

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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**AMAZON.COM, INC.,**  
Petitioner,

v.

**JAWBONE INNOVATIONS, LLC,**  
Patent Owner.

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IPR2023-00275  
U.S. Patent No. 8,467,543

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**DECLARATION OF RICHARD M. STERN, Ph.D.**  
**IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW**  
**OF CLAIMS 1-26 OF U.S. PATENT NO. 8,467,543**

LGE EXHIBIT NO. 1002

|                                                                                      |
|--------------------------------------------------------------------------------------|
| <p><i>Amazon v. Jawbone</i><br/>U.S. Patent 8,467,543<br/><b>Amazon Ex. 1002</b></p> |
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I, Richard M. Stern, Ph.D., do hereby declare:

1. I am making this declaration at the request of Petitioner Amazon.com, Inc. (“Amazon”). I have been retained by Amazon as a technical expert in this matter.

2. I am being compensated for my work on this case. My compensation does not depend on the content of this Declaration or the outcome of these proceedings. I do not own any stock in Amazon and, to my knowledge, I have no financial interest in Amazon.

## **I. BACKGROUND**

### **A. Experience and Qualifications**

3. I am a Professor at Carnegie Mellon University in the Department of Electrical and Computer Engineering, the Department of Computer Science, and the Language Technologies Institute. I have been on the faculty of Carnegie Mellon since 1977.

4. I received the S.B. degree from the Massachusetts Institute of Technology (MIT) in 1970, the M.S. from the University of California, Berkeley, in 1972, and the Ph.D. from MIT in 1977, all in electrical engineering.

5. I am a fellow of the Institute of Electrical and Electronics Engineers (IEEE), the Acoustical Society of America, and the International Speech Communication Association (ISCA). I was the ISCA 2008-2009 Distinguished

Lecturer, a recipient of the Allen Newell Award for Research Excellence in 1992, and I served as the General Chair of Interspeech 2006. Interspeech is the world's largest technical conference focused on speech processing and application.

6. Much of my current research is in spoken language systems, where I am particularly concerned with the development of techniques with which automatic speech recognition can be made more robust with respect to changes in environment and acoustical ambience.

7. I have actively worked on the theory and application of systems using microphone arrays over a period of decades (*e.g.*, Stern et al., 2008; Stern and Menon, 2020), and my research group has developed several array-based algorithms to improve speech recognition accuracy in difficult acoustical environments (*e.g.*, Seltzer et al., 2004; Stern et al., 2007; Kim et al., 2009; Moghimi and Stern, 2019). I have also actively worked on the theory and application of systems to accomplish voice activity detection for more than twenty years. Most recently, my students developed the system that provided best performance worldwide in the 2021 Fearless Steps Phase-03 Speech Activity Detection (SAD) Challenge, which was organized and run by the University of Texas, Dallas (Vuong et al., 2021). My relevant publications, including those cited above, are available on Carnegie Mellon's web site at <http://www.cs.cmu.edu/afs/cs/user/robust/www/papers.html>.

8. I understand a copy of my current curriculum vitae, which lists my publications for the last ten years, is being submitted as Exhibit 1028.

**B. Materials Considered**

9. In preparing this Declaration, I have considered the following materials:

| <b>Exhibit No.</b> | <b>Description</b>                                                                                                                                                                                                   |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1001               | U.S. Patent No. 8,467,543 (“the ‘543 patent”)                                                                                                                                                                        |
| 1003               | U.S. Patent No. 6,377,919 (“Burnett ’919”)                                                                                                                                                                           |
| 1004               | U.S. Patent No. 5,825,897 (“Andrea”)                                                                                                                                                                                 |
| 1005               | U.S. Patent No. 5,471,538 (“Sasaki”)                                                                                                                                                                                 |
| 1006               | Amir Hussain et al., <i>A New Metric for Selecting Sub-Band Processing in Adaptive Speech Enhancement Systems</i> , Proc. 5 <sup>th</sup> Eur. Conf. on Speech Comm’n and Tech. (Eurospeech ’97) 2611-14 (“Hussain”) |
| 1007               | International Patent Publication No. WO2000/021194 (“Puthuff”)                                                                                                                                                       |
| 1008               | U.S. Patent No. 3,746,789 (“Alcivar”)                                                                                                                                                                                |
| 1009               | U.S. Patent No. 6,006,175 (“Holzrichter ’175”)                                                                                                                                                                       |
| 1010               | U.S. Patent No. 5,729,694 (“Holzrichter ’694”)                                                                                                                                                                       |
| 1011               | Bernard Widrow et al., <i>Adaptive Noise Cancelling: Principles and Applications</i> , 63 Proc. IEEE 12 (1975) (“Widrow 1975”)                                                                                       |

| Exhibit No. | Description                                                                                                                                                                                                                                               |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1012        | Bernard Widrow et al., <i>Adaptive Signal Processing</i> (1985) (“Widrow 1985”)                                                                                                                                                                           |
| 1013        | U.S. Patent No. 4,177,430 (“Paul”)                                                                                                                                                                                                                        |
| 1014        | U.S. Patent No. 4,589,137 (“Miller”)                                                                                                                                                                                                                      |
| 1015        | U.S. Patent No. 4,912,767 (“Chang”)                                                                                                                                                                                                                       |
| 1016        | U.S. Patent No. 4,956,838 (“Gilloire”)                                                                                                                                                                                                                    |
| 1017        | U.S. Patent No. 5,566,167 (“Duttweiler”)                                                                                                                                                                                                                  |
| 1018        | European Patent No. EP0615340B1 (“Dennis”)                                                                                                                                                                                                                |
| 1019        | Kenneth N. Stevens et al., <i>The Use of Miniature Accelerometer for Detecting Glottal Waveforms and Nasality</i> (1974) (“Stevens”)                                                                                                                      |
| 1020        | Vishu R. Viswanathan et al., <i>Noise-Immune Speech Transduction Using Multiple Sensors</i> , Proc. 1985 Int’l Conf. on Acoustics, Speech, and Signal Processing (ICASSP ’85) 712-15 (“Viswanathan 1985”)                                                 |
| 1021        | Vishu R. Viswanathan & Claudia M. Henry, <i>Noise-Immune Multi-sensor Speech Input: Formal Subjective Testing in Operational Conditions</i> , Proc. 1989 Int’l Conf. on Acoustics, Speech, and Signal Processing (ICASSP ’89) 373-76 (“Viswanathan 1989”) |
| 1022        | Excerpts from the ’543 patent’s file history                                                                                                                                                                                                              |

10. I have also relied on my education, training, and experience, and my knowledge of pertinent literature in the field of the ’543 patent.

## **II. APPLICABLE LEGAL STANDARDS**

11. I have been asked to provide my opinion as to whether the claims of the '543 patent would have been obvious to a person of ordinary skill in the art at the time of the alleged invention, in view of the prior art.

12. I am an electrical engineer by training and profession. The opinions I am expressing in this report involve the application of my training and technical knowledge and experience to the evaluation of certain prior art with respect to the '543 patent.

13. Although I have been involved as a technical expert in patent matters before, I am not an expert in patent law. Therefore, the attorneys from Knobbe, Martens, Olson & Bear, LLP have provided me with guidance as to the applicable patent law in this matter. The paragraphs below express my understanding of how I must apply current principles related to patent validity to my analysis.

### **A. Claim Construction**

14. It is my understanding that in determining whether a patent claim is obvious in view of the prior art, the Patent Office construes the claim by giving the claim terms their plain and ordinary meaning, as they would have been understood by a person of ordinary skill in the art at the time of the invention in view of the intrinsic record (patent specification and file history). For the purposes of this review, and to the extent necessary, I have interpreted each claim term in accordance

with its plain and ordinary meaning as it would have been understood by a person of ordinary skill in the art at the time of the invention, in view of the intrinsic record. I have been instructed that the time of the invention is March 27, 2002, which I understand to be the earliest claimed priority date of the '543 patent.

15. I understand that a patent and its prosecution history are considered “intrinsic evidence” and are the most important sources for interpreting claim language in a patent. I also understand that in reading the claim, I must not import limitations from the specification into the claim terms; in other words, I must not narrow the scope of the claim terms by implicitly adding disclosed limitations that have no express basis in the claims. The prosecution history of related patents and applications can also be relevant.

16. I understand that sources extrinsic to a patent and its prosecution history (such as dictionary definitions and technical publications) may also be used to help interpret the claim language, but that such extrinsic sources cannot be used to contradict the unambiguous meaning of the claim language that is evident from the intrinsic evidence.

17. Unless expressly stated herein, I have applied the plain and ordinary meaning of the claim terms, which I understand is the meaning that a person of ordinary skill in the art would have given to terms in March 2002, based on a review of the intrinsic evidence.

**B. Obviousness**

18. It is my understanding that a claim is “obvious” if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art at the time of the alleged invention. I understand that an obviousness analysis involves a number of considerations. I understand that the following factors must be evaluated to determine whether a claim would have been obvious: (i) the scope and content of the prior art; (ii) the differences, if any, between each claim of the ’543 patent and the prior art; (iii) the level of ordinary skill in the art in March 2002; and (iv) additional considerations, if any, that indicate that the invention was obvious or not obvious. I understand that these “additional considerations” are often referred to as “secondary considerations” of non-obviousness or obviousness.

19. I also understand that the frame of reference when evaluating obviousness is what a hypothetical person of ordinary skill in the pertinent art would have known in March 2002. I understand that the hypothetical person of ordinary skill is presumed to have knowledge of all pertinent prior art references.

20. I understand that a prior art reference may be a pertinent prior art reference (or “analogous art”) if it is in the same field of endeavor as the patent or if it is pertinent to the problem that the inventors were trying to solve. A reference is reasonably pertinent if it logically would have commended itself to an inventor’s attention in considering the problem at hand. If a reference relates to the same

problem as the claimed invention, that supports use of the reference as prior art in an obviousness analysis. Here, all of the references relied on in my obviousness analysis below are in the same field of endeavor as the '543 patent, e.g., signal capture and processing in speech or audio applications. The references are also pertinent to a particular problem the inventor was focused on, e.g., noise reduction.

21. It is my understanding that the law recognizes several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include:

- combining prior art elements according to known methods to yield predictable results;
- simple substitution of one known element for another to obtain predictable results;
- a predictable use of prior art elements according to their established functions;
- using known techniques to improve similar devices (methods, or products) in the same way;
- applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success (in which case a claim would have been obvious to try);

- known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; and
- some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

22. I understand that “secondary considerations” must be considered as part of the obviousness analysis when present. I further understand that the secondary considerations may include: (1) a long-felt but unmet need in the prior art that was satisfied by the claimed invention; (2) the failure of others; (3) skepticism by experts; (4) commercial success of a product covered by the patent; (5) unexpected results achieved by the claimed invention; (6) industry praise of the claimed invention; (7) deliberate copying of the invention; and (8) teaching away by others. I also understand that evidence of the independent and nearly simultaneous “invention” of the claimed subject matter by others is a secondary consideration supporting an obviousness determination and may support a conclusion that a claimed invention was within the knowledge of a person of ordinary skill as of March 2002. I am not aware of any evidence of secondary considerations that would suggest that the claims of the ’543 patent would have been nonobvious in March 2002.

23. I understand that when assessing obviousness, using hindsight is impermissible; that is, what is known today or what was learned from the teachings of the patent should not be considered. The patent should not be used as a road map for selecting and combining items of prior art. Rather, obviousness must be considered from the perspective of a person of ordinary skill at the time the alleged invention was made—March 2002 in this case.

24. I also understand that an obviousness analysis must consider the invention as a whole, as opposed to just a part or element of the invention. I understand this “as a whole” assessment to require showing that one of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the elements from the prior art and combined them in the claimed manner.

25. It is my understanding that something is “inherent in,” and therefore taught by, the prior art, if it necessarily flows from the explicit disclosure of the prior art. I understand that the fact that a certain result or characteristic may be present in the prior art is not sufficient to establish inherency. However, if the result or characteristic is necessarily present based upon the explicit disclosure in the prior art, it is inherent in the prior art and is therefore disclosed.

### **III. PERSON OF ORDINARY SKILL IN THE ART**

26. It is my understanding that when interpreting the claims of the '543 patent and evaluating whether a claim would have been obvious, I must do so based on the perspective of a person of ordinary skill in the art at the relevant priority date. I have been instructed to assume for the purposes of my opinions that the relevant priority date of the '543 patent is March 27, 2002. However, my opinions would not change even if the '543 patent were entitled to a priority date in July 2000.

27. I understand that in determining the level of ordinary skill in the art, several factors are considered. Those factors may include: (i) the type of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. A person of ordinary skill in the art must have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

28. Based on my review of the specification and claims of the '543 patent, it is my opinion that a person of ordinary skill in the art would have had a minimum of a bachelor's degree in computer engineering, computer science, electrical engineering, mechanical engineering, or a similar field, and approximately three years of industry or academic experience in a field related to acoustics, speech recognition, speech detection, or signal processing. Work experience could

substitute for formal education and additional formal education could substitute for work experience.

29. My conclusions below that the claims of the '543 patent would have been obvious would remain the same even if the priority date, field of endeavor, or level of ordinary skill were slightly different.

30. I meet the above definition of a person of ordinary skill in the art, and did so as of March 2002 (and as of 2000). Also, I have worked with persons of ordinary skill in the art through my professional and academic experiences, and I have an understanding of their skill level around March 2002.

#### **IV. TECHNOLOGY BACKGROUND**

##### **A. Noise Cancellation Systems Were Known.**

##### **1. Estimating and Subtracting Noise From a Desired Signal Was Known.**

31. Adaptive noise reduction systems that estimate noise and then subtract it from a speech signal have been used for decades. For example, in 1975, Widrow described using a dual-microphone noise-reduction system in which a signal containing noise is “adaptively filtered and subtracted from the primary input” to obtain a denoised signal. (Ex. 1011 (Widrow 1975), Abstract.) That article explained that noise could be reduced in a signal by “subtracting noise from a received signal” if “filtering and subtraction are controlled by an appropriate adaptive process.” (*Id.*, 1693.) Ten years later, in 1985, Widrow authored a textbook

on adaptive signal processing that described various systems capable of such adaptive noise reduction. (Ex. 1012 (Widrow 1985), 303-316.)

32. Many similar methods for estimating a noise signal and removing it from a primary signal were also known long before the '543 patent was filed. For example, U.S. Patent No. 4,177,430 to Paul, which issued in 1979, disclosed using an “adaptive transversal filter” that generated an estimate of noise and “subtract[ed] [the noise estimate] from the combination of the desired audio signal and the first broadband noise signal” to remove noise. (Ex. 1013 (Paul), Abstract; *id.*, 2:60-3:27.) U.S. Patent No. 4,589,137 to Miller, which issued in 1986, disclosed another “adaptive filter system [that] subtracts the noise in the reference channel from the signal-plus-noise in the primary channel,” thereby producing an output with the noise removed. (Ex. 1014 (Miller), Abstract; *id.*, 1:36-57.) As another example, U.S. Patent No. 4,912,767 to Chang, which issued in 1990, disclosed using adaptive filters to process noise signals and then subtracting the noise “from the voice-plus-noise signal . . . to provide the substantially noise-free voice signal.” (Ex. 1015 (Chang), 6:4-7; *id.*, 5:36-68.) The '543 patent also explicitly admits that such systems were well known and provides a drawing of a “classical ANC (adaptive noise cancellation)” device labelled as “prior art.” (Ex. 1001 (the '543 patent), 16:44-46, Fig. 1B (“Prior Art”).)

**2. Noise Canceling Communications Systems with Microphones Oriented Toward and Away From a Speaker Were Known.**

33. By the mid-1990s, it was widely known that orienting microphones in certain directions improves noise removal in communications devices such as handsets and headsets. For example, Andrea, which I discuss in detail below, described a telephone handset and headset that implemented an active noise cancellation system using two microphones oriented in different directions. (Ex. 1004 (Andrea), 1:19-22, 12:31-43; ¶¶93-95 (overview of Andrea), below.)

**3. Noise Canceling Systems Operating in Frequency Sub-bands Were Known.**

34. Sub-band processing in adaptive noise cancellation systems was well known and was described in Hussain, as I discuss below. (¶46 (overview of Hussain), below). Many other references also described noise cancellation systems that implemented sub-band processing. For example, U.S. Patent No. 4,956,838 to Gilloire, which issued in 1990, described an “echo cancelling device” that processed “successive mutually adjacent sub-bands” using “an adaptive filter delivering an estimated echo value in the sub-band to the subtractive input of the subtractor” in order to output a denoised signal. (Ex. 1016 (Gilloire), Abstract; *id.*, Fig. 3.) Similar systems using sub-band processing for noise removal were disclosed in other references as well. (Ex. 1015 (Chang), 5:36-6:7; Ex. 1017 (Duttweiler), 1:46-57

(describing an improved sub-band echo canceler); Ex. 1018 (Dennis), 2:15-38 (describing an adaptive noise canceler that filters signals into “a plurality of subband[s]”).)

**B. Detecting Voicing Activity With Non-Acoustic Sensors Was Known.**

35. Voice activity detectors, including sensors for detecting voice through tissue vibrations, were also known and used in the art for decades before the '543 patent's priority date. For example, as early as 1973, Alcivar described a “tissue conduction microphone” that detects speech through “tissue vibrations due to modulation of the vocal chords.” (Ex. 1008 (Alcivar), 4:65-5:54.) The next year, another reference published describing the use of an accelerometer “to produce a waveform related to the glottal acoustic output when attached to the throat of a speaker” as early as 1974. (Ex. 1019 (Stevens), 1.) Detecting voice through tissue vibrations was also disclosed in multiple references by Viswanathan in the 1980s. (Ex. 1020 (Viswanathan 1985), 712 (using “an accelerometer that measures the skin vibrations”); Ex. 1021 (Viswanathan 1989), 373 (“we collected speech in acoustic background noise using the neckstrap-mounted accelerometer”).)

36. Puthuff, which was filed in 1998, disclosed using “a motion transducer comprising a vibration sensor, and specifically, in a preferred embodiment, an accelerometer” to detect voice. (Ex. 1007 (Puthuff), 5:1-3.) Puthuff explained that

devices such as “vibration transducers,” “accelerometers [used] to detect bone vibration,” and “throat microphones [that] pick[] up vibrations at the talker’s throat” were known for decades. (*Id.*, 3:19-25.) Puthuff disclosed that such sensor-based VADs could be used to control other devices. (*Id.*, 3:12-20.)

**C. Using Non-Acoustic Sensors for Voice Activity Detection in Noise Cancellation Systems Was Known.**

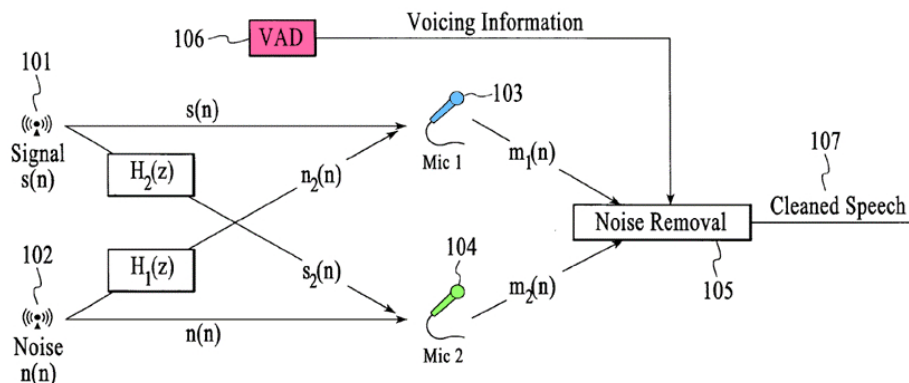
37. By the late 1990s, systems including both a noise reduction system that subtracts noise from the received signal and a non-acoustic VAD to indicate when voicing activity is present were known. For example, engineers at the Lawrence Livermore National Laboratory (“LLNL”) filed a patent application in 1999 describing exactly this combination. That patent issued in 2002 as Burnett ’919, which is described in detail below. (¶45 (overview of Burnett ’919), below.)

**V. THE ’543 PATENT**

**A. Summary of the ’543 Patent**

38. The ’543 patent relates to systems “for detecting and processing a desired acoustic signal in the presence of acoustic noise.” (Ex. 1001 (the ’543 patent), 1:28-30.) The specification states that prior art systems generally used a “single-microphone Voice Activity Detector (VAD) to determine the background noise characteristics.” (*Id.*, 1:45-49.) The ’543 patent also explains that these single-microphone VAD systems had limitations. (*Id.*, 1:60-2:2.)

39. The '543 patent purports to improve upon such prior art systems by using a non-acoustic VAD (106, pink) along with two microphones (103, 104, blue and green, respectively), and a noise removal system 105:



(Ex. 1001 (the '543 patent), Fig. 1, 2:7-13, 5:28-34, 14:40-50.)<sup>1</sup> The microphones both receive signals from speech source 101 and noise source 102. (*Id.*) VAD 106 detects voicing activity and indicates whether speech is occurring. (*Id.*, 4:52-57.)

40. The '543 patent explains various known VADs that can be used in the voice detection subsystem, including EM sensors (Ex. 1001 (the '543 patent), 11:51-12:12), accelerometers, skin surface microphones, two-microphone acoustic VADs, and conventional single-microphone VADs. (*Id.*, 11:40-14:39.) The VAD's signal is used to "control the method of noise removal." (*Id.*, 4:52-57, 14:51-15:35.)

41. The '543 patent also explains that the system can use two conventional unidirectional or omnidirectional microphones in various configurations, including

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<sup>1</sup> Figures in this Declaration may be highlighted.

one facing toward the speaker and one facing away, in addition to the voice detection subsystem. (Ex. 1001 (the '543 patent), 6:44-11:39 (describing configurations), Figs. 3A-9C.) The patent alleges that these configurations allow the microphones to be “placed very close together” (*id.*, 6:58-63), but also states that the microphones may be placed “15 centimeters or more away” from each other (*id.*, 8:13-15).

42. The '543 patent then describes an adaptive noise cancellation system that is “very similar” to prior art systems, but alleges differences between the disclosed system and prior art systems. (Ex. 1001 (the '543 patent), 16:44-54; *id.*, 14:39-19:22.) These alleged differences include: (a) using a VAD to control the noise cancellation system; (b) processing the signals in frequency sub-bands; and (c) using microphone configurations such as placing one microphone facing toward the speaker and the other away from the speaker to allow the secondary microphone to capture some speech signal. (*Id.*; *see also id.*, 16:55-17:34.) However, using a VAD, performing signal processing on individual frequency sub-bands, and the claimed microphone configurations were all well-known in the art by the '543 patent's earliest possible priority date.

#### **B. The Priority Date of the '543 Patent**

43. I understand that the '543 patent issued on June 18, 2013, from U.S. Patent Application 10/400,282 (“the '282 application”), filed March 27, 2003. I also understand that the '282 application claims priority to U.S. Provisional Application

No. 60/368,209 (“the ’209 application”), which was filed on March 27, 2002. (Ex. 1001 (the ’543 patent).) I understand that the ’543 patent’s earliest possible priority date is therefore March 27, 2002.

**VI. CLAIMS 1-26 OF THE ’543 PATENT WOULD HAVE BEEN OBVIOUS.**

**A. Claims 1-2 and 5-7 Would Have Been Obvious in View of Burnett ’919 and Hussain.**

44. Burnett ’919 and Hussain render obvious claims 1-2 and 5-7.

**1. Overview of Burnett ’919**

45. Burnett ’919 discloses a “noise canceling microphone system” that uses an EM sensor to “remove[] background acoustic noise from unvoiced and voiced speech.” (Ex. 1003 (Burnett ’919), 17:49-52.) Burnett ’919’s noise cancelling microphone system uses two microphones (“user microphone 1210 and microphone 1220”, blue and green, respectively) and a voicing sensor (EM sensor 1240, pink) to “determine no-speech time periods.” (*Id.*, 17:56-61.)

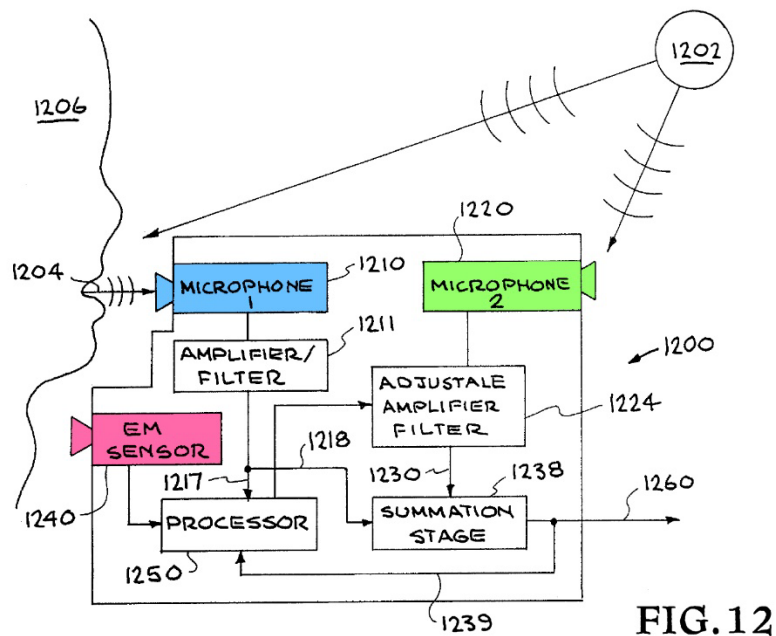
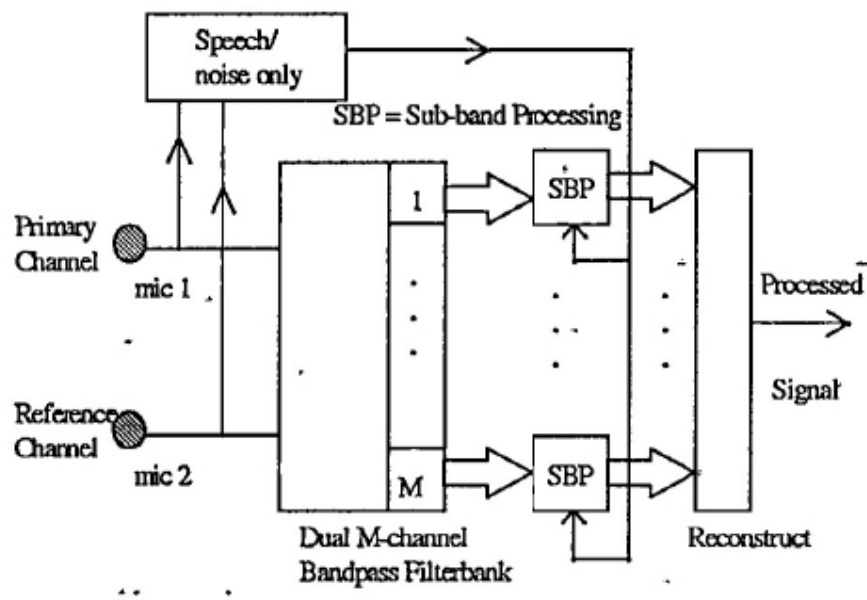


FIG. 12

(*Id.*, Fig. 12.) Processor 1250 uses the signal output by EM sensor 1240 and outputs a control signal to amplifier and filter circuit 1224 so that “[c]ancellation values determined by circuit 1224 are defined during periods of no-speech, and frozen during periods of speech production.” (*Id.*, 17:48-18:17.) By controlling when the amplifier and filter circuit 1224 can adapt, the noise canceler generates an “amplified and filtered background microphone signal 1230” that estimates the noise portion of the signal received by user microphone 1210. (*Id.*, 17:48-18:17.) Using this noise estimate, the system minimizes the “residual signal level in all frequency bands of signal 1260” (e.g., noise in the output signal). (*Id.*, 17:48-18:17.)

## 2. Overview of Hussain

46. Hussain discloses an adaptive noise canceling system that achieves improved noise cancellation in reverberant environments by processing acoustic signals on individual sub-bands before recombining them to produce a denoised signal. (Ex. 1006 (Hussain), 2611-2612, 2614.) In Hussain's system, an adaptive filter determines a "differential acoustic-path transfer function" for individual subbands when no voice activity is detected. (*Id.*, 2612.) However, when voice is detected, the transfer function is used "to process the noisy speech signal" and output a denoised speech signal. (*Id.*) The system uses a bandpass filterbank to split microphone signals into multiple sub-bands, applies sub-band processing ("SBP") to each sub-band, reconstructs the processed signals, and outputs the denoised processed signal, as shown below.



(*Id.*, Fig. 1.)

### **3. Claim 1**

#### **a. 1: Preamble**

47. The preamble of claim 1 recites a “communications system.” Burnett ’919 discloses this limitation because it discloses a system for use in “public address systems, telephone conference systems, telephone networks” and similar communications systems. (Ex. 1003 (Burnett ’919), 14:47-50; *id.*, 15:55-59.)

#### **b. 1[a]: Voice Detection Subsystem**

48. Claim 1 recites “a voice detection subsystem configured to receive voice activity signals that include information associated with human voicing activity, the voice detection subsystem configured to automatically generate control signals using the voice activity signals.” Burnett ’919 discloses and/or renders obvious this limitation.

49. Burnett ’919 discloses a noise cancelling system that “removes background acoustic noise from unvoiced and voiced speech.” (Ex. 1003 (Burnett ’919), 17:49-51.) The system uses an “EM sensor [1240] to determine no-speech time periods” (e.g., as part of a voice activity detector) as shown in Figure 12:

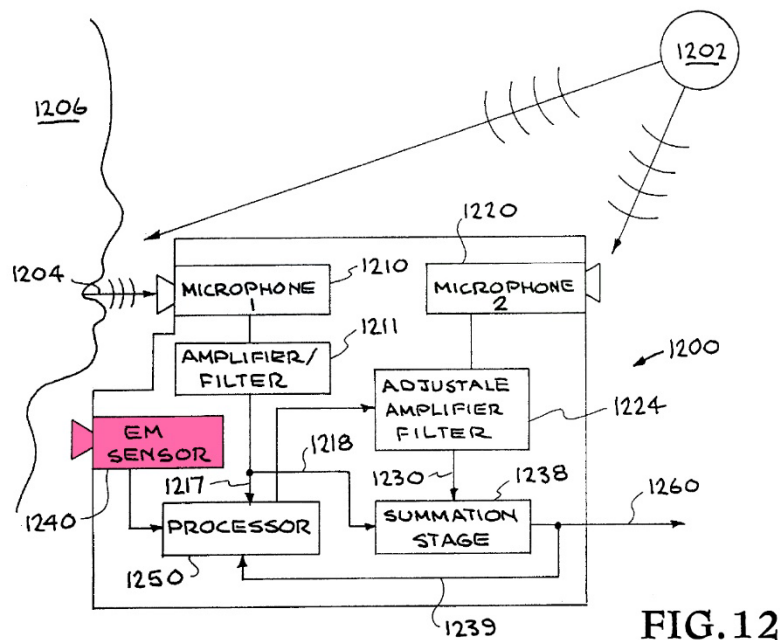


FIG. 12

(*Id.*, 17:56-67, Fig. 12.) The EM sensor 1240 (shown in pink above) in Burnett '919's noise cancelling system detects "sub-millimeter motions of wall tissues in either a sub-glottal or supra-glottal region (i.e., below or above vocal folds), as vocal folds oscillate" during voice production (e.g., voice activity signals that include information associated with human voicing activity). (*Id.*, 2:62-3:9.) These voice activity signals can then be used to "describe periods of no speech or of unvoiced speech" and to determine when acoustic speech signals are being produced by the speaker. (*Id.*, 3:36-58.) EM sensor 1240 outputs the received voice activity signals to processor 1250. (*Id.*, Fig. 12.)

50. As shown in Figure 12 above, processor 1250 outputs a signal that controls the operation of amplifier and filter circuit 1224 by notifying the amplifier

and filter circuit when voicing activity is occurring and when it is not, thereby allowing the filter to adapt “cancellation values determined by circuit 1224 [which] are defined during periods of no-speech” while pausing the filter’s adaptation “during periods of speech production.” (Ex. 1003 (Burnett ’919), 17:56-18:8, Fig. 12.) Because the signal output from processor 1250 controls the operation of amplifier and filter circuit 1224, it is a “control signal.” (*Id.*, 17:56-18:8.) Burnett ’919 further discloses that the system uses “[a]utomated procedures for defining time-periods during which background noise can be characterized” and therefore the processor, which is part of the automated system, outputs the signal automatically. (*Id.*, 17:50-56.) Alternatively, a person of ordinary skill in the art would have understood that the above disclosure requires that Burnett ’919’s system automatically generates control signals identifying the periods of no-speech and/or periods of speech production. (*Id.*, 17:50-18:17, Fig. 12.)

51. Burnett ’919’s noise cancelling system uses the voice activity signals received by the EM sensor to generate the control signals discussed above. Burnett ’919 discloses identifying periods of speech and non-speech using a “master speech onset algorithm,” which is disclosed in U.S. Patent Application No. 08/597596, now U.S. Patent No. 6,006,175 (“Holzrichter ’175”), which Burnett ’919 incorporates by reference. (Ex. 1003 (Burnett ’919), 11:65-12:3; *id.*, 1:52-56; Ex. 1009 (Holzrichter ’175).) Through its incorporation of Holzrichter ’175, Burnett ’919 discloses that

the master speech onset algorithm uses input from “one or more EM sensor modules,” along with other inputs, to determine periods of speech and non-speech. (Ex. 1009 (Holzrichter ’175), 31:51-53; *id.*, 31:33-32:54, Fig. 19.) Thus, Burnett ’919’s control signals are generated using voice activity signals received by the EM sensor.

52. Burnett ’919 therefore discloses and/or renders obvious this limitation.

**c. 1[b]: Denoising Subsystem**

53. Claim 1 recites “a denoising subsystem coupled to the voice detection subsystem,” as well as additional requirements for the denoising system, which are discussed below. Burnett ’919 discloses these limitations.

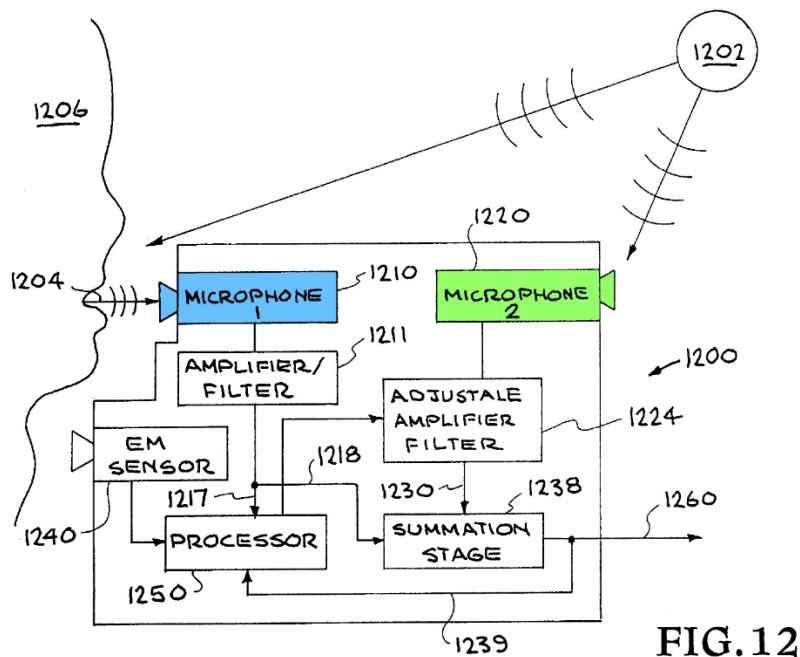
54. Burnett ’919 discloses a denoising subsystem that uses “conventional automatic algorithms [that] can be used to remove the noise from the following (or preceding) speech signals.” (Ex. 1003 (Burnett ’919), 12:37-39.) As described below, Burnett ’919’s denoising subsystem includes a microphone array that captures acoustic signals using two microphones and a processor that uses input from a voice detection subsystem (§§48-52 (claim element 1[a]), above) to automatically remove noise from the signals captured by the microphone array. (§§56-69 (claim elements 1[b][1]-1[b][4]), below.)

55. Accordingly, Burnett ’919 discloses this limitation.

**i. 1[b][1]: Microphone Array**

56. Claim 1 recites “the denoising subsystem comprising a microphone array including a plurality of microphones . . . , the microphone array providing acoustic signals of an environment to components of the denoising subsystem.” Burnett ’919 discloses and/or renders obvious this limitation.

57. Burnett ’919 discloses a microphone array consisting of first and second microphones 1210 and 1220 (“Microphone 1” and “Microphone 2,” highlighted in blue and green, respectively, below):



(Ex. 1003 (Burnett ’919), Fig. 12, 17:58-66.) The acoustic signals received by the first and second microphones include acoustic signals of the environment, such as

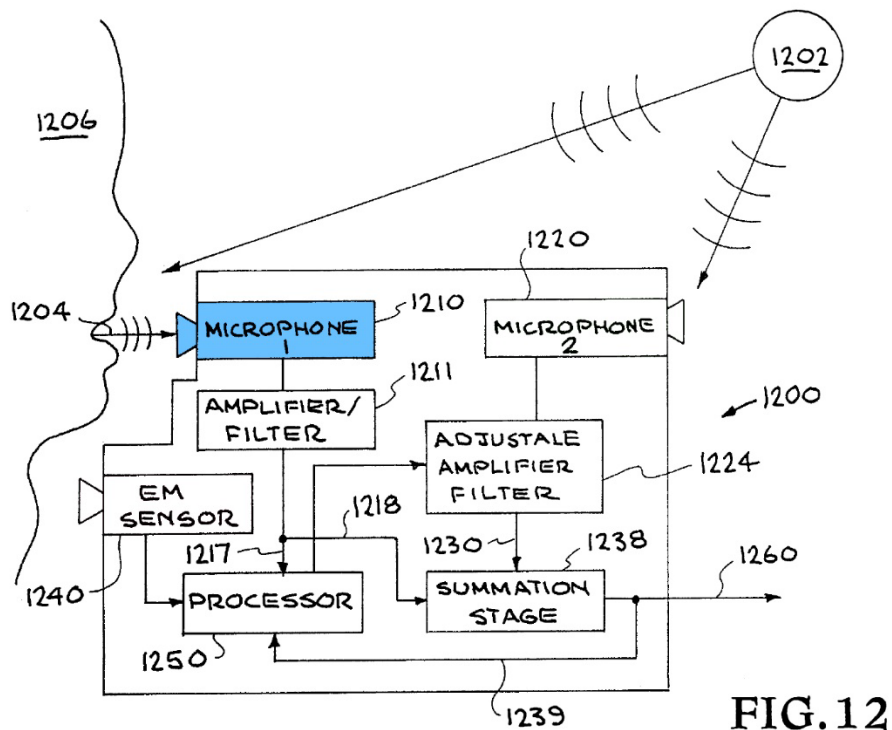
background noise 1202, and the microphones' output signals are provided to components of the denoising subsystem (e.g., adjustable amplifier filter 1224, processor 1250, and summation stage 1239) as shown in Figure 12. (*Id.*)

58. Thus, Burnett '919 discloses this limitation.

**ii. 1[b][2]: First Microphone**

59. Claim 1 further recites “wherein a first microphone of the array is fixed at a first position relative to a mouth, wherein the first position orients a front of the first microphone towards the mouth.” Burnett '919 discloses this limitation.

60. Burnett '919 discloses that the first microphone (“microphone 1” or 1210) is oriented toward the speaker’s mouth as shown in Figure 12:



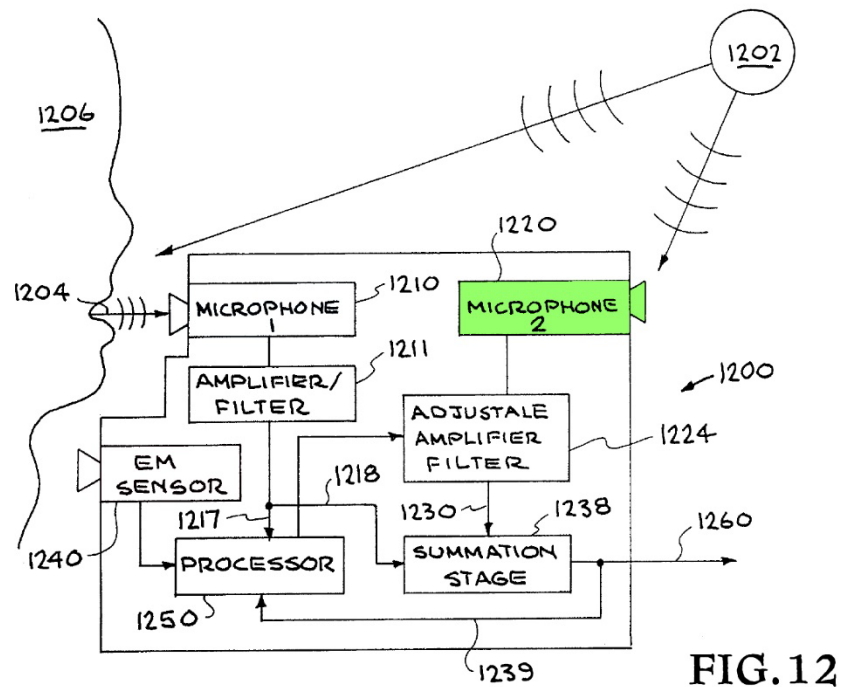
(Ex. 1003 (Burnett '919), Fig. 12.) This microphone, called the “user microphone,” receives “primary speech signals.” (*Id.*, 17:58-61, 18:13-17.) A person of ordinary skill in the art would therefore have understood that the first microphone is fixed in a position towards a speaker’s mouth. For example, Burnett '919 discloses that its system “can be especially useful for telephone and conference calls ....” (Ex. 1003 (Burnett '919), 15:55-56; Ex. 1010 (Holzrichter '694), 11:17-32 (disclosing a “[t]el-ephone receiver/transmitter unit with EM sensors”); ¶¶89-90 (claim 6), below.) A person of ordinary skill would have understood that in a phone handset, the microphones are fixed in place with respect to the speaker’s mouth.

61. Alternatively, it would have been obvious to a person of ordinary skill in the art to fix the first microphone in a position towards the speaker’s mouth to ensure a consistent acoustic environment between the speaker’s mouth and the microphone. Accordingly, Burnett '919 discloses and/or renders obvious this limitation.

### **iii. 1[b][3]: Second Microphone**

62. Claim 1 further recites “wherein a second microphone of the array is fixed at a second position relative to the mouth, wherein the second position orients a front of the second microphone away from the mouth such that the second position forms an angle relative to the first position, wherein the angle is greater than zero degrees.” Burnett '919 discloses this limitation.

63. Burnett '919 discloses that the second microphone (“microphone 2” or 1220) is oriented away from the speaker’s mouth, forming an angle relative to the first microphone of roughly 180 degrees (and therefore greater than zero degrees) as shown in Figure 12:



(Ex. 1003 (Burnett '919), Fig. 12.) Burnett '919 teaches that the second microphone is used “to measure background noise” and distortion can occur if it picks up “a substantial amount of speech.” (*Id.*, 17:58-61, 18:13-17.) A person of ordinary skill in the art would have immediately understood from this disclosure that the second microphone is fixed in a position facing away from the speaker’s mouth. Alternatively, it would have been obvious to a person of ordinary skill in the art to fix the second microphone facing away from the speaker’s mouth to ensure a consistent

acoustic environment and to prevent distortion due to picking up a “substantial amount of speech.”

64. Accordingly, Burnett ’919 discloses and/or renders obvious this limitation.

**iv. 1[b][4]: Generating Denoised Output**

65. Claim 1 further recites “processing the acoustic signals . . . to generate denoised acoustic signals, [including] generating a noise waveform estimate associated with noise of the acoustic signals and subtracting the noise waveform estimate from the acoustic signal when the acoustic signal includes speech and noise.” Burnett ’919 discloses and/or renders obvious this limitation.

66. Burnett ’919 discloses that its system processes acoustic signals to generate denoised acoustic signals by “remov[ing] background acoustic noise from unvoiced and voiced speech.” (Ex. 1003 (Burnett ’919), 17:49-53, Fig. 12.) Acoustic signal 1218, which contains the unvoiced and voiced speech, is received by and output from microphone 1210. (*Id.*, 17:49-18:3, Fig. 12.) Burnett ’919 also discloses processing acoustic signals from background microphone 1220. (*Id.*) Thus, Burnett ’919’s system processes acoustic signals (e.g., signals received by microphones 1210 and 1220) to generate denoised acoustic signals (e.g., the output

of Burnett '919's system, which removes background noise from the original signals).

67. Burnett '919's system processes the received acoustic signals from microphones 1210 and 1220 using adaptively-adjusted amplifier and filter circuit 1224, which produces signal 1230. (Ex. 1003 (Burnett '919), 17:49-18:17.) A person of ordinary skill in the art would have understood that signal 1230 is a noise waveform estimate associated with noise of the acoustic signals. Burnett '919 discloses that, during periods when no speech is occurring, "background (i.e., non-user-generated speech) acoustic signals can be characterized." (*Id.*, 12:3-5.) Burnett '919 interchangeably refers to these background acoustic signals as "noise." A person of ordinary skill in the art would have understood the characterization of these background acoustic signals would be conducted by amplifier and filter circuit 1224 to produce signal 1230. (*Id.*, Fig. 12 (showing signal 1230 produced by circuit 1224); *id.*, 17:53-56 (system uses "Noise [R]emoval Method 1"), 11:61-12:49 (discussing Noise Removal Method 1).) Burnett '919 further discloses that background acoustic signal characterization "can include obtaining an average amplitude of a background signal, peak signal energy and/or power of one or more peak noise amplitudes ... and their time locations in a time frame." (*Id.*, 12:27-32.) A person of ordinary skill in the art would have understood that such disclosure describes estimating a noise waveform because that person would have understood

that amplitude, peak signal energy, and power are characteristics of a waveform. Accordingly, Burnett '919 discloses generating a noise waveform estimate (e.g., background acoustic signal characterization) associated with noise of the acoustic signals (e.g., noise captured by microphones 1210 and 1220).

68. Burnett '919 then discloses subtracting the noise estimate from the acoustic signal when the acoustic signal contains speech and noise. Burnett '919 discloses that the noise estimate 1230 “is set equal and opposite in sign to a speaker’s microphone signal 1218,” with which it is then summed. (Ex. 1003 (Burnett '919), 17:66-18:3, Fig. 12.) A person of ordinary skill in the art would have understood that this describes subtracting the noise estimate 1230 from the speaker’s microphone signal 1218, which is an acoustic signal captured by the microphone 1210. (*Id.*, 17:58-18:3, Fig. 12.) A person of ordinary skill in the art would further have understood that this occurs when the acoustic signal contains speech and noise. (*See id.*, 17:49-18:17.)

69. Thus, Burnett '919 discloses and/or renders obvious this limitation.

**v. 1[b][5]: Using a Frequency Sub-band Method**

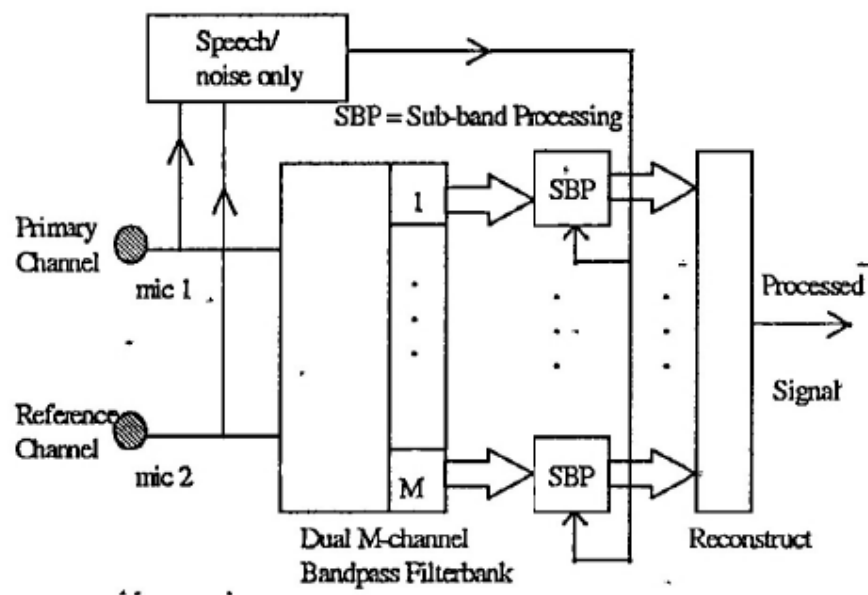
70. Claim 1 further recites “components of the denoising subsystem automatically selecting at least one denoising method appropriate to data of at least one frequency subband of the acoustic signals using the control signals and

processing the acoustic signals using the selected denoising method to generate denoised acoustic signals.” Hussain and Burnett ’919 disclose and/or render obvious this limitation.

71. Hussain discloses an “adaptive noise cancellation scheme” that improves performance in reverberant environments by processing acoustic signals in separate sub-bands to produce a denoised signal. (Ex. 1006 (Hussain), Abstract, 2611-2613, Fig. 1.) Like Burnett ’919, Hussain receives acoustic signals from the environment at a dual microphone array. (*Id.*) A filter bank separates signals received by the microphones into individual sub-bands for processing. (*Id.*)

72. After the signals are separated into individual sub-bands, Hussain processes the signals of each sub-band separately, selecting the best method for each individual sub-band. (Ex. 1006 (Hussain), 2612.) For example, Hussain suggests that “the signal in [a] band need not be modified” if there is little noise present in that band. (*Id.*) However, adaptive noise cancellation methods are used in other sub-bands that include noise. (*Id.*) Hussain discloses that the decision of which method is best for each sub-band is determined, at least in part, by the output of a VAD because it assumes that “an effective voice activity detector (VAD) is available” and that such a VAD is used for “selecting the best SBP [sub-band processing] option.” (*Id.*)

73. Hussain separates the acoustic signals into individual sub-bands, applies sub-band processing to each sub-band, reconstructs the processed signals, and outputs the denoised processed signal, as shown below.



(Ex. 1006 (Hussain), Fig. 1.) Hussain therefore discloses using control signals (from a VAD) to automatically select at least one denoising method appropriate to data of at least one frequency sub-band of received acoustic signals, and processing the acoustic signals using the selected denoising method to generate denoised acoustic signals.

**(a) Motivation to Combine  
Burnett '919 with Hussain**

74. A person of ordinary skill in the art would have been motivated to combine Burnett '919 with Hussain's teachings and to incorporate sub-band processing as disclosed in Hussain into Burnett '919's denoising system. For

example, a person of ordinary skill in the art would have been motivated to use Burnett '919's microphone array to capture acoustic signals and use Burnett '919's VAD (including EM sensor) to create control signals; use Hussain's sub-band processing and selection of best denoising method to process the acoustic signals using the control signals to decide on the best denoising method; and use Burnett '919's adaptive denoising method, along with Hussain's no-processing-necessary method, as options for denoising methods. A person of ordinary skill in the art would have been motivated to combine Burnett '919 and Hussain in this way for the reasons discussed below.

75. First, Burnett '919 and Hussain both address the same problem of removing noise from acoustic speech signals, and they address the problem with similar solutions (e.g., the use of a voice detection subsystem and adaptive noise removal methods). (Ex. 1003 (Burnett '919), Abstract, 12:20-26; Ex. 1006 (Hussain), Title, Abstract, 2611-2612.)

76. Second, Burnett '919 suggests removing noise, including echoes and signal reverberations, from an acoustic signal that includes both a desired signal and noise, and discloses one method of doing so. (¶¶65-69 (claim element 1[b][4], above.) Hussain explains that using adaptive noise cancellation methods on individual sub-bands rather than full-band processing is advantageous as compared to full-band processing because it provides improved performance in reverberant

environments. (Ex. 1006 (Hussain), 2611, Abstract.) A person of ordinary skill in the art would have therefore been motivated to incorporate Hussain's teachings into Burnett '919's system because of the benefits disclosed by Hussain.

77. Third, sub-band processing of acoustic signals has been known for decades. (¶34 (discussing Duttweiler, Gilloire, and Dennis), above.) For example, sub-band processing has been an inherent component of several approaches I have developed based on auditory processing. (E.g., Thomas M. Sullivan and Richard M. Stern, *Multi-Microphone Correlation-Based Processing for Robust Speech Recognition*, Proc. of the ICASSP '93 at 91-94.) The combination of Burnett '919 and Hussain therefore represents nothing more than the simple addition of one known element (Hussain's sub-band processing) to another known element (Burnett '919's noise cancellation system) to obtain the predictable results of efficient, effective noise cancellation in real-world environments where signal reverberation would be expected. Moreover, the combination represents the use of a known technique (processing signals in individual sub-bands, as in Hussain) to improve a similar device and method (Burnett '919's noise cancellation system) in the same way. The combination also applies a known technique (sub-band processing as in Hussain) to a known device and method (Burnett '919's system) that is ready for improvement and yields predictable results (a noise cancellation system that works effectively and efficiently in real-world environments).

78. A person of ordinary skill in the art would have had a reasonable expectation of success in combining Burnett '919 and Hussain because they relate to similar systems for adaptive noise removal and because the principle of operating on individual frequency sub-bands was well known in the art.

**d. 1[c]: Independent VAD Sensor**

79. Claim 1 next recites “wherein the voice detection subsystem is configured to receive the voice activity signals using a sensor independent from the microphone array and to output the control signals generated from the voice activity signals to the denoising system, the denoising system configured to use the control signals to denoise the acoustic signals from the microphone array.” Burnett '919 discloses this limitation.

80. Burnett '919 discloses a voice detection subsystem that receives voice activity signals using a sensor (e.g., EM sensor 1240) that is independent from the microphone array (e.g., microphones 1210 and 1220). The voice detection subsystem then outputs a control signal, which is generated using the voice activity signals received by Burnett '919's EM sensor, to the denoising system. (¶¶48-52 (claim element 1[a]), above.) Additionally, Burnett '919 and Hussain disclose that the denoising system uses the control signals to denoise the acoustic signals from the microphone array. (¶¶48-52 (claim element 1[a]), 65-78 (claim elements 1[b][4]-1[b][5]), above.) Thus, Burnett '919 discloses this limitation.

81. As discussed above, Burnett '919 and Hussain disclose a communication system that includes a denoising subsystem, which receives acoustic signals using a dual-microphone array and processes the acoustic signals using frequency sub-band methods to generate a denoised output, and a voice detection subsystem that uses a non-acoustic sensor that is independent of the microphone array to detect voice activity signals and output control signals to the denoising subsystem. Burnett '919 and Hussain therefore render claim 1 obvious.

#### **4. Claim 2**

82. Claim 2 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises[] at least one glottal electromagnetic micropower sensor (GEMS) including at least one antenna for receiving the voice activity signals[,] and at least one voice activity detector (VAD) algorithm for processing the GEMS voice activity signals and generating the control signals.” Burnett '919 discloses this limitation.

83. Burnett '919 discloses that its voice detection subsystem (¶¶48-52 (claim element 1[a]), above) uses a “low power EM sensor [that] detects tissue motion in a glottal region ... .” (Ex. 1003 (Burnett '919), 2:62-65.) Furthermore, Burnett '919 discloses that “the terms glottal EM sensor and GEMS (i.e., glottal electromagnetic sensor) are used interchangeably.” (*Id.*, 3:7-9.) Although the '543 patent defines “GEMS” as “glottal electromagnetic micropower sensor” rather than

“glottal electromagnetic sensor” as Burnett ’919 does, a person of ordinary skill would have immediately understood that the terms are interchangeable as shown by Burnett ’919’s use of both “EM sensor” and “micro-power EM sensor” interchangeably. (*Id.*, 5:49-54.) Thus, Burnett ’919 discloses that its voice detection subsystem comprises a GEMS. Moreover, to the extent this limitation requires the sensor of claim 1 and an additional sensor, Burnett ’919 discloses the use of multiple voicing sensors through incorporation of Holzrichter ’175, which discloses embodiments with multiple distinct non-acoustic sensors. (Ex. 1009 (Holzrichter ’175), 31:51-53, Fig. 19.)

84. Burnett ’919 further discloses (and a person of ordinary skill in the art would have known) that EM sensors (e.g., GEMS) include one or more antennas. For example, Burnett ’919 teaches that “[i]n many cases, one or more antennas 1306, 1308 of the EM sensor” can detect tissue motion. (Ex. 1003 (Burnett ’919), 18:38-41.) The incorporated reference Holzrichter ’175 also discloses the use of EM sensors that include one or more antennas. (Ex. 1009 (Holzrichter ’175), 7:51-8:49.)

85. As discussed above, Burnett ’919 discloses that its voice detection subsystem detects voice activity signals (using one or more GEMS) and generates control signals automatically, using the algorithm disclosed in Burnett ’919 and incorporated reference Holzrichter ’175. (¶¶48-52 (claim element 1[a]), above.)

Thus, Burnett '919 discloses a VAD algorithm for processing the GEMS voice activity signals and generating the control signals.

86. Accordingly, Burnett '919 discloses and/or renders obvious claim 2.

## **5. Claim 5**

87. Claim 5 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises at least one manually activated voice activity detector (VAD) for generating the voice activity signals.” Burnett '919 discloses and/or renders this limitation obvious.

88. Burnett '919, through incorporated reference Holzrichter '175, discloses that a voice detection system may be manually activated. Holzrichter '175 discloses that a VAD system may be operated by “the use of a finger or other body part to actuate a button or similar sensor device to start the operation of the EM sensor system.” (Ex. 1009 (Holzrichter '175), 17:43-48.) Alternatively, such a configuration would have been obvious to a person of ordinary skill in the art because on-off buttons or switches have long been known in the art. A person of ordinary skill in the art would have been motivated to use such a button or similar device with Burnett '919's system for at least the reasons disclosed in Holzrichter '175, including that such a button or similar device would “keep the EM irradiation of the human body low” and “minimize system power usage.” (*Id.*, 17:39-43.) Thus, Burnett '919 discloses and/or renders obvious claim 5.

**6. Claim 6**

89. Claim 6 depends from claim 1 and further recites “including a portable handset that includes the microphones, wherein the portable handset includes at least one of cellular telephones, satellite telephones, portable telephones, wireline telephones, Internet telephones, wireless transceivers, wireless communication radios, personal digital assistants (PDAs), and personal computers (PCs).” Burnett ’919 discloses and/or renders obvious this limitation.

90. Burnett ’919 discloses that its system can be used with communication devices such as telephones. For example, Burnett ’919 discloses that its system “can be especially useful for telephone and conference calls ... .” (Ex. 1003 (Burnett ’919), 15:55-56.) Burnett ’919, through its incorporation by reference of U.S. Patent No. 5,729,694 (“Holzrichter ’694”), discloses “devices [that] can be used as part of a speech coding system or all together for a variety of user chosen speech related applications” including a “[t]elephone receiver/transmitter unit with EM sensors.” (Ex. 1003 (Burnett ’919), 1:24-32; Ex. 1010 (Holzrichter ’694), 11:17-32.) Thus, a person of ordinary skill in the art would have understood that Burnett ’919’s system, including the microphones, may be contained in a portable handset (of the type often found in cellular, satellite, portable, and/or wireline telephones). Alternatively, it would have been obvious in view of this disclosure to include Burnett ’919’s system, including the microphones, in a portable handset such as a cellular, satellite,

portable, and/or wireline telephone, because such devices were commonplace and were known to be used in noisy environments where a noise cancellation system like Burnett '919's would be advantageous to include. Thus, Burnett '919 discloses and/or renders obvious claim 6.

## **7. Claim 7**

91. Claim 7 depends from claim 6 and further recites “wherein the portable handset includes at least one of the voice detection subsystem and the denoising subsystem.” Burnett '919 discloses and/or renders obvious this limitation because, as discussed above, Burnett '919 discloses and/or suggests that its system (including the voice detection subsystem and denoising subsystem) could be included in a portable handset. (¶¶89-90 (claim 6), above.)

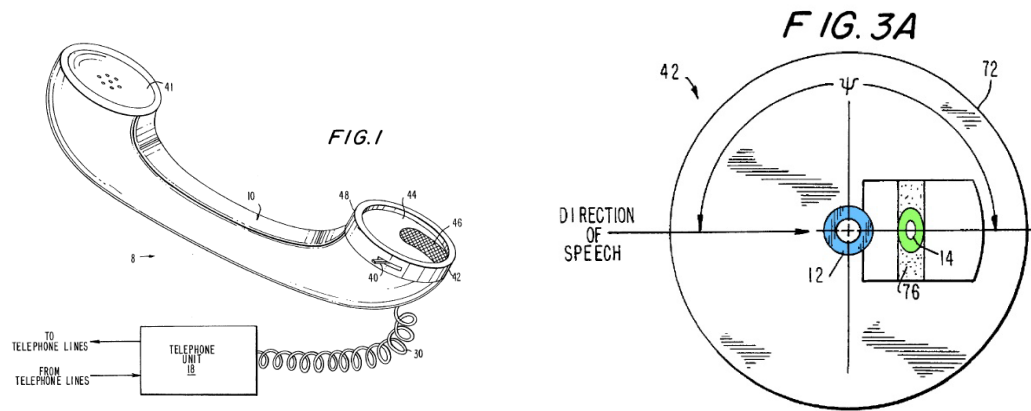
## **B. Claims 1-2, 5-13, and 26 Would Have Been Obvious in View of Burnett '919, Hussain, and Andrea.**

92. Even if Burnett '919 and Hussain did not disclose or render obvious each limitation of claims 1-2 and 5-7, those claims, along with claims 8-13 and 26, would have been obvious in further view of Andrea, as I discuss below.

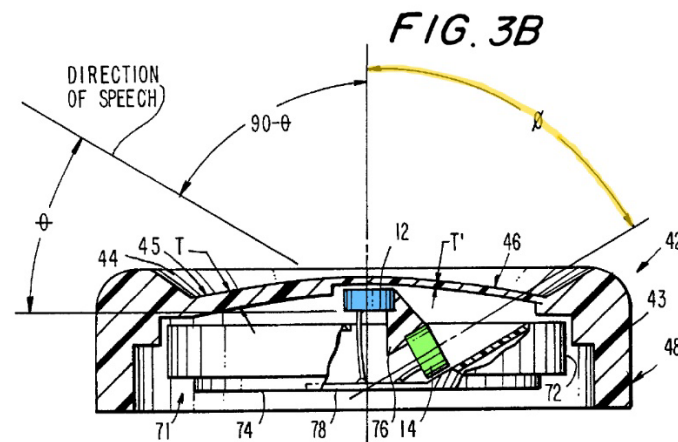
### **1. Overview of Andrea**

93. Andrea discloses the use of an “active noise reduction system” in a telephone handset. (Ex. 1004 (Andrea), 1:19-22.) The handset contains a “receiver portion 42 [that] includes first and second microphones 12 and 14,” and can be a

wired or wireless handset. (*Id.*, 12:31-43.) Andrea's handset (Figure 1) and the microphones 12 and 14 therein (Figure 3A) are shown below:

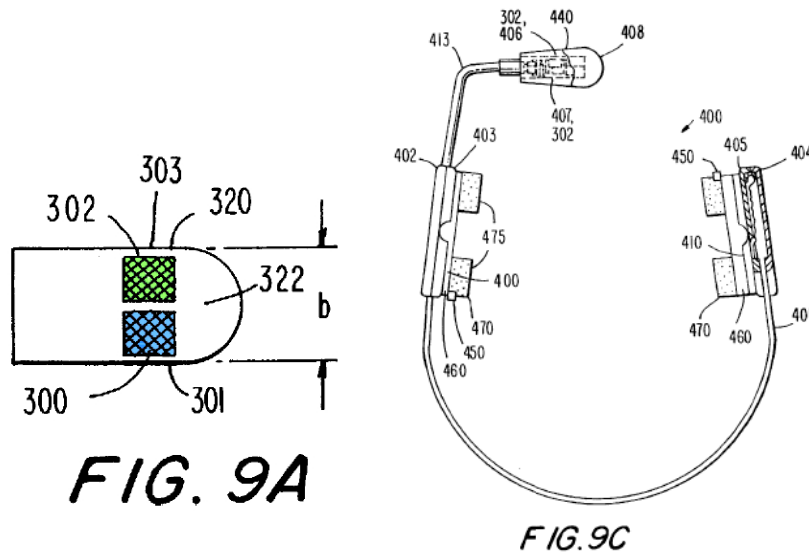


(*Id.*, Figs. 1, 3A.) The first and second microphones (12, 14, blue and green, respectively) are arranged at an angle (yellow) “in a range between  $30^\circ$  and  $60^\circ$ ” with respect to each other as shown in Figure 3B:



(*Id.*, 14:5-32, Figs. 3A-3B.)

94. Andrea also disclosed a headset with “a microphone boom 440 [that] includes first and second microphones 300 and 302” as shown in Figures 9A and 9C:



(Ex. 1004 (Andrea), 19:63-64, 20:1-3, Figs. 9A, 9C.) The microphones are arranged “substantially 180° apart from each other.” (*Id.*, 19:11-16, Fig. 9A.) Therefore, in both of Andrea’s embodiments, one microphone is oriented toward the user’s mouth, while the other is oriented away from the user’s mouth. Such a microphone configuration was well known, as shown by other references’ disclosure of dual-microphone arrays with a primary microphone oriented facing towards the desired signal source and a secondary or reference microphone oriented facing away from the desired signal source. (*See, e.g.*, Ex. 1005 (Sasaki); ¶¶157-64 (claim 14), below.)

95. Andrea’s system outputs a denoised signal “representing substantially the speech to the telephone unit” by subtracting the noise signal received at the second microphone from the acoustic signal received at the first microphone. (Ex. 1004 (Andrea), 12:46-64.) Receiving acoustic signals, including both noise and a desired signal, using a dual-microphone array and removing noise from a primary signal by subtracting an estimated noise signal from the primary signal was therefore known in the art, as disclosed in Andrea.

## **2. Claim 1**

### **a. 1: Preamble**

96. Andrea discloses the preamble because Andrea discloses a system “for use with telecommunication systems.” (Ex. 1004 (Andrea), 6:57-60.)

### **b. 1[a]: Voice Detection Subsystem**

97. Claim 1 recites “a voice detection subsystem configured to receive voice activity signals that include information associated with human voicing activity, the voice detection subsystem configured to automatically generate control signals using the voice activity signals.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶48-52 (Burnett ’919 claim element 1[a]), above.)

**c. 1[b]: Denoising Subsystem**

98. Claim 1 recites “a denoising subsystem coupled to the voice detection subsystem,” as well as additional requirements for the denoising system, which I discuss below. Burnett ’919 discloses these limitations for the reasons discussed above. (¶¶53-55 (Burnett ’919 claim element 1[b]), above.)

**i. 1[b][1]: Microphone Array**

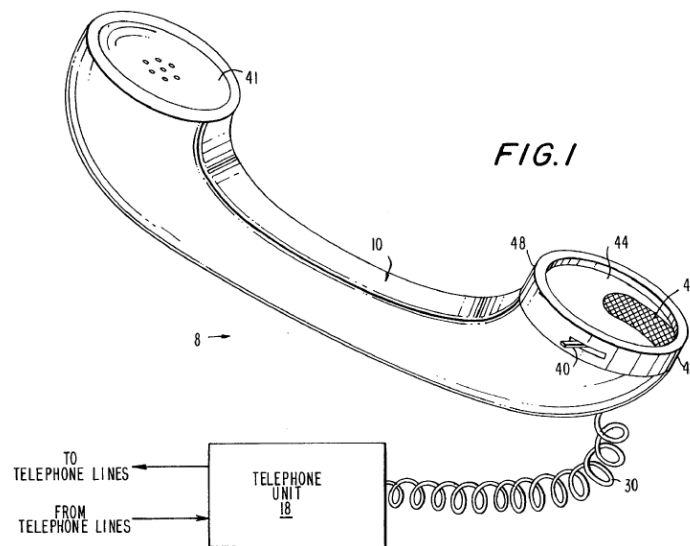
99. Claim 1 recites “the denoising subsystem comprising a microphone array including a plurality of microphones . . . , the microphone array providing acoustic signals of an environment to components of the denoising subsystem.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶56-58 (Burnett ’919 claim element 1[b][1]), above.) Moreover, this limitation was disclosed by Andrea.

100. Andrea discloses a noise reduction system that uses a two-microphone array having a first microphone 12 and a second microphone 14. (Ex. 1004 (Andrea), 12:39-60, Figs. 2, 3A-3B, 9A-9B.) Andrea’s array receives acoustic signals from the environment, including both “speech or the like and background noise” and outputs the received acoustic signals to a denoising system which outputs a denoised signal that is “substantially the speech.” (*Id.*, 12:53-66.) Accordingly, Andrea discloses this limitation.

**ii. 1[b][2]: First Microphone**

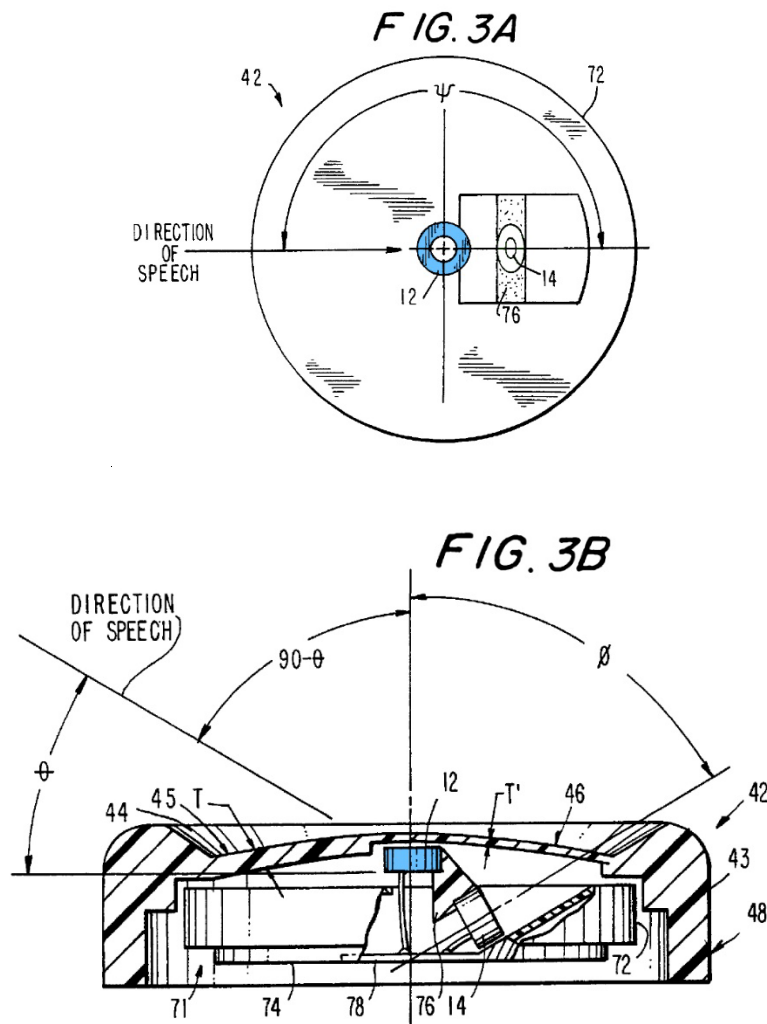
101. Claim 1 further recites “wherein a first microphone of the array is fixed at a first position relative to a mouth, wherein the first position orients a front of the first microphone towards the mouth.” Burnett ’919 discloses this limitation for the reasons discussed above. (¶¶59-61 (Burnett ’919 claim element 1[b][2]), above.) Additionally, Andrea discloses this limitation.

102. Andrea discloses a microphone configuration in which the microphone array is arranged in a handset, as shown in Figure 1:



(Ex. 1004 (Andrea), Fig. 1, 12:31-43.) The first microphone of the array (microphone 12, highlighted blue, below) is “positioned relatively close to the underside of the [receiver] portion 46” so that “the speech travels a relatively short distance from an operator, who is speaking into the receiver portion 42.” (*Id.*, 13-65-14:29;

*id.* Figs. 3A-3B.) The first microphone includes “[a] receiving or ‘sensitive’ surface” oriented towards the direction of speech (the user’s mouth) to “receive[] both the speech from the operator and the background acoustic noise which is present in the vicinity ... .” (*Id.*, 13:65-14:29.) The direction of the first microphone 12 is shown in Figures 3A and 3B:



(*Id.*, Figs. 3A-3B.)

103. Andrea also discloses that the first microphone 12 is in a fixed position in the handset. (*See* Ex. 1004 (Andrea), 13:65-14:29, Figs. 3A-3B.) Accordingly, a person of ordinary skill in the art would have understood Andrea to disclose that the first microphone 12 is fixed at a position relative to the operator's mouth because the receiver would be held at a fixed position while the system is in use (e.g., the user would hold the handset at a fixed position when speaking into it).

104. In another configuration, Andrea discloses a headset containing “a microphone boom 320 having a first microphone 300 and a second microphone 302” that are arranged at fixed positions within the microphone boom. (Ex. 1004 (Andrea), 19:9-26, Fig. 9A.)

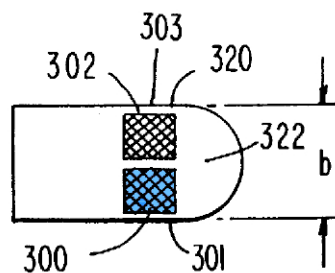


**FIG. 9A**

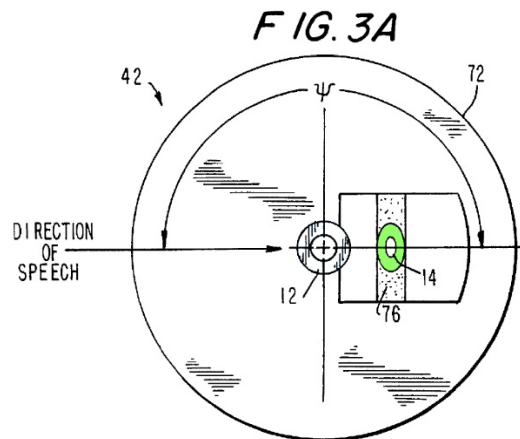
(*Id.*, Fig. 9A.) Andrea discloses that the first microphone (highlighted in blue) receives primarily speech from a user while the second microphone receives “primarily only the background noise.” (*Id.*, 19:26-45.) A person of ordinary skill in the art would have understood that the first microphone is fixed in the direction of the

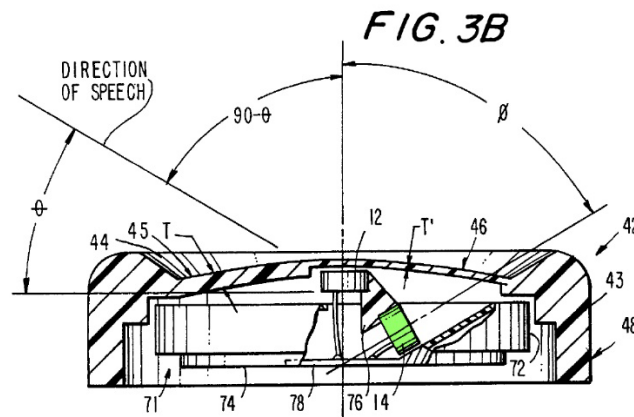
speaker's mouth because it is positioned facing towards the speaker's mouth and is part of a headset which would be held at a fixed position while worn. Accordingly, Andrea discloses this limitation.

**iii. 1[b][3]: Second Microphone**

105. Claim 1 further recites “wherein a second microphone of the array is fixed at a second position relative to the mouth, wherein the second position orients a front of the second microphone away from the mouth such that the second position forms an angle relative to the first position, wherein the angle is greater than zero degrees.” Burnett '919 discloses this limitation for the reasons discussed above. (¶¶62-64 (Burnett '919 claim element 1[b][3]), above.) Moreover, Andrea discloses this limitation.

106. In its handset embodiment, Andrea discloses a second microphone 14 (highlighted green, below) positioned in the receiving portion 42. This is shown in Figures 3A and 3B:

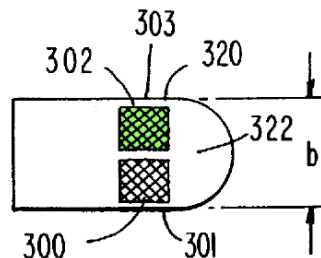




(Ex. 1004 (Andrea), Figs. 3A-3B, 13:65-14:27.)

107. Andrea discloses that the front of the second microphone is oriented away from the speaker's mouth with a relative angle  $\phi$  to the first microphone's orientation "which preferably has a value in a range between  $30^\circ$  and  $60^\circ$ ." (Ex. 1004 (Andrea), 14:4-32; *id.*, Figs. 3A-3B.) However, Andrea also explains that "the first and second microphones 12 and 14, respectively, may nevertheless operate satisfactorily even if arranged so as to have an angle  $\phi$  which lies outside this range." (*Id.*) From Andrea's disclosure, a person of ordinary skill in the art would have immediately understood that the second microphone is fixed in a direction away from the speaker's mouth, with a relative angle to the first microphone in the range of  $30^\circ$ - $60^\circ$  (e.g., greater than zero degrees).

108. In Andrea's headset embodiment, the second microphone 302 (highlighted in green) is oriented  $180^\circ$  away from the first microphone 300, as shown in Figure 9A:



(Ex. 1004 (Andrea), Fig. 9A; *id.*, 19:35-41 (“the pressure sensitive surface 303 of the second microphone 302 is preferably arranged at an angle of substantially 180° from the pressure sensitive surface 301 of the first microphone 300.”).) Since the first microphone 300 is fixed in a direction toward the speaker’s mouth (¶¶101-104 (Andrea claim element 1[b][2]), above), the second microphone 302 is fixed in a direction away from the speaker’s mouth, with a relative angle to the first microphone of 180° (e.g., greater than zero degrees).

109. Accordingly, Andrea discloses this limitation.

**iv. 1[b][4]: Generating Denoised Output**

110. Claim 1 further recites “processing the acoustic signals . . . to generate denoised acoustic signals, [including] generating a noise waveform estimate associated with noise of the acoustic signals and subtracting the noise waveform estimate from the acoustic signal when the acoustic signal includes speech and

noise.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶65-69 (Burnett ’919 claim element 1[b][4]), above.)

**v. 1[b][5]: Using a Frequency Sub-band Method**

111. Claim 1 further recites “components of the denoising subsystem automatically selecting at least one denoising method appropriate to data of at least one frequency subband of the acoustic signals using the control signals and processing the acoustic signals using the selected denoising method to generate denoised acoustic signals.” Hussain and Burnett ’919 disclose and/or render obvious this limitation for the reasons discussed above. (¶¶70-78 (Burnett ’919 claim element 1[b][5]), above.)

**d. 1[c]: Independent VAD Sensor**

112. Claim 1 next recites “wherein the voice detection subsystem is configured to receive the voice activity signals using a sensor independent from the microphone array and to output the control signals generated from the voice activity signals to the denoising system, the denoising system configured to use the control signals to denoise the acoustic signals from the microphone array.” Burnett ’919 discloses this limitation for the reasons discussed above. (¶¶79-81 (Burnett ’919 claim element 1[c]), above.)

**e. Motivation to Combine Burnett '919 with Andrea**

113. A person of ordinary skill in the art would have been motivated to combine the teachings of Burnett '919 (with sub-band processing as taught by Hussain) and Andrea, and to use Burnett's noise cancellation system with the microphone configurations taught by Andrea, for several reasons.

114. First, Andrea and Burnett '919 address the same problem of removing noise from acoustic signals that contain both speech and noise in communications systems such as telephone systems. (Ex. 1003 (Burnett '919), 15:55-57, 17:48-53; Ex. 1004 (Andrea), Title, Abstract, 1:32-39, Fig. 1.)

115. Second, Burnett '919 suggests the combination. Burnett '919's figures disclose positioning microphones so they are oriented away from each other, with the primary microphone oriented towards the source of speech, but Burnett '919 does not limit its disclosure to an exact position or application. (Ex. 1003 (Burnett '919), Fig. 12.) Burnett '919 and its incorporated Holzrichter references disclose the use of Burnett '919's system with a telephone (¶¶89-90 (Burnett '919 claim 6), above), but do not disclose any optimal orientation for the microphones in such a system. A person of ordinary skill in the art would have been motivated to look to other references, such as Andrea, to understand the appropriate orientation for microphones when used in such an application (e.g., phone handsets and headsets).

Andrea discloses the claimed configuration and explains its benefits in headsets and handsets. Thus, a person of ordinary skill would have been motivated to use Andrea's microphone configurations with Burnett '919's noise canceling system, particularly when interested in the types of devices Andrea discloses (e.g., telephones, headsets).

116. Third, Andrea discloses the importance of positioning microphones so that they are phased properly as to avoid canceling out the speech signal. (Ex. 1004 (Andrea), 7:19-35.) A person of ordinary skill in the art would have been motivated to look to Andrea's teachings for effectively configuring the microphones of Burnett '919's microphone array for optimal performance.

117. Fourth, various configurations of microphones in arrays have been known for decades. For example, I have worked with arrays consisting of equally spaced elements along a line (e.g., Thomas M. Sullivan and Richard M. Stern, *Multi-Microphone Correlation-Based Processing for Robust Speech Recognition*, Proc. of the ICASSP '93 at 91-94) as well as linear arrays with the elements unevenly spaced to preserve more constant beamwidth over a broad range of frequencies (e.g., Richard M. Stern et al., *Signal Processing for Robust Speech Recognition*, in *Speech Recognition* 351-378 (Lee and Soong eds., 1996). In addition, two-dimensional planar configurations and spherical microphone arrays are common in the art. Thus, this combination represents nothing more than the simple addition of one known

element (Andrea's handset or headset microphone array configurations) to another known element (Burnett '919's noise cancellation system having two microphones) to obtain the predictable results of inexpensive, effective denoising of speech signals. Moreover, the combination represents the use of a known technique (using microphones configured as in Andrea's handset or headset embodiments) to improve a similar device and method (Burnett '919's noise cancellation system) in the same way. The combination also applies a known technique (using microphones configured as in Andrea's handset or headset embodiments) to a known device and method (Burnett '919's noise cancellation system) that is ready for improvement and yields predictable results (a noise cancellation system that works inexpensively and efficiently).

118. Fifth, Andrea discloses that its microphone arrays “may be used with processing devices operating in accordance with predetermined processing algorithms ... .” (Ex. 1004 (Andrea), 35:26-28.) Thus, a person of ordinary skill in the art would have been motivated to combine one of Andrea's microphone array configurations with Burnett '919's system, which is a processing device operating in accordance with predetermined processing algorithms. Furthermore, as I discuss above, Burnett '919's disclosure is not limited to a particular configuration of microphones in its array. Accordingly, a person of ordinary skill in the art would

have had a reasonable expectation of success in using one of Andrea's microphone arrays with Burnett '919's system.

### **3. Claim 2**

119. Claim 2 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises[] at least one glottal electromagnetic micropower sensor (GEMS) including at least one antenna for receiving the voice activity signals[,] and at least one voice activity detector (VAD) algorithm for processing the GEMS voice activity signals and generating the control signals.” Burnett '919 discloses this limitation for the reasons discussed above. (¶¶48-52 (Burnett '919 claim element 1[a]), above.)

### **4. Claim 5**

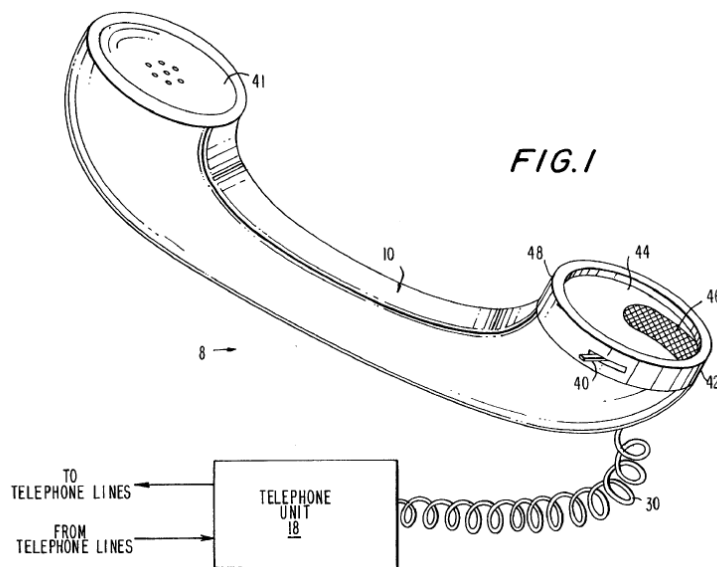
120. Claim 5 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises at least one manually activated voice activity detector (VAD) for generating the voice activity signals.” Burnett '919 discloses and/or renders this limitation obvious for the reasons discussed above. (¶¶87-88 (Burnett '919 claim 5), above.)

### **5. Claim 6**

121. Claim 6 depends from claim 1 and further recites “a portable handset that includes the microphones, wherein the portable handset includes at least one of cellular telephones, satellite telephones, portable telephones, wireline telephones,

Internet telephones, wireless transceivers, wireless communication radios, personal digital assistants (PDAs), and personal computers (PCs).” Andrea discloses and/or renders obvious this limitation.

122. Burnett ’919 (and its incorporated Holzrichter references) discloses using its system with a telephone handset. (¶¶89-90 (Burnett ’919 claim 6), above.) Andrea discloses “a telephone 8 which utilizes a noise reduction apparatus.” (Ex. 1004 (Andrea), 12:31-41.) Andrea’s telephone includes a portable handset that includes microphones under receiver portion 46, as shown in Figure 1:



(*Id.*, Fig. 1; *id.*, 12:31-43, Figs. 3A-3B.) The microphones in Andrea’s telephone handset satisfy the limitations of claim 1, as I discuss above. (¶¶98-109 (Andrea claim elements 1[b]-1[b][3]), above.) Thus, the references disclose and/or render

obvious implementing Burnett '919's system (with microphones configured as in Andrea) in a telephone handset.

123. The Burnett '919-Andrea combination would have been obvious for the reasons set forth above. (¶¶113-118 (Andrea claim 1 motivation to combine), above) Moreover, implementing Burnett '919's EM sensor-based system, with Andrea's microphone configuration, in a telephone handset would have been obvious because it would facilitate easy telephone and conference calls and improve the phone's performance.

124. Furthermore, a person of ordinary skill in the art would have understood that Burnett '919's system and Andrea's microphone configuration were designed to be used with telephone handsets and thus would have reasonably expected success. (*See, e.g.*, Ex. 1009 (Holzrichter '175), 8:50-60 (disclosing "a telephone receiver with modification for under chin EM sensor modules"); Ex. 1010 (Holzrichter '694), 11:17-32; Ex. 1004 (Andrea), 12:31-43, Figs. 3A-3B.)

125. Additionally, various telephone handsets have been known for decades. Thus, the combination represents the use of a known technique (telephone handset with microphones oriented as in Andrea) to improve a similar device and method (Burnett '919's noise cancellation system) in the same way. The combination also applies a known technique (telephone handset with microphones oriented as in Andrea) to a known device and method (Burnett '919's system) that is ready for

improvement and yields predictable results (a handset-based noise cancellation system).

126. Thus, Burnett '919 and Andrea disclose and/or render obvious claim 6.

## **6. Claim 7**

127. Claim 7 depends from claim 6 and further recites “wherein the portable handset includes at least one of the voice detection subsystem and the denoising subsystem.” Burnett '919 and Andrea disclose and/or render obvious this limitation.

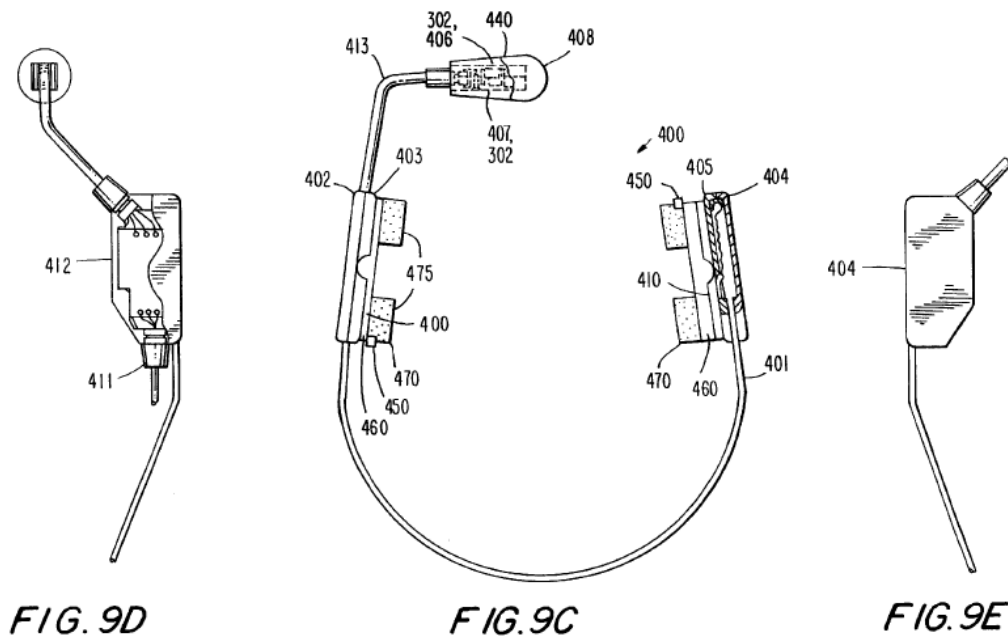
128. As I discuss above, a person of ordinary skill in the art would have been motivated to implement Burnett '919's system, including Andrea's microphone configuration, in a portable handset. (¶¶121-126 (Andrea claim 6), above.) Such a portable handset would thus include Burnett '919's system, which includes a voice detection subsystem and a denoising subsystem. (¶¶48-78 (Burnett '919 claim elements 1[a], 1[b]), above.) Thus, Burnett '919, Hussain, and Andrea disclose and/or render obvious claim 7.

## **7. Claim 8**

129. Claim 8 depends from claim 1 and recites “further including a portable headset that includes the microphones along with at least one speaker device.” Andrea discloses and/or renders obvious this limitation.

130. Andrea discloses a portable headset that includes “microphone boom 440 [that] includes first and second microphones 300 and 302” and “output

transducer 460” (e.g., a speaker device). (Ex. 1004 (Andrea), 19:63-20:11.) One embodiment of Andrea’s headset is shown in Figures 9C-9E:



(*Id.*, Figs. 9C-9E.) As I discuss above, the microphones 300 and 302 of Andrea’s headset satisfy the limitations of claim 1. (¶¶98-109 (Andrea claim elements 1[b]-1[b][3]), above.)

131. A person of ordinary skill in the art would have been motivated to combine the teachings of Andrea and Burnett ’919, and implement Burnett ’919’s system in a system that includes a headset (with microphones configured as in Andrea) for several reasons. As I discuss above, Burnett ’919 (and its incorporated Holzrichter references) discloses using its system with a telephone. (¶¶89-90 (Burnett ’919 claim 6), above.) A person of ordinary skill in the art would have understood that implementing Burnett ’919’s EM sensor-based system in a system

that includes a headset with microphones and a speaker configured as in Andrea would facilitate telephone and conference calls and would improve the performance of Burnett '919's system in that context. Furthermore, a person of ordinary skill would have understood that headsets were common, well-known ways of conducting telephone and conference calls, and would have reasonably expected success in using a headset with Burnett '919's system for this reason.

132. Furthermore, portable headsets have been known for decades. Thus, this combination represents nothing more than the simple addition of one known element (headset with microphones/speaker configured as in Andrea) to another known element (Burnett '919's noise cancellation system) to obtain the predictable results of a noise cancelling communication system that includes a headset. Moreover, the combination represents the use of a known technique (using a headset as in Andrea) to improve a similar device and method (Burnett '919's communication system) in the same way. The combination also applies a known technique (using a headset as in Andrea) to a known device and method (Burnett '919's system) that is ready for improvement and yields predictable results (a noise cancelling system including a headset).

133. Thus, Burnett '919 and Andrea disclose and/or render obvious claim 8.

**8. Claim 9**

134. Claim 9 depends from claim 8 and further recites “wherein the portable headset couples to at least one communication device selected from among cellular telephones, satellite telephones, portable telephones, wireline telephones, Internet telephones, wireless transceivers, wireless communication radios, personal digital assistants (PDAs), and personal computers (PCs).” Burnett ’919 discloses and/or renders obvious this limitation because Burnett ’919’s system is designed to connect to a telephone. For example, Holzrichter ’694, which Burnett ’919 explicitly incorporates by reference, discloses a “[t]elephone receiver/transmitter unit with EM sensors.” (Ex. 1010 (Holzrichter ’694), 11:17-32.)

135. This limitation was also obvious over Andrea. Andrea discloses a portable headset, discussed above (¶¶129-133 (claim 8), above), that “can interface with computers, telephones or other equipment ....” (Ex. 1004 (Andrea), 26:2-10.) For example, Andrea discloses a headset including a “cable assembly 411 for supplying signals to and from outside or host equipment[.]” (*Id.*, 20:42-48, Fig. 9D.) The cable assembly is “connected to 3 meter cable.” (*Id.*, 26:15-16)

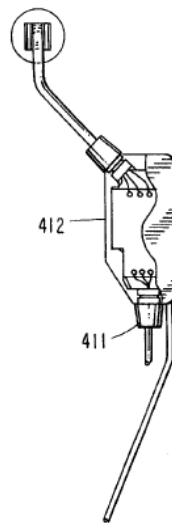


**FIG. 9D**

(*Id.*, Fig .9D.) A person of ordinary skill in the art would have understood that the cable assembly and/or cable constitutes a wired coupling between Andrea's headset and another device such as a computer or telephone.

136. A person of ordinary skill would have understood in view of the disclosure above that a system that includes a portable headset and implements Burnett '919's system would couple to a phone or computer as recited in claim 9. Moreover, even if the combination of Burnett '919 and Andrea is itself a telephone, such a telephone would be used to connect to other telephones and therefore would connect to a communications device. Thus, Burnett '919 and Andrea disclose and/or render obvious claim 9.

**9. Claim 10**

137. Claim 10 depends from claim 9 and further recites “wherein the portable headset couples to the communication device using at least one of wireless couplings, wired couplings, and combination wireless and wired couplings.” Andrea discloses and/or renders obvious this limitation. (¶¶134-136 (claim 9), above.)

138. Furthermore, this limitation would have been obvious to a person of ordinary skill in the art based on their own knowledge. Given a headset that connects to a communication device, a person of ordinary skill in the art would have had only three choices for how such a connection could be made: through a wireless coupling, through a wired coupling, or through a combination of wired and wireless couplings. The limitation therefore represents a choice from a small finite number of identified, predictable solutions, each of which was common in the prior art.

139. Thus, Burnett ’919 and/or Andrea disclose and/or render obvious claim 10.

**10. Claim 11**

140. Claim 11 depends from claim 9 and further recites “wherein the communication device includes at least one of the voice detection subsystem and the denoising subsystem.” Burnett ’919 and Andrea disclose and/or render obvious this limitation.

141. A person of ordinary skill in the art would have understood that, when implementing Burnett '919's system in a system that includes a portable headset as discussed for claim 8 (§§129-133 (claim 8), above), one option would be to connect the headset (comprising the microphones) to a device (e.g., phone) containing the voice detection and/or denoising subsystems. A person of ordinary skill would have been motivated to structure the system this way at least because it would allow for Burnett '919's system to operate as designed in conjunction with a lightweight, low-cost headset of the type disclosed in Andrea, which was a popular and common way of conducting telephone calls. Furthermore, this limitation would have been obvious because, when implementing Burnett '919 in a system comprising a headset, a person of ordinary skill would have had only two choices for locating the subsystems: either in the headset or in the communication device. Thus, the limitation represents a choice from a small finite number of identified, predictable solutions, each of which was known in the art. A person of ordinary skill in the art would have reasonably expected success at least because Burnett '919 discloses that its sensors may be located remote from the rest of the system and, e.g., connected wirelessly. (§§145-148 (claim 13), below.) Thus, Burnett '919, Hussain, and Andrea disclose and/or render obvious claim 11.

## **11. Claim 12**

142. Claim 12 depends from claim 8 and further recites “wherein the portable headset includes at least one of the voice detection subsystem and the denoising subsystem.” Burnett ’919 and Andrea disclose and/or render obvious this limitation.

143. As discussed above, Andrea discloses a portable headset. (¶¶129-133 (claim 8), above.) Andrea’s portable headset includes a denoising system, including two “microphones 300 and 302” and “circuitry utilized in processing the acoustic signals” (e.g., circuitry which is used to remove noise from the acoustic signals), which “may be installed within the headset assembly 400.” (Ex. 1004 (Andrea), 19:54-20:47, 22:41-52 (noise cancellation circuitry “may be installed within the headset assembly 400”).) Thus, a person of ordinary skill in the art would have been motivated to implement at least the Burnett ’919’s denoising subsystem in a headset. Moreover, a person of ordinary skill would have understood that, when implementing Burnett ’919’s system in a system that includes a portable headset (¶¶129-133 (claim 8), above), one option would be to implement Burnett ’919’s entire system (e.g., including the voice detection and/or denoising subsystems) in the headset. A person of ordinary skill would have been motivated to do so because it would allow the system to be self-contained and connect to many different

communication devices, which would not require special hardware to implement parts of Burnett '919's system.

144. Furthermore, when implementing Burnett '919 in a system comprising a headset connected to a communication device, a person of ordinary skill in the art would have had only two choices for locations for the subsystems: either in the headset or in the communication device. Thus, the limitation represents a choice from a small finite number of identified, predictable solutions, each of which was known. A person of ordinary skill would have reasonably expected success because, as discussed above, Andrea discloses a portable headset including a denoising system. (Ex. 1004 (Andrea), 19:54-20:47, 22:41-52.) Thus, Burnett '919 and Andrea disclose and/or render obvious claim 12.

## **12. Claim 13**

145. Claim 13 depends from claim 8 and further recites “wherein the portable headset is a portable communication device selected from among cellular telephones, satellite telephones, portable telephones, wireline telephones, Internet telephones, wireless transceivers, wireless communication radios, personal digital assistants (PDAs), and personal computers (PCs).” Burnett '919 and Andrea disclose and/or render obvious this limitation.

146. Andrea's portable “boom microphone headset can interface with computers, telephones or other equipment,” which a person of ordinary skill in the

art would have understood describes coupling a portable headset with, for example, a device containing one or more of Burnett '919's subsystems. (Ex. 1004 (Andrea), 26:7-13.)

147. Burnett '919, through incorporated reference Holzrichter '175, discloses that its device may connect with sensors “by a wireless (RF or optical) link” and that “acoustic signals can be outputted on wireless or cable links[.]” (Ex. 1009 (Holzrichter '175), 18:49-67.) A person of ordinary skill in the art would have understood this disclosure to mean that when implementing Burnett '919's system with a portable headset, the coupling between the headset (which may include the microphones and EM sensor) and the communication device (which may include one or more of Burnett '919's subsystems) could be accomplished wirelessly. A person of ordinary skill in the art would have been motivated to use a wireless connection at least because it would eliminate the limiting wired connection between the two components and allow for increased convenience and freedom for a user. Accomplishing the coupling between the portable headset and Burnett '919's subsystem(s) wirelessly means that the portable headset is at least a wireless transceiver or a wireless communication radio.

148. Thus, Burnett '919 and Andrea disclose and/or render obvious claim 13.

### **13. Claim 26**

#### **a. 26: Preamble**

149. The preamble of claim 26 recites “[a] voice communications system.” Burnett ’919 discloses and/or renders obvious the preamble for the reasons discussed above. (¶47 (Burnett ’919 claim 1 preamble), above.)

#### **b. 26[a]: Voice Detection Subsystem**

150. Claim 26 recites “a voice detection subsystem configured to receive voice activity signals that include information associated with human voicing activity, the voice detection subsystem configured to automatically generate control signals using the voice activity signals.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶48-52 (Burnett ’919 claim element 1[a]), above.)

#### **c. 26[b]: Denoising Subsystem**

151. Claim 26 recites “a denoising subsystem coupled to the voice detection subsystem.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶53-55 (Burnett ’919 claim element 1[b]), above.) Individual components of the subsystems are addressed below.

**i. 26[b][1]-[3]: Microphone Array,  
First Microphone, and Second  
Microphone**

152. Claim 26 recites “the denoising subsystem comprising a microphone array including a plurality of microphones, wherein a first microphone of the array is fixed at a first position relative to a mouth, wherein the first position orients a front of the first microphone towards the mouth, wherein a second microphone of the array is fixed at a second position relative to the mouth, wherein the second position orients a front of the second microphone away from the mouth such that the second position forms an angle relative to the first position, wherein the angle is greater than zero degrees, the microphone array providing acoustic signals of an environment to components of the denoising subsystem.” Burnett ’919 and Andrea each disclose and/or render obvious these limitations for the reasons discussed above. (¶¶56-64 (Burnett ’919 claim elements 1[b][1]-1[b][3]), 99-109 (Andrea claim elements 1[b][1]-1[b][3]), above.)

**ii. 26[b][4]-[5]: Generating Denoised  
Output and Using a Frequency  
Sub-band Method**

153. Claim 26 recites “components of the denoising subsystem automatically selecting at least one denoising method appropriate to data of at least one frequency subband of the acoustic signal using the control signal and processing the acoustic signals using the selected denoising method to generate denoised

acoustic signals, wherein the denoising method includes generating a noise waveform estimate associated with noise of the acoustic signals and subtracting the noise waveform estimate from the acoustic signal when the acoustic signal includes speech and noise.” Burnett ’919 and Hussain render obvious these limitations for the reasons discussed above. (¶¶65-78 (Burnett ’919 claim elements 1[b][4]-1[b][5]), above.)

**d. 26[c]: Independent VAD Sensor**

154. Claim 26 recites “wherein the voice detection subsystem is configured to receive the voice activity signals using a sensor independent from the microphone array and to output the control signals generated from the voice activity signals to the denoising system, the denoising system configured to use the control signals to denoise the acoustic signals from the microphone array.” Burnett ’919 discloses and/or renders obvious this limitation for the reasons discussed above. (¶¶79-81 (Burnett ’919 claim element 1[c], above.)

**e. 26[d]: Portable Headset**

155. Claim 26 recites “a portable headset comprising the plurality of microphones and at least one speaker device, wherein the portable headset couples to at least one communication device selected from among cellular telephones, satellite telephones, portable telephones, wireline telephones, Internet telephones, wireless transceivers, wireless communication radios, personal digital assistants

(PDAs), personal computers (PCs), and at least one of the voice detection subsystem and the denoising subsystem.” Burnett ’919 and Andrea disclose and/or render obvious this limitation, and a person of ordinary skill in the art would have been motivated to combine the references, for the reasons discussed above. (¶¶129-136 (claims 8-9), above.)

**C. Claims 14-25 Would Have Been Obvious in View of Burnett ’919, Hussain, Optionally Andrea, and Sasaki.**

156. Claims 14-25 depend, directly or indirectly, from claim 1. The limitations of claim 1 are disclosed and/or rendered obvious by the references discussed above (¶¶47-81 (Burnett ’919 claim 1), 96-118 (Andrea claim 1), above.) Sasaki, Burnett ’919, and/or Andrea disclose the additional limitations of claims 14-25. Accordingly, claims 14-25 would have been obvious in view of Burnett ’919, Hussain, optionally Andrea, and Sasaki.

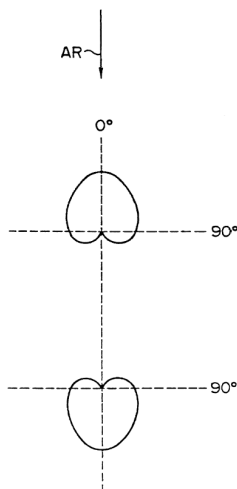
**1. Claim 14**

157. Claim 14 depends from claim 1 and further recites “wherein the first microphone is a unidirectional microphone and the second microphone is a unidirectional microphone.” Sasaki discloses and/or renders obvious this limitation.

158. Sasaki discloses a system that uses a two-microphone array in which “main input microphone 11 is unidirectional and placed with its most sensible side in the front direction” while “reference input microphone [21] is also unidirectional

and is placed with its most sensible side in the rear direction” as shown by the microphones’ sensitivity patterns in Figure 6:

F I G. 6



(*Id.*, Fig. 6, 6:6-20.) Thus, Sasaki discloses first and second unidirectional microphones.

159. A person of ordinary skill in the art would have been motivated to use Sasaki’s unidirectional microphones with the combination of references discussed above, for several reasons.

160. First, Burnett ’919, Andrea, and Sasaki each address the same problem—removing noise from speech. (Ex. 1003 (Burnett ’919), 15:55-57, 17:48-53; Ex. 1004 (Andrea), Title, Abstract, 1:32-39, Fig. 1; Ex. 1005 (Sasaki), 3:36-54 (describing an “adaptive noise reduction system”), 4:17-28.)

161. Second, Burnett '919 includes two microphones (a primary “user microphone 1210” and a reference “microphone 1220,”) but cautions that, if “a substantial amount of speech enters microphone 1220,” distortion may occur. (Ex. 1003 (Burnett '919), 17:59-60, 18:4-17.) Thus, a person of ordinary skill in the art would have been motivated to look to Sasaki’s teachings on the use of unidirectional microphones to reduce speech signal received by microphone 1220 and thereby reduce distortion. This is particularly important when the microphones are arranged as disclosed in Andrea (¶¶99-109 (Andrea claim elements 1[b][1]-1[b][3]), above) because the microphones are close together, causing a higher incidence of speech to be received in the microphone 1220. Furthermore, using a unidirectional microphone as Burnett '919’s user microphone 1210, as Sasaki teaches, allows for the user microphone 1210 to pick up less noise because a unidirectional microphone “itself contributes to noise reduction to some extent.” (Ex. 1005 (Sasaki), 6:21-28.)

162. Third, unidirectional microphones were well known and both Burnett '919 and Sasaki disclose a primary microphone for detecting a desired signal and a reference microphone for detecting primarily noise. (Ex. 1003 (Burnett '919), 18:4-17; Ex. 1005 (Sasaki), Abstract, 6:6-20.) For example, I have found in my own work as early as 1993 that the use of directional microphones can substantially improve speech recognition accuracy in noisy environments. (*E.g.*, Thomas M. Sullivan and Richard M. Stern, *Multi-Microphone Correlation-Based Processing for Robust*

*Speech Recognition*, Proc. of the ICASSP '93 at 91-94.) In the years since I have enjoyed continued success with a variety of multi-microphone techniques. Thus, this combination represents nothing more than the simple addition of one known element (unidirectional microphones as in Sasaki) to another known element (an acoustic microphone array as in Burnett '919) to obtain the predictable results of improved speech detection. Moreover, the combination represents the use of a known technique (using unidirectional microphones as in Sasaki) to improve a similar device and method (Burnett '919's) in the same way. The combination also applies a known technique (using unidirectional microphones as in Sasaki) to a known device and method (Burnett '919's) that is ready for improvement and yields predictable results (a system with improved speech detection). Finally, the combination represents a choice from a finite number of identified, predictable solutions. Given a system with microphones, a person of ordinary skill in the art would have had two choices for each microphone: a unidirectional microphone or an omnidirectional (e.g., nondirectional) microphone. Both options are disclosed in the prior art, including in Sasaki. (*E.g.*, Ex. 1005 (Sasaki), 3:10-15 (disclosing directional and omnidirectional microphones).)

163. A person of ordinary skill in the art would have had a reasonable expectation of success in combining Burnett '919 (including as modified by Andrea) and Sasaki because unidirectional microphones were well known in the art and using

them to selectively attenuate a desired signal and a reference signal based on direction of arrival would have yielded a predictable result. A person of ordinary skill in the art would further have reasonably expected success because Sasaki discloses that its invention “is also applicable to any microphone systems[.]” (Ex. 1005 (Sasaki), 7:58-64.)

164. Thus, Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 14.

## **2. Claim 15**

165. Claim 15 depends from claim 14 and further recites “wherein the first microphone and the second microphone are separated by a distance in a range of approximately zero (0) centimeters to 15 centimeters.” Andrea discloses the additional limitations of claim 15.

166. As discussed above, Andrea discloses a telephone handset with a “receiver portion” that “includes first and second microphones.” (Ex. 1004 (Andrea), 12:38-40, Figs. 1, 3A-3B; ¶¶101-109 (Andrea claim elements 1[b][2]-1[b][3]), 121-128 (Andrea claims 6-7), above.) A person of ordinary skill in the art would have understood that such an embodiment requires separating the first and second microphone by a distance of between zero and 15 centimeters.

167. Additionally, the first and second microphones in Andrea’s headset embodiment (¶¶129-133 (claim 8), above), are in “relatively close proximity to each

other,” and specifically within 0.5 inches of each other. (Ex. 1004 (Andrea), 19:44-50.) Thus, Andrea discloses and/or renders obvious this limitation.

168. Thus, Burnett '919, Andrea, and Sasaki disclose and/or render obvious claim 15.

### **3. Claim 16**

169. Claim 16 depends from claim 14 and further recites “wherein the angle is in a range of approximately greater than zero (0) degrees and one of equal to and less than 180 degrees.” Burnett '919 and Andrea disclose and/or render obvious the additional limitations of claim 16.

170. As discussed above, Burnett '919 discloses an angle of roughly 180 degrees between the first and second microphones. (¶¶62-64 (Burnett '919 claim element 1[b][3]), above.) Because Burnett '919 discloses an angle greater than zero degrees and equal to or less than 180 degrees, Burnett '919 therefore discloses and/or suggests this limitation.

171. Andrea's handset embodiment discloses that the first and second microphones are positioned with a relative angle of “between 30° and 60°.” (Ex. 1004 (Andrea), 14:5-32; ¶¶105-109 (Andrea claim element 1[b][3]), above.) This range falls between zero degrees and 180 degrees. Moreover, Andrea's headset embodiment includes first and second microphones positioned “substantially 180°

apart from each other.” (Ex. 1004 (Andrea), 19:14-17, 19:39-43.) Those microphones are greater than zero degrees and equal to 180 degrees apart.

172. Thus, Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 16.

#### **4. Claim 17**

173. Claim 17 depends from claim 14 and further recites “wherein the angle is in a range of approximately greater than zero (0) degrees and one of equal to and less than 135 degrees.” Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 17 for the reasons discussed above. (¶¶169-172 (claim 16), above.)

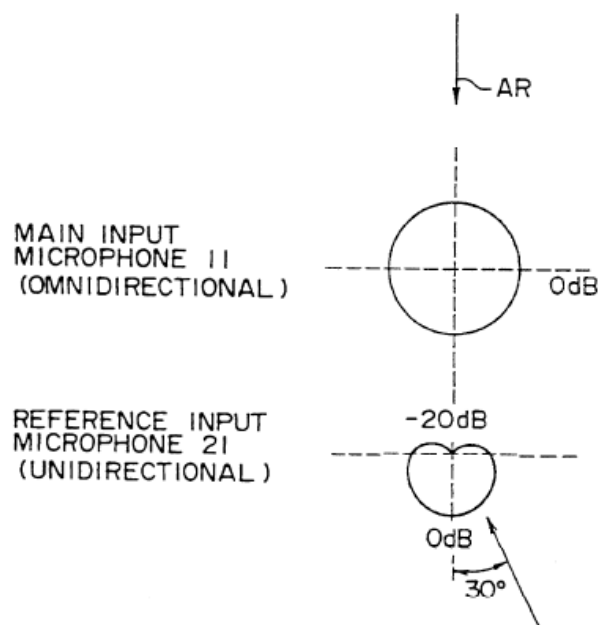
#### **5. Claim 18**

174. Claim 18 depends from claim 14 and further recites “wherein the angle is in a range of approximately greater than zero (0) degrees and one of equal to and greater than 90 degrees.” A person of ordinary skill in the art would have understood that an angle of roughly 180 degrees is both “approximately greater than zero (0) degrees” and “greater than 90 degrees.” Accordingly, Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 18 for the reasons discussed above. (¶¶169-172 (claim 16), above.)

## 6. Claim 19

175. Claim 19 depends from claim 1 and further recites “wherein the first microphone is an omnidirectional microphone and the second microphone is a unidirectional microphone.” Sasaki discloses and/or renders obvious this limitation.

176. Sasaki discloses an embodiment wherein the first microphone (e.g., the microphone designated to pick up speech and thus facing the user) “is constituted by an omnidirectional microphone as shown in Figure 3, while the reference input microphone 21 [e.g., the second microphone] is constituted by a unidirectional microphone[.]”



(Ex. 1005 (Sasaki), Fig. 3, 3:10-15.) A person of ordinary skill in the art would have been motivated to modify Burnett '919's system (as modified by Hussain and/or

Andrea) to include a unidirectional second microphone for the reasons discussed above. (¶¶157-164 (claim 14), above.) A person of ordinary skill in the art would have been motivated to use an omnidirectional microphone as the first microphone because, for example, omnidirectional microphones were cheaper and simpler than unidirectional microphones. A person of ordinary skill in the art would also have understood that the use of an omnidirectional first microphone and a unidirectional second microphone could provide a desirable directional characteristic, depending on what characteristic the person of ordinary skill in the art wanted to achieve. (Ex. 1005 (Sasaki), 8:4-14.)

177. Thus, Burnett '919, Andrea, and Sasaki disclose and/or render obvious claim 19.

## **7. Claim 20**

178. Claim 20 depends from claim 19 and further recites “wherein the first microphone and the second microphone are separated by a distance approximately in a range of zero (0) centimeters to 15 centimeters.” Burnett '919, Andrea, and Sasaki disclose and/or render obvious claim 20 for the reasons discussed above. (¶¶165-168 (claim 15), above.)

## **8. Claim 21**

179. Claim 21 depends from claim 19 and further recites “wherein the angle is approximately in a range of 30 degrees to 180 degrees.” Burnett '919, Andrea,

and Sasaki disclose and/or render obvious claim 21 for the reasons discussed above.  
(¶¶169-172 (claim 16), above.)

**9. Claim 22**

180. Claim 22 depends from claim 19 and further recites “wherein the angle is approximately in a range of 60 degrees to 180 degrees.” Burnett ’919 and Andrea each disclose and/or render obvious this limitation because they disclose microphones disposed at an angle of approximately 180 degrees from each other, as discussed above. (¶¶169-172 (claim 16), above.) Thus, Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 22.

**10. Claim 23**

181. Claim 23 depends from claim 19 and further recites “wherein the angle is approximately in a range of 90 degrees to 180 degrees.” Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 23 for the reasons discussed above.  
(¶¶169-172 (claim 16), above.)

**11. Claim 24**

182. Claim 24 depends from claim 1 and further recites “wherein the first microphone is a unidirectional microphone and the second microphone is an omnidirectional microphone.” Sasaki renders this limitation obvious.

183. As discussed above, Sasaki discloses the use of a unidirectional microphone for the primary, user-facing (e.g., first) microphone, and a person of

ordinary skill in the art would have been motivated to use that microphone in Burnett '919's system for the reasons discussed above. (¶¶157-164 (claim 14), above.) Sasaki also discloses the use of a unidirectional microphone for the noise (e.g., non-user-facing second) microphone (*id.*), but explains that “[f]urther substituting the second microphone with a microphone having a different directional characteristic [e.g., with an omnidirectional microphone] may change the directional characteristic of the entire microphone system, thus providing wide freedom in implementation of the directional characteristics.” (Ex. 1005 (Sasaki), 8:7-12.) A person of ordinary skill in the art would have been motivated by Sasaki's disclosure to use an omnidirectional microphone as the second microphone to achieve desired directional characteristics. For example, the person of ordinary skill in the art may want to remove noise coming from the direction of, or similar to the direction of, the speaker. Furthermore, a person of ordinary skill in the art would have been motivated to use an omnidirectional microphone as the second microphone (instead of a unidirectional microphone, as also disclosed by Sasaki) because an omnidirectional microphone is cheaper and simpler than a unidirectional microphone. Accordingly, a person of ordinary skill in the art would have understood Sasaki to disclose, or at least suggest, using an omnidirectional microphone as the second microphone.

184. Thus, Burnett '919, Andrea, and Sasaki disclose and/or render obvious claim 24.

## **12. Claim 25**

185. Claim 25 depends from claim 24 and further recites “wherein the first microphone and the second microphone are separated by a distance approximately in a range of zero (0) centimeters to 15 centimeters.” Burnett ’919, Andrea, and Sasaki disclose and/or render obvious claim 25 for the reasons discussed above. (¶¶165-168 (claim 15), above.)

### **D. Claim 3 Would Have Been Obvious in View of Burnett ’919, Hussain, Optionally Andrea, and Puthuff.**

186. Claim 3 depends from claim 1. As I discuss above, the limitations of claim 1 are disclosed by Burnett ’919, Hussain, and/or Andrea. (¶¶47-81 (Burnett ’919 claim 1), 96-118 (Andrea claim 1), above.) Puthuff discloses the additional limitations of claim 3. Accordingly, claim 3 would have been obvious in view of Burnett ’919, Hussain, optionally Andrea, and Puthuff.

187. Puthuff discloses a system that includes “sens[ing] sound through bone conduction.” (Ex. 1007 (Puthuff), 4:13-21.) A user’s voice is detected in part through “a motion transducer [80] comprising a vibration sensor” (e.g., an accelerometer). (*Id.*, 5:1-3.)

## **1. Claim 3**

188. Claim 3 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises[] at least one accelerometer sensor in contact

with skin for receiving the voice activity signals[,] and at least one voice activity detector (VAD) algorithm for processing the accelerometer sensor voice activity signals and generating the control signals.” Burnett ’919 and Puthuff disclose and/or render obvious this limitation.

189. Puthuff discloses a system for “sens[ing] sound [e.g., speech] through bone conduction” that includes a “vibration sensor” such as an “accelerometer.” (Ex. 1007 (Puthuff), 4:13-21, 5:1-9.) Puthuff’s vibration sensor “is a transducer device which senses the vibratory displacement of the bones in proximity to the ear as imparted primarily by vibrations during speech.” (*Id.*, 9:1-6; *id.*, 8:12-16.) The device is “held against the skin of the talker’s skull and may take the form of an ear level pickup worn behind the ear, or a telephone handset held against the ear during telephonic communication.” (*Id.*, 8:16-19.) Furthermore, Puthuff discloses that its system functions as a VAD to indicate whether or not speech is present. For example, Puthuff teaches that the incorporation of a vibration sensor “improves system immunity to false triggering due to noisy environments” and determines “the absence of the user’s voice” to conserve power. (*Id.*, 6:6-10.) Thus, Puthuff discloses using an accelerometer sensor in contact with the skin for receiving voice activity signals.

190. As I discuss above, Burnett ’919 discloses that its voice detection subsystem detects voice activity signals (using one or more sensors) and generates

control signals automatically, using the algorithm disclosed in Burnett '919 and incorporated reference Holzrichter '175. (¶¶48-52 (Burnett '919 claim element 1[a]), above.) Thus, Burnett '919 discloses a VAD algorithm for processing voice activity signals and generating control signals. A person of ordinary skill in the art would have understood that Burnett '919's algorithm could be used with one or more accelerometers as in Puthuff replacing one or more EM sensors in Burnett '919's system. A person of ordinary skill in the art would have been motivated to use the same algorithm to ensure compatibility with the rest of Burnett '919's system.

191. Thus, Burnett '919 and Puthuff disclose and/or render obvious claim 3.

## **2. Motivation to Combine Burnett '919 with Puthuff**

192. A person of ordinary skill in the art would have been motivated to combine Burnett '919 (including as modified by Hussain, Andrea, and/or Sasaki) with Puthuff, and to use Puthuff's accelerometer as Burnett '919's voice detection sensor in place of Burnett '919's EM sensor, for several reasons.

193. First, Burnett '919 and Puthuff both address the same problem—detecting voice activity in noisy environments. (Ex. 1003 (Burnett '919), 11:55-57, 17:50-53; Ex. 1007 (Puthuff), Abstract, 1:7-2:6.)

194. Second, Puthuff discloses that its system can operate using “off-the-shelf components” for reduced cost. (Ex. 1007 (Puthuff), 12:17-18.) A person of

ordinary skill in the art would have looked to use such off-the-shelf components to detect voice activity in Burnett '919's system because readily available and inexpensive components such as an accelerometer were cheaper and simpler than Burnett '919's EM sensors.

195. Third, Puthuff discloses that detecting speech through an accelerometer or other vibration sensor is “particularly suitab[le] to voice-activated applications” because of reduced “false triggering due to noisy environments,” for example when determining “the absence of the user’s voice.” (Ex. 1007 (Puthuff), 6:6-10.) A person of ordinary skill in the art would have therefore looked to use a vibration sensor with Burnett '919's system in noisy environments for improved performance.

196. Fourth, vibration sensors such as accelerometers have been known for decades. (Ex. 1007 (Puthuff), 3:19-4:11.) Thus, this combination represents nothing more than the simple addition of one known element (an accelerometer as in Puthuff) to another known element (Burnett '919's noise cancellation system) to obtain the predictable results of efficient, effective noise cancellation. Moreover, the combination represents the use of a known technique (using an accelerometer as in Puthuff) to improve a similar device and method (Burnett '919's noise cancellation system) in the same way. The combination also applies a known technique (using an accelerometer as in Puthuff) to a known device and method (Burnett '919's

system) that is ready for improvement and yields predictable results (a noise cancellation system that works effectively and efficiently).

197. Fifth, Puthuff discloses that its system is useful for “dual microphone” systems. (Ex. 1007 (Puthuff), 6:11-23.) Thus, a person of ordinary skill in the art would have been motivated to apply Puthuff’s teachings on detecting voice signals to Burnett ’919’s dual microphone system and would have had a reasonable expectation of success in doing so.

198. A person of ordinary skill in the art would also have had a reasonable expectation of success in combining Burnett ’919 and Puthuff because they relate to similar systems for identifying voice through non-acoustic means, and because the use of accelerometers and other vibration sensors to detect speech was well known. (Ex. 1007 (Puthuff), 3:19-4:11; Ex. 1008 (Alcivar), 4:65-5:54, Abstract.)

**E. Claim 4 Would Have Been Obvious in View of  
Burnett ’919, Hussain, Optionally Andrea, and  
Alcivar.**

199. Claim 4 depends from claim 1. As discussed above, the limitations of claim 1 are disclosed by Burnett ’919, Hussain, and/or Andrea. (¶¶47-81 (Burnett ’919 claim 1), 96-118 (Andrea claim 1), above.) Alcivar discloses the additional limitations of claim 4. Accordingly, claim 4 would have been obvious in view of Burnett ’919, Hussain, optionally Andrea, and Alcivar.

**1. Claim 4**

200. Claim 4 depends from claim 1 and further recites “wherein the voice detection subsystem further comprises[] at least one skin-surface microphone sensor in contact with skin for receiving the voice activity signals[,] and at least one voice activity detector (VAD) algorithm for processing the skin-surface microphone sensor voice activity signals and generating the control signals.” Alcivar discloses this limitation.

201. Alcivar discloses a “tissue-conduction microphone [] positioned in contact with the user’s neck tissue in the vicinity of the larynx” for use in voice communication systems to detect voicing activity and control a voice-activated switch. (Ex. 1008 (Alcivar), Abstract; *id.*, 1:5-8, 1:21-28, 1:31-33, 4:65-5:12.) Alcivar’s tissue-conduction microphone detects “tissue vibrations due to modulation of the vocal chords (speech)[.]” (*Id.*, 4:65-5:6.) A person of ordinary skill in the art would therefore have understood Alcivar to disclose a skin-surface microphone (“SSM”) (e.g., a microphone that picks up voice signals using contact with a speaker’s skin) that is in contact with skin for receiving voice activity signals.

202. Alcivar’s system receives voice activity signals using the tissue-conducting microphone and uses them to generate a “transmitter keying signal.” (Ex. 1008 (Alcivar), 4:65-67.) Alcivar further processes the output of its tissue-conducting microphone, including using a “Schmitt trigger circuit 68,” which

“provide[s] sharply defined ON/OFF levels and some degree of immunity to low-level random noise inputs.” (*Id.*, 5:55-67.) The signal is then sent to “audio detector 62.” (*Id.*, 6:1-11.) A person of ordinary skill in the art would have understood that the output of Alcivar’s audio detector is a control signal that denotes when the user is or is not speaking. (*Id.*, 5:55-67, 8:3-16.) Thus, Alcivar discloses a VAD algorithm for processing the voice activity signals and generating control signals.

203. Burnett ’919 also discloses and/or renders obvious the VAD algorithm limitation for the reasons discussed above. (¶¶48-52, 190 (discussing Burnett ’919 and claim elements 1[a]), above.)

## **2. Motivation to Combine Burnett ’919 with Alcivar**

204. A person of ordinary skill in the art would have been motivated to combine Burnett ’919 (including as modified by Hussain, Andrea, and/or Sasaki) with Alcivar, and to use Alcivar’s SSM as Burnett ’919’s voice detection sensor in place of Burnett ’919’s EM sensor, for several reasons.

205. First, Burnett ’919 and Alcivar both address the same problem of detecting voice activity in noisy environments. (Ex. 1003 (Burnett ’919), 11:55-57, 17:50-53; Ex. 1008 (Alcivar), Abstract, 1:5-8, 1:25-27, 1:55-62.)

206. Second, Alcivar explains SSMs can “discriminate against unwanted noises on the basis of amplitude alone, without having to resort to more elaborate

signal processing techniques.” (Ex. 1008 (Alcivar), 5:8-12.) Thus, one of ordinary skill in the art would have recognized that simpler and cheaper alternatives to Burnett ’919’s EM sensors, such as SSMs as disclosed in Alcivar, could be used in Burnett ’919’s system and would have looked to use a SSM in place of Burnett ’919’s EM sensors to detect voicing activity in Burnett ’919’s system.

207. Third, Alcivar discloses that its tissue-conduction microphone is “particularly suited for high noise environment communications systems” compared to acoustic microphone-based systems that are “highly susceptible to false keying” of, for example, voice operated components “by non-speech noises.” (Ex. 1008 (Alcivar), 1:55-62, 1:5-20; *id.*, Abstract, 1:25-27.) Thus, a person of ordinary skill in the art would have looked to use a SSM with Burnett ’919’s system in noisy environments for improved performance.

208. Fourth, this combination represents nothing more than the simple addition of one known element (a SSM as in Alcivar) to another known element (Burnett ’919’s noise cancellation system) to obtain the predictable results of efficient, effective noise cancellation. Moreover, the combination represents the use of a known technique (using a SSM as in Alcivar) to improve a similar device and method (Burnett ’919’s noise cancellation system) in the same way. The combination also applies a known technique (using a SSM as in Alcivar) to a known device and method (Burnett ’919’s system) that is ready for improvement and yields

predictable results (a noise cancellation system that works effectively and efficiently).

209. Alcivar also discloses that its system “can be used in other communication systems[,]” leading a person of ordinary skill in the art to reasonably expect success in combining it with Burnett ’919. (Ex. 1008 (Alcivar), 1:55-62; *id.*, 1:5-8, 1:34-36 (system “can be easily incorporated in existing communication systems”).) A person of ordinary skill in the art would also have had a reasonable expectation of success in combining Burnett ’919 and Alcivar because they relate to similar systems (identifying voice through non-acoustic means), and the use of SSMs and other vibration sensors to detect voice was well known. (*Id.*, 4:65-5:54, Abstract; Ex. 1007 (Puthuff), 3:19-4:11.)

## **VII. SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS**

210. I am not aware of any secondary considerations of nonobviousness. If Patent Owner identifies any alleged evidence of secondary considerations in the future, I reserve the right to respond to that information.

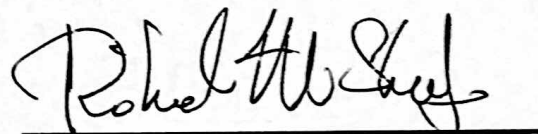
## **VIII. CONCLUSION**

211. For the foregoing reasons, it is my opinion that claims 1-26 of the ’543 patent would have been obvious to a person of ordinary skill in the art at the time of the alleged invention in view of the prior art discussed above.

212. I reserve the right to supplement my opinions in the future to address or respond to any issues that the Patent Owner may raise, as well as new information including, but not limited to, any claim constructions advanced by the Patent Owner or adopted by the Board in the Institution Decision, and respond to any alleged secondary considerations as they become available to me.

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on November 27, 2022 at Pittsburgh, Pennsylvania.



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Richard M. Stern, Ph.D.