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(54) Title: ELECTROLARYNX DEVICES AND USES THEREOF

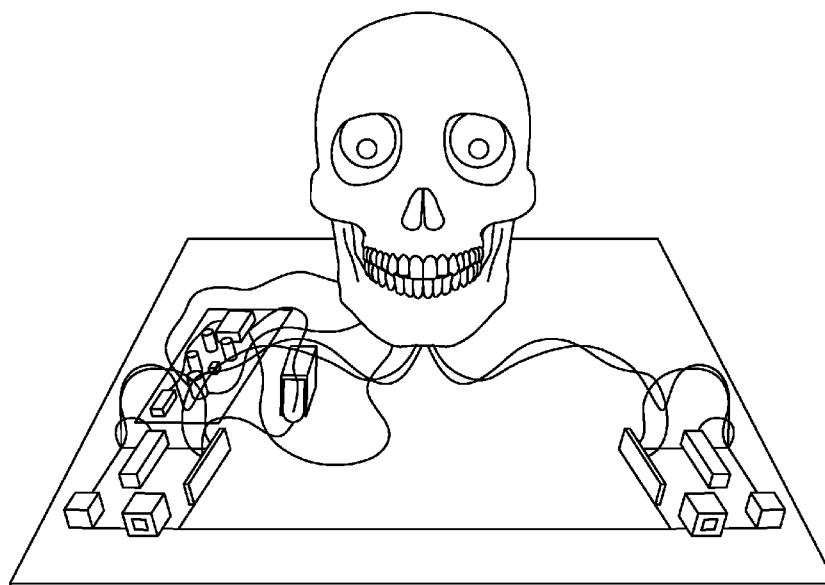


FIG. 2

(57) Abstract: The present disclosure relates to electrolarynx devices, systems, and their use. In particular, the present disclosure relates to methods and compositions (e.g., devices) that provide electrolarynx (EL) users with improved speech quality.

Published:

— *with international search report (Art. 21(3))*

ELECTROLARYNX DEVICES AND USES THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to U.S. Provisional Patent Application Serial
5 No. 62/492,526, filed May 1, 2017, which is hereby incorporated by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to electrolarynx devices, systems, and their use. In
particular, the present disclosure relates to methods and compositions (e.g., devices) that
10 provide electrolarynx (EL) users with improved speech quality.

BACKGROUND

Normal human speech is in part facilitated by the larynx, an organ just below the
vocal tract that helps to control the pitch and volume of the voice. When a patient's larynx
15 must be surgically removed—often due to laryngeal cancer—the laryngectomy loses the
ability to speak in the usual manner. Electrolarynx (EL) devices are often used by such
patients to communicate; these medical instruments act as artificial larynxes by producing the
mechanical vibration necessary to excite the remaining vocal tract. The sound waves that are
produced by this vibration are then articulated by the teeth, tongue, and lips.

20 Audible speech is produced by this method, but EL speech is far less intelligible than
normal human speech. Rather than using the larynx as the sound source, EL speech uses a
crude, buzzing diaphragm, which does not produce a waveform with the same acoustic
characteristics that are present in a human voice. This diaphragm, which is held against the
neck so that the mechanical vibration is transmitted to the vocal tract, produces a sound that
25 is neither pleasant nor particularly clear.

There is a great need to improve current EL designs so that laryngectomees can
communicate with a level of expression and intelligibility that is enjoyed by the normal
population.

30 SUMMARY

The present disclosure relates to electrolarynx devices, systems, and their use. In
particular, the present disclosure relates to methods and compositions (e.g., devices) that
provide electrolarynx (EL) users with improved speech quality.

In some embodiments, the present disclosure provides an electrolarynx device or system, comprising: a) a sensor configured to be placed in the stoma or on the neck of a human subject; b) a control element configured to obtain signal from the sensor and translate the signal into speech; and c) a speaker configured to amplify the speech. In some embodiments, the control element is configured to turn the speaker on when the subject is talking and turn the speaker off when the subject is silent. In some embodiments, the control element comprises one or more of an electrical circuit, a computer processor, or computer memory. In some embodiments, the control element is further configured to perform articulatory pattern recognition of the subject's speech. In some embodiments, the device is controlled by a sensor that senses the subject's breath. In some embodiments, the device utilizes a sensor that senses movement of the jaw. In some embodiments, the signal is transmitted from the sensor to the control element via an electrical cable.

Further embodiments provide a method of generating artificial speech, comprising: contacting the device with a subject's stoma under conditions such that said device generates speech and transmits the speech through the speaker of the device. In some embodiments, the subject lacks a larynx. In some embodiments, the subject has previously been diagnosed with oral cancer. In some embodiments, the method is performed hands free.

Additional embodiments are described herein.

DESCRIPTION OF THE FIGURES

FIG. 1 shows a flow chart of components of an exemplary electrolarynx of embodiments of the present disclosure.

FIG. 2 shows a photograph of an exemplary device of embodiments of the present disclosure.

FIG. 3 shows electrical circuits of a servo control and accelerator monitoring element of exemplary devices of embodiments of the present disclosure.

FIG. 4 shows electrical circuits of a playback stage for recording simulating speech of exemplary devices of embodiments of the present disclosure.

FIG. 5 shows electrical circuits of a flex-sensor amplifier and A/D stage of exemplary devices of embodiments of the present disclosure.

FIG. 6 shows electrical circuits of a power supply and audio amplifier element of exemplary devices of embodiments of the present disclosure.

FIG. 7 shows electrical circuits of electrolarynx buzz activation circuit (stoma sensor circuit) of exemplary devices of embodiments of the present disclosure.

FIG. 8 shows a photograph of an exemplary device of embodiments of the present disclosure.

FIG. 9 shows a photograph of an exemplary device of embodiments of the present disclosure.

5 FIG. 10 shows a schematic of an exemplary device of embodiments of the present disclosure.

DETAILED DESCRIPTION

10 The present disclosure relates to electrolarynx devices, systems, and their use. In particular, the present disclosure relates to methods and compositions (e.g., devices) that provide electrolarynx (EL) users with improved speech quality.

15 With the surgical removal of the natural larynx, there is a loss of the vocal cord and the connection thereof with the trachea. Laryngectomees therefore lack phonation due to this missing air-pressure-modulating functionality and hence have to undergo speech or voice rehabilitation.

20 There are three methods of voice rehabilitation after laryngectomy: esophageal speech, tracheo-esophageal speech, and electrolaryngeal speech. Considering its ease of use compared to the other alternatives, the electronic larynx device (electrolarynx) is the most widely adopted for voice rehabilitation after laryngectomy. Its limitations include distortion and mechanical perception demonstrated by the robotic nature of the speech produced with the device (this leads to difficulty in comprehension for the listener and unwanted attention to the user), confusion with voiced and voiceless pairs especially at the start of sentences hence reduced speech intelligibility, inability to track and match speech prosody as the electrolaryngeal speech sounds monotonous without the needed inflections (this is especially evident when asking questions or in heavily tonal languages e.g. the Igbo language and many East Asian languages), limited speech intensity (the amplitude is relatively lower than laryngeal speech and can be easily drowned in noisy environment), and inconvenience from the hand-held nature (EL users cannot simultaneously talk while using both of their hands).

25 The anatomy changes after a laryngectomy. After a total laryngectomy, the individual is breathing through the stoma where the tracheostomy opens in the neck. There is no longer a connection between the trachea and the mouth and nose. These individuals are termed total neck breathers. After a partial laryngectomy, the individual breathes mainly through the stoma, but a connection still exists between the trachea and upper airways; these individuals are able to breathe air through the mouth and nose. They are therefore termed partial neck

breathers. The extent of breathing through the upper airways in these individuals varies and a tracheostomy tube is present in many of them. Ventilation and resuscitation of total and partial neck breathers is through their stoma; however, in these individuals the mouth should be kept closed and the nose sealed to prevent air escape.

5 People do not keep track of their pitch, volume, and on/off or pauses in-between words when speaking. Existing devices use a capacitive slider or pressure knob that require an extreme level of manual dexterity and consciousness which is not quite reasonable in addition to other disadvantages (e.g. charge buildup). In addition, existing devices do not mimic pitch. Pitch is a parameter that is very difficult to estimated externally hence it is
10 important to use the human's signal as control signals for the pitch adjustments.

 One of the distinguishing features of devices described herein is that they are not a corrective measure as many other techniques that aim to reverse-engineer the electrolarynx in order to make it sound better. The devices described herein instead generate accurate information from the sensor in the stoma to accurately form the speech. This can also
15 eliminate the use of square waves for modulation, which is by itself a source of distortion to the speech produced.

 Accordingly, provided herein is an electrolarynx that overcomes many of the limitations of existing devices. In some embodiments, the non-ideal excitation sound of the electrolarynx is corrected. In some embodiments, devices described herein utilize a
20 subsystem to fix the voice/voiceless indistinguishability by creating a synchronous on/off circuitry using human breath to turn on the electrolarynx at the onset of speech and turn it off when speech is over. By so doing, the buzz which would have otherwise filled in the spectral valley of the region of silence is eliminated that makes a "voiceless sound" be perceived as "voiced" in existing devices. In addition, in some embodiments, the sensed-human breath
25 "amplitude information" is used to control the speech volume.

 In some embodiments, the frequency part of the sensed human breath is used to control speech pitch (See e.g., UEMI et al. (1994)).

 In some embodiments, devices described herein encode speech articulatory patterns into bits recognizable as inputs to ASR systems for clearer communication. (e.g., flex-sensors
30 with resistors are used to measure jaw excursions (e.g., by use of an accelerometer placed underneath the jaw) and then the info is encoded into bits and fed into a microcontroller which is used to "switch" the speech into "normal sounding speech").

 An exemplary device is described in FIGS. 8-10. The figures shows a throat of a subject **2** with a stoma sensor **1** embedded therein or worn as a neck brace. Information from

the sensor is transmitted via wire **3** or wirelessly to the remote smart speech (e.g., electrolarynx) component **4**. The smart speech circuit **4** comprises a control element **5** and speaker **6**. The control element **5** comprises, for example, electrical circuits, a computer processor and computer memory (See e.g., Figures 3-6 for exemplary electrical circuits) that
5 translate signals from the stoma sensor into sound. The control element **5** further senses when speech starts and stops and silences the speaker **6** accordingly.

The control element **5** senses via information from the stoma sensor **1** when speech starts and stops and silences the speaker **6** accordingly. FIG. 8 shows an exemplary sensor **1**. Figure 7 shows the circuitry for information from the stoma sensor. FIG. 9 shows a diagram
10 of the stoma sensor and related components. FIG 9 a-c shows an electrolarynx buzz activation circuit (stoma sensor circuit) and stoma sensor. In some embodiments, systems utilize a mini-mic or mini-pressure sensor. In some embodiments, the entire electrolarynx, including motion sensor, is strapped to the neck. Such a system is completely hands-free in operation.

15 FIGS. 3-6 shows circuitry for a sensor that senses jaw movements /excursions rather than breath and translates it to speech. FIG. 9D shows a diagram of such a system.

A flow chart of an exemplary process for using the devices described herein is shown in FIG. 1. In use, a user speaks. The stoma sensor **1** transmits signal to control element **5**, which senses that the speaker is talking and thus activates speaker **6**. The control element **5**
20 utilizes circuits and computer processor to translate stoma sensor into speech, which is transmitted through speaker **6**. When the user is silent, the control center senses lack of speech from the stoma sensor **1** and turns off speaker **6**.

All publications, patents, patent applications and accession numbers mentioned in the
25 above specification are herein incorporated by reference in their entirety. Although the disclosure has been described in connection with specific embodiments, it should be understood that the disclosure as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications and variations of the described compositions and methods of the disclosure will be apparent to those of ordinary skill in the art and are
30 intended to be within the scope of the following claims.

CLAIMS

We Claim:

1. An electrolarynx system, comprising;
 - 5 a) a sensor configured to be placed in the stoma of a human subject;
 - b) a control element configured to obtain signal from said sensor and translate said signal into speech; and
 - c) a speaker configured to amplify said speech.
- 10 2. The system of claim 1, wherein said control element is configured to turn said speaker on when said subject is talking and turn said speaker off when said subject is silent.
3. The system of claim 1 or 2, wherein said control element comprises one or more of an electrical circuit, a computer processor, and computer memory.
- 15 4. The system of any one of claims 1 to 3, wherein said control element is further configured to perform articulatory pattern recognition of said subject's speech.
5. The system of any one of claims 1 to 4, wherein said device is controlled by
20 said subjects breath.
6. The system of any one of claims 1 to 5, wherein said signal is transmitted from said sensor to said control element via an electrical cable.
- 25 7. A method of generating artificial speech, comprising:
contacting the system of any one of claims 1 to 6 with a subject's stoma under conditions such that said device generates speech and transmit said speech through the speaker of said device.
- 30 8. The method of claim 7, wherein said subject lacks a larynx.
9. The method of claim 8, wherein said subject has previously been diagnosed with oral cancer.

10. The method of claim 8 or 9, wherein method is performed hands free.

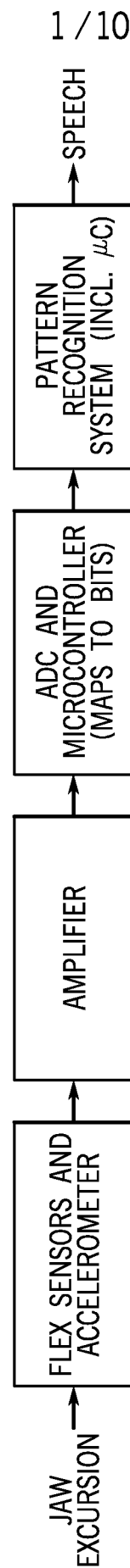


FIG. 1

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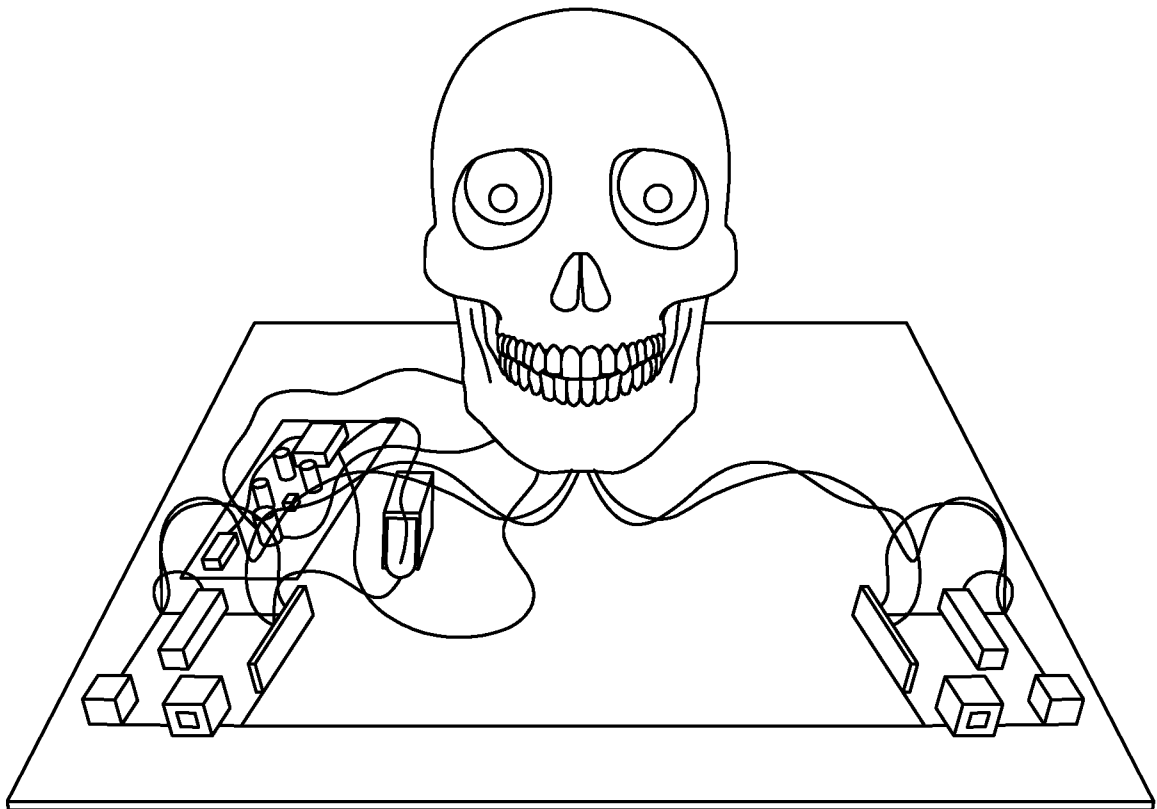
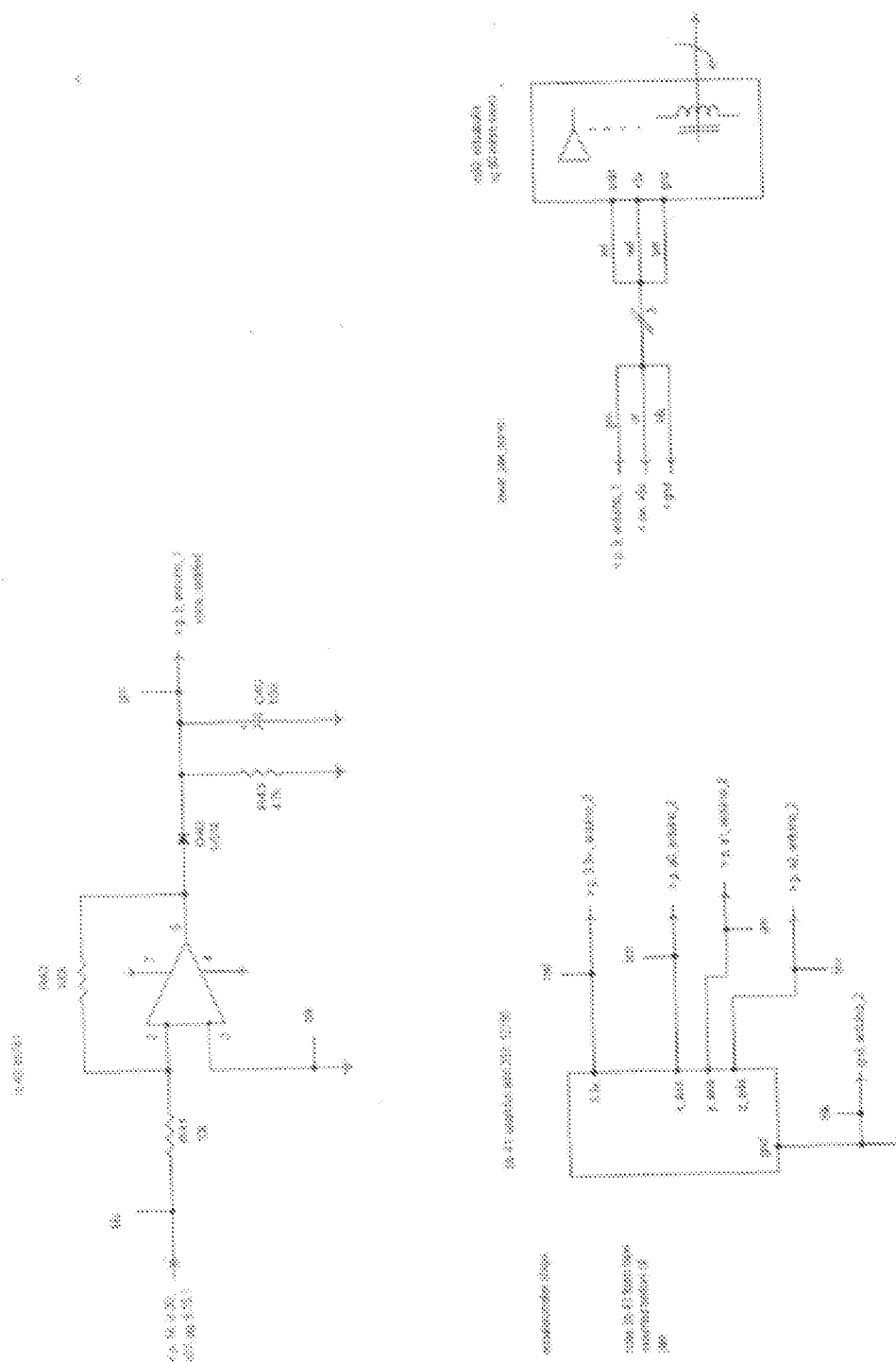


FIG. 2

FIG. 3



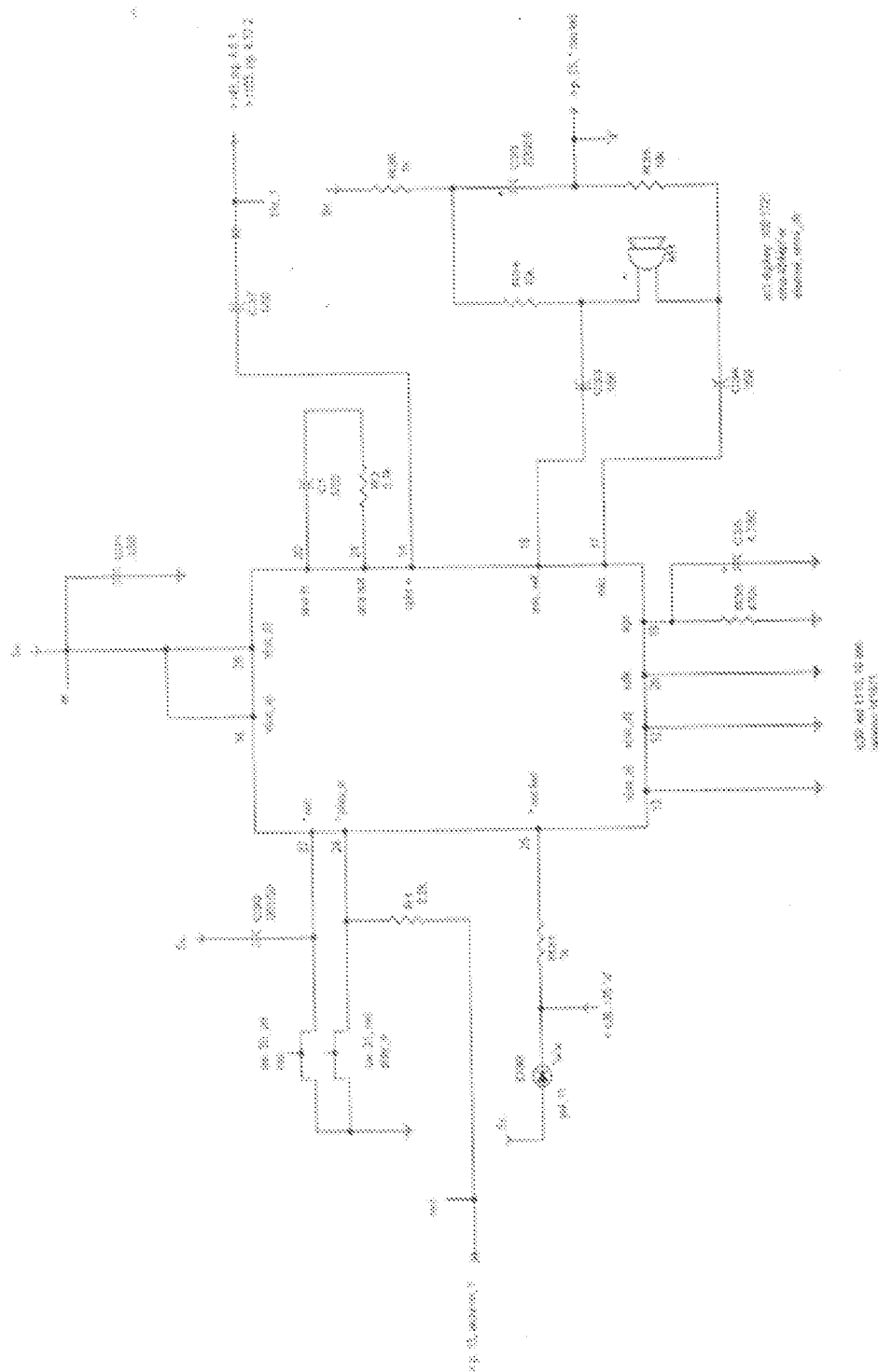


FIG. 4

FIG. 5

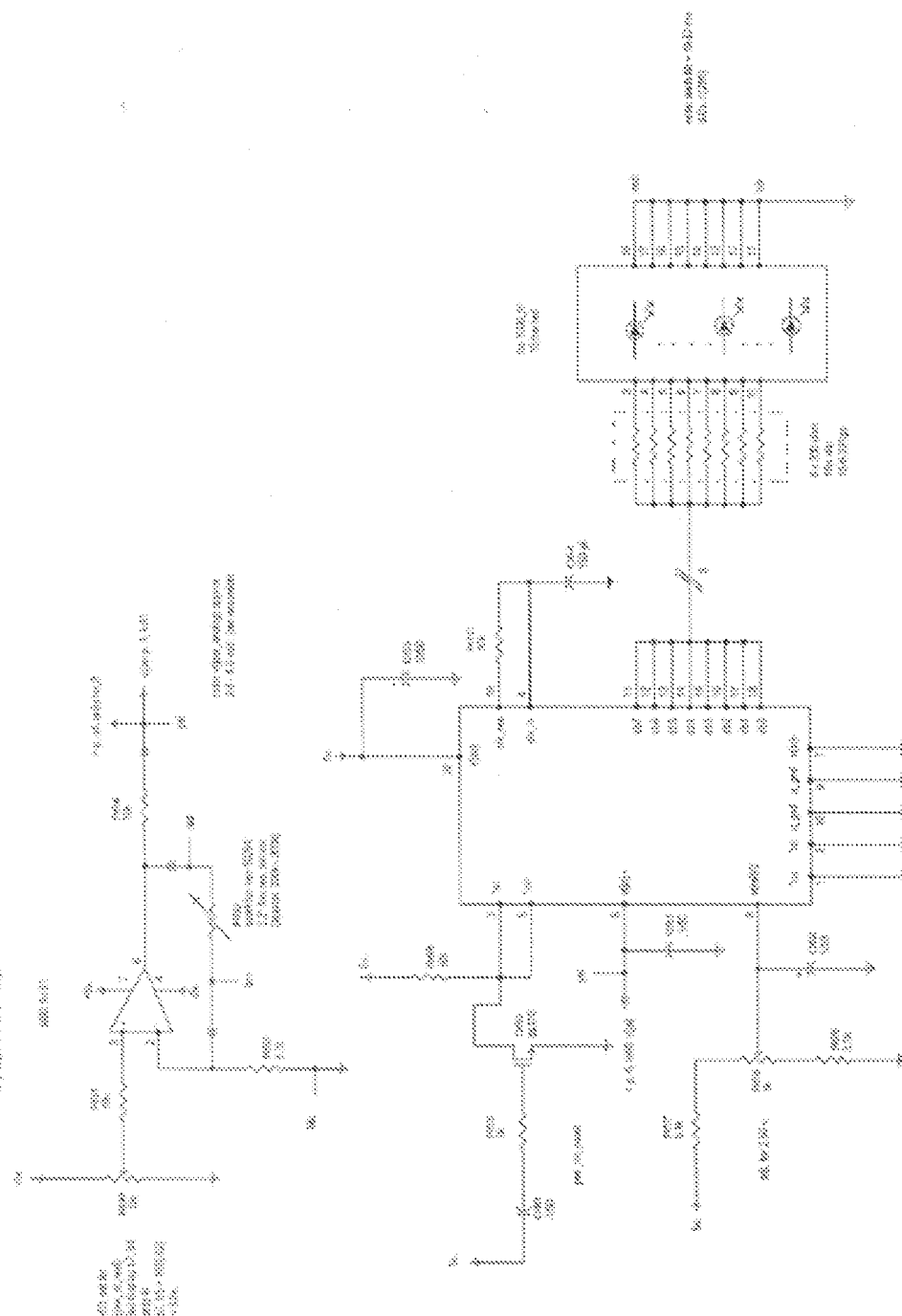


FIG. 6

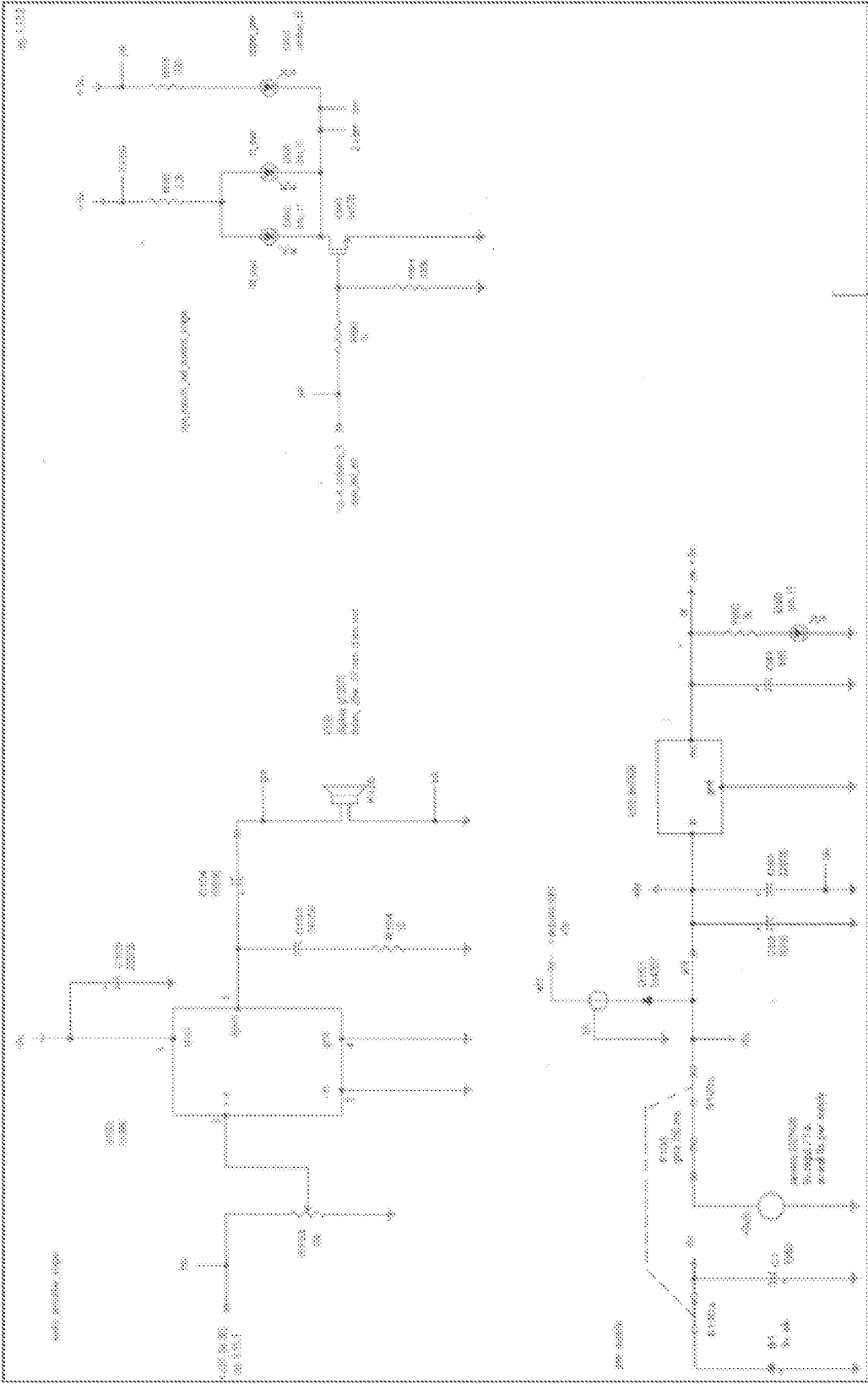
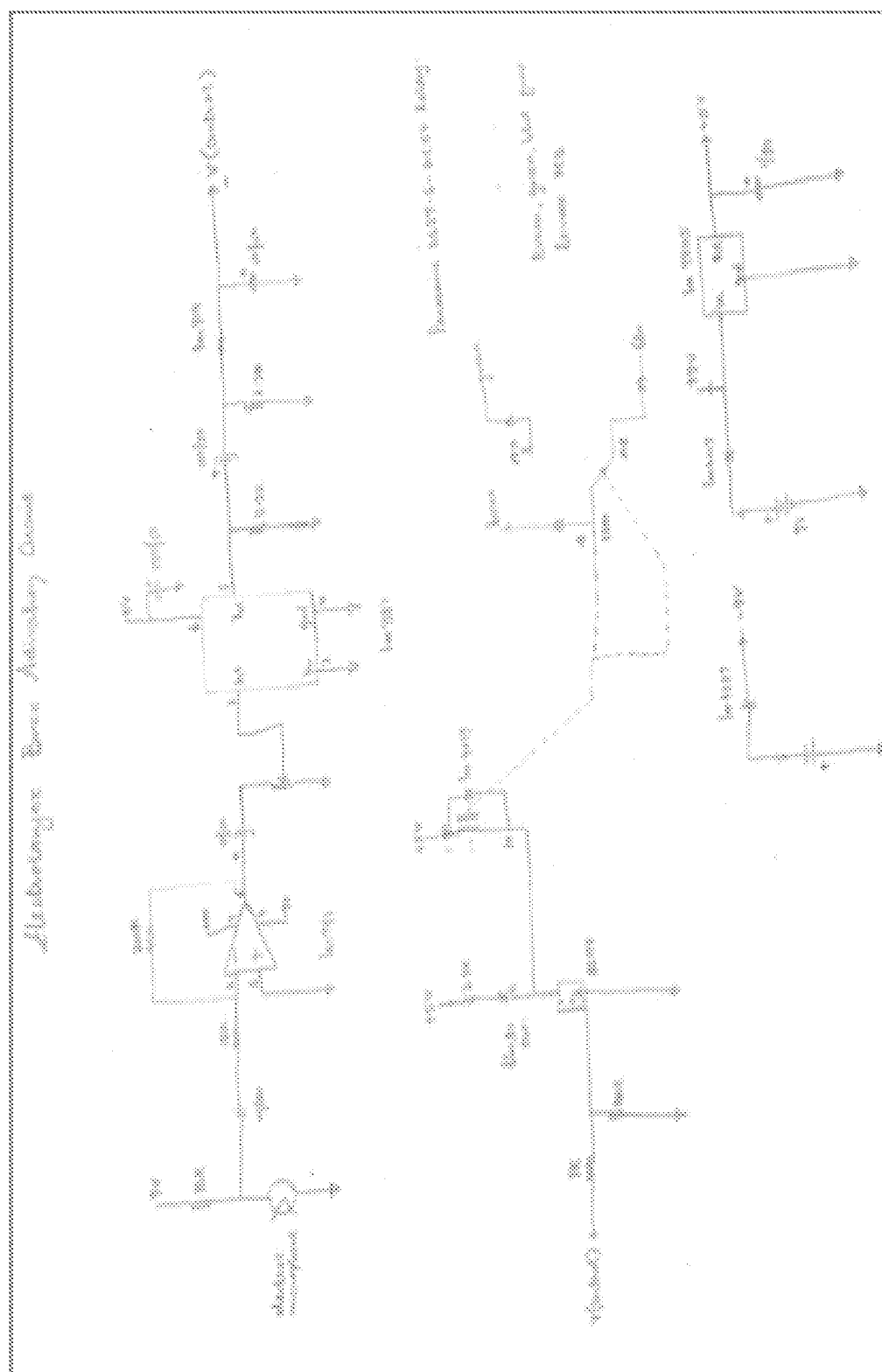


FIG. 7



8 / 10

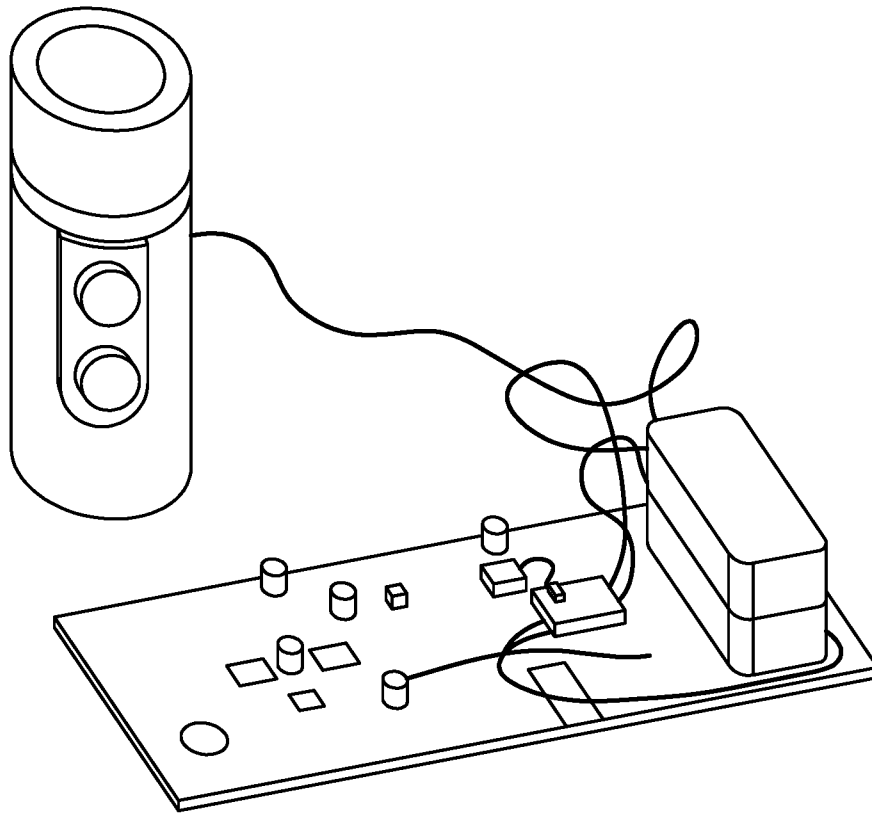
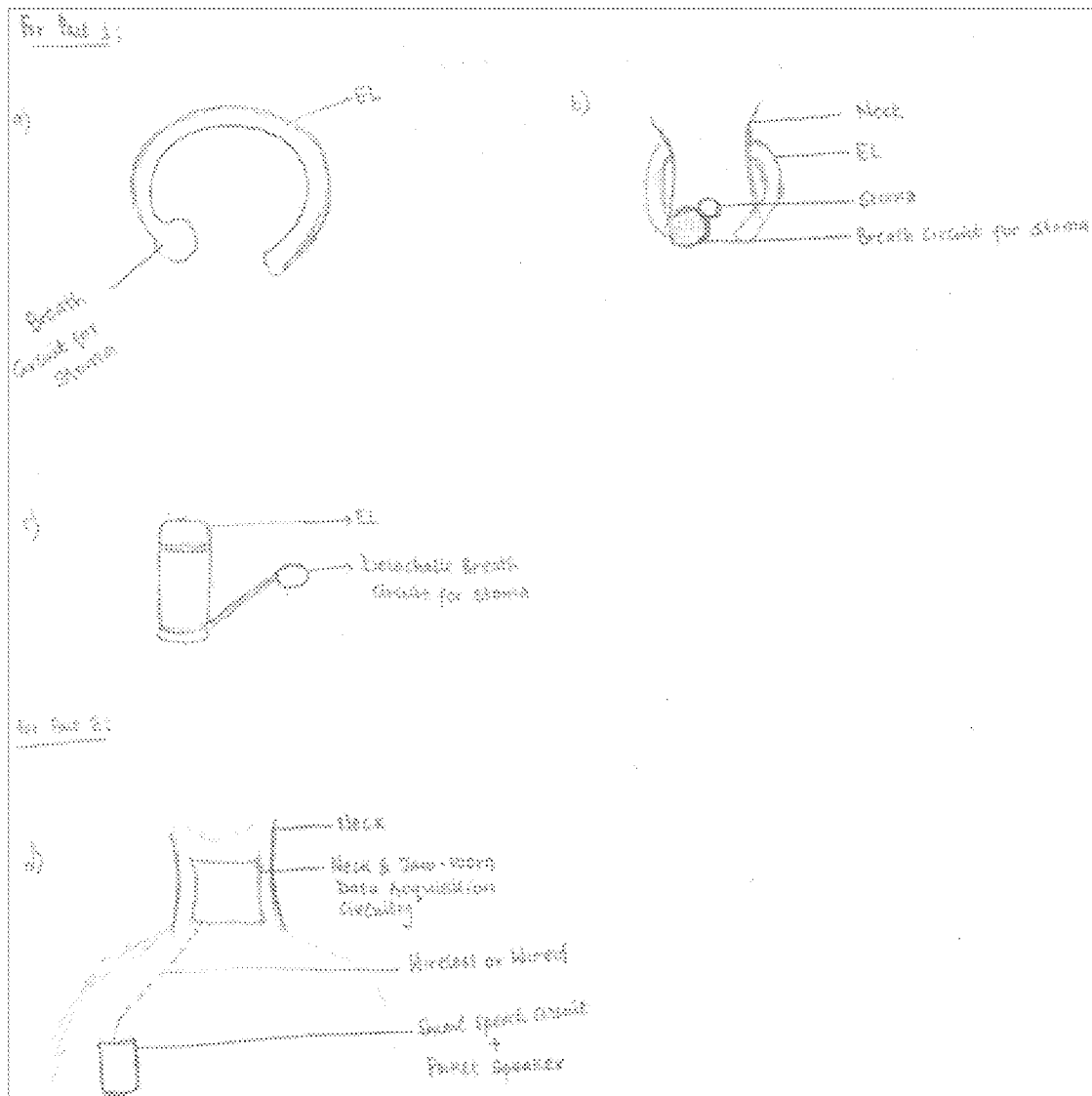


FIG. 8

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FIG. 9



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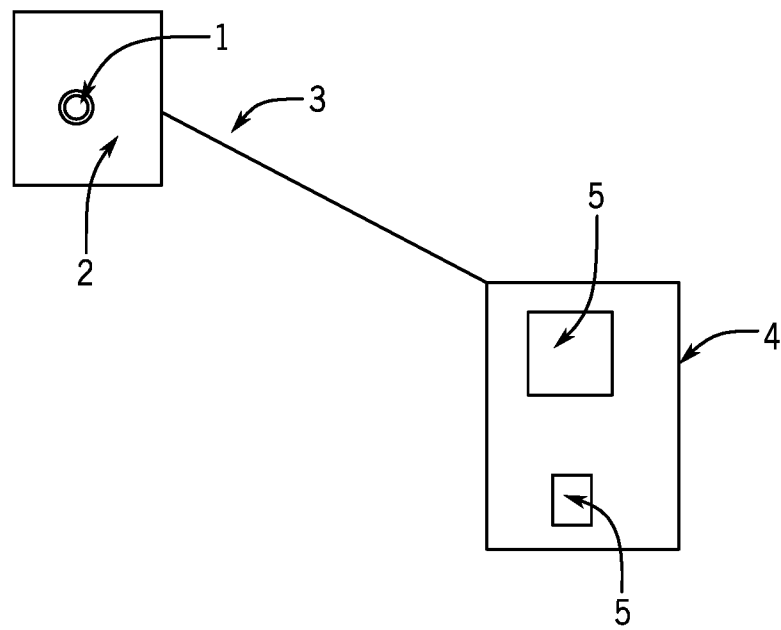


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/30182

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61F 2/20 (2018.01)

CPC - A61F 2/00, A61F 2/02, A61F 2/20, A61F 2/70, G10L 13/00, G10L 13/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

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

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,888,187 A (Jaeger et al) 30 March 1999 (30.03.1999) entire document, especially fig 8; col 6 ln 6-8, 13-14, 32-36, 42-44, 64-65	1, 3/[1]
Y		2, 3/[2]
Y	US 5,326,349 A (Baraff) 5 July 1994 (05.07.1994) entire document, especially col 12 ln 2-8	2, 3/[2]
A	US 2014/0358551 A1 (Liu et al) 4 December 2014 (04.12.2014) entire document	1-3
A	US 5,812,681 A (Griffin) 22 September 1998 (22.09.1998) entire document	1-3
A	US 2011/0190881 A1 (Russell et al) 4 August 2011 (04.08.2011) entire document	1-3
A	US 2013/0294613 A1 (Nagel et al) 7 November 2013 (07.11.2013) entire document	1-3
A	WO 2012/112033 A1 (Rijksuniversiteit Groningen) 23 August 2012 (23.08.2012) entire document	1-3

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

3 July 2018

Date of mailing of the international search report

20 JUL 2018

Name and mailing address of the ISA/US

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/30182

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

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

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

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

3. ☒ Claims Nos.: 4-10
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

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

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.