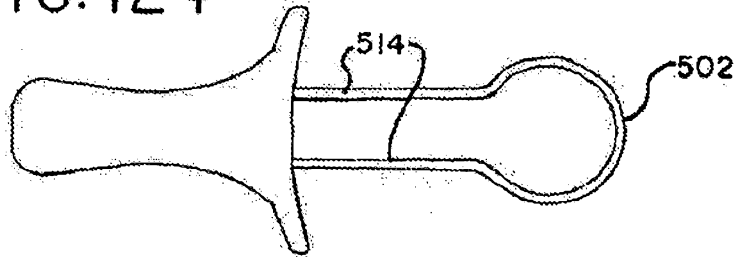


FIG. 125

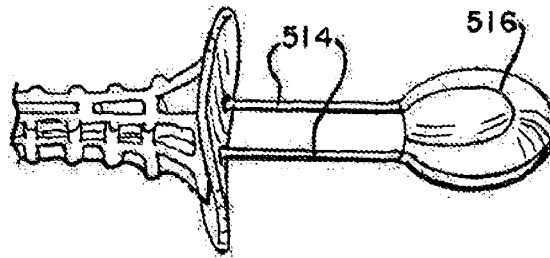


FIG. 126

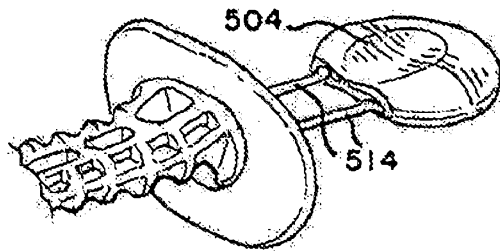


FIG. 127A

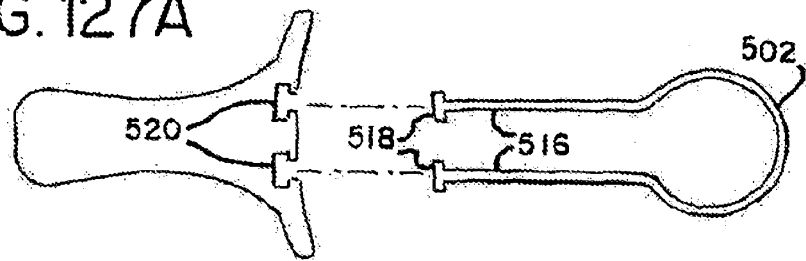


FIG. 127B

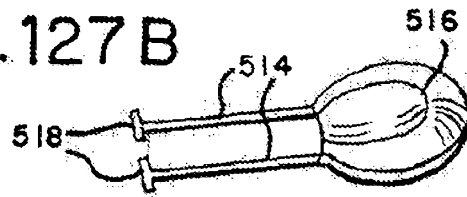


FIG. 127C

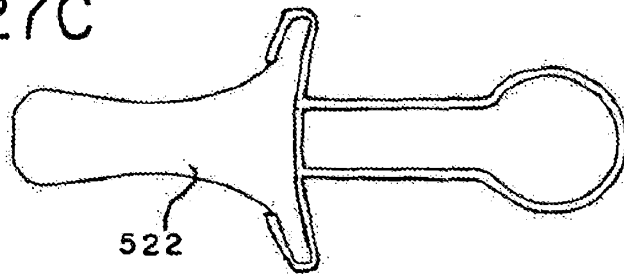


FIG. 128

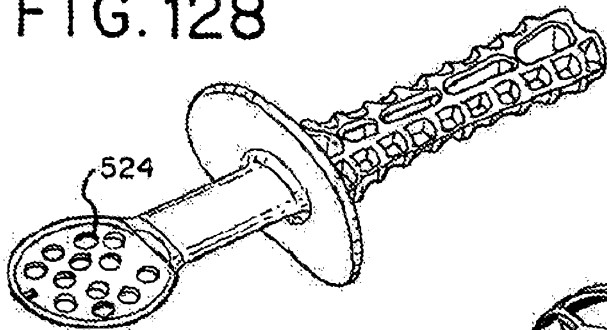
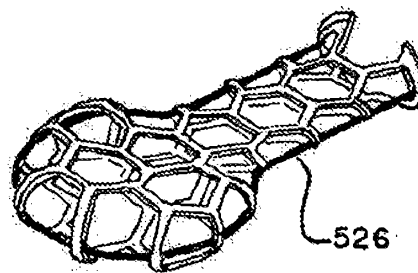


FIG. 129



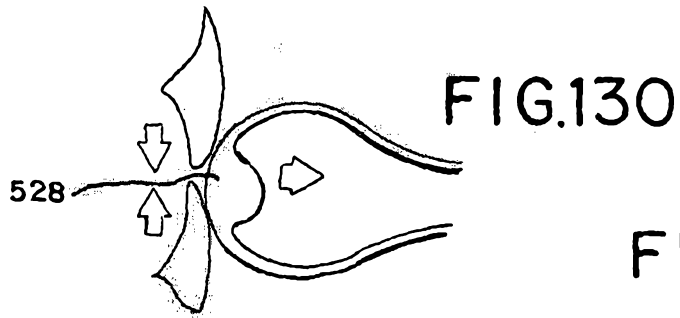


FIG. 131A

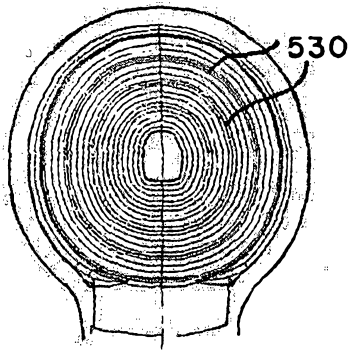


FIG. 131B

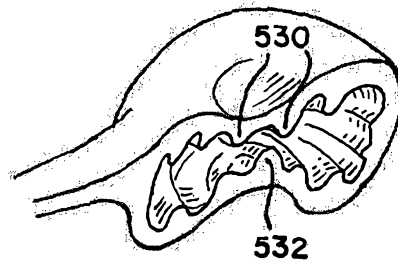


FIG. 131C

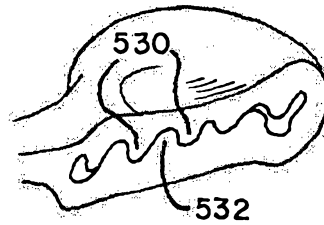


FIG. 132B

FIG. 132A

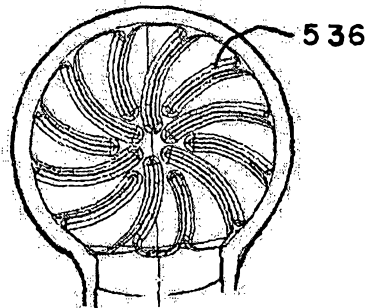
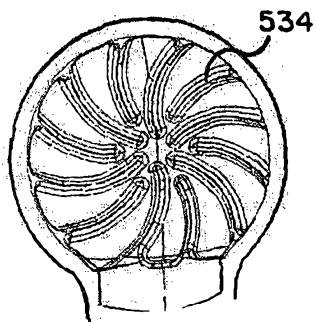


FIG. 132C

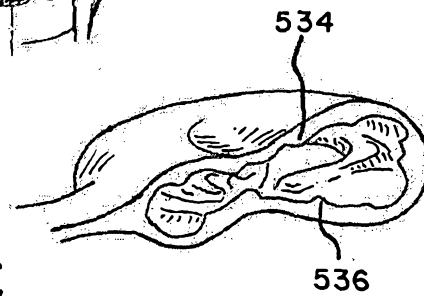


FIG. 133A

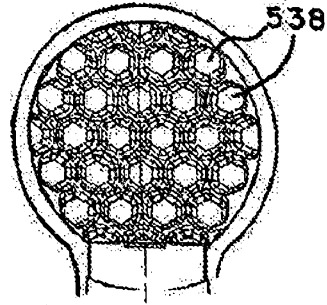


FIG. 133B

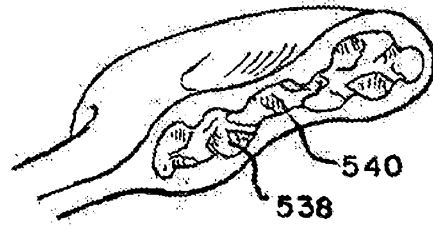


FIG. 134

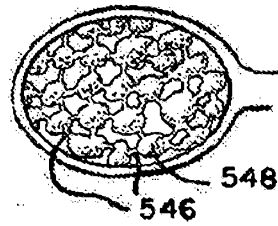


FIG. 135

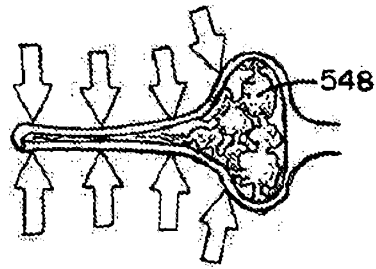


FIG. 136A

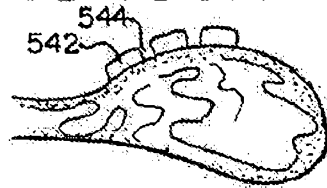


FIG. 136B

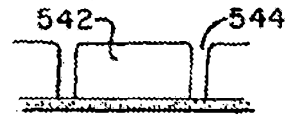


FIG. 136C

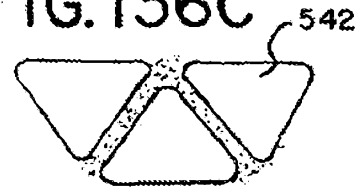


FIG. 137

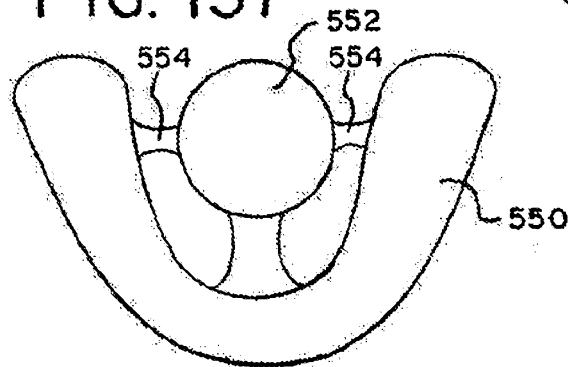


FIG. 138A

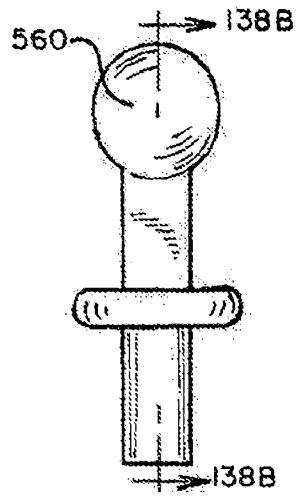


FIG. 138B

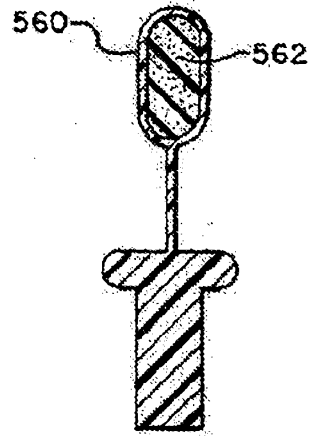


FIG. 139

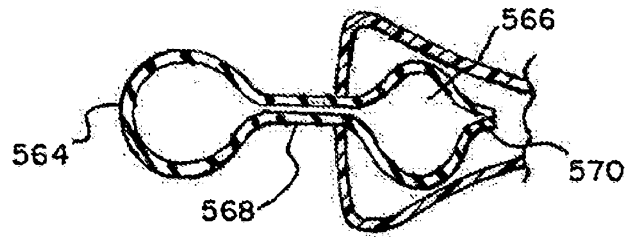


FIG. 140

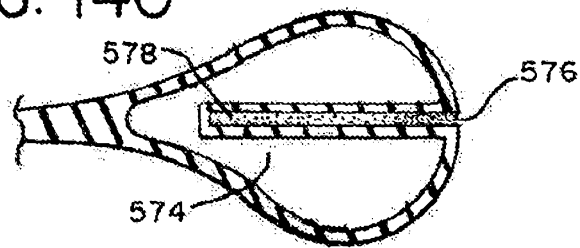


FIG. 141

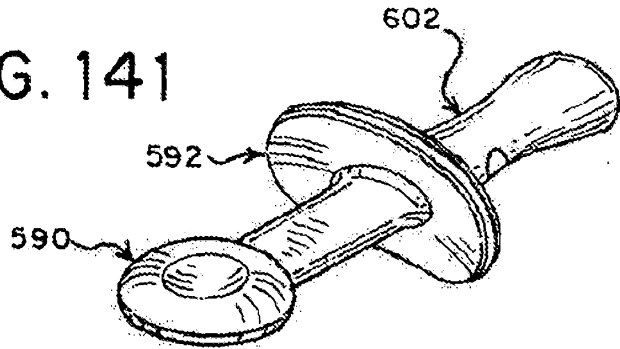


FIG. 142

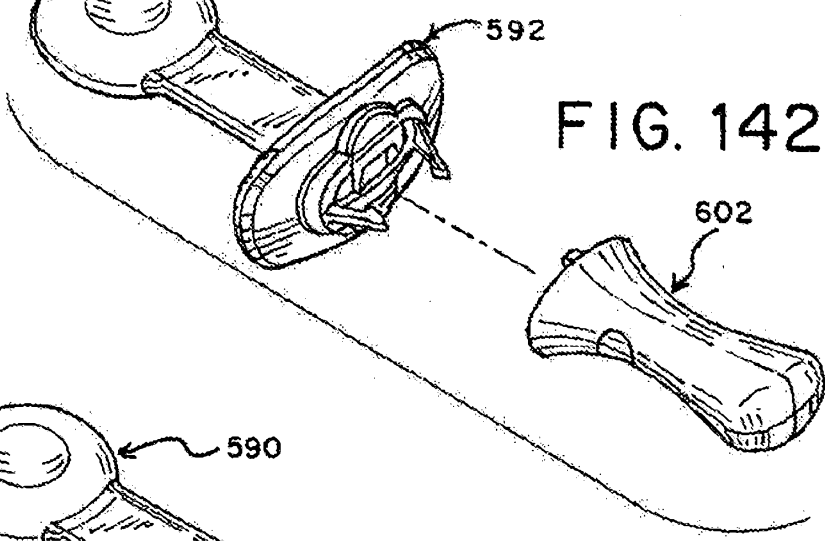


FIG. 143

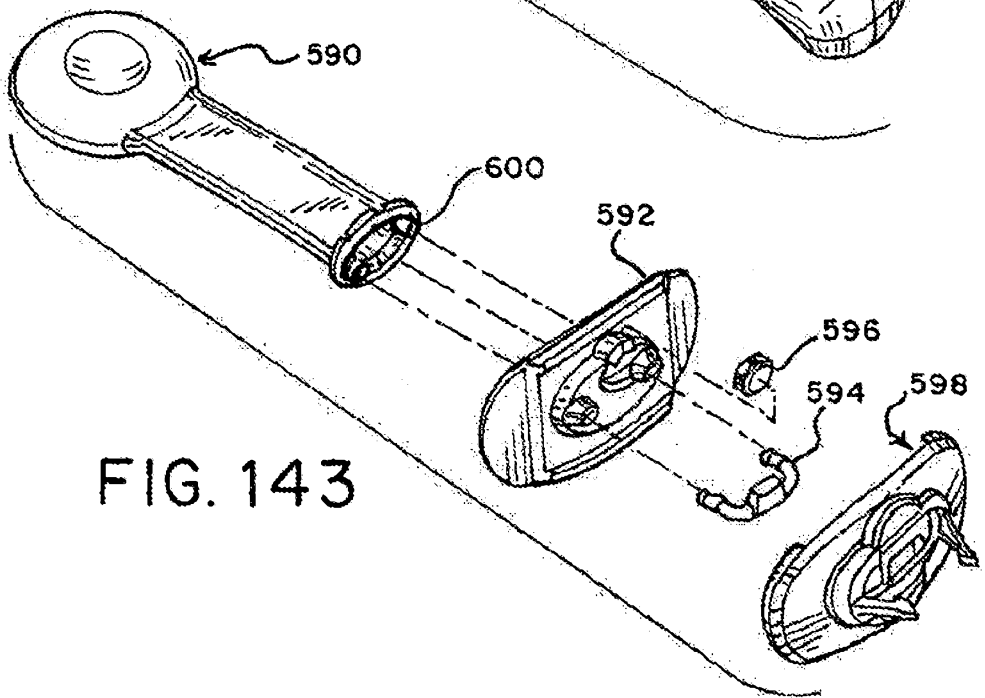


FIG. 144

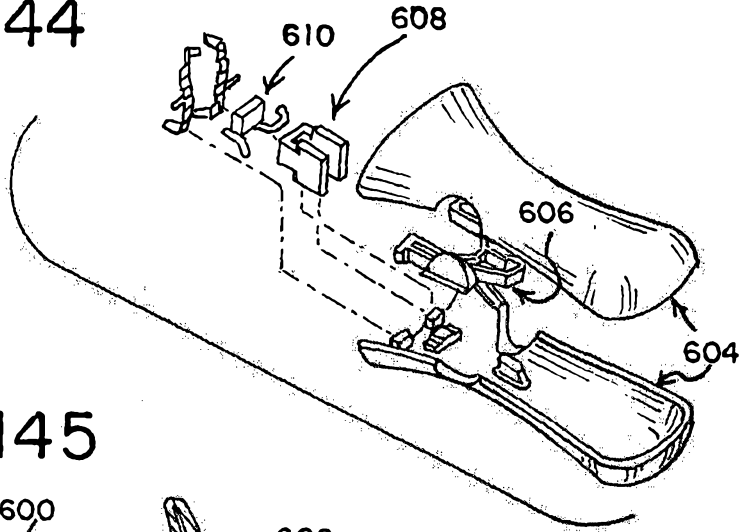


FIG. 145

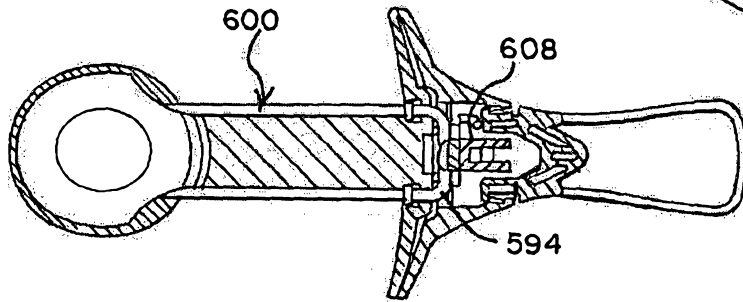


FIG. 146A

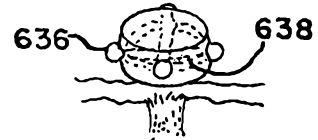
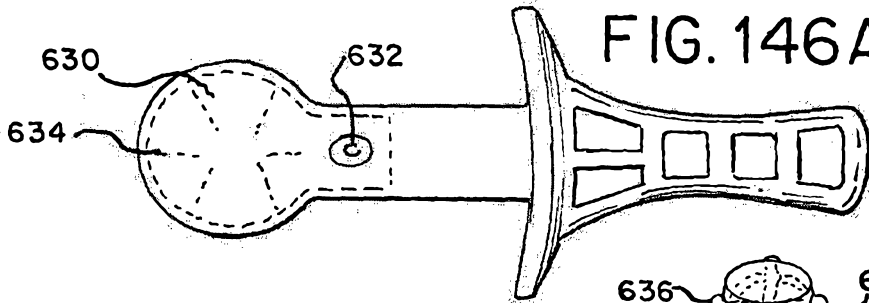


FIG. 146B

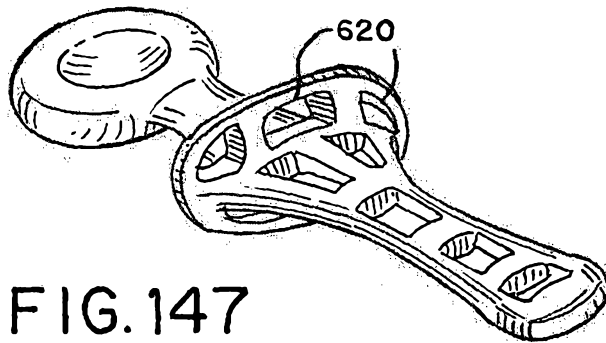


FIG. 147