

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Based on information presently available, Jawbone Innovations, LLC (“Jawbone”) contends that Defendant Google LLC (“Google” or “Defendant”) infringes claims 1-20 (the “Asserted Claims”) of U.S. Patent No. 10,779,080 (the “’080 Patent”) through the Accused Products which are manufactured, sold, offered for sale, and/or used by Google.

For example, the Accused Products include, but are not limited to, the following Accused Products: and all versions and variants of Google smartphones, smart speakers, and earbuds made, sold, offered for sale, used, or imported in the United States since 2015, including but not limited to: Nexus 5, Nexus 6, Nexus 5X, Nexus 6P, Pixel (1st Generation), Pixel 2, Pixel 3, Pixel 3a, Pixel 4, Pixel 4a, Pixel 5, Pixel 5a, Pixel 6, Pixel Buds, Pixel Buds A-Series, Pixel Buds 2, Google Home, Home Mini, Home Max, Home Hub/Nest Hub, Nest Mini, Nest Audio, and Nest Hub (2nd Generation).

For example, the Accused Products include, but are not limited to, software providing and/or utilizing acoustic noise suppression functionalities, including but not limited to all versions of the Android Operating System, Android Auto, GMS Core, and Android applications including voice sensing functionality, such as Google Assistant, Google Duo, Google Meet, Phone, Camera, Google Camera, Google Voice, and Google Now.

Google directly infringes each of the Asserted Claims by importing, using, selling, and/or offering to sell the Accused Products in violation of 35 U.S.C. § 271(a).

Google indirectly infringes the Asserted Claims in violation of 35 U.S.C. § 271(b) by inducing third parties, including Google customers and end users, to directly infringe through their operation and use of the Accused Products. Google has knowingly and intentionally induced this direct infringement by, *inter alia*, (i) selling, importing, or otherwise providing the Accused Products to third parties with the intent that the Accused Products will operated and be used in a manner that practices the Asserted Claims; and (ii) marketing and advertising the Accused Products. Google’s marketing and promotional materials for the Accused Products are found, for example, on Google’s website. For example, Google’s website offers customers downloadable User Manuals for the Accused Products that instruct customers to, among other things, set up and use applications and products including acoustic noise suppression functionality. On information and belief, Google knows that its actions will result in infringement of the Asserted Claims, or subjectively believes that there is a high probability that its actions will result in infringement of the Asserted Claims but has taken deliberate actions to avoid learning these facts.

Google also contributorily infringes each of the Asserted Claims in violation of 35 U.S.C. § 271(c) by selling, importing, and offering for sale the Accused Products, which when used directly infringe the Asserted Claims. The Accused Products constitute a material part of the Asserted Claims.

The following chart identifies specifically where each limitation of each Asserted Claim is found within the Accused Products and, in particular, the corresponding elements that meet the limitation in Google Pixel 6, Pixel Buds 2, Google Home Max, and substantially similar Pixel, Pixel Buds, Home, and Nest products. On information and belief, the charted products are representative of all Accused Products.

Jawbone does not concede that any claims of the ’080 Patent that are not listed below are not infringed by the identified Accused Products. Moreover, the citations to certain documents and other information below are intended to be exemplary only and in no way foreclose Jawbone from citing or relying on additional documents, information, source code, and/or testimony at a later time. These contentions are preliminary in nature, and an analysis of Google’s products, internal documentation, source code, and/or testimony from relevant witnesses may more fully and accurately describe the infringing features of its Accused Products. Accordingly, Jawbone reserves the right to supplement, correct, modify, and/or amend these contentions once such additional information is made available to Jawbone. Furthermore, Jawbone reserves the right to supplement, correct, modify,

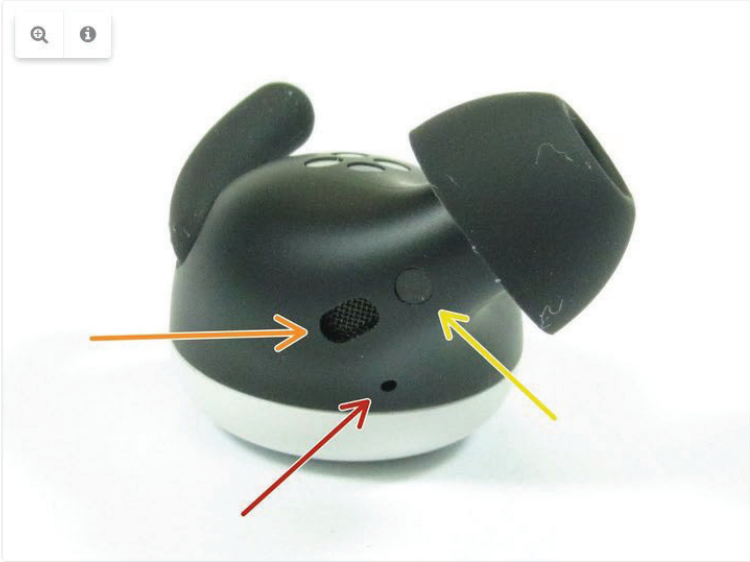
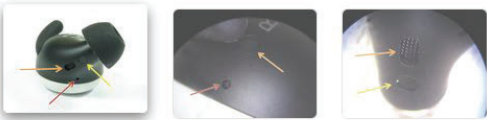
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

and/or amend these contentions as discovery in this case progresses; in view of the Court's claim construction order(s); in view of any positions taken by Google including, but not limited to, positions on claim construction, invalidity, and/or non-infringement; and in connection with the preparation and exchange of expert reports.

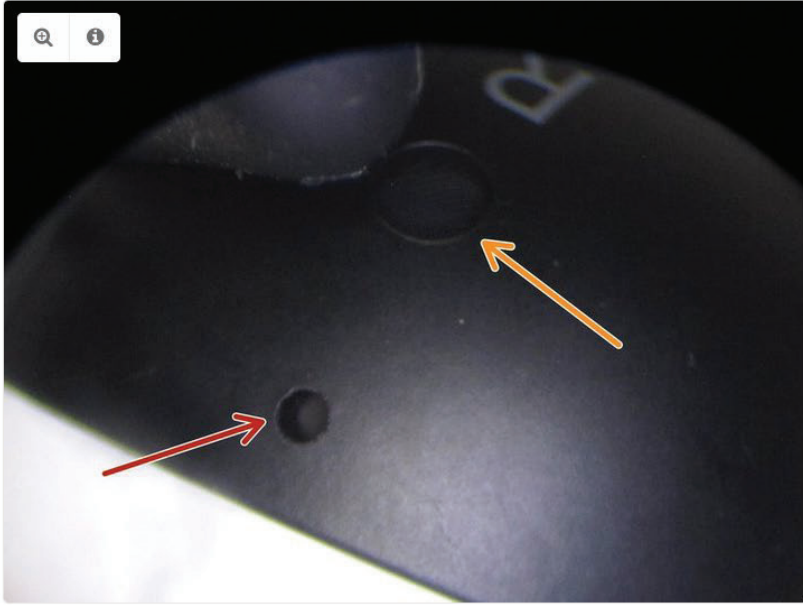
To the extent Google contends that any element of the Accused Products is attributable to a third party, Jawbone contends that the activities are attributable to Google such that they constitute direct infringement by Google under 271(a). The acts may be attributable to Google because Google directs or controls the others' performance, and because Google and the other entity form a joint enterprise. *Akamai Techs., Inc. v. Limelight Networks, Inc.*, 797 F.3d 1020, 1022 (Fed. Cir. 2015). Additionally, Google is vicariously liable for the activities of these other entities. *Centillion Data Sys., LLC v. Qwest Commc'ns Int'l, Inc.*, 631 F.3d 1279, 1286 (Fed. Cir. 2011). Further, the activities of these entities (including manufacturers, distributors, and users of the Accused Products consumers) are attributable to Google because Google (1) conditions participation in an activity or receipt of a benefit upon others' performance of one or more steps of a patented method, and (2) establishes the manner or timing of that performance. *Eli Lilly & Co. v. Teva Parenteral Medicines, Inc.*, 845 F.3d 1357, 1365 (Fed. Cir. 2017). These acts are also attributed to Google because it initiated the activities of its end-users. *SiRF Tech., Inc. v. Int'l Trade Comm'n*, 601 F.3d 1319, 1330 (Fed. Cir. 2010).

Claim	Support
1[p]. A system, comprising:	Every Accused Product comprises of a system as recited in claim 1.
1[a]. a microphone array including a first physical microphone outputting a first microphone signal and a second physical microphone outputting a second microphone signal;	Every Accused Product comprises of a system including a microphone array including a first physical microphone outputting a first microphone signal and a second physical microphone outputting a second microphone signal. For example, each bud of the accused earbud products comprises at least two outward-facing physical microphones, which receive acoustic signals (<i>e.g.</i>, in the form of sound waves). For example, each physical microphone generates an electric signal based on the received acoustic signals. For example, the Pixel Buds 2 include and utilize at least two outward facing microphones on each earbud.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 5   ● Microphone port. One on each side, and opposite one another. ● Spatial vent / grounded mesh ● IR Detector for in ear detection https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 5   ● Microphone port. One on each side, and opposite one another. ● Spatial vent / grounded mesh ● IR Detector for in ear detection https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, a lower microphone is closer to a talker's mouth and, upon information and belief, detects signals with less attenuated speech signals than at least a second outward facing microphone which is further away, and which detects signals with a greater noise content and more attenuated speech.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

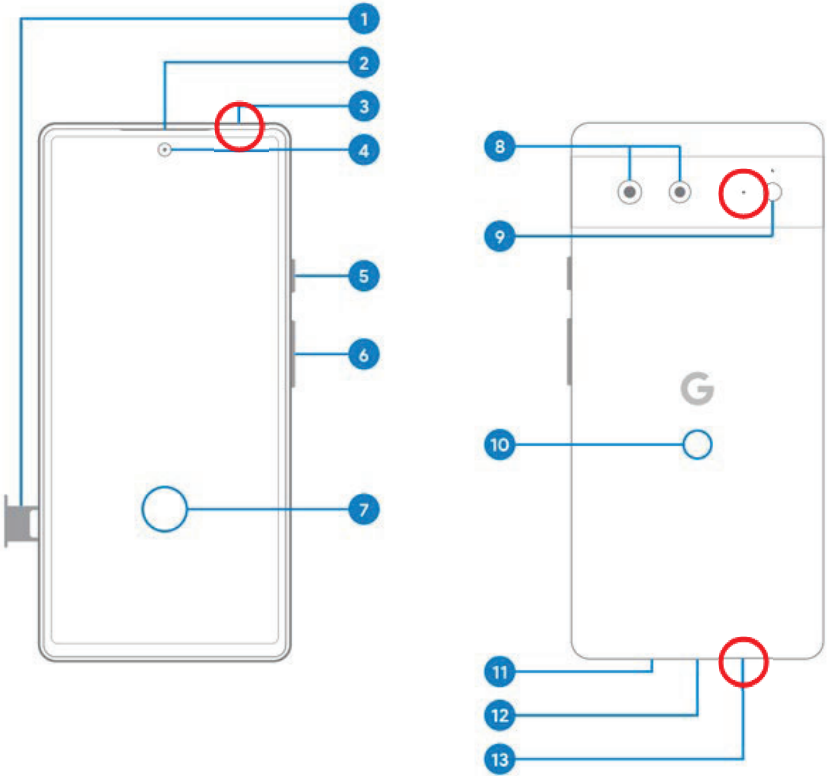
Claim	Support
	For example, the Pixel 6 includes and utilizes at least three microphones, positioned in at least three different locations (<i>e.g.</i> , a bottom, top, and rear microphone):

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Pixel 6



To learn about the features of your Pixel 6, see the diagram below:



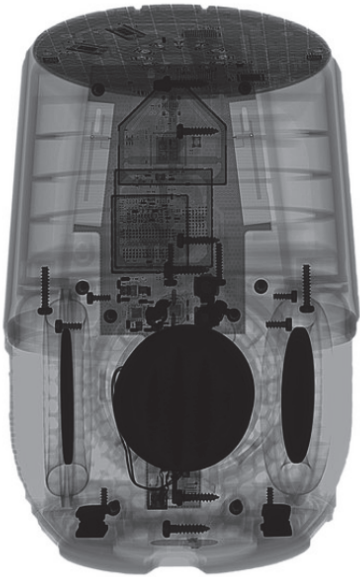
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	1. SIM card tray 2. Top speaker 3. Top microphone 4. Front-facing camera 5. Power button 6. Volume up/down button 7. Fingerprint sensor 8. Rear-facing camera 9. LED flash 10. NFC 11. Bottom speaker 12. USB-C port 13. Bottom microphone For example, the Google Home receives acoustic signals at an array of at least two physical microphones (<i>e.g.</i>, outlined in yellow below).

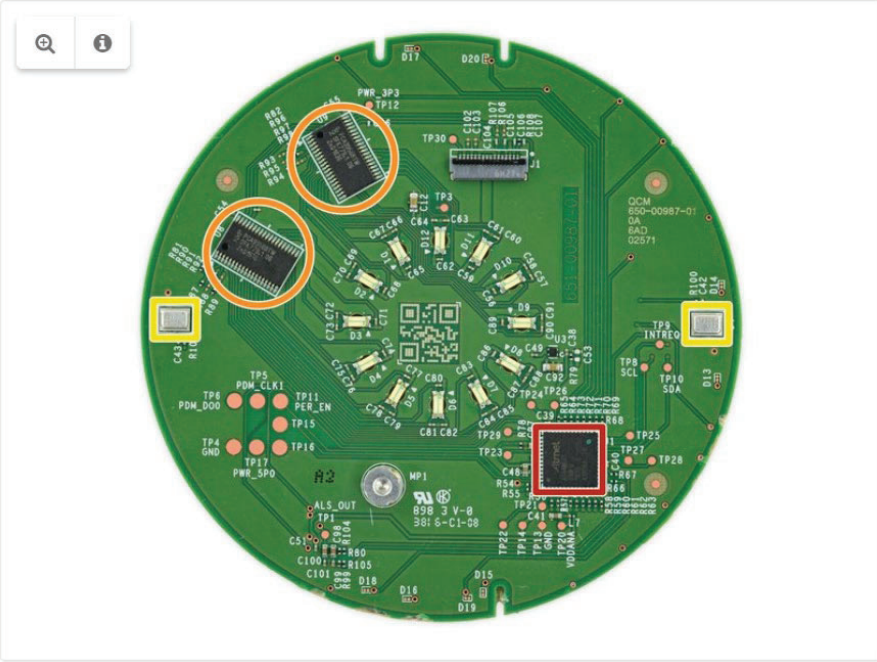
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 1 Google Home Teardown

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	

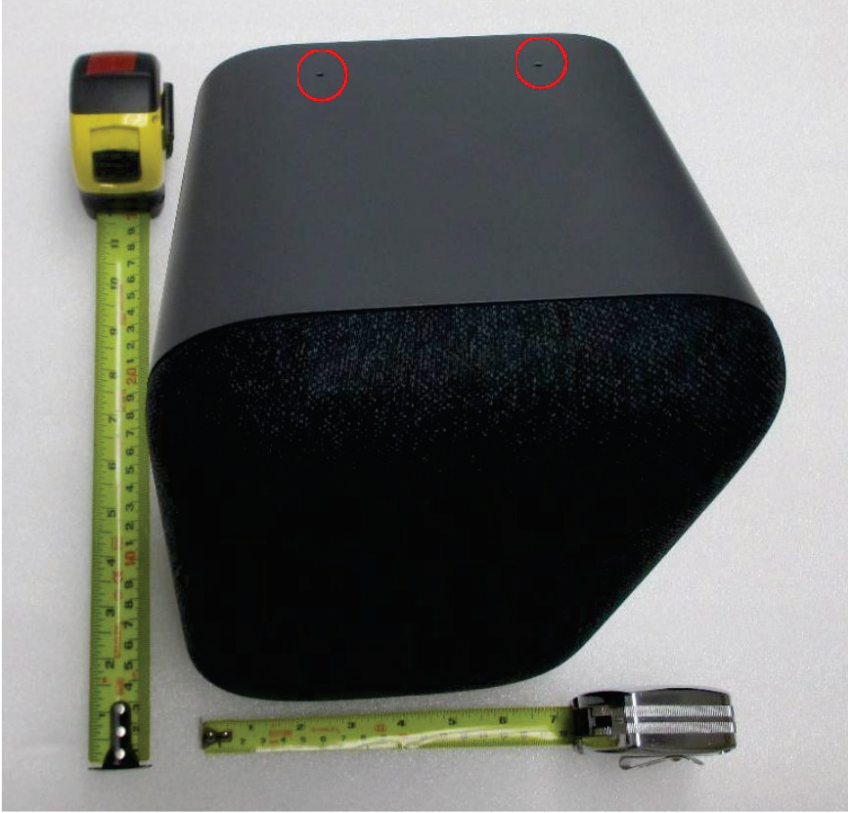
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://www.ifixit.com/Teardown/Google+Home+Teardown/72684 For example, the Google Home Max receives acoustic signals at an array of six physical microphones, outlined in red across the two images below.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://fccid.io/A4R-H0B/External-Photos/External-Photos-H0B-3623979

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://fccid.io/A4R-H0B/External-Photos/External-Photos-H0B-3623979

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, the microphones of the Accused Products are omnidirectional MEMs microphones. For example, the microphones are part of an array of microphones. Upon information and belief, he Accused Products include functionality to select an input from an array of physical microphones and beamformers, <i>e.g.</i>, combined signals from multiple physical microphones. <i>See</i> MicrophoneInfo Added in API level 28 Kotlin Java <pre>public final class MicrophoneInfo extends Object java.lang.Object └─ android.media.MicrophoneInfo</pre> Class providing information on a microphone. It indicates the location and orientation of the microphone on the device as well as useful information like frequency response and sensitivity. It can be used by applications implementing special pre processing effects like noise suppression of beam forming that need to know about precise microphone characteristics in order to adapt their algorithms. https://developer.android.com/reference/android/media/MicrophoneInfo

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Core TopicsCompatibilityAndroid DevicesReference AOSP > Docs > Core TopicsWas this helpful?   Configuring Preprocessing Effects  Send feedback The Android 10 release includes the following requirements for capture with <code>VOICE_COMMUNICATION</code>. • Implementations should provide an acoustic echo canceler (AEC) on the capture path when capturing with <code>VOICE_COMMUNICATION</code>. • If providing an AEC, it must be discoverable and controllable through the SDK API's <code>AcousticEchoCanceller</code>. The Android platform provides audio effects on supported devices in the <code>audiofx</code>  package, which is available for developers to access. For example, the Nexus 10 supports the following preprocessing effects: • Acoustic Echo Cancellation • Automatic Gain Control • Noise Suppression https://source.android.com/devices/audio/implement-pre-processing

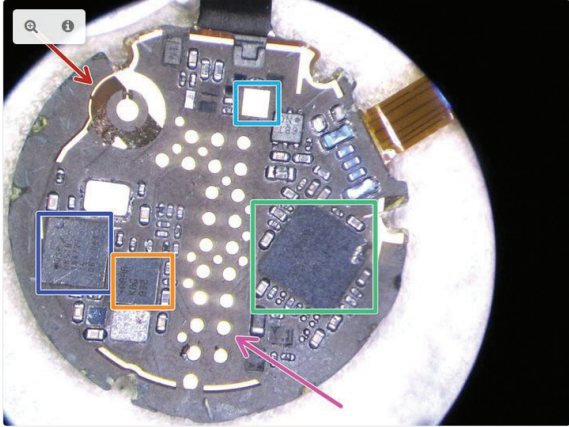
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	NoiseSuppressor  Added in API level 16 Kotlin Java <pre data-bbox="415 483 806 651"> public class NoiseSuppressor extends AudioEffect java.lang.Object └─ android.media.audiofx.AudioEffect └─ android.media.audiofx.NoiseSuppressor </pre> Noise Suppressor (NS). Noise suppression (NS) is an audio pre-processor which removes background noise from the captured signal. The component of the signal considered as noise can be either stationary (car/airplane engine, AC system) or non-stationary (other peoples conversations, car horn) for more advanced implementations. NS is mostly used by voice communication applications (voice chat, video conferencing, SIP calls). An application creates a NoiseSuppressor object to instantiate and control an NS engine in the audio framework. To attach the NoiseSuppressor to a particular AudioRecord , specify the audio session ID of this AudioRecord when creating the NoiseSuppressor. The audio session is retrieved by calling AudioRecord.getAudioSessionId() on the AudioRecord instance. https://developer.android.com/reference/android/media/audiofx/NoiseSuppressor.html

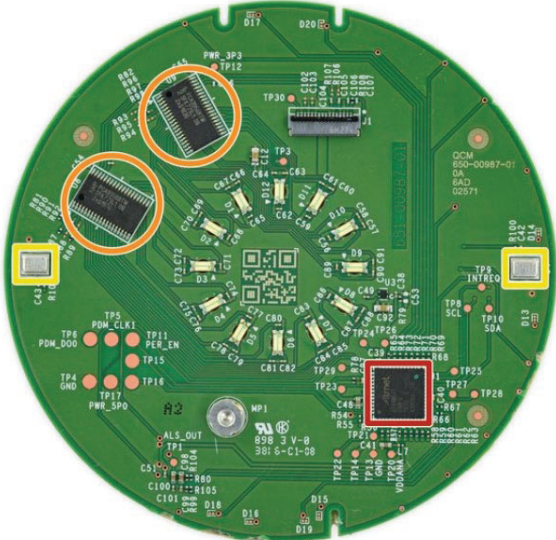
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
1[b]. a processing component coupled to the microphone array and generating a virtual microphone array including a first virtual microphone and a second virtual microphone,	Every Accused Product comprises of a system including a processing component coupled to the microphone array and generating a virtual microphone array including a first virtual microphone and a second virtual microphone. On information and belief, all of the accused products have at least one processor/DSP coupled to plurality of microphones and voice activity sensors (<i>e.g.</i>, accelerometers). For example, the Pixel Buds 2 use a DS18B Audio DSP:

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 9  ● Closeup view of the bottom side of the Main PCB ● DSP Group - DS18B - Audio DSP ● Maxim Audio Amplifier - most likely MAX98502 ● ST Micro - STM32L431RC6 - MCU ● Unknown component. Labelled "ix6". Please leave a comment if you happen to know this component ● Programming Interface and test points. Looks to be the standard ARM 20 Pin connector layout. ● Bluetooth Antenna. Runs around the outside of the Main PCB - Top and Bottom https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, upon information and belief, the Accused Pixels comprise and utilize an DSP such as a Google Tensor, and/or dedicated audio chip (<i>e.g.</i>, audio IC and/or audio codec). https://support.google.com/pixelphone/answer/7158570?hl=en#zippy=%2Cpixel For example, the Home comprises a DSP (<i>e.g.</i>, an ATSAMD21 32-bit ARM Cortex-M0+, outlined in red) that is coupled to the microphones.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://www.ifixit.com/Teardown/Google+Home+Teardown/72684

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 MICROCHIP SAM D21/DA1 Family Low-Power, 32-bit Cortex-M0+ MCU with Advanced Analog and PWM Features • Processor – Arm® Cortex®-M0+ CPU running at up to 48 MHz • Single-cycle hardware multiplier • Micro Trace Buffer (MTB) http://ww1.microchip.com/downloads/en/DeviceDoc/SAM_D21_DA1_Family_DataSheet_DS40001882F.pdf For example, the Accused Products generate an array of beamformed microphones using combinations of signals output by physical microphones. For example, upon information and belief, differently processed signals output by a physical microphone are used in different combinations of physical microphone signals to generate different beamformed microphones. For example, the Accused Products include functionality to select an input from an array of physical microphones and beamformers, <i>e.g.</i>, combined signals from multiple physical microphones. For example, on information and belief, the Accused Pixel 6 generates beamformed microphones from combinations of bottom, upper, and rear microphones.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	MicrophoneInfo Added in API level 28 Kotlin Java <pre>public final class MicrophoneInfo extends Object java.lang.Object ↳ android.media.MicrophoneInfo</pre> Class providing information on a microphone. It indicates the location and orientation of the microphone on the device as well as useful information like frequency response and sensitivity. It can be used by applications implementing special pre processing effects like noise suppression of beam forming that need to know about precise microphone characteristics in order to adapt their algorithms. https://developer.android.com/reference/android/media/MicrophoneInfo

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Core TopicsCompatibilityAndroid DevicesReference AOSP > Docs > Core Topics Was this helpful?   Configuring Preprocessing Effects  Send feedback The Android 10 release includes the following requirements for capture with <code>VOICE_COMMUNICATION</code>. • Implementations should provide an acoustic echo canceler (AEC) on the capture path when capturing with <code>VOICE_COMMUNICATION</code>. • If providing an AEC, it must be discoverable and controllable through the SDK API's <code>AcousticEchoCanceler</code>. The Android platform provides audio effects on supported devices in the <code>audiofx</code>  package, which is available for developers to access. For example, the Nexus 10 supports the following preprocessing effects: • Acoustic Echo Cancellation • Automatic Gain Control • Noise Suppression https://source.android.com/devices/audio/implement-pre-processing

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	NoiseSuppressor Added in API level 16 KotlinJava <pre>public class NoiseSuppressor extends AudioEffect java.lang.Object └─ android.media.audiofx.AudioEffect └─ android.media.audiofx.NoiseSuppressor</pre> Noise Suppressor (NS). Noise suppression (NS) is an audio pre-processor which removes background noise from the captured signal. The component of the signal considered as noise can be either stationary (car/airplane engine, AC system) or non-stationary (other peoples conversations, car horn) for more advanced implementations. NS is mostly used by voice communication applications (voice chat, video conferencing, SIP calls). An application creates a NoiseSuppressor object to instantiate and control an NS engine in the audio framework. To attach the NoiseSuppressor to a particular <code>AudioRecord</code>, specify the audio session ID of this AudioRecord when creating the NoiseSuppressor. The audio session is retrieved by calling <code>AudioRecord.getAudioSessionId()</code> on the AudioRecord instance. https://developer.android.com/reference/android/media/audiofx/NoiseSuppressor.html

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, on information and belief, each earbud and/or pair of earbuds of the Pixel Buds 2 generates beamformed microphones from combinations of outward facing microphones: (see https://support.google.com/googlepixelbuds/answer/7545575?hl=en) What are the new Google Pixel Buds? Pixel Buds A-Series bring you rich, high-quality sound for a lot less than you'd expect. With custom-designed 12 mm dynamic speaker drivers, Pixel Buds A-Series deliver high-quality audio. Their beamforming mics help make your calls crystal clear.¹ The flush-to-ear design is stylish, and the stabilizer arc keeps them in place so you can wear them even during the sweatiest workout.² Get real-time language translation right in your ear.³ Talk to Google to get important messages and notifications hands-free – just say, “Hey Google.”⁴ And with up to 5 hours of listening time on one charge or up to 24 hours using the charging case, you can keep listening anywhere.⁵ Buy Now  ¹Call quality depends on signal strength, environment, network traffic, and many other factors. Actual results may vary. ²Pixel Buds A-Series (earbuds only) have a water protection rating of IPx4 under IEC standard 60529. Water resistance is not a permanent condition and may be compromised by normal wear and tear, repair, disassembly, or damage. https://support.google.com/googlepixelbuds/answer/7545575?hl=en

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Voice Dual beamforming microphones Voice detecting accelerometer https://support.google.com/googlepixelbuds/answer/7544332?hl=en For example, on information and belief, the accused Google Home generates beamformed microphones from combinations of physical microphone inputs.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Abstract Joint multichannel enhancement and acoustic modeling using neural networks has shown promise over the past few years. However, one shortcoming of previous work [1, 2, 3] is that the filters learned during training are fixed for decoding, potentially limiting the ability of these models to adapt to previously unseen or changing conditions. In this paper we explore a neural network adaptive beamforming (NAB) technique to address this issue. Specifically, we use LSTM layers to predict time domain beamforming filter coefficients at each input frame. These filters are convolved with the framed time domain input signal and summed across channels, essentially performing FIR filter-and-sum beamforming using the dynamically adapted filter. The beamformer output is passed into a waveform CLDNN acoustic model [4] which is trained jointly with the filter prediction LSTM layers. We find that the proposed NAB model achieves a 12.7% relative improvement in WER over a single channel model [4] and reaches similar performance to a “factored” model architecture which utilizes several fixed spatial filters [3] on a 2,000-hour Voice Search task, with a 17.9% decrease in computational cost. Index Terms: speech recognition, multichannel, beamforming, adaptive filtering https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Figure 1: <i>Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity.</i> https://static.googleusercontent.com/media/research.google.com/en/pubs/archive/45399.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Google Home's smart audio design integrates a high-excursion driver with a dual passive radiator design that delivers crystal-clear highs and deep lows for Hi-Fi sound that streams over WiFi. That means a lot of big sound from a small package. Even while you jam out to music, it can easily hear you from across the room, thanks to two omnidirectional microphones and neural beamforming. https://www.blog.google/products/home/make-yourself-home-google-home/ 8. Conclusions In this paper, we described the various aspects of the Google Home multichannel speech recognition system. Technical achievements include a WPE to perform dereverberation, fCLP to perform <u>beamforming</u> jointly with acoustic modeling, and a Grid-LSTM to model frequency variations. In addition, we also presented results by adapting the model based on data from real traffic. Overall, we are able to achieve a 8-28% relative reduction in WER compared to the current production system. http://www.cs.cmu.edu/~chanwook/MyPapers/b_li_interspeech_2017.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Neural Adaptive Beamforming (NAB) - LSTM for each channel predicts a set of filter coefficients $h_1(k)[t], h_2(k)[t]$ - Convolve each channel with the filter coefficients $y(k)[t] = x_1(k) * h_1(k)[t] + x_2(k) * h_2(k)[t]$ - This layer is mimicking F+S Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Neural Adaptive Beamforming (NAB) - LSTM-based adaptive beamforming - Passed to a spectral layer to get frame-level features - Gated history feedback $g^{fb}(t) = \sigma(w_x^T \cdot x_t + w_s^T \cdot s_{t-1} + w_v^T \cdot v_{t-1})$ Current inputs Previous state AM feedback $\begin{bmatrix} x_t^T & g^{fb}(t) v_{t-1}^T \end{bmatrix}^T$ - Denoising MTL Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	NAB Analysis • Output of NAB at every frame gives a freq x direction x time beampattern • Plot the beampattern of the NAB filters in the direction of the target speech and noise directions • Responses in the target speech direction have relatively more speech-dependent variations than those in the noise direction https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf The figure consists of four vertically stacked spectrograms. The top two are labeled 'Noisy Speech' and 'Clean Speech', showing speech signals with and without noise. The bottom two are labeled 'Target' and 'Noise', showing the beamformer responses for the target speech and interfering noise directions. The x-axis for all plots is 'Time frame index' ranging from 0 to 200. The y-axis represents frequency. Color bars on the right of each plot indicate the magnitude of the responses. Figure 2: Visualizations of the predicted beamformer responses at different frequency (Y-axis) across time (X-axis) at the target speech direction (3rd) and interfering noise direction (4th) with the noisy (1st) and clean (2nd) speech spectrograms.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Figure 1: <i>Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity.</i> https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf

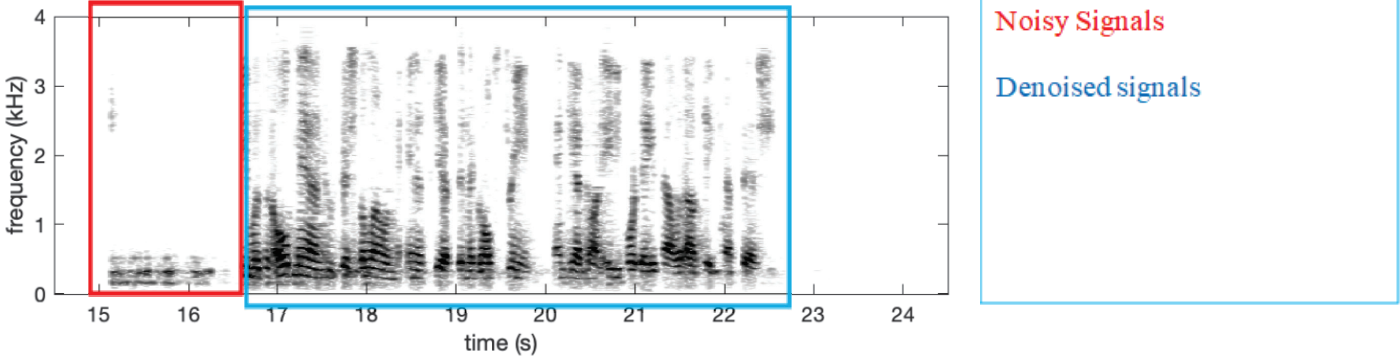
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
1[c]. the first virtual microphone including a first combination of the first microphone signal and the second microphone signal,	Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided. Every Accused Product comprises of a system including the first virtual microphone including a first combination of the first microphone signal and the second microphone signal. For example, upon information and belief, the Accused Products comprise beamformed microphone comprising a combination of first and second microphone signals (<i>e.g.</i>, a combination outputs from a first and second physical microphone and/or beamformer). For example, upon information and belief, the Pixel Buds 2 include a beamformed microphone comprising a first combination of signals from the outer microphones of an earbud. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
1[d]. the second virtual microphone including a second combination of the first microphone signal and the second microphone signal, wherein the second combination is different from the first combination,	Every Accused Product comprises of a system including the second virtual microphone including a second combination of the first microphone signal and the second microphone signal, wherein the second combination is different from the first combination. Upon information and belief, all of the accused products use virtual microphones generated from a combination of multiple physical microphones. For example, the Accused Products include functionality to select an input from an array of physical microphones and beamformers, <i>e.g.</i>, combined signals from multiple physical microphones. For example, upon information and belief, the Pixel Buds 2 include a beamformed microphone comprising a second combination of signals from the outer microphones of an earbud and/or upper or lower microphones of a pair of earbuds For example, upon information and belief, the Pixel 6 includes a beamformed microphone comprising a first combination of signals from a lower and a top and/or rear microphone. For example, upon information and belief, the Google Home Max includes a beamformed microphone comprising microphones opposite or perpendicular to microphones closest to a talker, and/or a differently processed combination of outputs of microphones closest to a talker. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
1[e]. wherein the first virtual microphone and the second virtual microphone have substantially similar responses to noise and substantially dissimilar responses to speech; and	Every Accused Product comprises of a system wherein the first virtual microphone and the second virtual microphone have substantially similar responses to noise and substantially dissimilar responses to speech. For example, upon information and belief, the beamformed microphones of the Accused Products (<i>e.g.</i>, beamformed microphones of each earbud of the Pixel Buds 2, beamformed microphones generated by separate microphones of a pair of Pixel Buds 2, Home Max, and/or of Pixel 6) have substantially similar responses to noise and substantially dissimilar responses to speech. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
1[f]. an adaptive noise removal application coupled to the processing component and generating denoised output signals by forming a plurality of combinations of signals output from the first virtual microphone and the second virtual microphone,	Every Accused Product comprises of a system including an adaptive noise removal application coupled to the processing component and generating denoised output signals by forming a plurality of combinations of signals output from the first virtual microphone and the second virtual microphone. Upon information and belief, all of the Accused Products generate denoised output signals by performing adaptive beamforming (<i>e.g.</i>, combining signals from a first and second beamformed microphone).microphones. For example, the Accused Products generate denoised acoustic signals. <u>Pixel 5a Spectrogram:</u>

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 The figure is a spectrogram with frequency in kHz on the y-axis (0 to 4) and time in seconds on the x-axis (15 to 24). A red rectangular box is drawn over the time interval 15 to 16.5 seconds, covering frequencies from 0 to 4 kHz. A blue rectangular box is drawn over the time interval 16.5 to 22.5 seconds, covering frequencies from 0 to 4 kHz. To the right of the spectrogram, there is a legend with a red box containing the text 'Noisy Signals' and a blue box containing the text 'Denoised signals'. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
1[g]. by filtering and summing the plurality of combinations of signals in the time domain, and	Every Accused Product practices a system by filtering and summing the plurality of combinations of signals in the time domain. Upon information and belief, all of the accused products combine signals from a first and second physical microphone by delaying, applying gains, filtering, and summing in the time domain. For example, upon information and belief, the Accused Products achieve beamforming by filtering and adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone). For example, upon information and belief, the Accused Products achieve noise reduction by filtering and adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone). Upon information and belief, all of the accused products combine signals from multiple physical microphones, <i>e.g.</i>, a first and second physical microphone or a first and third physical microphone, by applying a delay and adding and/or subtracting (possibly scaled versions of) the signals to achieve a desired spatial directivity.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, the Accused Products practice delay and sum beamforming by applying a delay adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone or a first and third physical microphone). For example, the Accused Products further practice delay and sum beamforming by filtering and summing the signals of microphones (<i>e.g.</i>, a first and second physical microphone first and third physical microphone). For example, upon information and belief, a first beamformed microphone is formed by subtracting a second microphone signal (<i>e.g.</i>, a microphone signal with greater noise and more attenuated speech) from a first microphone signal (<i>e.g.</i>, a microphone with greater speech content, and more attenuated noise).

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Abstract Joint multichannel enhancement and acoustic modeling using neural networks has shown promise over the past few years. However, one shortcoming of previous work [1, 2, 3] is that the filters learned during training are fixed for decoding, potentially limiting the ability of these models to adapt to previously unseen or changing conditions. In this paper we explore a neural network adaptive beamforming (NAB) technique to address this issue. Specifically, we use LSTM layers to predict time domain beamforming filter coefficients at each input frame. These filters are convolved with the framed time domain input signal and summed across channels, essentially performing FIR filter-and-sum beamforming using the dynamically adapted filter. The beamformer output is passed into a waveform CLDNN acoustic model [4] which is trained jointly with the filter prediction LSTM layers. We find that the proposed NAB model achieves a 12.7% relative improvement in WER over a single channel model [4] and reaches similar performance to a “factored” model architecture which utilizes several fixed spatial filters [3] on a 2,000-hour Voice Search task, with a 17.9% decrease in computational cost. Index Terms: speech recognition, multichannel, beamforming, adaptive filtering https://static.googleusercontent.com/media/research.google.com/en/pubs/archive/45399.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

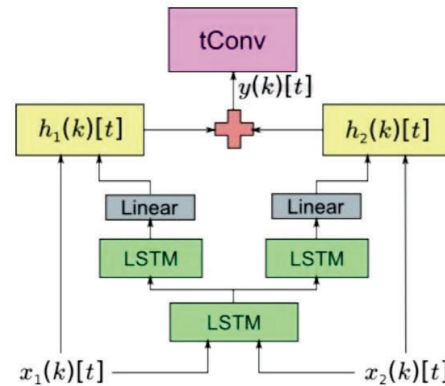
Claim	Support
	Figure 1: Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf Google Home's smart audio design integrates a high-excursion driver with a dual passive radiator design that delivers crystal-clear highs and deep lows for Hi-Fi sound that streams over WiFi. That means a lot of big sound from a small package. Even while you jam out to music, it can easily hear you from across the room, thanks to two omnidirectional microphones and neural beamforming. https://www.blog.google/products/home/make-yourself-home-google-home/ 8. Conclusions In this paper, we described the various aspects of the Google Home multichannel speech recognition system. Technical achievements include a WPE to perform dereverberation, fCLP to perform beamforming jointly with acoustic modeling, and a Grid-LSTM to model frequency variations. In addition, we also presented results by adapting the model based on data from real traffic. Overall, we are able to achieve a 8-28% relative reduction in WER compared to the current production system.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

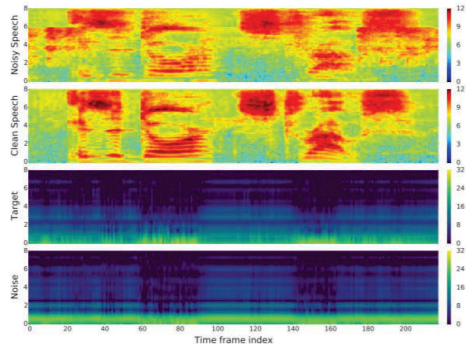
Claim	Support
	http://www.cs.cmu.edu/~chanwook/MyPapers/b_li_interspeech_2017.pdf Neural Adaptive Beamforming (NAB) - LSTM for each channel predicts a set of filter coefficients $h_1(k)[t], h_2(k)[t]$ - Convolve each channel with the filter coefficients $y(k)[t] = x_1(k)[t] * h_1(k)[t] + x_2(k)[t] * h_2(k)[t]$ - This layer is mimicking F+S Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf



Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Neural Adaptive Beamforming (NAB) • LSTM-based adaptive beamforming • Passed to a spectral layer to get frame-level features • Gated history feedback $g^{\text{fb}}(t) = \sigma(w_x^T \cdot x_t + w_s^T \cdot s_{t-1} + w_v^T \cdot v_{t-1})$ Current inputs Previous state AM feedback $\begin{bmatrix} x_t^T & g^{\text{fb}}(t) v_{t-1}^T \end{bmatrix}^T$ • Denoising MTL Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	NAB Analysis • Output of NAB at every frame gives a freq x direction x time beampattern • Plot the beampattern of the NAB filters in the direction of the target speech and noise directions • Responses in the target speech direction have relatively more speech-dependent variations than those in the noise direction https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf  Figure 2 consists of four vertically stacked spectrograms. The top two are labeled 'Noisy Speech' (1st) and 'Clean Speech' (2nd), showing speech signals with and without noise. The bottom two are labeled 'Target' (3rd) and 'Noise' (4th), showing the beamformer responses in the target speech and interfering noise directions. The x-axis for all plots is 'Time frame index' from 0 to 200. The y-axis represents frequency. Color bars on the right of each plot indicate the magnitude of the responses. Figure 2: Visualizations of the predicted beamformer responses at different frequency (Y-axis) across time (X-axis) at the target speech direction (3rd) and interfering noise direction (4th) with the noisy (1st) and clean (2nd) speech spectrograms.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Figure 1: Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
1[h]. by a varying linear transfer function between the plurality of combinations of signals,	Every Accused Product practices a system by a varying linear transfer function between the plurality of combinations of signals. For example, upon information and belief, the Accused Products comprise a processor (<i>e.g.</i> , a DSP) coupled to a plurality of microphones (<i>e.g.</i> , outward facing physical microphones used in beamforming) to apply a varying linear transfer function between first and second microphone signals For example, the Pixel Buds 2 use a DS18B Audio DSP:

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 9 ● Closeup view of the bottom side of the Main PCB ● DSP Group - DS18B - Audio DSP ● Maxim Audio Amplifier - most likely MAX98502 ● ST Micro - STM32L431RC6 - MCU ● Unknown component. Labelled "ix6". Please leave a comment if you happen to know this component ● Programming Interface and test points. Looks to be the standard ARM 20 Pin connector layout. ● Bluetooth Antenna. Runs around the outside of the Main PCB - Top and Bottom https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, upon information and belief, the Accused Pixels comprise and utilize an DSP such as a Google Tensor, and/or dedicated audio chip (e.g., audio IC and/or audio codec). https://support.google.com/pixelphone/answer/7158570?hl=en#zippy=%2Cpixel

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, the Home comprises a DSP (e.g., an ATSAM21 32-bit ARM Cortex-M0+, outlined in red) that is coupled to the microphones. https://www.ifixit.com/Teardown/Google+Home+Teardown/72684

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 MICROCHIP SAM D21/DA1 Family Low-Power, 32-bit Cortex-M0+ MCU with Advanced Analog and PWM Features • Processor – Arm® Cortex®-M0+ CPU running at up to 48 MHz • Single-cycle hardware multiplier • Micro Trace Buffer (MTB) http://ww1.microchip.com/downloads/en/DeviceDoc/SAM_D21_DA1_Family_DataSheet_DS40001882F.pdf Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
I[i]. wherein the denoised output signals include less acoustic noise than acoustic signals received at the microphone array.	Every Accused Product comprises of a system wherein the denoised output signals include less acoustic noise than acoustic signals received at the microphone array. For example, the accused products implement noise suppression techniques (<i>e.g.</i>, beamforming, filtering, and applying transfer functions) to attenuate noise relative to speech content of a signal. For example, the signals output by the system (<i>e.g.</i>, speech transmitted by a device) include less noise than the acoustic signals received at the microphone array. For example, the accused products utilize noise suppression during phone calls, recordings, and while listening to commands for a virtual assistant.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://store.google.com/us/product/pixel_buds

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Pixel Buds designer Isabelle Olsen described them as "floating computers in your ear:" Not surprisingly you can access Google Assistant hands-free by simply saying, "Hey, Google," without touching any buttons. The Buds also have sensors to pick up ambient noise and adjust speaker volume and microphone range accordingly. And Google said the Buds are equipped with beamforming microphones and sensors that know when your jaw is moving to help focus those microphones on your voice when you're having a phone conversation or accessing your voice assistant. https://www.cnet.com/news/google-pixel-buds-2-take-on-Pixel Buds 2-sleeker-design-seals-out-ambient-sound/ The representative Google Home practice a method as set forth below.

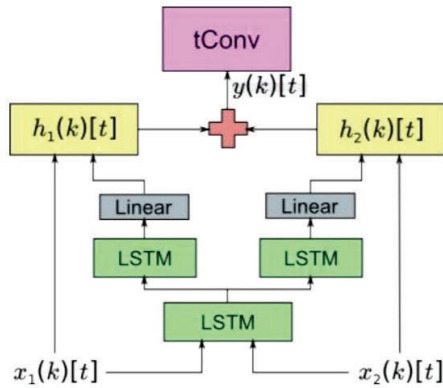
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://store.google.com/us/product/google_home

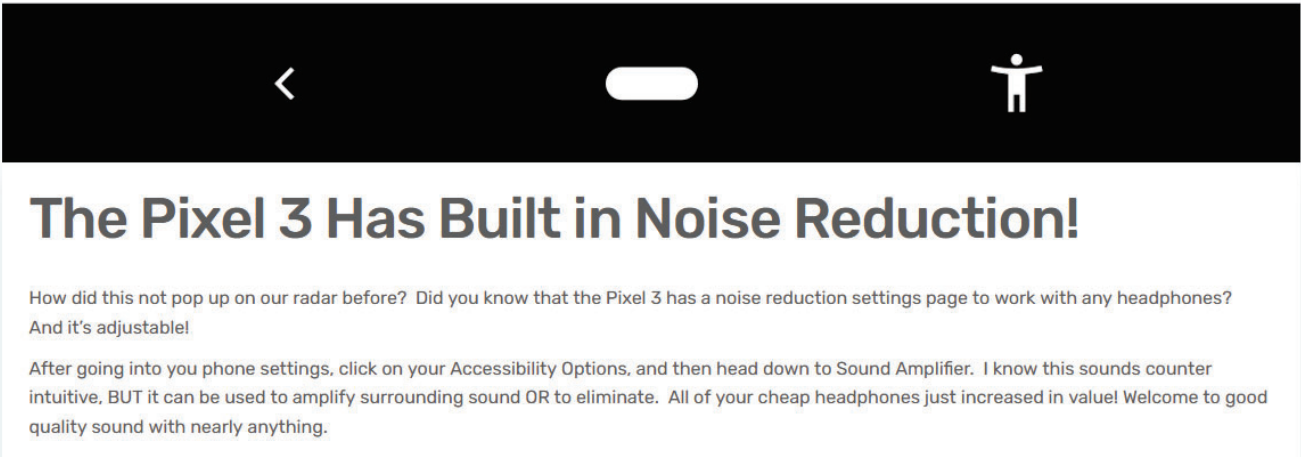
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	8. Conclusions In this paper, we described the various aspects of the Google Home multichannel speech recognition system. Technical achievements include a WPE to perform dereverberation, fCLP to perform <u>beamforming</u> jointly with acoustic modeling, and a Grid-LSTM to model frequency variations. In addition, we also presented results by adapting the model based on data from real traffic. Overall, we are able to achieve a 8-28% relative reduction in WER compared to the current production system. http://www.cs.cmu.edu/~chanwook/MyPapers/b_li_interspeech_2017.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Neural Adaptive Beamforming (NAB) - LSTM for each channel predicts a set of filter coefficients $h_1(k)[t], h_2(k)[t]$ - Convolve each channel with the filter coefficients $y(k)[t] = x_1(k) * h_1(k)[t] + x_2(k) * h_2(k)[t]$ - This layer is mimicking F+S  Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

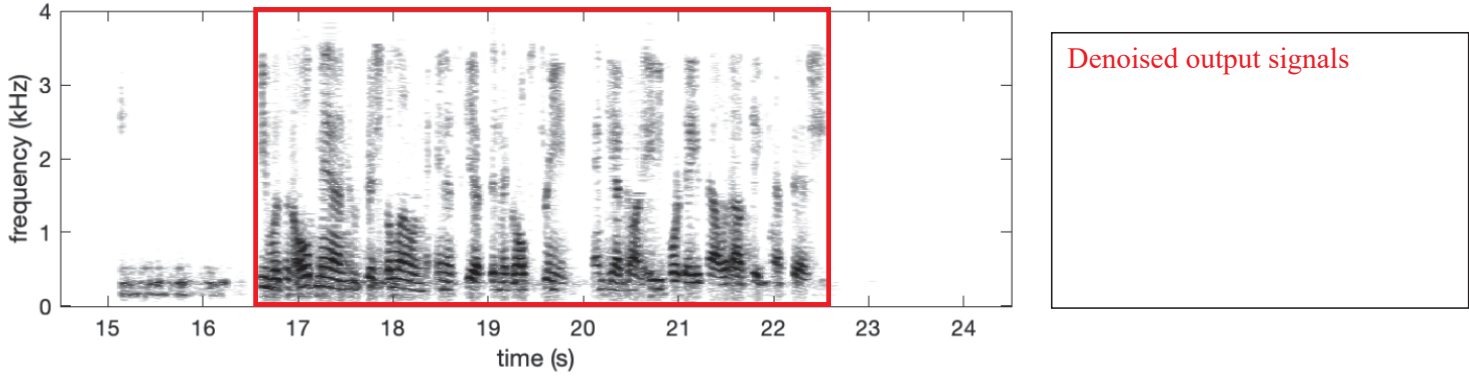
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 The Pixel 3 Has Built in Noise Reduction! How did this not pop up on our radar before? Did you know that the Pixel 3 has a noise reduction settings page to work with any headphones? And it's adjustable! After going into you phone settings, click on your Accessibility Options, and then head down to Sound Amplifier. I know this sounds counter intuitive, BUT it can be used to amplify surrounding sound OR to eliminate. All of your cheap headphones just increased in value! Welcome to good quality sound with nearly anything. https://thechromebookpastor.com/the-pixel-3-has-built-in-noise-reduction/

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Android Developers > Docs > Reference Was this helpful?   MicrophoneInfo  Added in API level 28 Kotlin Java <pre>public final class MicrophoneInfo extends Object java.lang.Object └─ android.media.MicrophoneInfo</pre> Class providing information on a microphone. It indicates the location and orientation of the microphone on the device as well as useful information like frequency response and sensitivity. It can be used by applications implementing special pre processing effects like noise suppression of beam forming that need to know about precise microphone characteristics in order to adapt their algorithms. https://developer.android.com/reference/android/media/MicrophoneInfo Upon information and belief, all accused products use substantially similar software implementations (<i>e.g.</i>, algorithms, filtering and summing) to generate beamformed microphones and suppress noise. <u>Pixel 5a Spectrogram:</u>

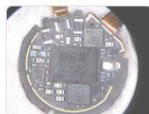
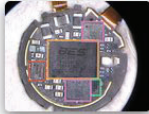
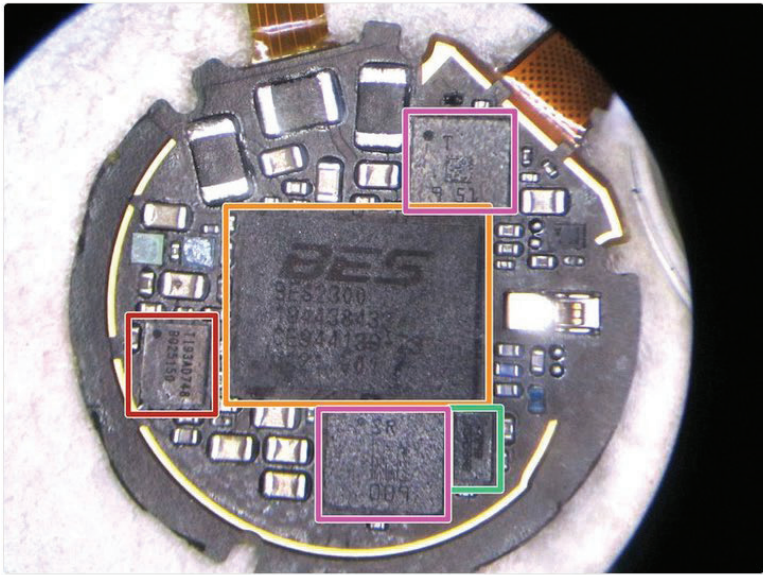
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 frequency (kHz) time (s) Denoised output signals Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
2. The system of claim 1, wherein the acoustic noise comprises noise content and the acoustic signals comprise speech content.	Every Accused Product comprises of the system of claim 1, wherein the acoustic noise comprises noise content and the acoustic signals comprise speech content. For example, speech signals include human speech of a talker (<i>e.g.</i>, voiced and/or unvoiced speech). For example, noise signals include acoustic noise (<i>e.g.</i>, background noise). Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
3. The system of claim 2, wherein the speech content comprises human speech.	Every Accused Product the system of claim 2, wherein the speech content comprises human speech. <i>See Claim 2.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.

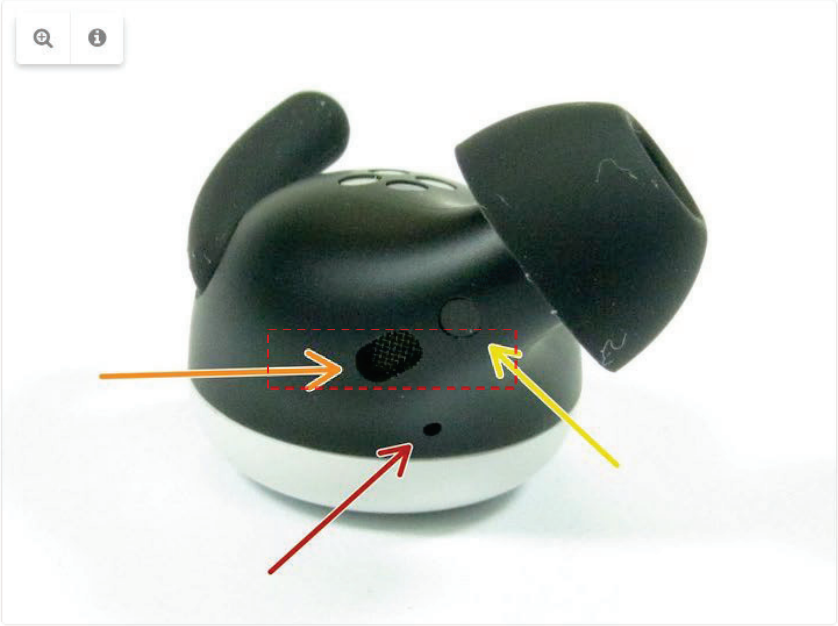
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
4. The system of claim 1 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals.	Every Accused Product the system of claim 1 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals. Every accused product comprises a voice activity detector, such as an accelerometer which detects vibration in human tissue during voicing activity. For example, upon information and belief, the Pixel Buds 2 comprise a speech detecting accelerometer, generate a VAD signal, such as based on the acoustic speech signals received by a speech-detecting accelerometer, IR sensor, and/or motion-detecting accelerometer, or a combination thereof. Clear calls anywhere When it's time to talk instead of listen, Pixel Buds make sure the sound of your voice is at the forefront. Two microphones in each earbud focus on the sound of your voice while suppressing other sounds in the background, which extends to the most challenging environments. Pixel Buds have a voice accelerometer that can detect speech through the vibrations of your jawbone, so that you can be heard even in windy conditions, like when you're running or biking. https://blog.google/products/pixel/new-pixel-buds/

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 11  ● Closeup view of the top side of the Main PCB ● TI - BQ25150 - Battery Charge and Power Management ● BES Technic - BES 2300 - Bluetooth Radio ● Unknown Device - +7048/A5A59AB - May be the Accelerometer and Gyroscope used for voice detection. Please leave a comment if you know this device ● Unknown Device - T 9 51 - Could be Flash Memory or RAM. Please leave a comment if you know this device ● Unknown Device - SR 009 - Could be Flash Memory or RAM. Please leave a comment if you know this device https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 5    Microphone port. One on each side, and opposite one another.  Spatial vent / grounded mesh  IR Detector for in ear detection

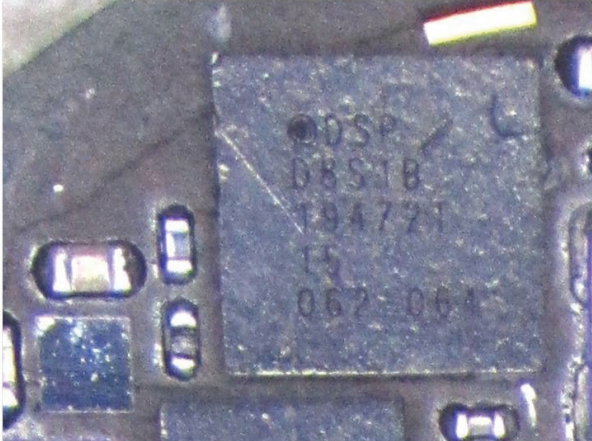
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, upon information and belief, the Pixel 6 include and utilizes an accelerometer in close contact with human tissue, such as during a phone call. Sensors • Proximity sensor • Ambient light sensor • Accelerometer • Gyrometer • Magnetometer • Barometer https://support.google.com/pixelphone/answer/7158570?hl=en#zippy=%2Cpixel For example, log files generated by a Pixel 5a tested with background noise identify a VAD: File Pixel5a-Voice-Match-Setup\Pixel5a-Voice-Match-Setup.main.log

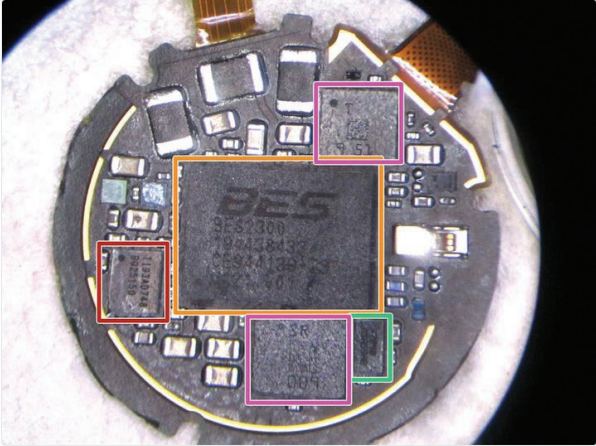
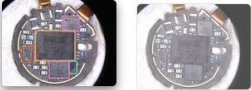
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	10726: 01-08 08:37:38.342 D/sound_trigger_hw(865): get_session_exec_mode: mode=0 NS=0 RKW=1 RU=1 VACKW=0 VACU=0 VADKW=1, VADU=1 For example, upon information and belief, the voice detecting accelerometers of the Accused Products, and/or a processor or DSP coupled to the accelerometers, output an electrical signal when detecting vibration associated with voicing activity. For example, upon information and belief, the signal further indicates characteristics of voicing activity and/or speech (<i>e.g.</i>, an amplitude and/or frequency content of voiced speech). For example, upon information and belief, the VAD signal further indicates whether voicing activity and/or speech is generated by the wearer/user of the Accused Product or if the voicing activity and/or speech is generated by another nearby individual.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 10  ● Closeup view of some of the components on the bottom side of the Main PCB ● DSP Group - DS18B - Audio DSP ● ST Micro - STM32L431RC6 MCU ● Maxim Audio Amplifier - most likely MAX98502 One comment https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 11   ● Closeup view of the top side of the Main PCB ● TI - BQ25150 - Battery Charge and Power Management ● BES Technic - BES 2300 - Bluetooth Radio ● Unknown Device - +7048/A5A59AB - May be the Accelerometer and Gyroscope used for voice detection. Please leave a comment if you know this device ● Unknown Device - T 9 51 - Could be Flash Memory or RAM. Please leave a comment if you know this device ● Unknown Device - SR 009 - Could be Flash Memory or RAM. Please leave a comment if you know this device https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
5. The system of claim 1 and further comprising: a	Every Accused Product the system of claim 1 and further comprising: a communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel.	For example, the Pixel 6 further comprises a communications channel (<i>e.g.</i>, a wireless communications channel based on a Bluetooth, cellular and/or internet connection), <i>e.g.</i>, a channel coupled with a processing component (<i>e.g.</i>, SoC, baseband processor, and/or Bluetooth chip). For example, the Pixel Buds 2 comprise a communication channel (<i>e.g.</i>, a Bluetooth channel) coupled with a processor (<i>e.g.</i>, a Bluetooth module), and further comprises a communication channel of a phone to which the Galaxy Buds Pro are connected via Bluetooth. For example, the below log messages generated by a Pixel 5a show communications between a phone and earbuds using Bluetooth protocol: 01-07 21:29:45.941 I/Recorder_RecordingEngin(8453): Starting engine from state: 1 01-07 21:29:45.942 D/BluetoothHeadset(8453): startVoiceRecognition() 01-07 21:29:45.944 I/HeadsetService(3763): startVoiceRecognition: device=14:22:3B:DD:BE:C1, uid/pid=10178/8453 01-07 21:29:45.944 I/Recorder_AudioSource(8453): Start a recording with audio source: 6 and RecordingConfig{audioFormat=2, sampleRate=32000, channelCount=1} 01-07 21:29:45.945 I/Recorder_RepositoryImpl(8453): New SyncState: UploadStatus=OFF, DownloadStatus=COMPLETED, SyncStatus=OFF 01-07 21:29:45.945 E/bt_btif (3763): StartVoiceRecognition: voice recognition not supported, features=0x3f7 01-07 21:29:45.945 E/BluetoothHeadsetServiceJni(3763): Failed to start voice recognition, status: 6 01-07 21:29:45.945 W/HeadsetStateMachine(3763): Connected: currentDevice=14:22:3B:DD:BE:C1, msg=Failed to start voice recognition 01-07 21:29:45.946 D/audio_hw_primary(865): adev_set_parameters: enter: A2dpSuspended=true 01-07 21:29:45.946 D/audio_hw_hfp(865): hfp_set_parameters: enter 01-07 21:29:45.946 D/audio_hw_hfp(865): hfp_set_parameters: enter

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	01-07 21:29:45.946 D/a2dp_offload(865): Setting a2dp to suspend state 01-07 21:29:45.947 D/DefaultSelectionTracker(8453): Ignoring onDataChange. No active selection. 01-07 21:29:45.948 D/AvrcpTargetJni(3763): getCurrentPlayStatus 01-07 21:29:45.948 D/AvrcpNativeInterface(3763): getPlayStatus 01-07 21:29:45.948 D/audio_hw_primary(865): check_a2dp_restore_l: enter: usecase(1: low-latency-playback) 01-07 21:29:45.954 D/audio_hw_primary(865): out_standby_l: enter: stream (0xe7d40010) usecase(1: low-latency-playback) 01-07 21:29:45.984 D/audio_hw_primary(865): disable_audio_route: reset and update mixer path: low-latency-playback bt-a2dp 01-07 21:29:45.985 E/soundtrigger(865): audio_extn_sound_trigger_update_stream_status: invalid input device 0x0, for event 2 01-07 21:29:45.985 D/soundtrigger(865): audio_extn_sound_trigger_update_stream_status: uc_info->id 1 of type 0 for Event 2, with Raise=0 01-07 21:29:45.985 D/msm8974_platform(865): platform_split_snd_device: snd_device(38) num devices(0) new_snd_devices(0) 01-07 21:29:45.985 I/msm8974_platform(865): platform_get_custom_mtmx_params: no matching param with id 0 ip_ch 2 op_ch 2 uc_id 1 snd_dev 38 01-07 21:29:45.985 D/hardware_info(865): hw_info_append_hw_type : device_name = bt-a2dp 01-07 21:29:45.985 D/audio_hw_primary(865): disable_snd_device: snd_device(38: bt-a2dp) 01-07 21:29:45.985 D/msm8974_platform(865): platform_split_snd_device: snd_device(38) num devices(0) new_snd_devices(0) 01-07 21:29:45.986 I/btaudio_offload(865): audio_stream_stop

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	01-07 21:29:45.986 I/btif_av (3763): btif_av_stream_started_ready: Peer 14:22:3b:dd:be:c1 : state=3 flags=0x0(None) ready=1 01-07 21:29:45.987 I/bt_stack(3763): [INFO:a2dp_encoding.cc(111)] SuspendRequest: accepted 01-07 21:29:45.987 I/btif_av (3763): btif_av_stream_suspend 01-07 21:29:45.987 I/btif_av (3763): virtual bool BtifAvStateMachine::StateStarted::ProcessEvent(uint32_t, void *): Peer 14:22:3b:dd:be:c1 : event=BTIF_AV_SUSPEND_STREAM_REQ_EVT(0x1e) flags=0x0(None) 01-07 21:29:45.987 I/bt_btif_a2dp_source(3763): btif_a2dp_source_set_tx_flush: enable=true state=STATE_RUNNING 01-07 21:29:45.987 I/bt_bta_av(3763): BTA_AvStop: bta_handle=0x41 suspend=true 01-07 21:29:45.987 I/btaudio_offload(865): audio_stream_stop: ack status = A2DP_CTRL_ACK_UNKNOWN 01-07 21:29:45.987 E/bt_btif (3763): bta_av_str_stopped: peer 14:22:3b:dd:be:c1 bta_handle:0x41 audio_open_cnt:1, p_data 0xb400007ae45b7550 start:1 01-07 21:29:45.987 D/btaudio_offload(865): wait_for_stack_response 01-07 21:29:45.987 W/btaudio_offload(865): wait_for_stack_response: entering conditional wait: ack_recvd = 0 01-07 21:29:45.987 W/bt_btif (3763): bta_dm_rm_cback:2, status:6 01-07 21:29:45.987 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:18, app_id:1 01-07 21:29:45.987 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:18, app_id:0 01-07 21:29:45.987 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:5, app_id:0 01-07 21:29:45.987 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:26, app_id:1

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	01-07 21:29:45.987 W/bt_btif (3763): bta_dm_pm_ssr ssr:2, lat:1200 01-07 21:29:45.989 W/bt_stack(3763): [WARNING:btif_bqr.cc(385)] A2DP Choppy, Handle: 0x0005, 2DH3, Master, PwLv: 0x0b, RSSI: -58, SNR: 0, UnusedCh: 34, UnidealCh: 0, ReTx: 0, NoRX: 0, NAK: 0, FlowOff: 0, Overflow: 0, UndFlow: 0 01-07 21:29:46.144 D/InterruptStateProvider(3783): No bubble up: not allowed to bubble: 0 com.google.android.apps.recorder 1 null 10178 01-07 21:29:46.145 D/InterruptStateProvider(3783): No heads up: unimportant notification: 0 com.google.android.apps.recorder 1 null 10178 01-07 21:29:46.237 W/bt_btif (3763): bta_dm_rm_cback:2, status:6 01-07 21:29:46.238 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:18, app_id:1 01-07 21:29:46.238 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:18, app_id:0 01-07 21:29:46.238 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:5, app_id:0 01-07 21:29:46.238 W/bt_btif (3763): bta_dm_pm_ssr: conn_srvc id:26, app_id:1 01-07 21:29:46.238 W/bt_btif (3763): bta_dm_pm_ssr ssr:2, lat:1200 01-07 21:29:46.238 I/btif_av (3763): virtual bool BtifAvStateMachine::StateStarted::ProcessEvent(uint32_t, void *): Peer 14:22:3b:dd:be:c1 : event=BTA_AV_SUSPEND_EVT(0xf) status=0 initiator=1 flags=0x1(LOCAL_SUSPEND_PENDING) 01-07 21:29:46.238 I/bt_btif_a2dp(3763): btif_a2dp_on_suspended: ## ON A2DP SUSPENDED ## p_av_suspend=0xb400007af4626290 01-07 21:29:46.238 I/bt_btif_a2dp_source(3763): btif_a2dp_source_on_suspended: state=STATE_RUNNING 01-07 21:29:46.238 I/bt_stack(3763): [INFO:a2dp_encoding.cc(491)] ack_stream_suspended: result=SUCCESS_FINISHED

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	01-07 21:29:46.238 I/BTAudioProviderStub(865): streamSuspended - SessionType=A2DP_HARDWARE_OFFLOAD_DATAPATH, status=SUCCESS 01-07 21:29:46.238 I/BTAudioProviderSession(865): ReportControlStatus - status=SUCCESS for SessionType=A2DP_HARDWARE_OFFLOAD_DATAPATH, bluetooth_audio=0x0200 suspended 01-07 21:29:46.238 I/btaudio_offload(865): stack_resp_cb: status = 0 01-07 21:29:46.238 D/btaudio_offload(865): audio_stream_stop: success 01-07 21:29:46.238 D/a2dp_offload(865): Stop A2DP playback, total active sessions :0 01-07 21:29:46.238 I/soundtrigger(865): audio_extn_sound_trigger_update_device_status: device 0x26 of type 0 for Event 0, with Raise=0 01-07 21:29:46.238 I/btif_av (3763): btif_report_audio_state: peer_address=14:22:3b:dd:be:c1 state=1 01-07 21:29:46.238 D/audio_hw_primary(865): out_standby_l: exit 01-07 21:29:46.239 D/audio_hw_primary(865): out_standby: enter: stream (0xe7d40010) usecase(1: low-latency-playback) 01-07 21:29:46.239 D/audio_hw_primary(865): out_standby: exit 01-07 21:29:46.239 I/BluetoothA2dpServiceJni(3763): bta2dp_audio_state_callback 01-07 21:29:46.240 D/A2dpNativeInterface(3763): onAudioStateChanged: A2dpStackEvent {type:EVENT_TYPE_AUDIO_STATE_CHANGED, device:14:22:3B:DD:BE:C1, value1:STOPPED} 01-07 21:29:46.240 D/A2dpStateMachine(3763): handleMessage: E msg.what=101 01-07 21:29:46.240 D/A2dpStateMachine(3763): processMsg: Connected

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	01-07 21:29:46.240 D/A2dpStateMachine(3763): Connected process message(14:22:3B:DD:BE:C1): STACK_EVENT 01-07 21:29:46.240 D/A2dpStateMachine(3763): Connected: stack event: A2dpStackEvent {type:EVENT_TYPE_AUDIO_STATE_CHANGED, device:14:22:3B:DD:BE:C1, value1:STOPPED} 01-07 21:29:46.240 I/A2dpStateMachine(3763): Connected: stopped playing: 14:22:3B:DD:BE:C1 01-07 21:29:46.240 D/A2dpStateMachine(3763): A2DP Playing state : device: 14:22:3B:DD:BE:C1 State:PLAYING->NOT_PLAYING 01-07 21:29:46.241 D/a2dp_offload(865): a2dp_set_bit_format: set AFE input bit format = 16 01-07 21:29:46.241 D/A2dpStateMachine(3763): handleMessage: X 01-07 21:29:46.244 D/audio_hw_primary(865): out_standby: enter: stream (0xe7d40010) usecase(1: low-latency-playback) 01-07 21:29:46.244 D/audio_hw_primary(865): out_standby: exit 01-07 21:29:46.247 D/a2dp_offload(865): a2dp_reset_backend_cfg: reset source backend sample rate =KHZ_8 01-07 21:29:46.248 D/a2dp_offload(865): a2dp_reset_backend_cfg: reset afe source channels =Zero 01-07 21:29:46.348 I/msm8974_platform(865): platform_check_and_set_capture_codec_backend_cfg:txbecf: afe: bitwidth 16, samplerate 32000, channel 1 format 1, backend_idx 10 usecase = 22 device (bt-sco-mic-wb) Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
6. The system of claim 5 and further comprising: a communication device wirelessly coupled with the wireless channel of the communications channel.	Every Accused Product the system of claim 5 and further comprising: a communication device wirelessly coupled with the wireless channel of the communications channel. <i>See claim 6.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[p]. A system, comprising:	Every Accused Product comprises of a system as recited in claim 7.
7[a]. a first virtual microphone formed from a first combination of a first microphone signal and a second microphone signal, wherein the first microphone signal is generated by a first physical microphone and the second microphone signal is generated by a second physical microphone;	Every Accused Product comprises of a system including a first virtual microphone formed from a first combination of a first microphone signal and a second microphone signal, wherein the first microphone signal is generated by a first physical microphone and the second microphone signal is generated by a second physical microphone. <i>See Claims 1[a]-[c].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[b]. a second virtual microphone formed from a second combination	Every Accused Product comprises of a system including a second virtual microphone formed from a second combination of the first microphone signal and the second microphone signal, wherein the second combination is different from the first combination, wherein the first virtual microphone has a first linear response to speech and first linear response to noise.

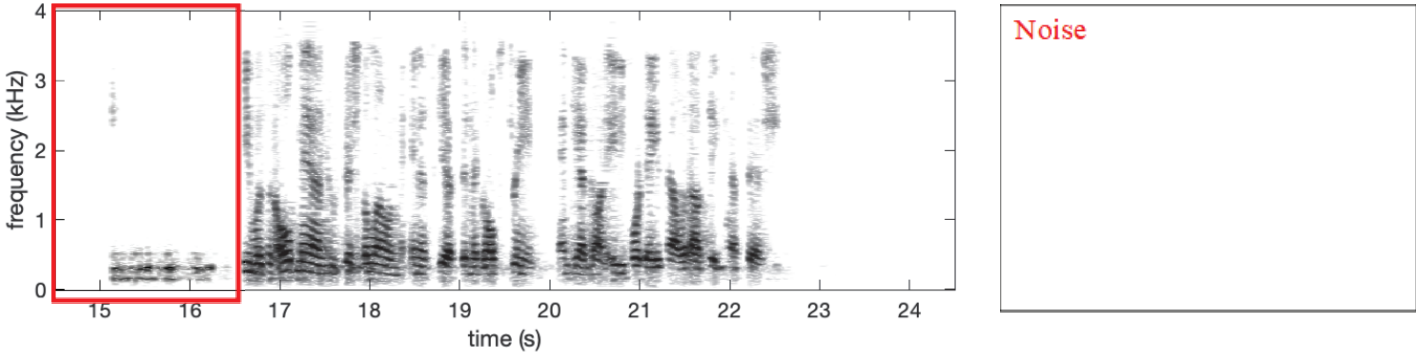
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
of the first microphone signal and the second microphone signal, wherein the second combination is different from the first combination,	See Claims 1[a]-[b] and [d]. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[c]. wherein the first virtual microphone has a first linear response to speech and first linear response to noise,	Every Accused Product comprises a system wherein the first virtual microphone has a first linear response to speech and first linear response to noise. For example, each earbud of the Pixel Buds 2 generates at least one beamformed microphone. Upon information and belief, the beamformed has a linear response to both speech and noise. For example, upon information and belief, a first beamformed microphone of the Pixel 6 (e.g., a beamformed microphone primarily focuses on speech content) has linear responses to speech and noise. For example, the Google Home Max generates a first beamformed microphone (e.g., based on inputs of physical microphone closest to a talker), with a first linear response to speech and noise. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[d]. the first linear response to speech being substantially similar across a	Every Accused Product comprises of a system including the first linear response to speech being substantially similar across a plurality of frequencies for a speech source located within a predetermined angle relative to an axis of the microphone array and devoid of a null.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
plurality of frequencies for a speech source located within a predetermined angle relative to an axis of the microphone array and devoid of a null,	For example, upon information and belief, the first linear response to speech is substantially similar across frequencies (<i>e.g.</i>, a range of frequencies and/or subbands associated with speech) for a speech from an orientation near a talker's mouth. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[e]. wherein the second virtual microphone has a second linear response to speech that has a single null oriented in a direction toward a source of the speech and a second linear response to noise,	Every Accused Product comprises of a system wherein the second virtual microphone has a second linear response to speech that has a single null oriented in a direction toward a source of the speech and a second linear response to noise. For example, each earbud of the Pixel Buds 2 generates at least a second beamformed microphone. Upon information and belief, the beamformed has a linear response to both speech and noise, different than that of the first beamformed microphone. For example, the second earbud of each pair of Pixel Buds 2 earbuds further comprises a second beamformed microphone. Upon information, the second beamformed microphone of the second earbud has linear responses to speech and noise that are different than that of the first earbud. For example, upon information and belief, a second beamformed microphone of the Pixel 6 (<i>e.g.</i>, a beamformed microphone primarily focused on noise content) has linear responses to speech and noise. For example, upon information and belief, a second beamformed microphone of the Home Max (<i>e.g.</i>, a beamformed microphone primarily focused on noise content) has linear responses to speech and noise. For example, upon information and belief, the first and second linear responses to noise are substantially similar (<i>e.g.</i>, both beamformed microphones have similar responses to noise in terms of frequency response). Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[f]. wherein the second linear response to noise is	Every Accused Product comprises of a system wherein the second linear response to noise is substantially similar to the first linear response to noise, one or both of the first linear response to noise and the second linear response to noise being non-zero in a direction toward a source of noise, and the second linear response to speech is substantially dissimilar to the first linear response to speech, wherein the speech is human speech.

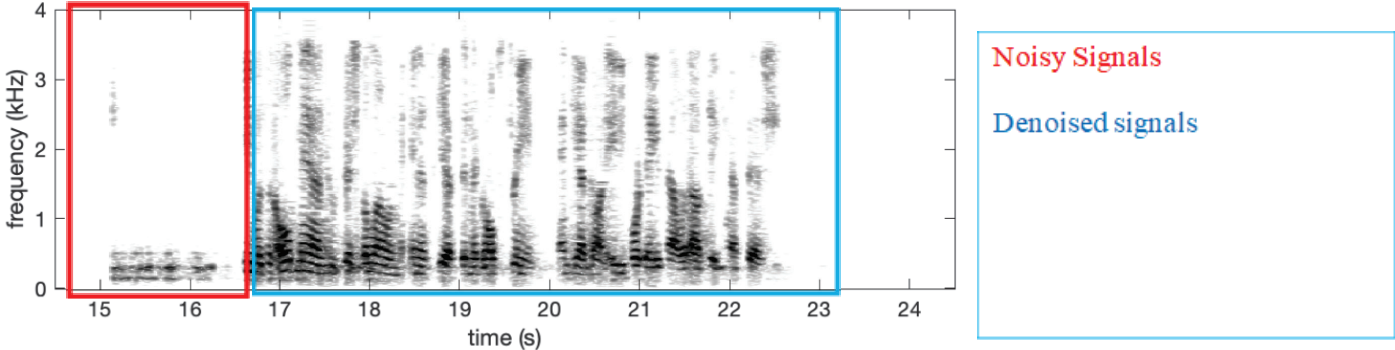
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
substantially similar to the first linear response to noise, one or both of the first linear response to noise and the second linear response to noise being non-zero in a direction toward a source of noise, and the second linear response to speech is substantially dissimilar to the first linear response to speech, wherein the speech is human speech; and	For example, upon information and belief, the first and second linear responses to noise are substantially similar (<i>e.g.</i>, both beamformed microphones have similar responses to noise in terms of frequency response). For example, upon information and belief, the linear response to noise of at least one beamformed microphone of the Accused Products is non-zero in a direction towards the noise source. For example, tests of the Accused Products in noisy acoustic environments show a non-zero linear response to noise in a direction toward the noise source. Since the noise is less attenuated in parts of the recording, the linear response to the noise is non-zero in a direction toward the noise source. <u>Pixel 5a Spectrogram:</u>  For example, upon information and belief, the first and second linear responses to noise are substantially similar (<i>e.g.</i>, the beamformed microphones have dissimilar responses to speech in terms of frequency response).

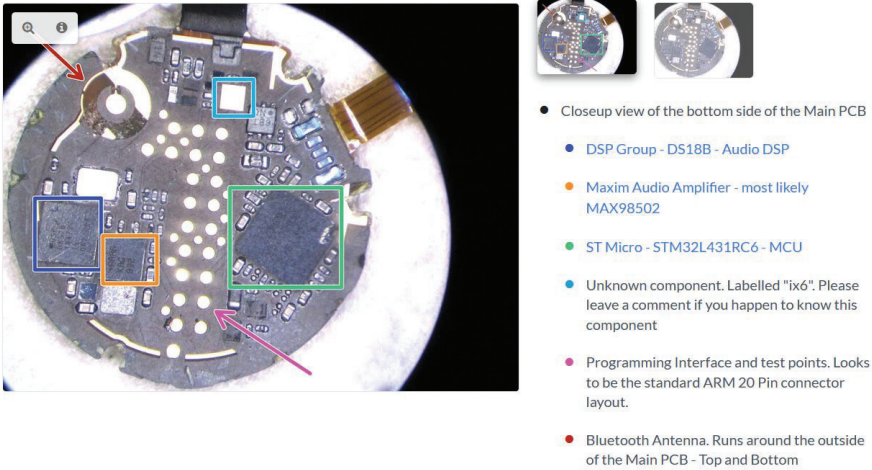
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, speech signals include human speech of a talker (<i>e.g.</i>, voiced and/or unvoiced speech). For example, noise signals include acoustic noise (<i>e.g.</i>, background noise). Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[g]. an adaptive noise removal application coupled to the first and second virtual microphones and generating denoised output signals by forming a plurality of combinations of signals output from the first virtual micro-phone and the second virtual microphone,	Every Accused Product comprises of a system including an adaptive noise removal application coupled to the first and second virtual microphones and generating denoised output signals by forming a plurality of combinations of signals output from the first virtual micro-phone and the second virtual microphone. Upon information and belief, all of the Accused Products generate denoised output signals by performing adaptive beamforming (<i>e.g.</i>, combining signals from a first and second beamformed microphone).microphones. For example, the Accused Products generate denoised acoustic signals shortly after speech begins. <u>Pixel 5a Spectrogram:</u>

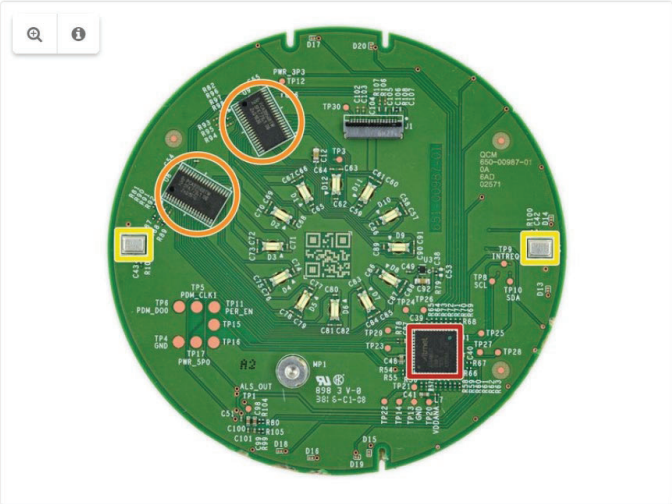
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 frequency (kHz) time (s) Noisy Signals Denoised signals Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[h]. by filtering and summing the plurality of combinations of signals in the time domain, and	Every Accused Product practices a system by filtering and summing the plurality of combinations of signals in the time domain. Upon information and belief, all of the accused products combine signals from a first and second physical microphone by delaying, applying gains, filtering, and summing in the time domain. For example, upon information and belief, the Accused Products achieve beamforming by filtering and adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone). For example, upon information and belief, the Accused Products achieve noise reduction by filtering and adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone). Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
7[i]. by a varying linear transfer function between the plurality of	Every Accused Product practices a system by a varying linear transfer function between the plurality of combinations of signals.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
combinations of signals,	For example, upon information and belief, the Accused Products comprise a processor (<i>e.g.</i>, a DSP) coupled to a plurality of microphones (<i>e.g.</i>, outward facing physical microphones used in beamforming) to apply a varying linear transfer function between first and second microphone signals For example, the Pixel Buds 2 use a DS18B Audio DSP: Step 9  ● Closeup view of the bottom side of the Main PCB ● DSP Group - DS18B - Audio DSP ● Max audio Amplifier - most likely MAX98502 ● ST Micro - STM32L431RC6 - MCU ● Unknown component. Labelled "ix6". Please leave a comment if you happen to know this component ● Programming Interface and test points. Looks to be the standard ARM 20 Pin connector layout. ● Bluetooth Antenna. Runs around the outside of the Main PCB - Top and Bottom https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, upon information and belief, the Accused Pixels comprise and utilize an DSP such as a Google Tensor, and/or dedicated audio chip (<i>e.g.</i>, audio IC and/or audio codec). https://support.google.com/pixelphone/answer/7158570?hl=en#zippy=%2Cpixel

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	For example, the Home comprises a DSP (e.g., an ATSAM21 32-bit ARM Cortex-M0+, outlined in red) that is coupled to the microphones.  https://www.ifixit.com/Teardown/Google+Home+Teardown/72684

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	MICROCHIP SAM D21/DA1 Family Low-Power, 32-bit Cortex-M0+ MCU with Advanced Analog and PWM Features • Processor – Arm® Cortex®-M0+ CPU running at up to 48 MHz • Single-cycle hardware multiplier • Micro Trace Buffer (MTB) http://ww1.microchip.com/downloads/en/DeviceDoc/SAM_D21_DA1_Family_DataSheet_DS40001882F.pdf
7[j]. wherein the denoised output signals include less acoustic noise than acoustic signals received at the first and second physical microphones.	Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided. Every Accused Product comprises of a system wherein the denoised output signals include less acoustic noise than acoustic signals received at the first and second physical microphones. For example, the accused products implement noise suppression techniques (<i>e.g.</i>, beamforming, filtering, and applying transfer functions) to attenuate noise relative to speech content of a signal. For example, the signals output by the system (<i>e.g.</i>, speech transmitted by a device) include less noise than the acoustic signals received at the microphone array. For example, the accused products utilize noise suppression during phone calls, recordings, and while listening to commands for a virtual assistant.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://store.google.com/us/product/pixel_buds

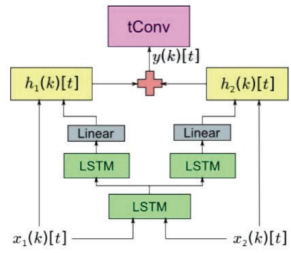
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Pixel Buds designer Isabelle Olsen described them as "floating computers in your ear." Not surprisingly you can access Google Assistant hands-free by simply saying, "Hey, Google," without touching any buttons. The Buds also have sensors to pick up ambient noise and adjust speaker volume and microphone range accordingly. And Google said the Buds are equipped with beamforming microphones and sensors that know when your jaw is moving to help focus those microphones on your voice when you're having a phone conversation or accessing your voice assistant. https://www.cnet.com/news/google-pixel-buds-2-take-on-Pixel Buds 2-sleeker-design-seals-out-ambient-sound/ The representative Google Home practice a method as set forth below.

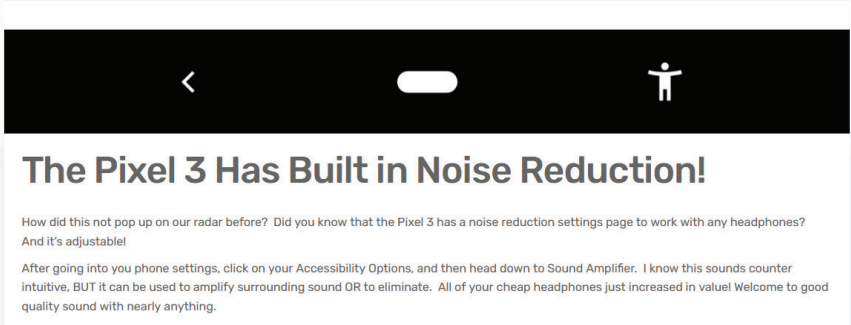
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 https://store.google.com/us/product/google_home

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	8. Conclusions In this paper, we described the various aspects of the Google Home multichannel speech recognition system. Technical achievements include a WPE to perform dereverberation, fCLP to perform beamforming jointly with acoustic modeling, and a Grid-LSTM to model frequency variations. In addition, we also presented results by adapting the model based on data from real traffic. Overall, we are able to achieve a 8-28% relative reduction in WER compared to the current production system. http://www.cs.cmu.edu/~chanwook/MyPapers/b_li_interspeech_2017.pdf Neural Adaptive Beamforming (NAB) - LSTM for each channel predicts a set of filter coefficients $h_1(k)[t], h_2(k)[t]$ - Convolve each channel with the filter coefficients $y(k)[t] = x_1(k) * h_1(k)[t] + x_2(k) * h_2(k)[t]$ - This layer is mimicking F+S  Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	 The Pixel 3 Has Built in Noise Reduction! How did this not pop up on our radar before? Did you know that the Pixel 3 has a noise reduction settings page to work with any headphones? And it's adjustable! After going into you phone settings, click on your Accessibility Options, and then head down to Sound Amplifier. I know this sounds counter intuitive, BUT it can be used to amplify surrounding sound OR to eliminate. All of your cheap headphones just increased in value! Welcome to good quality sound with nearly anything. https://thechromebookpastor.com/the-pixel-3-has-built-in-noise-reduction/

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Android Developers > Docs > Reference Was this helpful?   MicrophoneInfo  Added in API level 28 Kotlin Java <pre>public final class MicrophoneInfo extends Object java.lang.Object └─ android.media.MicrophoneInfo</pre> Class providing information on a microphone. It indicates the location and orientation of the microphone on the device as well as useful information like frequency response and sensitivity. It can be used by applications implementing special pre processing effects like noise suppression of beam forming that need to know about precise microphone characteristics in order to adapt their algorithms. https://developer.android.com/reference/android/media/MicrophoneInfo Upon information and belief, all accused products use substantially similar software implementations (<i>e.g.</i>, algorithms, filtering and summing) to generate beamformed microphones and suppress noise. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
8. The system of claim 7 and further comprising: a	Every Accused Product comprises of The system of claim 7 and further comprising: a microphone array, the first and second physical microphones positioned m the microphone array.

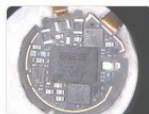
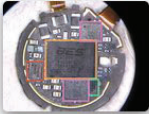
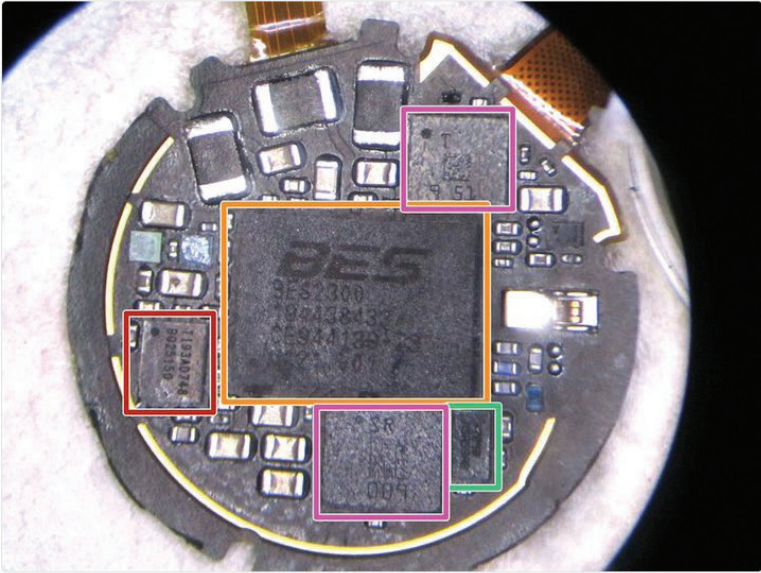
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
microphone array, the first and second physical microphones positioned in the microphone array.	See claim 1[a]. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
9. The system of claim 7, wherein the single null is a region of the second linear response to speech having a measured response level that is lower than the measured response level of any other region of the second linear response to speech.	Every Accused Product comprises of the system of claim 7, wherein the single null is a region of the second linear response to speech having a measured response level that is lower than the measured response level of any other region of the second linear response to speech. For example, on information and belief, the linear response to speech of the second beamformed microphone has a single null in the direction of the speech source. For example, on information and belief, the measured response level of the single null of the second linear response to speech of the Pixel Buds 2, Google Home Max and the Pixel 6 is lower than any other region of the second linear response to speech. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
10. The system of claim 7 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals.	Every Accused Product comprises of the system of claim 7 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals. Every accused product comprises a voice activity detector, such as an accelerometer which detects vibration in human tissue during voicing activity. For example, upon information and belief, the Pixel Buds 2 comprise a speech detecting accelerometer, generate a VAD signal, such as based on the acoustic speech signals received by a speech-detecting accelerometer, IR sensor, and/or motion-detecting accelerometer, or a combination thereof.

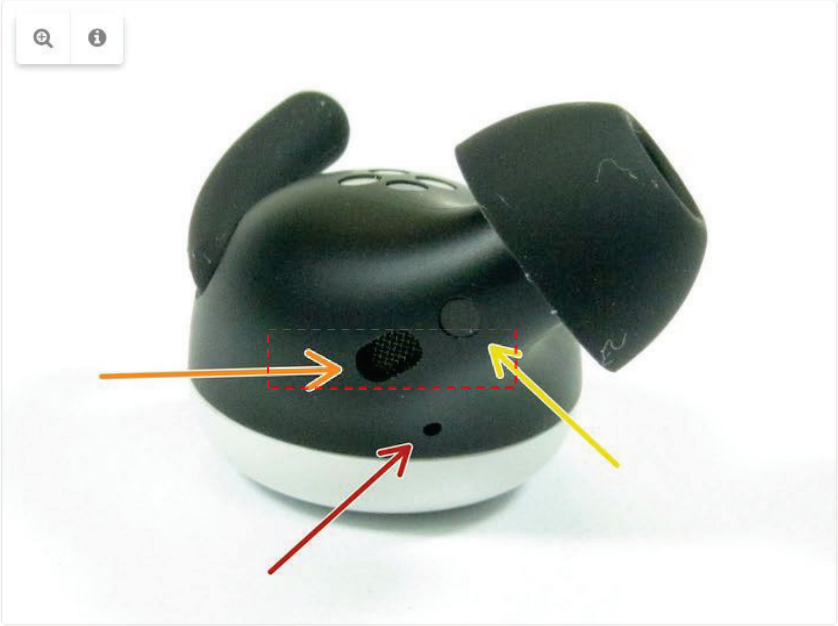
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Clear calls anywhere When it's time to talk instead of listen, Pixel Buds make sure the sound of your voice is at the forefront. Two microphones in each earbud focus on the sound of your voice while suppressing other sounds in the background, which extends to the most challenging environments. Pixel Buds have a voice accelerometer that can detect speech through the vibrations of your jawbone, so that you can be heard even in windy conditions, like when you're running or biking. https://blog.google/products/pixel/new-pixel-buds/

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 11  ● Closeup view of the top side of the Main PCB ● TI - BQ25150 - Battery Charge and Power Management ● BES Technic - BES 2300 - Bluetooth Radio ● Unknown Device - +7048/A5A59AB - May be the Accelerometer and Gyroscope used for voice detection. Please leave a comment if you know this device ● Unknown Device - T 9 51 - Could be Flash Memory or RAM. Please leave a comment if you know this device ● Unknown Device - SR 009 - Could be Flash Memory or RAM. Please leave a comment if you know this device https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 5    Microphone port. One on each side, and opposite one another.  Spatial vent / grounded mesh  IR Detector for in ear detection 

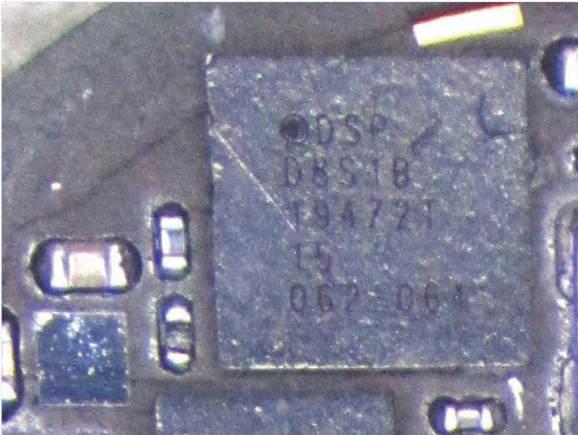
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 For example, upon information and belief, the Pixel 6 include and utilizes an accelerometer in close contact with human tissue, such as during a phone call. Sensors • Proximity sensor • Ambient light sensor • Accelerometer • Gyrometer • Magnetometer • Barometer https://support.google.com/pixelphone/answer/7158570?hl=en#zippy=%2Cpixel For example, log files generated by a Pixel 5a tested with background noise identify a VAD: File Pixel5a-Voice-Match-Setup\Pixel5a-Voice-Match-Setup.main.log

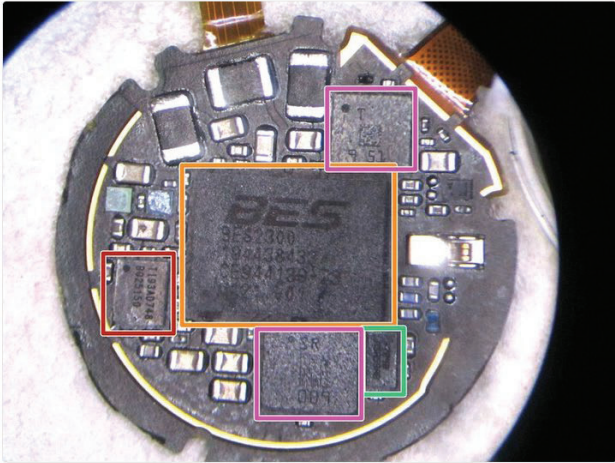
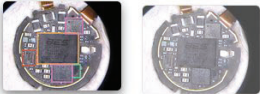
Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	10726: 01-08 08:37:38.342 D/sound_trigger_hw(865): get_session_exec_mode: mode=0 NS=0 RKW=1 RU=1 VACKW=0 VACU=0 VADKW=1, VADU=1 For example, upon information and belief, the voice detecting accelerometers of the Accused Products, and/or a processor or DSP coupled to the accelerometers, output an electrical signal when detecting vibration associated with voicing activity. For example, upon information and belief, the signal further indicates characteristics of voicing activity and/or speech (<i>e.g.</i>, an amplitude and/or frequency content of voiced speech). For example, upon information and belief, the VAD signal further indicates whether voicing activity and/or speech is generated by the wearer/user of the Accused Product or if the voicing activity and/or speech is generated by another nearby individual.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 10  ● Closeup view of some of the components on the bottom side of the Main PCB ● DSP Group - DS18B - Audio DSP ● ST Micro - STM32L431RC6 MCU ● Maxim Audio Amplifier - most likely MAX98502  One comment https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Step 11   ● Closeup view of the top side of the Main PCB ● TI - BQ25150 - Battery Charge and Power Management ● BES Technic - BES 2300 - Bluetooth Radio ● Unknown Device - +7048/A5A59AB - May be the Accelerometer and Gyroscope used for voice detection. Please leave a comment if you know this device ● Unknown Device - T 9 51 - Could be Flash Memory or RAM. Please leave a comment if you know this device ● Unknown Device - SR 009 - Could be Flash Memory or RAM. Please leave a comment if you know this device https://www.ifixit.com/Teardown/Google+Pixel+Buds+2+Teardown/133888 Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
11. The system of claim 7 and further	Every Accused Product comprises of the system of claim 7 and further comprising: a communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
comprising: a communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel.	<i>See Claim 5.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
12. The system of claim 11 and further comprising: a communication device wirelessly coupled with the wireless channel of the communications channel.	Every Accused Product comprises of the system of claim 11 and further comprising: a communication device wirelessly coupled with the wireless channel of the communications channel. <i>See Claim 6.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
13[a]. The system of claim 7, wherein the second microphone signal is multiplied by a ratio,	Every Accused Product comprises of the system of claim 7, wherein the second micro-phone signal is multiplied by a ratio. For example, upon information and belief, the second microphone signal is further multiplied by a ratio, such as a ratio based on a function of the distance between a talker's mouth and the physical microphones. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
13[b]. wherein the ratio is a ratio of a	Every Accused Product comprises of a system wherein the ratio is a ratio of a third distance to a fourth distance, the third distance being between the first physical microphone and the speech source and the fourth distance being between the second physical microphone and the speech source.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
third distance to a fourth distance, the third distance being between the first physical microphone and the speech source and the fourth distance being between the second physical microphone and the speech source.	For example, upon information and belief, the difference between a third and fourth distance is the difference between the distance between a talker's mouth and first physical microphone and the distance between a talker's mouth and a second physical microphone. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[P]. A system, comprising:	Every Accused Product comprises of a system. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[a]. a first virtual microphone comprising a first combination of a first microphone signal and a second microphone signal,	Every Accused Product comprises of a system including a first virtual microphone comprising a first combination of a first microphone signal and a second microphone signal. <i>See claim 7[a].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[b]. the first virtual microphone having a first linear response to speech and a first linear response to noise,	Every Accused Product comprises of a system including the first virtual microphone having a first linear response to speech and a first linear response to noise. <i>See claim 7[c].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[c]. the first linear response to speech being substantially	Every Accused Product comprises of a system including the first linear response to speech being substantially similar across a plurality of frequencies for a speech source located within a predetermined angle relative to an axis of a microphone array.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
similar across a plurality of frequencies for a speech source located within a predetermined angle relative to an axis of a microphone array,	<i>See</i> claim 7[d]. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[d]. wherein the first microphone signal is output from a first physical microphone and the second microphone signal is output from a second physical microphone;	Every Accused Product comprises of a system wherein the first microphone signal is output from a first physical microphone and the second microphone signal is output from a second physical microphone. <i>See</i> claim 1[a]. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[e]. a second virtual microphone comprising a second combination of the first microphone signal and the second microphone signal,	Every Accused Product comprises of a system including a second virtual microphone comprising a second combination of the first microphone signal and the second microphone signal. <i>See</i> claim 1[d]. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[f]. the second virtual microphone having a second linear response to speech and a second	Every Accused Product comprises of a system including the second virtual microphone having a second linear response to speech and a second linear response to noise. <i>See</i> claim 7[e].

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
linear response to noise,	Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[g]. the second linear response to noise being substantially similar to the first linear response to noise,	Every Accused Product comprises of a system including the second linear response to noise being substantially similar to the first linear response to noise. <i>See claim 7[f].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[h]. one or both of the first linear response to noise and the second linear response to noise being non-zero in a direction toward a source of noise, and	Every Accused Product comprises of a system including one or both of the first linear response to noise and the second linear response to noise being non-zero in a direction toward a source of noise. <i>See claim 7[f].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[i]. the second linear response to speech being substantially dissimilar to the first linear response to speech,	Every Accused Product comprises of a system including the second linear response to speech being substantially dissimilar to the first linear response to speech. <i>See claim 7[f].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[j]. wherein the second combination is different from the first combination,	Every Accused Product comprises of a system wherein the second combination is different from the first combination. <i>See claim 1[d].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[k]. wherein the first virtual microphone and the	Every Accused Product comprises of a system wherein the first virtual microphone and the second virtual microphone are distinct virtual directional microphones.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
second virtual microphone are distinct virtual directional microphones; and	For example, the Accused Products further comprise directional microphones (<i>e.g.</i>, beamformed microphones). Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[l]. a processing component coupled to the first and second virtual microphones,	Every Accused Product comprises of a system including a processing component coupled to the first and second virtual microphones, <i>See claim 1[b].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[m]. the processing component including an adaptive noise removal application receiving acoustic signals from the first virtual microphone and the second virtual microphone,	Every Accused Product comprises of a system including the processing component including an adaptive noise removal application receiving acoustic signals from the first virtual microphone and the second virtual microphone. <i>See claim 1[f].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[n]. filtering and summing the acoustic signals in the time domain,	Every Accused Product comprises of a system of filtering and summing the acoustic signals in the time domain. <i>See claim 1[g].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[o]. applying a varying linear transfer function between the acoustic signals, and	Every Accused Product comprises of a system of applying a varying linear transfer function between the acoustic signals. <i>See claim 1[h].</i>

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
14[p]. generating an output signal, wherein the output signal is a denoised acoustic signal.	Every Accused Product comprises of a system of generating an output signal, wherein the output signal is a denoised acoustic signal. <i>See claim 1[i].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
15. The system of claim 14 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals.	Every Accused Product comprises of the system of claim 14 and further comprising: a voice activity detector (VAD) coupled with the processing component and operative to generate voice activity signals. <i>See claim 4.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
16. The system of claim 14 and further comprising: a communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel.	Every Accused Product comprises of the system of claim 14 and further comprising: a communications channel coupled with the processing component and including one or more of a wireless channel, a wired channel, and a hybrid wireless/wired channel. <i>See claim 5.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
17. The system of claim 16 and further	Every Accused Product comprises of the system of claim 16 and further comprising: a communication device wirelessly coupled with the wireless channel of the communications channel.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
comprising: a communication device wirelessly coupled with the wireless channel of the communications channel.	<i>See claim 6.</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
18. The system of claim 14, wherein the acoustic signals from the first virtual microphone, the second virtual microphone or both are delayed.	Every Accused Product comprises of the system of claim 14, wherein the acoustic signals from the first virtual microphone, the second virtual microphone or both are delayed. Upon information and belief, all of the accused products combine signals from multiple physical microphones, <i>e.g.</i>, a first and second physical microphone or a first and third physical microphone, by applying a delay and adding and/or subtracting (possibly scaled versions of) the signals to achieve a desired spatial directivity. For example, the Accused Products practice delay and sum beamforming by applying a delay adding and/or subtracting the signals of microphones (<i>e.g.</i>, a first and second physical microphone or a first and third physical microphone). For example, the Accused Products further practice delay and sum beamforming by filtering and summing the signals of microphones (<i>e.g.</i>, a first and second physical microphone first and third physical microphone). For example, upon information and belief, a first beamformed microphone is formed by subtracting a second microphone signal (<i>e.g.</i>, a microphone signal with greater noise and more attenuated speech) from a first microphone signal (<i>e.g.</i>, a microphone with greater speech content, and more attenuated noise).

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Abstract Joint multichannel enhancement and acoustic modeling using neural networks has shown promise over the past few years. However, one shortcoming of previous work [1, 2, 3] is that the filters learned during training are fixed for decoding, potentially limiting the ability of these models to adapt to previously unseen or changing conditions. In this paper we explore a neural network adaptive beamforming (NAB) technique to address this issue. Specifically, we use LSTM layers to predict time domain beamforming filter coefficients at each input frame. These filters are convolved with the framed time domain input signal and summed across channels, essentially performing FIR filter-and-sum beamforming using the dynamically adapted filter. The beamformer output is passed into a waveform CLDNN acoustic model [4] which is trained jointly with the filter prediction LSTM layers. We find that the proposed NAB model achieves a 12.7% relative improvement in WER over a single channel model [4] and reaches similar performance to a “factored” model architecture which utilizes several fixed spatial filters [3] on a 2,000-hour Voice Search task, with a 17.9% decrease in computational cost. Index Terms: speech recognition, multichannel, beamforming, adaptive filtering https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf Upon information and belief, the Accused Products implement filter and sum beamforming such that “signals from different microphones are aligned in time to adjust for the propagation delay from the target speaker to each microphone, and then mixed to a single channel. This has the effect of enhancing the signal from the target direction and attenuating noise coming from other directions.” See https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

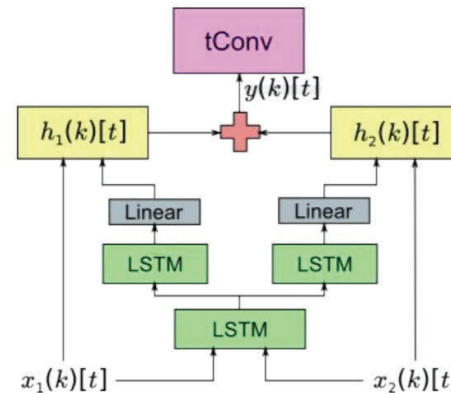
Claim	Support
	Figure 1: <i>Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity.</i>

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf Google Home's smart audio design integrates a high-excursion driver with a dual passive radiator design that delivers crystal-clear highs and deep lows for Hi-Fi sound that streams over WiFi. That means a lot of big sound from a small package. Even while you jam out to music, it can easily hear you from across the room, thanks to two omnidirectional microphones and neural beamforming. https://www.blog.google/products/home/make-yourself-home-google-home/ 8. Conclusions In this paper, we described the various aspects of the Google Home multichannel speech recognition system. Technical achievements include a WPE to perform dereverberation, fCLP to perform beamforming jointly with acoustic modeling, and a Grid-LSTM to model frequency variations. In addition, we also presented results by adapting the model based on data from real traffic. Overall, we are able to achieve a 8-28% relative reduction in WER compared to the current production system.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	http://www.cs.cmu.edu/~chanwook/MyPapers/b_li_interspeech_2017.pdf Neural Adaptive Beamforming (NAB) - LSTM for each channel predicts a set of filter coefficients $h_1(k)[t], h_2(k)[t]$ - Convolve each channel with the filter coefficients $y(k)[t] = x_1(k) * h_1(k)[t] + x_2(k) * h_2(k)[t]$ - This layer is mimicking F+S Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf



Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Neural Adaptive Beamforming (NAB) - LSTM-based adaptive beamforming - Passed to a spectral layer to get frame-level features - Gated history feedback $g^{fb}(t) = \sigma(\mathbf{w}_x^T \cdot \mathbf{x}_t + \mathbf{w}_s^T \cdot \mathbf{s}_{t-1} + \mathbf{w}_v^T \cdot \mathbf{v}_{t-1})$ Current inputs Previous state AM feedback $\begin{bmatrix} \mathbf{x}_t^T & g^{fb}(t) \mathbf{v}_{t-1}^T \end{bmatrix}^T$ - Denoising MTL Google https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	NAB Analysis • Output of NAB at every frame gives a freq x direction x time beampattern • Plot the beampattern of the NAB filters in the direction of the target speech and noise directions • Responses in the target speech direction have relatively more speech-dependent variations than those in the noise direction https://asru2017.org/Slides/AS17_Keynote_Sainath.pdf

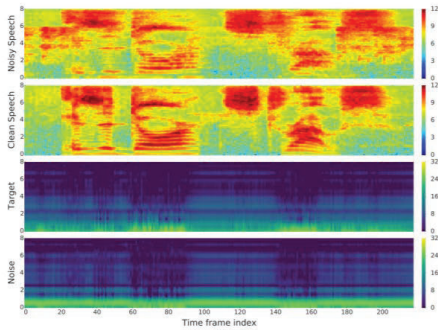


Figure 2: Visualizations of the predicted beamformer responses at different frequency (Y-axis) across time (X-axis) at the target speech direction (3rd) and interfering noise direction (4th) with the noisy (1st) and clean (2nd) speech spectrograms.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
	Figure 1: Neural network adaptive beamforming (NAB) model architecture. It consists of filter prediction (FP), filter-and-sum (FS) beamforming, acoustic modeling (AM) and multitask learning (MTL) blocks. Only two channels are shown for simplicity. https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/45399.pdf Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
19. The system of claim 18, wherein the delay is raised to a power that is proportional to a time difference between arrival of the speech at the first virtual microphone and arrival of the speech at the second virtual microphone.	Every Accused Product comprises of the system of claim 18, wherein the delay is raised to a power that is proportional to a time difference between arrival of the speech at the first virtual microphone and arrival of the speech at the second virtual microphone. For example, upon information and belief, the first microphone signal is delayed, and the delay is raised to a power that is proportional to a time difference of arrival of the speech at the first and second beamformed microphones. Computing this delay is the first step of delay and sum beamforming. For example, upon information and belief, the delay is raised to a power that is proportional to a time difference of arrival between the first and second beamformed microphones. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.
20[a]. The system of claim 19, wherein the power is proportional to a sampling frequency multiplied by a quantity equal to a third distance subtracted from a fourth distance the third distance being between a first physical microphone and the speech source, the fourth distance being between a second physical microphone	Every Accused Product comprises of the system of claim 19, wherein the power is proportional to a sampling frequency multiplied by a quantity equal to a third distance subtracted from a fourth distance the third distance being between a first physical microphone and the speech source For example, upon information and belief, the first microphone signal is delayed, and the delay is raised to a power proportional to a sampling frequency multiplied by a third distance subtracted by a fourth distance corresponding to the difference of the distances from the first and second microphones to the speech source. Computing this delay is the first step of delay and sum beamforming. For example, upon information and belief, the difference between a third and fourth distance is the difference between the distance between a talker's mouth and first physical microphone and the distance between a talker's mouth and a second physical microphone. Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.

Appendix H - Claim Chart For U.S. Patent No. 10,779,080

Claim	Support
and the speech source,	
20[b]. and the first and second physical microphones are positioned in the microphone array.	Every Accused Product comprises of a system including the fourth distance being between a second physical microphone and the speech source, and the first and second physical microphones are positioned in the microphone array. <i>See claim 1[a].</i> Plaintiff may supplement these contentions, including once access to relevant documents and/or source code is provided.